Nesting and Habitat Parameters for Selected Raptors in the Desert of Northwestern Utah

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NESTING AND HABITAT PARAMETERS FOR SELECTED RAPTORS IN THE DESERT OF NORTHERN UTAH

by

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David L. Peterson

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ABSTRACT

Nesting and Habitat Parameters for Selected Raptors
in the Desert of Northwestern Utah

by

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Utah State University, 1988

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This study examined the effects of habitat parameters, disturbances and predation on the reproductive success of golden eagles (Aquila chrysaetos), ferruginous hawks (Buteo regalis), red-tailed hawks (Buteo jamaicensis) and prairie falcons (Falco mexicanus) in the desert area southwest of the Great Salt Lake in northwestern Utah.

The prairie falcon was the only species examined that had a normal reproductive output during the study years of 1984-1986. The prairie falcon was better able to utilize the avian prey species which were very difficult for the larger and slower raptor species to capture. During the reproductive period prairie falcons used Townsend ground squirrel (Spermophilus townsendii) heavily. The golden eagles, ferruginous, and red-tailed hawks were not able to obtain sufficient numbers of their primary prey species, the cottontail rabbit (Sylvilagus nuttallii) and black-tailed jackrabbit (Lepus californicus), to allow for a normal reproductive output. These prey species were at the low point of their cyclic population pattern.

Disturbance to raptors was not an important factor on this remote study area. Predation, primarily terrestrial mammals, did have a negative effect on reproductive success; however, it was not a major consideration due to lack of predator access on most of the cliff nesting sites of the golden eagle, red-tailed hawk, and prairie falcon. Predation appeared to have a greater impact on the ferruginous hawk nesting success as their nest sites were normally accessable to mammalian predators.

Raptor nest site exposure was unimportant to nesting raptors. The nest exposure was very similar to the exposure ratio of the available cliff sites. (119 pages)

INTRODUCTION

Conservationists first recognized the value of raptors as "indicators" of environmental quality in the 1940s (Hickey 1969). From that time until the present, interest and research relating to raptors and their management has shown a steady increase.

This baseline study was financed by the U.S. Air Force to obtain information of value for raptor management on its desert training areas in Utah. The Great Salt Lake Desert, where this study was done, is a dry, harsh desert with few human inhabitants. It has been overgrazed by domestic livestock. Military training has set it on fire with various explosive devices, bombs and rockets. In recent years, off-road vehicles users have contributed to the negative impact on this environment, even in the most remote sections. Fortunately, many raptorial species can adapt to altered environments and human activity. However, there is a need to know the status of these species and their needs in order to reduce or modify man's impact when possible.

This study has focused on the habitat parameters, reproduction success, and movement patterns of four of the most common raptors breeding in Utah. The species investigated were the golden eagle (Aquila chrysaetos), ferruginous hawk (Buteo regalis), red-tailed hawk (Buteo jamaicensis), and the prairie falcon (Falco mexicanus).

A complete list of raptors known to be within the boundaries of the Air Force natural resources project area is shown in Table 1.

Dr. Tom Cade (1982) stated that even our best efforts to preserve some fragments of "natural ecosystems" for future generations of men and wildlife will not prevent man-induced alterations and degradation of habitat to continue as long as the human population remains at its present level or becomes larger. The Air Force land in Utah provides wildlife with some excellent "natural ecosystem" areas because of land protection and remoteness. Dr John J. Craighead (1987) stated in his foreword to the Raptor Management Techniques Manual:

> Because of their position at the top of the food chain, raptors are reliable indicators of the health of terrestrial ecosystems around the world. Thus, we should not overlook the value of baseline studies conducted over the past 50 years as ecological benchmarks for the future. This data will enable us to better evaluate changes that have occurred and to judge our progress in protecting not just these birds but our entire planet. (p. xiii)

Raptors lend themselves especially well to studies of population regulation and the influence of food availability on reproductive rates. Left alone, some species show extreme stability of breeding populations over long periods of time. Also, the role of spacing behavior in limiting their densities in relation to food and other resources has been demonstrated in recent research (Newton 1979).

Table 1. Diurnal raptors known to be within boundaries of the Air Force natural resource project area.

Species present	Breeder	Resident	Occurrence
Bald eagle (*Haliaeetus leucocephalus*)	no	winter	common
Golden eagle (*Aquila chrysaetos*)	yes	all year	common
Ferruginous hawk (*Buteo regalis*)	yes	all year	common
Red-tailed hawk (*Buteo jamaicensis*)	yes	all year	common
Swainson's hawk (*Buteo swainsoni*)	yes	summer	common
Rough-legged hawk (*Buteo lagopus*)	no	winter	abundant
Gyrfalcon (*Falco rusticolus*)	no	winter	very rare
Peregrine falcon (*Falco peregrinus*)	yes	spring summer/fall	rare
Prairie falcon (*Falco mexicanus*)	yes	all year	common
Merlin (*Falco columbarius*)	no	winter	rare
Kestrel (*Falco sparverius*)	yes	all year	common
Goshawk (*Accipiter gentilis*)	yes	all year	uncommon
Cooper's hawk (*Accipiter cooperi*)	yes	all year	uncommon
Sharp-shinned hawk (*Accipiter striatus*)	yes	all year	uncommon
Harrier (*Circus cyaneus*)	yes	all year	common
Turkey vulture (*Cathartes aura*)	yes	summer	common
Osprey (*Pandion haliaetus*)	no	migrant	very rare

Definitions - taking into consideration seasons of the year and correct habitat type:

abundant - several observed each day
common - one or more observed each day
uncommon - one or more observed each week
rare - one or more observed each month
very rare - one or more observed each year

REVIEW OF LITERATURE

Several studies on raptor species common to the proposed study area have been conducted throughout the Intermountain West. The peregrine (Falco peregrinus) and prairie falcon ecology and competition were reviewed by Porter, et al. (1973), and the beginning of the comeback of the peregrine was discussed by White (1984).

Brigham Young University graduate students have studied some raptor species in the southeastern part of the study area, specifically near the Cedar Valley area. Woffinden and Murphy (1983) investigated ferruginous hawk selection of nest sites from 1972 to 1974. They also studied the relationship of jackrabbit abundance and the reproduction of ferruginous hawks during this same period. It was found that the availability of jackrabbits as prey had a great influence on the reproductivity of ferruginous hawks. Reduced numbers of jackrabbits adversely affected clutch size and nesting success. Golden eagles' spatial relationships were investigated by Smith and Murphy (1982a). Smith and Murphy (1973) examined population dynamics, habitat selection, and partitioning of ranges of breeding raptors. Breeding ecology and biology of the ferruginous hawks were also investigated by Smith and Murphy (1979) in the eastern part of the Great Basin Desert of Utah in 1973 and 1978. Smith and Murphy (1982a) also looked at the nest site selection in raptor communities in the eastern Great Basin Desert. Platt (1971) conducted a survey of nesting ferruginous and Swainson's hawks in Curlew Valley, Utah to the north of the study area.

Platt (1971) and Howard and Wolfe (1976) also conducted research on ferruginous hawks in the study area. The work was done mostly in Curlew Valley, Box Elder County, Utah, which is just to the north of the study area. Wakeley (1978) studied the hunting methods and factors affecting their use by ferruginous hawks.

The migratory movements and seasonal changes in the range of birds of prey appear to be adaptations related to temporal and spatial changes in their food source (prey populations) (Cade 1982). Food availability, in the absence of human factors, has the greatest impact on the breeding rate of raptor populations (Newton 1979). Newton listed three main aspects as evidence: (1) annual fluctuation in breeding rates are associated with annual fluctuations in prey numbers, while stable breeding rates are associated with stable prey numbers; (2) area differences in breeding rates are associated with area differences in prey numbers; and (3) sudden and long-term breeding rates follow sudden and long-term alterations in prey populations. Studies of competition (Porter et al. 1973), population limitation and breeding strategies (Newton 1979), and specific population (Brown and Hopcraft 1973, Platt 1981, Enderson 1964, Cade and Dague 1977) all contain valuable information used in this project.

Raptor migration studies have been conducted within or along the boundaries of the study area by Hoffman and Potts

(1977). Gessaman (1986) investigated raptor migration for several years in northern and western Utah and eastern Nevada. Shirley (1982) did raptor migration work in the southeastern part of the study area during the early 1980s. Cache Valley, located just east of the study area, was investigated as a wintering site for bald and golden eagles by Vandemoer (1980).

OBJECTIVES

1. To examine the nesting parameters for golden eagles, ferruginous hawks, red-tailed hawks, and prairie falcons in the desert of northwestern Utah.
2. To evaluate reproductive success of these raptors as it relates to prey and various habitat and disturbance parameters.
3. To examine daily, monthly and seasonal movement patterns of raptors in northwestern Utah.

Parameters investigated included the following: nest site characteristics, type, height, exposure, overhang, and terrestrial predator access. Nesting attempts, time of egg laying, hatching and fledging periods, productivity, and mortality were recorded. Distances to water, other raptors' nests, disturbances, and types of disturbances were noted. Data were also obtained on daily hunting methods, prey species abundance and availability, seasonal changes, annual migration periods, and characteristics.

Questions Pertinent to the Study

1. Is there a difference in productivity caused by human disturbance factors?
2. Is there a difference in nesting sites for the four raptor species?

3. Is there a difference in production of young due to predator's accessibility to nest site?
4. Is there a difference in the diet of selected raptors due to seasonal availability?
5. Does prey density and availability have an effect on raptor productivity within the study areas?
6. Is there a difference in raptor species or numbers present over the year?

METHODS

The area selected for nesting studies is that portion of the Great Salt Lake Desert located within the boundaries shown in Figure 1. The area for intensive study was determined and 72 nest sites were chosen to investigate productivity of the four major raptor species: the golden eagle, ferruginous hawk, red-tailed hawk, and prairie falcon (Tables 2 and 3). Many remote sites were checked from the air during a helicopter survey on May 13, 1986. Active sites were rechecked from the ground, with the exception of four sites which could not be checked because of U.S. Air Force range restrictions. The vegetative composition near and around the nest sites is listed in Table 4. A complete list of plants located in the study area has been included in Appendix VI. The dominant vegetative species within 1/4 mile of each nest site was recorded on the nest site forms (Table 4). Those sites with a variety of plant species were described by those species that represented ten percent or more of the vegetative cover present.

The elevation of the lowest portions, the mud and salt flats of the study area, is approximately 1280 meters. The low mountain ranges that are found in the study area have only two peaks over 2012 meters, with the highest (2018 meters) found in the Lakeside Mountains on the eastern portion of the intensive study area. The majority of the area lies between 1280 meters and 1372 meters. It is a very dry area with less than 30.5 centimeters of precipitation

Study Area ______

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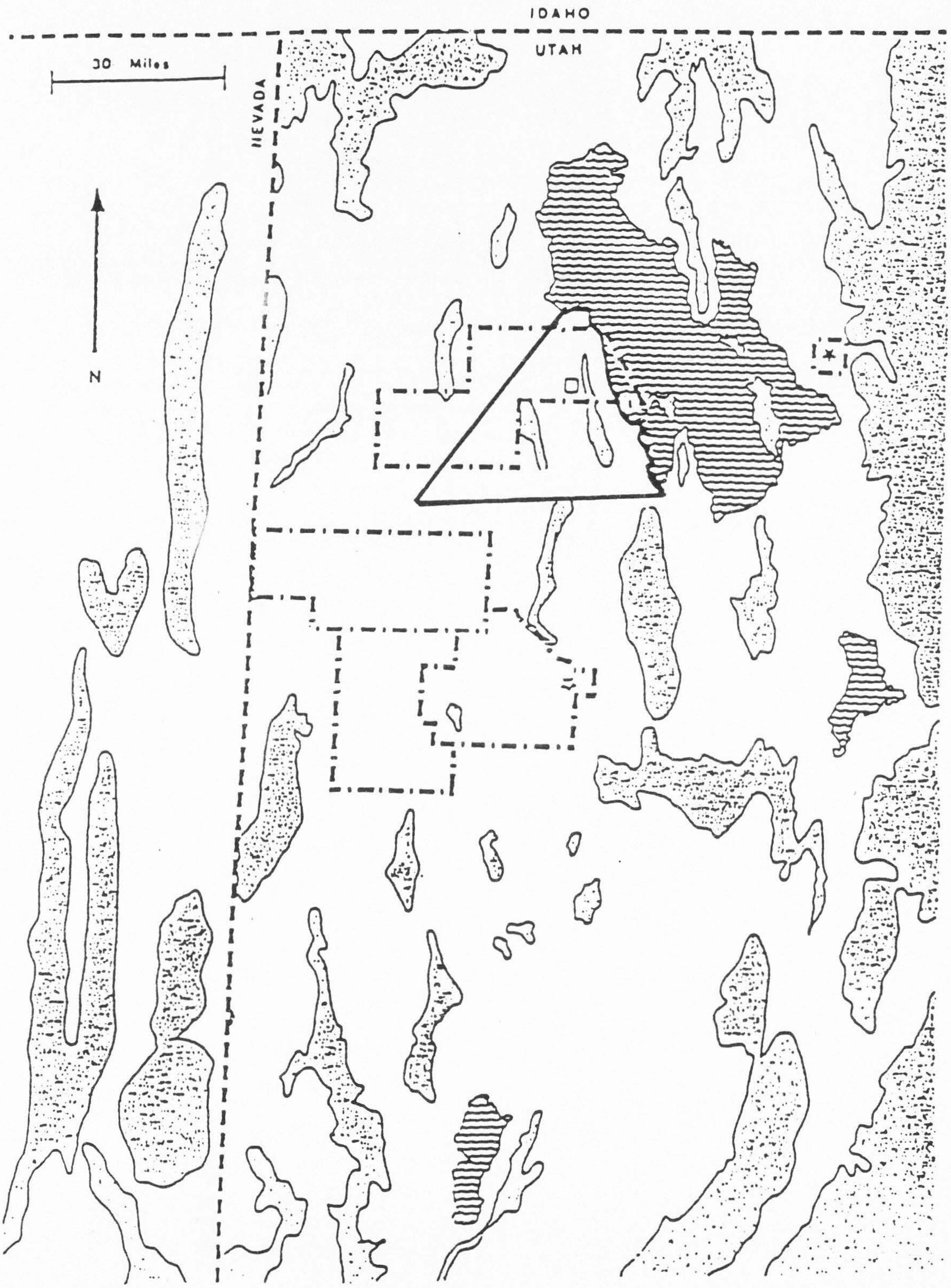


Figure 1. Map of study area.

Table 2. Percent of known raptor sites in the desert of northwestern Utah during 1985-86.

Raptor	Number of known sites	Percent of total raptor sites	Percent active 1985	1986	1985-86
Prairie falcon*	32	44.5	67.0 (12/18)	73.0 (19/26)	70.5 (31/44)
Golden eagle	15	20.8	0.0 (0/10)	15.4 (2/13)	8.7 (2/23)
Ferruginous hawk	11	15.3	50.0 (3/6)	15.4 (2/13)	26.3 (5/19)
Red-tailed hawk	14	19.4	25.0 (3/12)	8.0 (1/13)	16.0 (4/25)
Total	72	100.0			

*The prairie falcon was the only raptor that had a normal percent (70.5%) of sites active over the two years of the study. The other three raptors were considered to be at lower than normal reproductive levels compared to what had been observed before 1985 and 1986. (previous personal banding data)

Table 3. Percent of active nest sites for various raptor species in the western United States.

Source, location and date	Species	Nesting sites	Percent of active sites
Murphy Utah (UT 69)	ferruginous hawk	93	29.0
"	golden eagle	31	74.2
Snake River (ID 79) birds of prey	prairie falcon	132	83.5
	golden eagle	240	96.3
"	ferruginous hawk	66	75.6
"	red-tailed hawk	154	89.8
Anderson (WY 85) Wyoming study	prairie falcon	386	83.0
This study (UT 87)	prairie falcon	44	70.5
"	golden eagle	23	8.7
"	ferruginous hawk	19	26.3
"	red-tailed hawk	25	16.0

Table 4. Raptor nests were located in the following vegetative types.

Prairie falcon	
Sites	
8	Cheatgrass and shadscale
5	Cheatgrass, shadscale and sagebrush
5	Cheatgrass, shadscale and greasewood
9	Cheatgrass, shadscale, sagebrush and greasewood
5	Cheatgrass, shadscale, sagebrush, greasewood and junipers
32	Total
Golden eagle	
2	Cheatgrass
1	Cheatgrass and shadscale
5	Cheatgrass, shadscale and sagebrush
3	Cheatgrass, shadscale, sagebrush and greasewood
3	Cheatgrass, shadscale, sagebrush, greasewood and junipers
14	Total
Ferruginous hawks	
6	Cheatgrass, shadscale, greasewood and sagebrush
5	Cheatgrass, shadscale, greasewood, sagebrush and junipers
11	Total
Red-tailed hawks	
12	Cheatgrass, shadscale, greasewood and sagebrush
2	Cheatgrass, shadscale, greasewood, sagebrush and junipers
14	Total

annually, much of that coming as snow during the winter months. Vegetation on the U.S. Air Force ranges is shown in Figures 2 and 3. Extensive mud and salt flats are located to the east, west, and north of the main study area and form a natural boundary.

The total size of the study area is 2476 km^2. The salt and mud flats contained within the study area have been subtracted from this total, as the raptors do not use them. The Great Salt Lake is the eastern boundary and Great Salt Lake baseline was chosen as the southern boundary because of the uniformity of the Great Salt Desert in this area. The nearest cliff sites are located approximately the same distance north and south from this arbitrary boundary. It was assumed that there is an equal overlap of raptor territories inside and outside of the study area along the southern boundary.

Bushnell 7 x 35 binoculars and a Bushnell zoom lens 15-60x spotting scope were used to locate potential nest sites. Likely areas, such as trees, rocky outcroppings, and cliffs, were investigated for nesting activity. Stick nests, prey remains, mute stains, ledges or potholes in cliff faces, and presence of raptors were cause for a closer search on foot to verify nesting activity. Nesting sites were recorded and marked on topographic maps. Known raptor nest sites were investigated by aerial and ground surveys. Whenever evidence of nesting activity was observed, a nest site form was used to record the parameters of interest, such as nest site

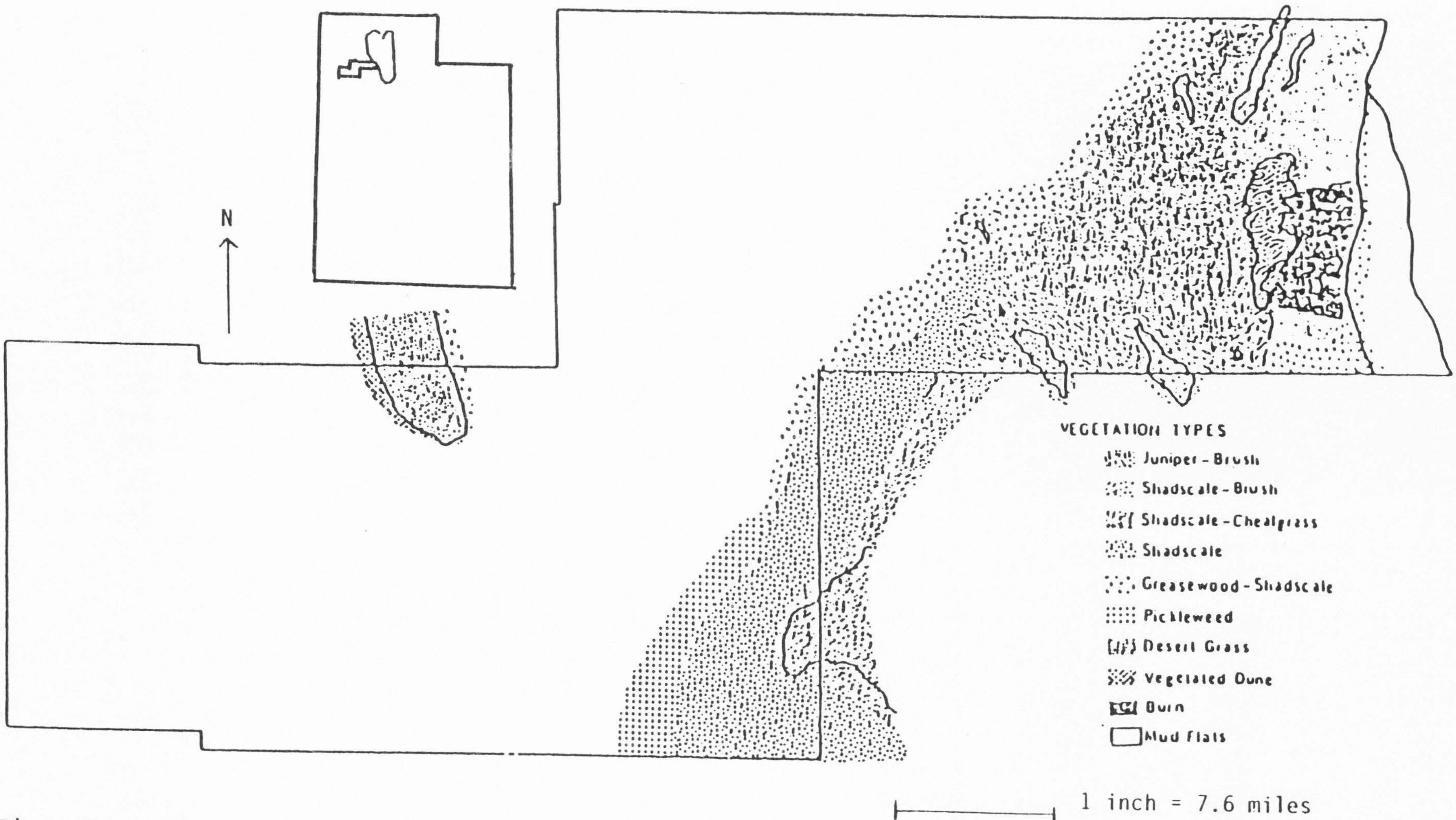


Figure 2. Plant cover map of the Utah Test and Training Range, North of Interstate Highway I-80, western Utah (after Fisher 1978).

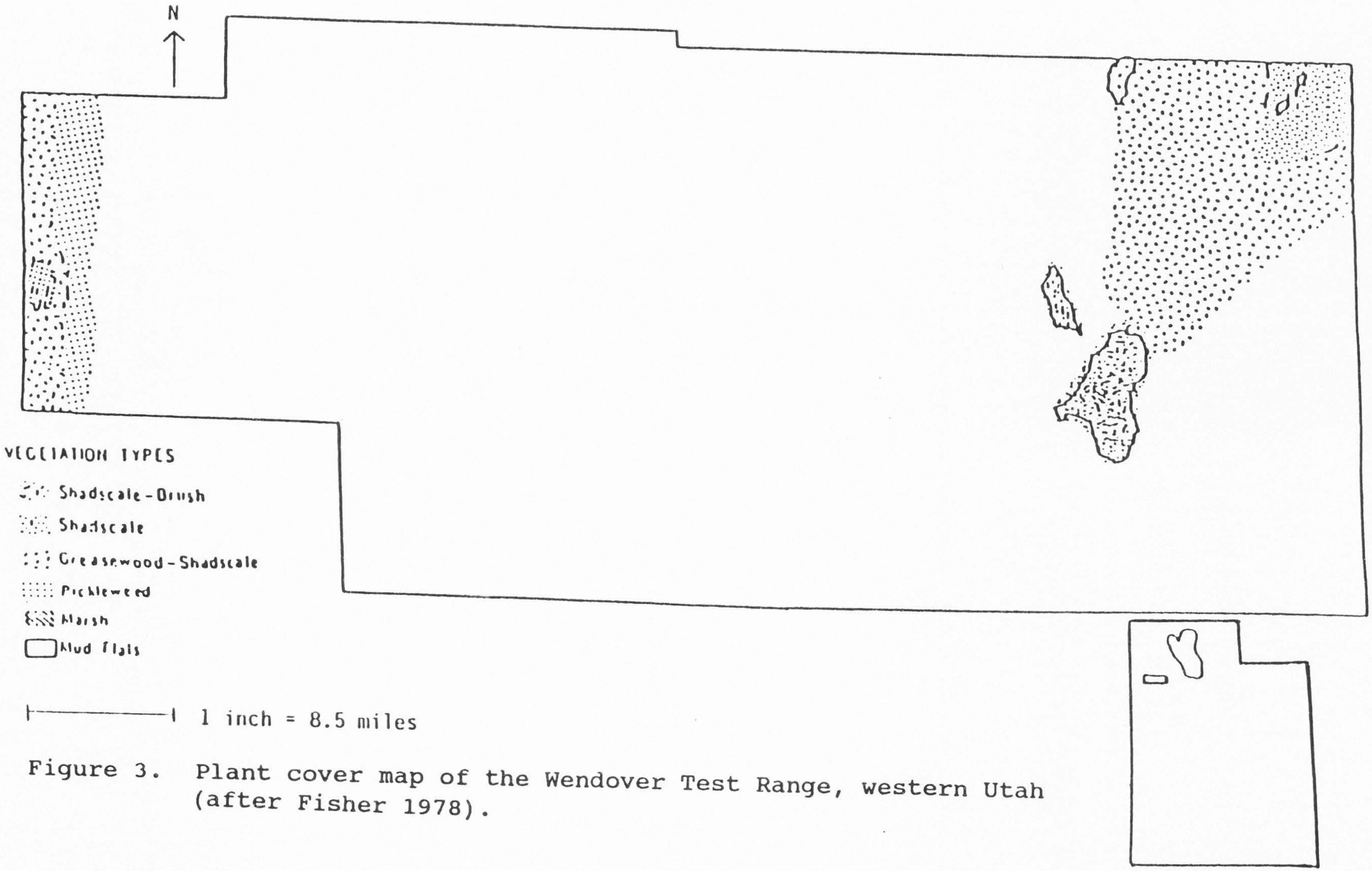


Figure 3. Plant cover map of the Wendover Test Range, western Utah (after Fisher 1978).

characteristics, reproductive information,and variables such as closest raptor nest, distance to water, distance from and probability of disturbance, etc.

Measurements were determined by using a 30-m measuring tape whenever possible. When a direct measurement was not possible, measurements were estimated. Distances to other nests, water, and disturbances were measured by odometers with the study vehicle.

Probability of disturbance was estimated as 1) low, area rarely visited by humans; 2) medium, area may be used by humans once or twice during breeding season; and 3) high, area used frequently by humans, primarily on weekends and holidays. The area of disturbance was defined as that area within 1 km of the nest site.

Definitions of some of the terms used throughout the study are as follows:

Sites checked - Total number of sites checked that were active in recent years.

Sites active - Number of sites checked that had one or both adults defending cliff or one egg laid.

Sites successful - Number of sites that raised at least one chick to within one week of fledging.

Mean clutch size - Average number of eggs in sites with one or more eggs present, that were checked after clutch was believed completed.

Mean brood size- Average number of chicks produced per active site.

Occupied sites were revisited as necessary to establish breeding success. Reproductive success was analyzed for number of young produced per occupied territory and number of young produced per successful nesting attempt. At least one young fledged per nest constituted a successful nest. A nesting attempt was recorded if one or more eggs were produced.

Evidence of productivity and mortality were recorded. Height, exposure, type of site, description of area, and nest site were also recorded. Additional sites were located during the summer, fall, and winter of 1985 and were investigated for occupancy and production in 1986.

Adult aggression was measured by assigning a value from one to five. No aggression was given a value of 1, little aggression (screaming)was given a 2, moderate aggression (screaming and diving to within 50 feet) was given a 3, high aggression (diving to within 10 feet) was given a 4, and extreme aggression (striking the intruder) was given a 5.

Prey remains at all nests and perching sites were noted. Hunting activity of fledging young were observed during the summer months. Raptor hunting methods and prey taken were recorded throughout the year. Transects were estabished to determine density and availability of the most common prey species throughout the year. Abundance of prey species were primarily determined from observations, and five line transects were conducted monthly in 1985 and 1986 (Figure 4).

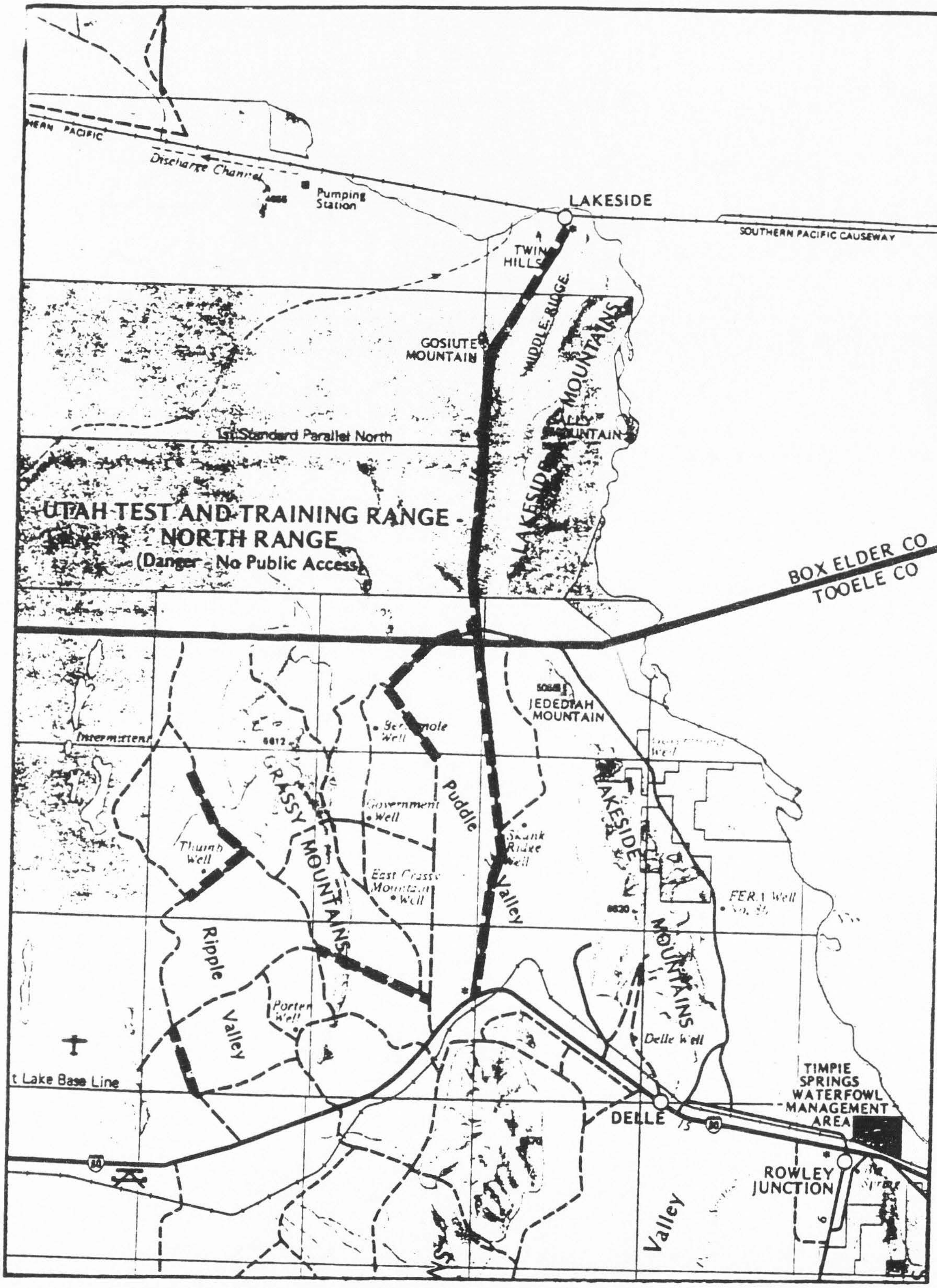


Figure 4. Locations of prey line transects in the study area, northwestern Utah. Designated by ▬ ▬ ▬ ▬ ▬ ▬ .

The transects were established along existing roads within the study area. A pickup truck was driven over the transects at a speed of 30 km/hr. The driver recorded all prey species observed along the transect. The transects were 7 to 50 km long and bisected the main raptor hunting areas. Bird species were counted each month. Reptiles and ground squirrels were only counted during the months they were active.

Townsend ground squirrels, horned larks, and meadow larks were the only species recorded in significant enough numbers to permit computation of population indices. Lagomorphs were only observed on rare instances, three times in 1985 and eight times in 1986. These transects were conducted at least two times each month using a pickup truck, and I was the observer-recorder. There were 65 kilometers of transects located on the intensive study area.

Raptor migration was the main focus of research during the fall, with additional observations made in early spring. This activity was coordinated with the work being done by Dr. James A. Gessaman of the Biology Department, Utah State University. Dr. Gessaman has been actively involved with raptor migration in and near the study area for the past several years, and his data collection techniques were of great value during this study. Dr. Gessaman has used sites in the Goshute Mountains to the west and the Wellsville Mountains to the east of the study area, on which migration data have been collected for several years (Gessaman 1982). Raptor numbers and species observed were recorded on an hourly, daily, and seasonal basis, along with altitude, weather conditions, and direction of movement (Appendix III).

Sample means and standard deviations were determined for habitat, nest site parameters, and productivity for each species of raptor. Statistical analysis was applied to the information collected for the various quantitative variables for the four species of raptors studied.

Regression analysis was also used to test variables to determine any significance in relation to number of young raptors fledged. Significance of the variables was tested for each raptor species, using the Pearson Correlation technique.

RESULTS AND DISCUSSION

Raptor Densities

Approximately 280 known raptor nest sites in northern Utah were located and recorded on maps during the course of the investigations for this project (Table 5). Sixteen prairie falcons were located on the intensive study area, representing a mean of 155 km^2 per nesting territory. The mud and salt flats were not included in estimates of home range size. The total number of territories found were considered to be at least 90 percent of territories present within the study area. The territory sizes are within the normal ranges for prairie falcons (Table 6). Golden eagle densities found in this study were 13 territories in 2476 km^2, an estimation of 190 km^2 per pair. This is a lower density than normally found (Table 7). There was a total of 12 territories for ferruginous hawks in this same area, for a density of one pair per 206 km^2. The total number of red-tailed hawk pairs with nesting territories in the study area during 1985 and 1986 was 7, which gave a range of 354 km^2 per pair. In the studies listed in Tables 5 and 6, a direct comparison would not be completely accurate, as some research estimates were obtained by telemetry methods. Other investigators arrived at their figures by dividing the known raptor pairs into the suitable habitat in their study area.

Table 5. Known raptor nest sites in or near the study area.

Location in study area	Prairie falcon	Golden eagle	Ferruginous hawks	Red-tailed hawks	Swainson hawks	Great horned owl
	Raptor species					
NW	8	20	16	10	0	8
NE	0	12	1	4	0	1
SW	23	33	34	21	2	6
SE	23	36	4	16	0	5
Totals	54	101	55	51	2	20
Percent of totals	19.1%	35.7%	19.4%	18.0%	0.7%	7.1%

* Includes nest site information obtained from Bureau of Land Management and Utah Division of Wildlife Resources.

Table 6. Density of prairie falcons in various studies.

Study	Location	Sample size	Home range estimate (per pair)
Olendorff (1973)	Canada		184 km
Kochert (1979)	Idaho		121 km^2
Haramata (1978)	California		104 km^2
This study (1987)	Utah		155 km2

Table 7. Density of golden eagle in various studies.

Study	Location	Sample size	Home range estimate (per pair)
Camenzind (1969)	Utah	unknown	98.4 km
McGahan (1968)	Montana	19	171.0 km^2
Reynolds (1969)	Montana	27	152.8 km^2
Kochert (1979)	Idaho	unknown	91.9 km^2
Kochert (1979)	Idaho	unknown	65.8 km^2
Dixon (1937)	California	27	49.2 to 152.8 km^2
Brown & Watson (1964)	Scotland	unknown	46.0 to 72.3 km^2
This study (1987)	Utah	13	190.4 km2

A report on prairie falcons on the Pawnee National Grasslands in northeast Colorado (Olendorff 1973) showed a density of 1.4 pair per 259 km^2. Home ranges of prairie falcons (Kochert 1979) nesting in the Snake River Birds of Prey area were elongated ranges running in a northeasterly direction from the nest sites in the cliffs along the river to the dense ground squirrel populations located to the northeast. Individual prairie falcon home range sizes in southern Idaho had a mean of 121 km^2 (Kochert 1979). The mean home range of seven pairs varied from 87 to 162 km^2. Pairs flew a mean of 22 km from the nest and 24 km from the river, with a maximum of 26 and 30 km, respectively. Prairie falcon home ranges exhibited a large degree of overlap, as has been observed in prairie falcons by other researchers (Newton 1976). The Craigheads (1956) found individual home ranges to average 26 km^2 near Moose, Wyoming, in the Jackson Hole region.

Mean individual home ranges for Mojave Desert prairie falcons were 59 km^2 (Haramata 1978). The individual home range size was 72 km^2 for males and 47 km^2 for females. Total home ranges for three pairs of instrumented prairie falcons were 68, 83, and 162 km^2. The ranges were occupied during the reproductive periods and the eyries (raptor nest sites) were situated near the center of the total range. Creosote brush and shadscale scrub were the two main habitat types in these ranges. Alkali sinks were also present on some of the ranges but were usually only a small fraction of the total. A comparison of pair densities is found in Tables 6 and 7.

Raptor-Prey Relationships

Prey availability during this study did have a strong influence on raptor reproductive rates. Line transects were established along five roads in the study area (Figure 4). Birds were counted each month. Ground squirrels were counted from February 1 through July 1 in 1985 and 1986. Black-tailed jackrabbits and cottontail rabbits were not observed on the transects. Three jackrabbits were observed in 1985, and eight in 1986. Other birds and reptiles were observed only rarely on the transects, and they were recorded but not given an index value. In 1985, the index value for horned larks per mile of transect was 7.9, compared to 7.64 in 1986. The meadowlark index in 1985 was 0.24, compared to 0.20 in 1986. The ground squirrel index for 1985 was 2.29, compared to 1.08 in 1986. The squirrel index was influenced by the relative amount of vegetation cover. Squirrels were easily observed on the transects in 1985, a dry year when the vegetation had been almost completely consumed by rodents and grasshoppers. The higher vegetation present in the second year reduced the number of squirrels observed per mile. Cheatgrass, which is normally 18 to 15 cm high in this area, reached heights of 36 to 41 cm. However, it is believed that the squirrel populations were about the same in both years, and the visibility of squirrels on the transects was responsible for the difference in the index figure.

Millions of grasshoppers were present during the spring and summer of 1985. Counts of over 100 insects per square meter were common, and in many areas the vegetation had been eaten to the ground. Grasshoppers were used as food by many raptor species. As the vegetation cover was eaten by these insects, small rodents and other prey normally hidden by the plants became more vulnerable to predation. It was feared that the grasshopper problem would be even worse in 1986. However, the spring of 1986 was much wetter and cooler than normal, which reduced the number of grasshoppers. This wet weather also allowed plants to recover and become desirable food and cover for many of the raptor prey species. It did not increase the rabbit population significantly.

Raptor feeding and hunting patterns change seasonally as does the level of prey populations in the study area. The Townsend ground squirrel is a prime example. Kochert (1979) found that male Townsend ground squirrels start to emerge from their winter dens in late January. Adult females and yearlings emerge 1-2 weeks later. Breeding occurs shortly after emergence. The last part of March and early April bring the new litters above ground. April has all age classes active and available as prey. Adult males begin to aestivate in mid-May. Adult females and yearlings go below ground in early June in normal years. Juveniles begin dormancy from mid-June to mid-July (Kochert 1979).

Horned lark, meadowlark, (not a true lark but a member of the blackbird family) and mourning dove (Zenaida macroura) young begin to fledge at the same time as prairie falcon young. This provides young, inexperienced prey for the young prairie falcons. Young prairie falcons leave the study area when ground squirrel numbers begin to go underground in late June and July. Juveniles do not reappear on the study area until October. All lagomorph species are normally important prey for young golden eagles, ferruginous hawks, and red-tailed hawks during the first several weeks after fledging. Reptiles were found to be a common item in the diet of red-tailed hawks, as gopher snakes (Pituophis melanoleucus) were commonly observed in their nests.

The information obtained from line transects is an index figure and is compared only to other index figures for the same species using similar census techniques (Anderson et al. 1976). A census index is defined in Wildlife Management Techniques (Giles 1971) as a count or ratio which is relative in some sense to the total number of animals in a specified population. A sample census is a special case of a census index. A census estimate is an estimate of the total number of animals in a specified population, obtained from a census index. Prey transects conducted by vehicle counts on a set course will give a species-specific abundance index expressed as the number of individuals per observer-mile.

Prey transects have been used by the U.S. Fish and Wildlife personnel from Utah State University to estimate jackrabbit population in Curlew Valley, located near the study area in western Box Elder County, Utah. Square-mile transects were randomly selected throughout the valley. Transects are walked each spring and fall by observers. Records are kept of the numbers and right-angle-flushing distances of jackrabbits observed. The transect data is computer analyzed, and the output is an estimate of absolute jackrabbit density, expressed as jackrabbits/km^2. This method of information was obtained from the January 1986 annual report, which also includes the relative abundance of coyotes, jackrabbits and rodents in Curlew Valley, Utah. The report was part of the Predator Ecology and Behavior Project of the U.S. Fish and Wildlife Service, Denver Wildlife Research Center.

The data in Figure 5 support the findings obtained from the study area. In 1986, no jackrabbits were observed on any of the transects (Knowlton 1987 pers. comm.). This was the first time in twenty years that this had happened; jackrabbit habitat is very similar to that found in the study area. There was no golden eagle production and very few ferruginous hawks fledged during 1985 and 1986 (Paul 1986 pers. comm.).

A study in Wyoming on prairie falcons (Anderson et al. 1985) also used roadside counts to determine the relative abundance of prey species. Horned larks, Richardson ground squirrels, and white-tailed prairie dogs (Cynomys gunnisoni)

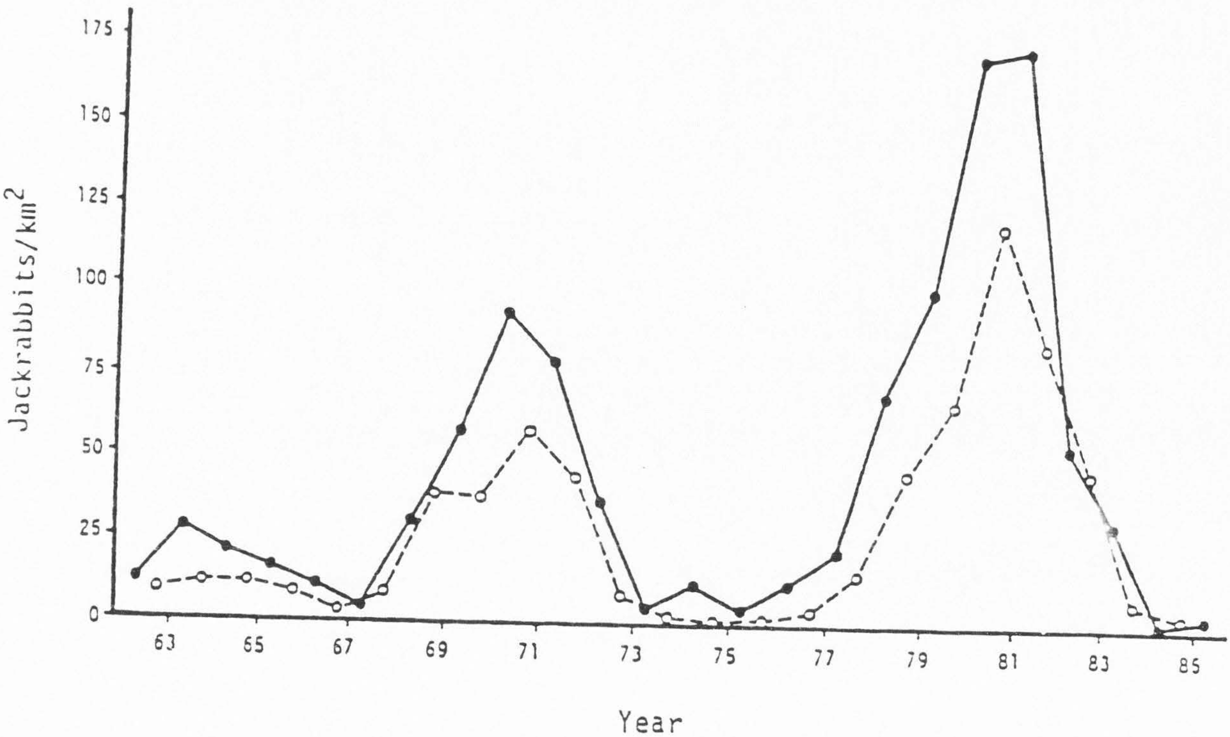


Figure 5. Spring (open circles) and fall (closed circles) jackrabbit density on the Curlew Valley area, 1962-1985 (Anonymous 1987).

were counted along roads through prairie falcon hunting areas with low shrub cover. Routes varied in length from 8 to 10 km. Prey species were counted at 3 points along each km of the transect.

Newton (1979) discussed two main times of stress in the breeding cycle of raptors (prelaying/laying period and the early nesting period). Prior to and during laying, the female needs extra food to produce eggs and to build reserves. To a large extent, breeding failure due to scarcity of prey occurs during this time. Many females on nesting territories do not lay or, if they do, soon desert their eggs. Breeding attempts that complete incubation most often fail soon after hatch if food is not abundant. This is an important period, as the male has to obtain more food than at any other stage. The male needs food for himself, the female, and the growing young. The amount of prey and the male's ability to obtain it are critical at this time. When the young are older they require more food. However, the female is able to help her mate obtain prey during this period, as brooding of the young is no longer necessary.

Prairie falcons often capture prey on the ground, with rodents and ground-dwelling birds comprising the major portion of their diet (Porter et al. 1973). Heavy utilization of key prey species has been discussed by Enderson (1964) and Porter et al. (1973). Often the two most important prey species utilized by a local population include one species of bird and one species of mammals. Enderson (1964) noted a predominance of horned larks (Eremophila alpestris) and Richardson's ground squirrels (Spermophilus richardsonii) in the diet of Wyoming and Colorado prairie falcons. Leedy (1972) observed similar use of these species in western Montana. Results of a five-year study by Kochert (1979)of the prey of prairie falcons in the Snake River Birds of Prey area in Idaho by Kochert (1979) indicate a heavy reliance on Townsend's ground squirrels (S. townsendii). Plains pocket gophers (Geomys bursarius) and horned larks are heavily utilized in New Mexico (Platt 1974).

Becker and Ball (1981) documented western meadow larks (Sturnella neglecta) and 13-lined ground squirrels (S. tridecemlineatus) as key prairie falcon prey in southeastern Montana. In each of the studies cited, numerous other prey species were identified as being used to a lesser extent, depending on the geographical area. The prairie falcon is prone to feed more on rodents and ground-dwelling birds such as quail, pheasant, meadows larks, and passerine birds (Porter et al. 1973). It is less inclined than the peregrine falcon to feed on pigeons, doves, and flickers. The prairie falcon utilizes a much wider variety of vertebrate species than does the peregrine falcon, including reptiles such as the whiptail lizard (Porter et al. 1973).

Some raptors feed primarily on prey species that show definite cycles in population numbers (Kennedy 1980). Prairie falcon populations are sensitive to major fluctuations of certain prey species. However, they can change from mammalian prey to avian prey much more effectively than many hawks and eagles. Many raptor species are subject to major productivity changes because of the extreme density changes in their major prey species, such as lagomorphs and microtines. Prairie falcons seem to be able to concentrate on one or two prey species, often the one mammal and one bird species most available at any given season.

Increased fledging success of prairie falcons appears to be related to increased densities of prey species (Garrett and Mitchell 1973). In California, small mammal control efforts are conducted annually; they reduce such prey species as the Beecher ground squirrel (Citellus beecheyi). This control appears to have significantly reduced the nest densities and distribution of prairie falcons, particularly in the southern San Joaquin Valley. Historically, the Beecher ground squirrel has been the main prey species of prairie falcons in California during their reproductive season (Bent 1938, Bond 1936, Dawson 1913).

Prairie falcon eyries are almost always associated with cliffs, rock outcroppings, and canyon walls. They are normally used year after year and are relatively easy to locate. This allows for accurate population monitoring on a long-term basis.

According to the literature, the breeding output of golden eagles fluctuates according to the numbers of black-tailed jackrabbits (Lepus californicus) in arid parts of the western United States (Smith and Murphy 1982b, Howard and Wolfe 1976). The jackrabbit is found in more than nine-tenths of the golden eagles' diet (Murphy 1975, Beecham and Kochert 1975).

Prey availability and raptor production are very closely associated, as shown in a prey summary from Kochert's (1979) Snake River Birds of Prey Special Report:

> Nearly 60% of the biomass consumed by golden eagles during this study were black-tailed

> jackrabbits. Reproductive performance of eagles declined in response to the declines of the black-tailed jackrabbit population. While cottontail proportions remained relatively constant in the eagle's diet; yearly changes in the proportions of jackrabbit in their diet reflected yearly changes in jackrabbit densities.
>
> Prairie falcon's nesting in the Birds of Prey study area during years of low ground squirrel abundance switched to other prey items. The reduced proportion of ground squirrel in their diet was accompanied by an increase in the consumption of birds, particularly rock doves in 1977, and an increase in jackrabbits in 1978.
>
> Linear regression analysis relating average March ground squirrel densities in the study area to prairie falcon productivity yielded a coefficient of determination (R2) of .981. This showed that ground squirrel density accounted for more than 98 percent of the variation in prairie falcons reproductive performance. Nestling survival averaged 89% in good ground squirrel years, compared to 66% in 1977-78 when ground squirrel densities were low. (p. 142)

Of the three major raptor species studied by Kochert (1979), red-tailed hawks were the most generalized predators. Ground squirrels, jackrabbits and cottontails comprised 68 percent of the biomass in the red-tailed hawk diet. Gopher snakes and kangaroo rats each comprised slightly more than 5 percent of the total number of individual prey items. In another study, Woffinden and Murphy (1977) observed declines in ferruginous hawk populations associated with jackrabbit declines. Becker and Ball (1981) presented similar information on the prey of prairie falcons in their paper on the impacts of mining on prairie falcons for the United State Fish and Wildlife Service.

Breeding varies widely in response to changes in mammal populations for the ferruginous hawk of western North America. In one area, the annual production varied between 0.6 and 3.0 young per pair, depending on the black-tailed jackrabbit numbers (Woffinden and Murphy 1977). In another area, a 47 percent reduction in success from one year to the next was associated with a 79 percent decline in jackrabbit numbers (Howard and Wolfe 1976).

Human Disturbance

Little human disturbance is known to occur in this area and no raptor nesting attempts were known to have failed because of it. This study area is quite remote and the military lands are all off limits to the public. There is little military activity occurring on the ground, as this area is used primarily as a bomb and gunnery range by the U.S. Air Force.

Human disturbances, when they occur, appear to be a major factor in golden eagle nesting failures. Bocker and Ray (1971) noted that human disturbance was responsible for 85 percent of the nesting failures observed in their study of eagles along the front range of the Rocky Mountains in New Mexico, Colorado, and Wyoming. Six of 13 nesting failures in Camenzind's Utah study (1969) were due to human interferences. Where human pressures are great, eagles have completely abandoned their nesting territories, and in some cases have moved to higher altitudes to nest (Murphy 1975).

In southwestern Idaho, Kochert (1979) had a 21 percent nesting failure due to human disturbances.

Prairie and peregrine falcons place their feet under their eggs while they are incubating. This practice can cause damage or loss of the eggs if the adult is flushed from the nest suddenly, such as when a person disturbs them from above or comes close to their nest ledge before the falcon is aware of their presence (Weaver and Cade 1983). When visiting a nest site for any reason during the period when eggs may be present, it is advisable to approach the cliff or nest site from the front or begin to make noises while still some distance away from the cliff. This will give the brooding falcon advance warning and allow it to get up more slowly and with less alarm then when suddenly surprised at close range.

The Bureau of Land Management's multiple land use philosophy in the Mojave Desert has resulted in nesting prairie falcons being subject to tremendous human disturbances. As a result, fledging success was found to be lower for nests located near roads versus nests away from roads (Haramata 1978).

In Haramata's (1978) study on a Mojave Desert range he discussed his observations of disturbances by military aircraft and human disturbances on the prairie falcon eyries as follows:

> Low level flights of military aircraft were common near The Buttes, Klinker Mountain and Red Mountain eyries. Squadrons of F-4 fighter bombers

> often flew within hundreds of meters of the Klinker Mountain and Red Mountain eyries. Similiarly, A-6, A-10, F-4, and F-15 jet aircraft passed close to The Buttes eyrie. Ground shaking sonic booms were also common in the area.
> The speed and high level of noise associated with the large aircraft during low level flights was portentious and unsettling to human observers, yet the falcons showed no apparent reaction. The falcons also did not react to the violent sonic booms. The incubating female at The Buttes, however, was seen to turn her head briefly as a B-1 bomber and T-38 chase plane passed over the eyrie. Apparently they have habituated to aircraft. (p. 114)

The ferruginous hawk preys on mammals that fluctuate greatly in annual abundance, and many pairs will desert their nests in years with less prey, even if not disturbed. They are very sensitive, especially early in the reproductive period when eggs are present. In one Utah area, 7 of 13 nests that were disturbed in one year were subsequently deserted, but no nests were deserted in the following year when prey numbers were much higher (Weston 1968).

On the Fort Carson Military Reservation in Colorado, an adult red-tailed hawk was monitored from August to November (Anderson et al. 1985). This area was subjected to periodic tank maneuvers and heavy weapons firing. The adult male red-tailed hawk altered its behavior to accommodate periods of military activity. During periods when there was military activity, none of the relocations obtained by telemetry were inside of the training area, and the bird shifted its center of activity approximately 1.6 km southeast away from the activity. During these activity periods, the bird was never west of a ridge which defined the east boundary of the training area. This north-south ridge supported the nest site and visually isolated the training area from the bird's southeast activity area.

The red-tailed hawk was never relocated in the training area when military personnel and equipment were present, although it returned to the area after training ceased. They did not know how frequently this short-term displacement behavior may occur in red-tailed hawks, or if it is exhibited by other raptors.

Prairie falcons are usually very aggressive in nest defense. A few falcons restricted eyrie defense only to persons that approached very close to the nest. Some of these falcons would vocalize briefly when people approached and then soar high overhead. Other falcons would quietly fly off, seldom noticed by the intruder. This gradation of defensive behavior seemed to be directly related to the remoteness of the eyrie. Those close to a road or regular disturbances showed the least defensive behavior patterns, while those seldom disturbed tended to show very aggressive defense behavior.

Adult Aggressiveness

This study found most prairie falcons to be very aggressive defenders of their nest sites. The defense is characterized by loud vocalizations and intimidating stoops. They may get very close but seldom strike a human. However, it appears that some falcons breeding in areas of intense human use have adopted an almost complete avoidance of humans when the nest site is approached.

Golden eagles seldom if ever defend their nest site against human intruders. The adults usually leave while the person or persons are a distance of one-half to one kilometer from the cliff site. The adults usually stay in the area, however, soaring at great heights until the disturbance is gone.

Ferruginous and red-tailed hawks usually react to human disturbances by flying overhead, screaming and occasionally diving toward the intruder; however, the birds usually pull up 10 to 20 meters above a human. Normally, ferruginous hawks scream overhead and may also actively defend the nest site but do not come as close to striking the individual as prairie falcons. Red-tailed hawks scream while they circle overhead, seldom diving at the intruder. Golden eagles will soar silently at much greater heights, sometimes completely out of sight overhead, but do little else.

Terrestrial Predation

Terrestrial predators in this study accounted for the failure of 7.1 percent of the prairie falcons nests, 14.3 percent of the golden eagles, 27.3 percent of the ferruginous hawks, and 8.3 percent of the red-tailed hawks. Nest attempts that failed because of terrestrial predators are listed in Table 8.

Table 8. Active raptor nest sites with predator access.

Raptor species	Active nests	With predator access	Number failed	Without predator access	Number failed	x^2 (0.05)
Prairie falcon	28	6	2	22	0	22.7
Golden eagle	14	2	0	12	0	14.0
Ferruginous hawks	11	11	3	0	0	4.6
Red-tailed hawks	12	1	1	11	0	1.0

(x^2 0.05,1 = 3.841)

The terrestrial predators suspected in nest predation are the coyote (Canis latrans), kit fox (Vulpes macrotis), and bobcat (Lynx rufus). Tracks of these three predators were common around the nest site cliffs on the study area. Badger (Taxidea taxus) tracks were also common on the study area. These animals may have been able to reach some of the cliff sites where predation occurred.

A chi-square test of independence was used to determine the possible significance of observed differences in the success rate between nest sites with terrestrial predator access and those sites without access. The prairie falcon, golden eagle, and ferruginous hawk did have a significant difference ($p \leq 0.05$), with the sites that had predator access showing a higher failure rate. No significant difference was found in the success rate between sites for red-tailed hawks.

A chi-square test was also used to determine if there was a significant difference in the success rate between years for the prairie falcon data in Table 9. It was found that there was a significant difference between sites with predator access in 1985 and 1986. There was significant difference at sites with terrestrial predator access in 1986. However, any difference found may have been due to the small numbers of sites with access.

Table 9. Prairie falcon reproductive failure due to terrestrial predation for the years 1984-1986.

Year	Sample size	Sites with predator access successful	Sites with predator access failed	Sites without predator access successful	Sites without predator access failed	x^2 (0.05)
1984	5	1	0	4	0	5.0
1985	8	2	0	6	0	8.0
1886	15	3	2	12	0	17.7
Totals	28	6	2	22	0	

(x^2 0.05 = 3.841)

A T-test was used to determine if there were a significant difference between years in the average number of young prairie falcons fledged per nesting attempt. No significant difference was found at the 0.05 level. Types of cliff sites used by prairie falcons are found in Table 10.

Golden eagles used rocky cliff faces for all of their nest sites; however, there were very few large trees that may have been suitable for nests in the study area. All were very large stick nests located on ledges that appeared to have been used for several years, as additional material is added each nesting season.

Table 10. Types of prairie falcon nest sites.

Sample	Potholes	Crevice	Ledge	Stick crevice	Nest
28	16	5	4	3	3

* Prairie falcon nest sites were all located on rocky cliff faces.

Ferruginous hawks used juniper trees, rocky outcroppings, and low cliffs, usually located at the point or edge of a ridge higher than the surrounding terrain. This species normally constructs a stick and sagebrush nest. These nests are usually just a pile of sticks and sagebrush when constructed on the ground. They may be quite large when built on a cliff ledge, rock outcropping, or in a juniper tree, as additional material is added each year. When the nest site is built on the ground or ridge top it does not usually increase in size, probably due to disturbance and scattering by large mammals such as badgers, coyotes, livestock, etc.

Among prairie falcons in Idaho, nests accessible to mammal predators were less successful than other nests and exposed nests. Cliff nests accessible to mammals were only successful in nine of 17 attempts (53 percent), compared to

82 of 93 attempts (88 percent) in nests inaccessible to mammals (Ogden and Hornocker 1977). Exposed nests suffered 90 percent more egg loss than secluded ones in the same study.

Among ferruginous hawks in Washington State, ground nests produced an average of only 0.6 young each, whereas tree nests produced 2.2 young (Fitzner et al. 1977).

Reproductive Information and Nest Site Parameters

The reproductive success and time periods for each raptor species are described in Tables 11-20 and Figures 6-9. In Tables 6-9, the age of young chicks were estimated based on previous experience with known-age chicks. If hatching and fledging dates were unknown, the dates were estimated by using the information found in Newton (1979) and Snow (1981) on average number of days incubated and average age of fledgings.

Means and standard deviations for the productivity parameters, number of eggs, number of chicks, and number of young fledged, were determined for each species each year (Tables 17-20). The data for each year were pooled for each species, and the means and standard deviations were complied (Tables 21-24). The reproductive parameters, such as numbers of eggs, chicks, and fledglings for the prairie falcon on the study area, are to be considered minimal, as actual production of eggs and young may be slightly higher. Nests that were visited late, or new sites located later in the

Table 11. Prairie falcon reproductive success in northwestern Utah during 1984-86.

Year	Active nests	Number of eggs	Average eggs per nesting attempt
1984	6	22	3.67
1985	8	23	2.88
1986	15	46	3.07
Total	29	91	3.14

Year	Active nests	Number of young	Average young per nesting attempt
1984	6	21	3.50
1985	8	22	2.75
1986	14	37	2.64
Total	28	80	2.86

Year	Active nests	Number fledged	Average fledged per nesting attempt
1984	6	16	2.67
1985	8	22	2.75
1986	14	32	2.28
Total	28	70	2.50

Year	Number of attempts sample size	Number of successful attempts	Fledging success percent
1984	6	5	83.3
1985	8	8	100.0
1986	14	13	92.8
Total	28	26	92.8

Year	Number of nests sampled	Young fledged per year	Average young fledged per successful attempt
1984	5	16	3.20
1985	8	22	2.75
1986	13	32	2.46
Total	26	70	2.69

Table 12. Reproductive rates of prairie falcon in various studies.

Source and date	Study years	Location	Sites checked	Sites active	Sites successful	Mean clutch size per active site	Mean number of chicks per active site	Mean fledged per active site	Mean fledged per successful site
Enderson (1964)	60-62	Colo.	94	87%	82%	4.5	1.9	1.2	
Ogden and Hornocker (1977)	71-72	Idaho	126	87%	81%	4.4	3.5	3.1	
Olendorff (1973)	71-72	Colo.	27	96%		4.4	3.9	3.4	
Leedy (1972)	70-71	Mont.	58			4.3	2.4	1.9	2.9
Oliphant et al (1976)	74-75	Canada	31	68%			2.8	2.5	4.2
Fyle et at (1969)	68	Canada					2.5		3.6
Parker (1973)	73	Wash.						3.0	3.4
Platt (1981)	76-78	Colo.	122	72%	76%	4.5	2.8	2.5	3.7
Denton (1975)	73-74	Ore.	61	82%		4.1	3.4	2.5	3.0
Haramata (1978)	78	Calif.	4	50%					3.0
Anderson et al (1985)	82-85	Wyo.	386	83%	66%			2.5	3.6
Becker and Ball (1981)	80-81	Mont.				4.6	4.2	3.9	4.5
Edwards (1973)	73	Alberta				4.5	2.5		1.6
Platt (1974)	74	New Mexico				3.2	2.9		
Lockhart et al (1977)	77	Mont.						3.4	
Johnstone (1980)	79-80	Ore.				4.3	3.8	3.2	
Lockhart et al (1980)	79-80	Wyo.						3.2	
Kochert (1979)	70-78	Idaho	365	75%		2.0	1.8	1.0	1.6
This study (1987)	84-86	Utah	44	71%	71%	3.1	2.9	2.5	2.5
Mean (except this study)				77%	77%	4.1	3.0	2.7	3.2

Table 13. Timing of reproductive periods for prairie falcons in various studies.

Source and date	Arrival at nest site	Egg laying	Hatching	Fledging
Enderson (1964)	Feb 22-Mid Mar	Apr 12-May 9	May 12-June 6	June 21-July 19
Ogden & Hornocker (1977)	Late Jan	Apr 20-May 22	May 1- June 7	June 9-July 16
Olendorff (1973)		Apr 12-May 10	May 12-June 10	June 13-June 19
Denton (1975)	Mid Mar	Apr 2-May 8	May 1-Jan 7	June 9-July 16
Haramata (1978)		Mar 24-Apr 15	Apr 25-June 9	May 31-June 28
Becker & Ball (1981)		Apr 15-May 18	May 14-June 28	May 28-July 24
Platt (1974)		Apr 4-Apr 30	May 4-May 30	June 7-July 3
Johnstone (1980)		Apr 20-May 17	Apr 19-June 6	May 28-July 19
Kochert (1979)	Early Jan/Feb	Mid Mar-Late May	Early Apr-July 1	Late May-Mid July
This study (1987)		Mar 22-Apr 20	Apr 24-May 21	June 2-July 1

Table 14. Reproductive success for golden eagles in northwestern Utah during 1985-86.

Year	Number of nest sites	Sites active	Sites active (%)	Observed number of eggs per site	Young fledged per active site	Successful attempts (%)
1984	2	2	100	1+	1	100
1985	11	0	0	0	0	0
1986	13	2	15.4	1+	1	100
Total	26	4				
Average			15.4	1	1	100

* Note a plus (+) sign indicates that the number shown is the minimun amount known, there could have been additional eggs or young present.

Table 15. Reproductive success for ferruginous hawks in the northwestern desert of Utah during 1985-86.

Year	Number of nest sites	Sites active	Sites active (%)	Observed number of eggs per site	Young fledged per active site	Successful attempts (%)
1984	2	2	100	3+	3	100
1985	6	3	50	3+	3	100
1986	9	3	33.3	1.67+	0	0
Total	17	8				
Average			61.1	2.6	2	66.6

Table 16. Reproductive success for red-tailed hawks in northwestern Utah during 1985-86.

Year	Number of nest sites	Sites active	Sites active (%)	Observed number of eggs	Young fledged per active site	Successful attempts (%)
1984	1	1	100	2+	2	100
1985	12	3	25	2.67+	1.67	100
1986	13	2	15.4	1+	1.5	50
Total	26	6				
Average			46.8	1.90	1.67	83.3

Table 17. Prairie falcon reproductive data by year in northwestern Utah.

Year	Variable	Sample size	Mean and standard deviation	Range
1984	No. eggs	6	3.7 (0.8)	3-5
1984	No. chicks	6	3.5 (0.6)	3-4
1984	No. fledged	6	3.3 (0.5)	3-4
1985	No. eggs	13	1.8 (1.9)	0-5
1985	No. chicks	13	1.7 (1.8)	0-5
1985	No. fledged	13	1.7 (1.8)	0-5
1986	No. eggs	22	2.1 (1.9)	0-5
1986	No. chicks	22	1.7 (1.7)	0-5
1986	No. fledged	22	1.5 (1.6)	0-5

Analysis of Variance
used between years for significant difference
at the 0.05 level

Year	Nest sites	Active sites	Mean fledged	$p \leq 0.05$
1984	6	6	3.3	.046
1985	13	8	1.7	--
1986	22	14	1.5	--

Year 1984 was found to be significantly different from both 1985 and 1986. However, sample size in 1984 was much smaller than the other years and data on inactive sites were not available.

Table 18. Golden eagle reproductive data by year in northwestern Utah.

Year	Variable	Sample size	Mean and standard deviation	Range
1984	No. eggs	4	0.5 (0.5)	0-1
1984	No. chicks	4	0.5 (0.5)	0-1
1984	No. fledged	4	0.5 (0.5)	0-1
1985	No. eggs	11	0.0 (0.0)	0
1985	No. chicks	11	0.0 (0.0)	0
1985	No. fledged	11	0.0 (0.0)	0
1986	No. eggs	13	0.2 (0.4)	0-1
1986	No. chicks	13	0.2 (0.4)	0-1
1986	No. fledged	13	0.2 (0.4)	0-1

Analysis of Variance
used between years for significant difference
at the 0.05 level

Year	Nest sites	Active sites	Mean fledged	$p \leq 0.05$
1984	4	2	0.5	--
1985	11	0	0.0	.049
1986	13	2	0.2	--

Year 1985 was found to be significantly different. This is believed to be a result of the small number of nest sites active during the study; 1985 had no sites active.

Table 19. Ferruginous hawk reproductive data by year in northwestern Utah.

Year	Variable	Sample size	Mean and standard deviation	Range
1984	No. eggs	2	3.0 (0)	3-3
1984	No. chicks	2	3.0 (0)	3-3
1984	No. fledged	2	3.0 (0)	3-3
1985	No. eggs	6	1.5 (1.6)	0-3
1985	No. chicks	6	1.5 (1.6)	0-3
1985	No. fledged	6	1.5 (1.6)	0-3
1986	No. eggs	8	0.6 (0.9)	0-2
1986	No. chicks	8	0.5 (0.9)	0-2
1986	No. fledged	8	0.0 (0.0)	0-2

Analysis of Variance
used between years for significant difference
at the 0.05 level

Year	Nest sites	Active sites	Mean fledged	$p \leq 0.05$
1984	2	2	3.0	--
1985	6	3	1.5	--
1986	8	3	0.0	.005

Year 1986 was found to be significantly different from both 1984 and 1985. No young were fledged in 1986.

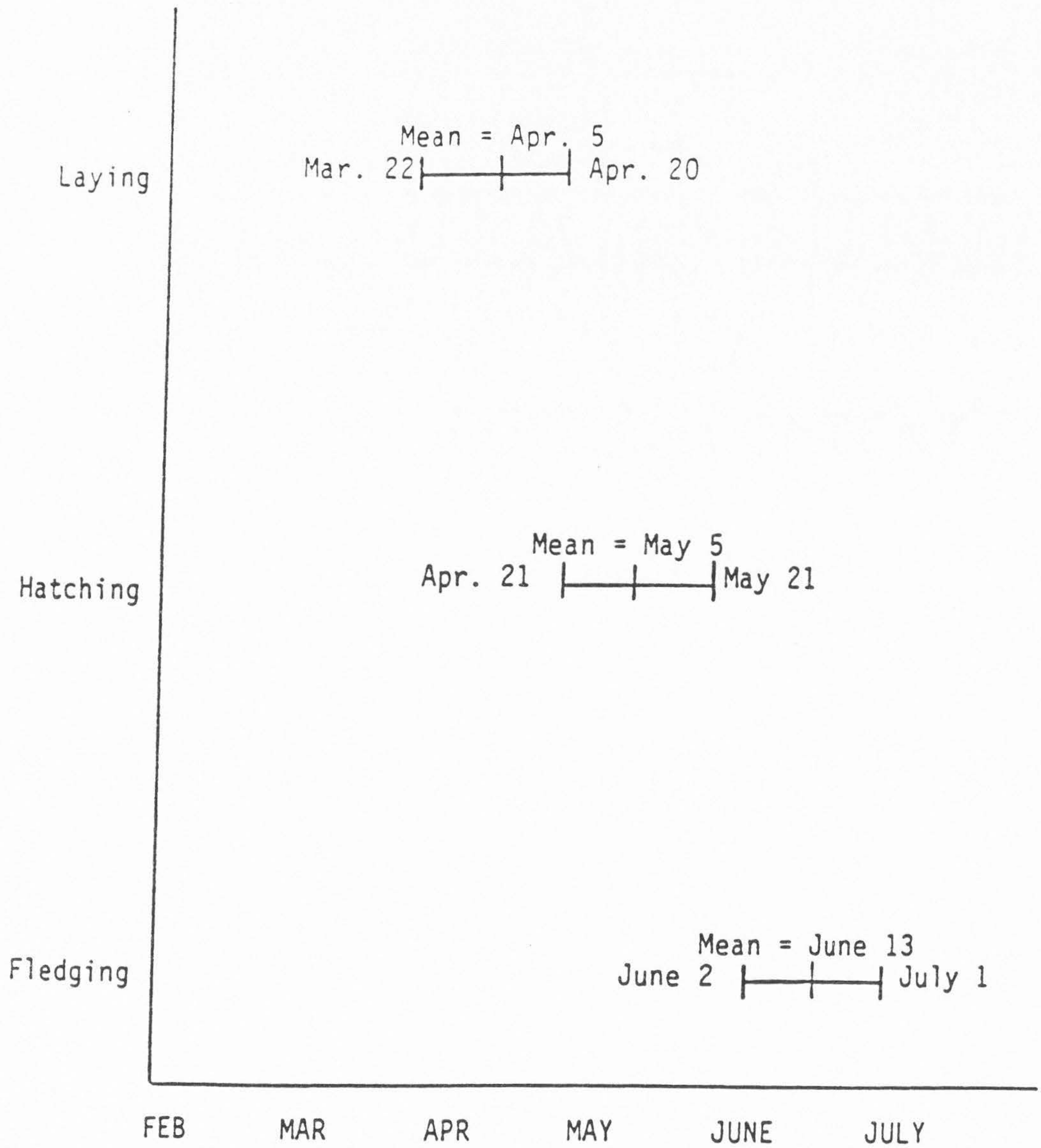
Table 20. Red-tailed hawk reproductive data by year in northwestern Utah.

Year	Variable	Sample size	Mean and standard deviation	Range
1984	No. eggs	2	1.0 (1.4)	0-2
1984	No. chicks	2	1.0 (1.4)	0-2
1984	No. fledged	2	1.0 (1.4)	0-2
1985	No. eggs	11	0.7 (1.3)	0-4
1985	No. chicks	11	0.5 (0.8)	0-2
1985	No. fledged	11	0.5 (0.8)	0-2
1986	No. eggs	13	0.2 (0.4)	0-1
1986	No. chicks	13	0.1 (0.3)	0-1
1986	No. fledged	13	0.1 (0.3)	0-1

Analysis of Variance
used between years for significant difference
at the 0.05 level

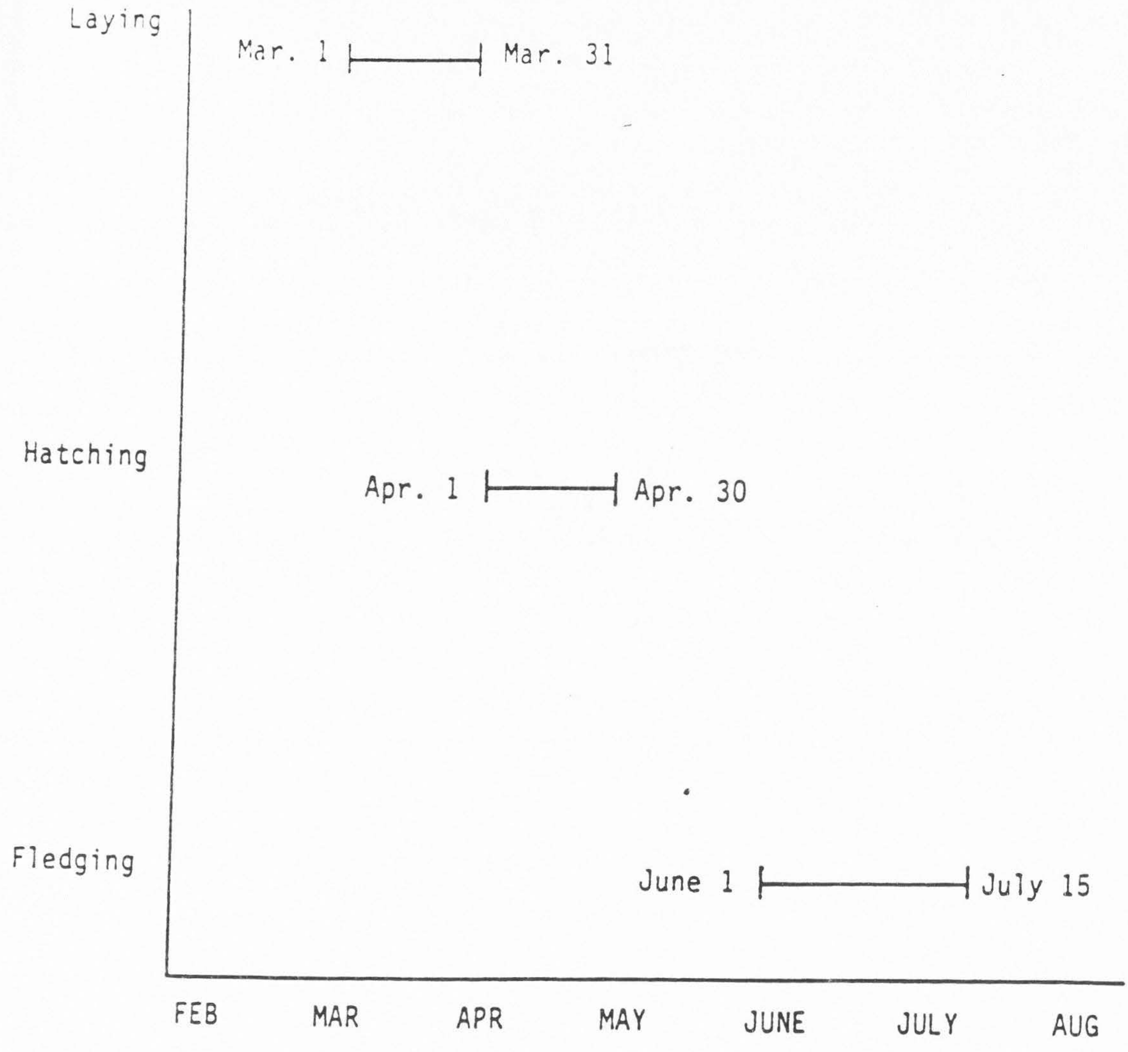
Year	Nest sites	Active sites	Mean fledged	$p \leq 0.05$
1984	2	1	1.0	--
1985	11	3	0.0	--
1986	13	2	0.01	--

No years were found to be significantly different.



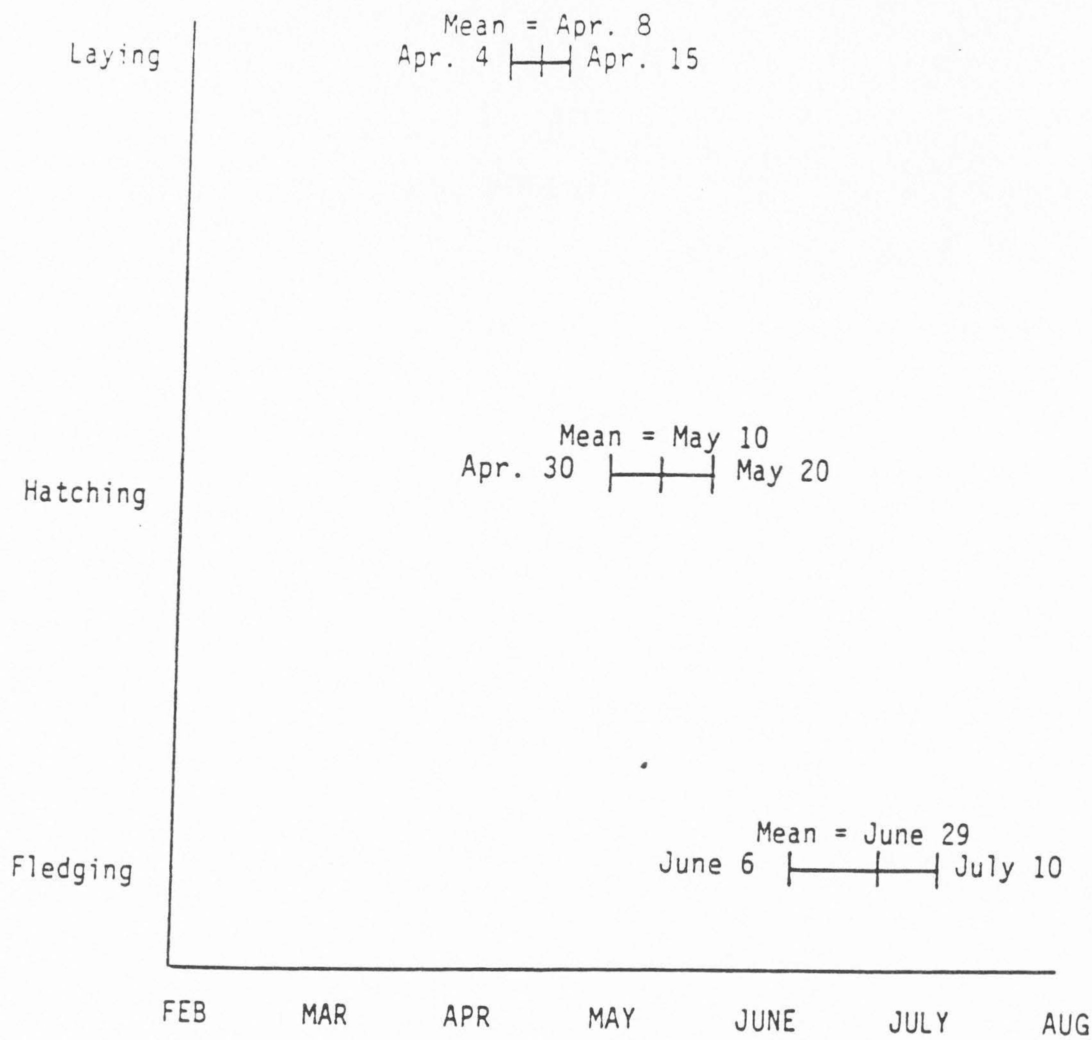
Egg laying to hatching = 31 days
Hatching to fledging = 40 days (Newton 1979)

Figure 6. Prairie falcon - reproductive periods in northwestern Utah.



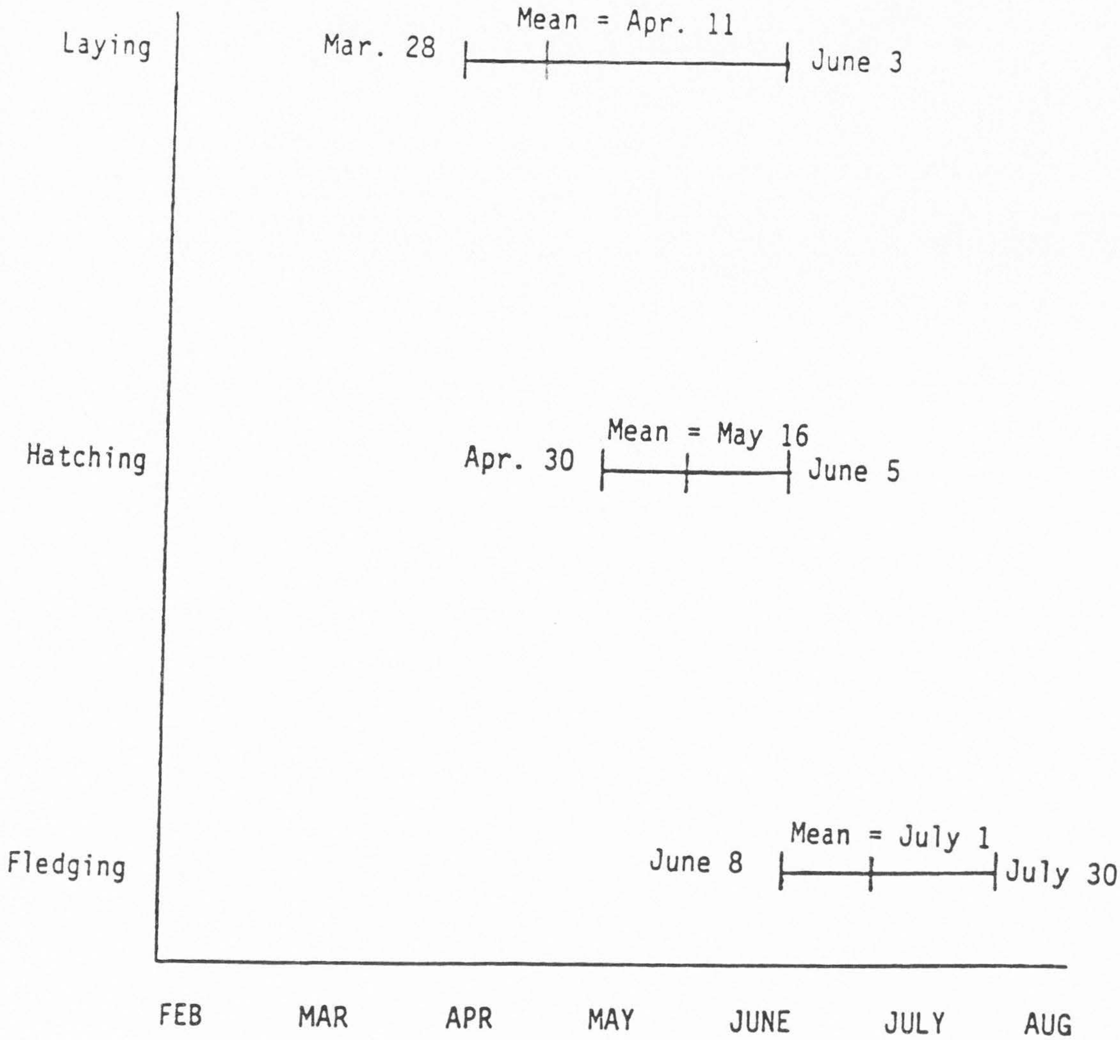
Means not calculated (insufficient data)
Egg laying to hatching = 44 days (Newton 1979)
and 41-43 days (Snow 1981)
Hatching to fledging = 63 to 70 days (Snow 1981 and Newton 1979).

Figure 7. Golden eagle - reproductive periods in northwestern Utah.



Egg laying to hatching = 34 days
Hatching to fledging = 46 days (Newton 1979)

Figure 8. Ferruginous hawk - reproductive periods in northwestern Utah.



Egg laying to hatching = 33 days
Hatching to fledging = 45 days (Newton 1979)

Figure 9. Red-tailed hawk - reproductive periods in northwestern Utah.

Table 21. Prairie falcon nest site parameters in northwestern Utah. Data from 1984-1986 (N=37) pooled.

Variable	Mean	Standard deviation	Minimum	Maximum
Height of cliff (meters)	18.0	8.9	2.4	38
Height of nest site (meters)	12.5	7.5	1.8	30
Amount of overhang (percent)	100.0	0.0	100	100
Closest raptor nest (kilometer)	2.0	1.5	0	5
Closest nest of same species (kilometer)	5.6	3.3	1.6	16
Distance to water (kilometer)	3.3	1.5	1.6	5
Distance to closest disturbance (meters)	591.0	391.0	15	1609
Probability of disturbance (1 to 3)	1.1	0.4	1	3

* Estimated probability of disturbance: low = 1 moderate = 2 high = 3

Table 22. Golden eagle nest site parameters in northwestern Utah. Data from 1984-1986 (N=7) pooled.

Variable	Mean	Standard deviation	Minimum	Maximum
Height of cliff (meter)	21.7	12.8	4.6	60
Height of nest site (meter)	15.1	9.7	2.4	45
Amount of overhang (percent)	3.7	7.5	0	20
Closest raptor nest (kilometer)	2.0	1.3	0	5
Closest nest of same species (kilometer)	3.7	1.5	1.6	5
Distance to water (kilometer)	2.1	2.9	1.6	8
Distance to closest disturbance (meter)	754.0	459.0	229	1609
Probability of disturbance (1 to 3)	1.2	.4	1	2

* Estimated probability of disturbance: Low = 1 Moderate = 2 High = 3

Table 23. Ferruginous hawks nest site parameters in northwestern Utah. Data from 1984-1986 (N=14) pooled.

Variable	Mean	Standard deviation	Minimum	Maximum
Height of cliff (meter)	4.2	2.2	1.2	9
Height of nest site (meter)	3.0	1.8	0	6
Amount of overhang (percent)	0.0	0.0	0	0
Closest raptor nest (kilometer)	0.8	0.5	1.6	2
Closest nest of same species (kilometer)	3.7	1.3	1.6	5
Distance to water (kilometer)	1.9	1.1	1.6	5
Distance to closest disturbance (meter)	520.0	607.0	5	1609
Probability of disturbance (1 to 3)	1.3	0.5	1	2

* Estimated probability of disturbance: low = 1 moderate = 2 high = 3

Table 24. Red-tailed hawk nest site parameters in northwestern Utah. Data from 1984-1986 (N=10) pooled.

Variable	Mean	Standard deviation	Minimum	Maximum
Height of cliff (meter)	14.4	17.7	4.6	76
Height of nest site (meter)	7.28	4.8	2.4	21
Amount of overhang (percent)	41.5	47.5	0	100
Closest raptor nest (kilometer)	2.9	0.97	0.48	5
Closest nest of same species (kilometer)	3.7	0.64	3.2	5
Distance to water (kilometer)	3.3	1.3	1.6	6
Distance to closest disturbance (meter)	612.0	496.0	48	1609
Probability of disturbance (1 to 3)	1.4	0.6	1	3

* Estimated probability of disturbance: low = 1 moderate = 2 high = 3

reproductive season that contained young about to fledge, were used to estimate numbers of eggs and young. If the nest held two fledglings, then 2+ young and 2+ eggs were recorded as the number of eggs and young produced at the site. The difference between the number of prairie falcons produced each year was not found to be significant.

Statewide, the average number of fledgings per productive pair of prairie falcons in California during 1970-72 was 3.2 (Garrett and Mitchell 1973). However, the average number of fledgings for all pairs observed during the same period was a low 1.59 fledgings per pair. Enderson (1969) suggested 2.0 fledgings as the level required to maintain a stable population based on two years of age at first breeding.

As shown in Tables 11 and 12, the results of 2.5 young fledged per nesting attempt falls within the normal range for a stable population. A chi-square test was used to determine if there were any significant differences in the reproductive rates in this study as compared to other studies on prairie falcons (Table 12). No significant difference was found at the 0.05 level.

Most studies have shown that a large majority of prairie falcons do not breed until their second year of age. However, when additional nesting sites are present and the prey densities high, more birds will breed at one year of age than during average years (Enderson 1969, Platt 1981).

The number of young fledged per golden eagle during 1984 through 1986 on this study was 1.0 young fledged per year; however, the sample size was quite small as there were only four pairs active during this study. Data from other eagle studies quoted in this section suggest 0.79 young fledged per year is closer to the norm.

The following information on golden eagle reproduction is summarized from Kochert's (1979) report on the Birds of Prey Study area in Idaho:

> It is more difficult to assess the recuitment required for population stability for golden eagles than for prairie falcons because of the lack of data on eagle mortality rates. The status of the Birds of Prey study of Idaho population can be appraised by comparing their long-term reproductive rate with that of other golden eagle populations reported in the literature.
>
> The seven year average of 0.75 young fledged/pair/annum in the Birds of Prey study area in Idaho (Table 18) compares favorably with long-term averages in other areas. The combined average for all undisturbed golden eagle populations studied is 0.79 young fledged per year, only slightly above the Birds of Prey study in Idaho average. Golden eagles in the Birds of Prey study in Idaho, then, appear to be doing as well as those reported in the literature. This fact, in addition to the stable number of traditional eagle sites occupied in the Birds of Prey study in Idaho, indicates a presently healthy, stable population of golden eagles in the Birds of Prey study in Idaho. (p. 142)

Results of Statistical Analysis

All of the field data collected was coded into a computer for statistical analysis. The Pearson correlation coefficients technique was employed to determine the parameters of significance for each species using an alpha

Table 25. Statistical analysis of nest site parameters compared to number of young fledged.

Species	Pearson correlation coefficient	Significant level $p<0.05$	Slope
Golden eagle	None found		
Red-tailed hawk	Adult aggression	.000	+
Ferruginous hawk	Adult aggression	.004	+
	Probability of disturbance	.015	+
Prairie falcon	Adult aggression	.006	+
	Cliff height	.003	-
	Nest height	.009	-

Species	Multiple regression mean substitution	Significant level $p<0.05$	Slope
Golden eagle	None found	--	--
Red-tailed hawk	Adult aggression	.000	+
Ferruginous hawk	None found	--	--
Prairie falcon	Cliff height	.006	+

Species	Multiple regression mean substitution (pairwise)	Significant level $p<0.05$	Slope
Golden eagle	None found	--	--
Red-tailed hawk	Adult aggression	.000	+
Ferruginous hawk	Adult aggression	.007	-
Prairie falcon	Cliff height	.002	+

level of 0.05 (Table 25). There were no significant parameters found using this technique for the golden eagle data. Adult aggression was found to be a significant parameter for red-tailed hawks, ferruginous hawks, and prairie falcons. The higher the value for aggression, the more young fledged. The golden eagle rarely shows aggression when the nest site is visited. This would explain why this parameter was significant for the other three species that do show some degree of aggression at the nest site. Cliff height and nest height were found to have a significant negative correlation.

The probability of disturbance parameter was found to be significant for the ferruginous hawk and prairie falcon. The cliff height also was significant for the prairie falcon when using this correlation technique.

The ferruginous hawk is the species most likely to desert its nest when disturbed. This has already been discussed previously in this paper. Of course, repeated disturbances will cause desertion of the nest by all raptor species if severe and frequent.

Cliff height did appear to be important to prairie falcons when a nest site was established. They appeared to favor the highest and steepest portion of the cliff for their nest site. Lower cliffs were avoided when possible, but were used when higher cliffs were not available.

A multiple regression analysis was run on the computer, and the mean was substituted for any missing data for each parameter. This was done to obtain the maximum number of values for the parameters. Again, no significance was found for the golden eagle. The ferruginous hawk had no parameters of significance using this method. Adult aggression was again significant for the red-tailed hawk, and the cliff height was again important to the prairie falcon as indicated by the Pearson correlation coefficient technique.

Multiple regression with mean substitution and pairwise analysis was used to examine the parameters for significant values. As in the other two techniques, no golden eagle nest site parameters were found to be of significant value at the 0.05 confidence level. Adult aggression was again a significant parameter for the red-tailed and ferruginous hawks, as has been shown in the results of the other statistical methods used. Cliff height for prairie falcons was found to be significant, as it was with the other two methods (Table 25). P values for all nest site parameters are listed in Table 26.

A multinomial chi-square distribution test was used to determine if any particular site exposure was selected. Cliffs and nest sites were assigned to the eight different directions used (N, NE, E, SE, S, SW, W, NW) (Figures 10-13).

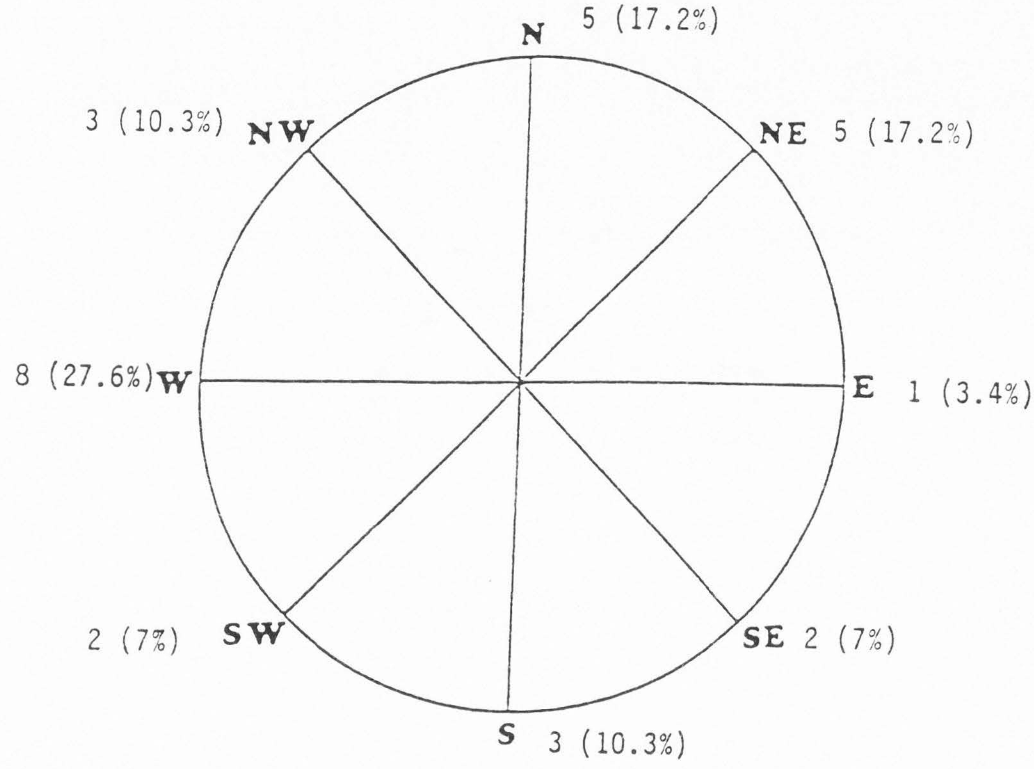
Each species was examined separately and compared to the chi-square value at the 0.05 level of 14.067. The chi-square value found for prairie falcons was $x^2 = 4.666$. The value found for golden eagles and for ferruginous hawks was $x^2 - 0.000$. Red-tailed hawk's chi-square value was $x^2 = 0.666$. These values all being much lower than 14.067,

Table 26. P values of nest site parameters compared to number of young fledged for golden eagles, red-tailed hawks, ferruginous hawks, and prairie falcons using Pearson correlation coefficients.

Species	Parameter	P Value	Slope
Golden eagle	Predator access	.071	
	Failed-due to predator access	--	
	Failed-without predator access	--	
	Adult aggression	--	
	Cliff height	.316	-
	Nest height	.079	-
	Cliff exposure	.245	-
	Nest exposure	.500	-
	Overhang	.117	
	Vegetation type	.269	-
	Closest raptor nest	.243	-
	Closest nest of same species	--	
	Closest water	.066	
	Closest disturbance	.088	-
	Type of disturbance	.162	
	Probability of disturbance	.435	-
Red-tailed hawk	Predator access	.310	-
	Failed-due to predator access	--	
	Failed-without predator access	--	
	Adult aggression	.000	
	Cliff height	.335	-
	Nest height	.474	-
	Cliff exposure	.410	
	Nest exposure	.424	
	Overhang	.322	
	Vegetation type	.147	
	Closest raptor nest	.073	-
	Closest nest of same species	.095	
	Closest water	.121	-
	Closest disturbance	.208	
	Type of disturbance	.474	-
	Probability of disturbance	.080	-

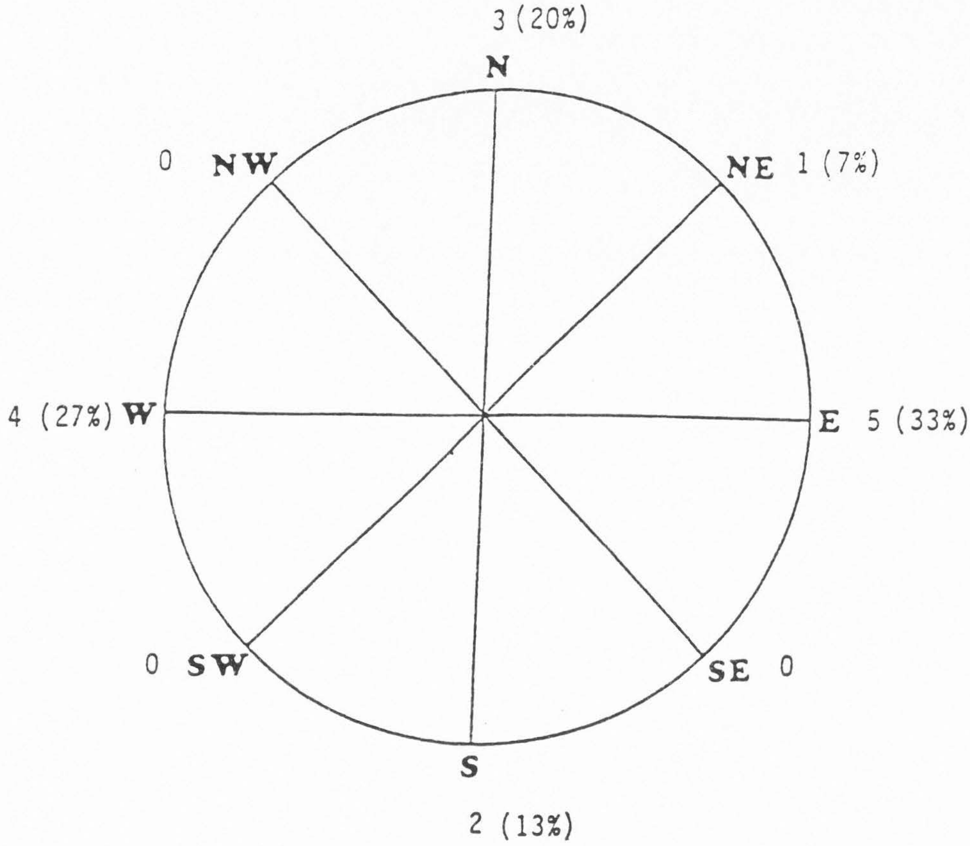
Table 26. P values of nest site parameters compared to number of young fledged . . . continued.

Species	Parameter	P Value	Slope
Ferruginous hawk	Predator access	--	
	Failed-due to predator access	.111	-
	Failed-without predator access	--	
	Adult aggression	.004	
	Cliff height	.052	-
	Nest height	.372	-
	Cliff exposure	.068	-
	Nest exposure	--	
	Overhang	--	
	Vegetation type	.426	-
	Closest raptor nest	.202	
	Closest nest of same species	.080	-
	Closest water	.399	-
	Closest disturbance	.068	-
	Type of disturbance	.120	-
	Probability of disturbance	.015	
Prairie falcon	Predator access	.374	
	Failed-due to predator access	.205	
	Failed-without predator access	--	
	Adult aggression	.006	
	Cliff height	.003	-
	Nest height	.009	-
	Cliff exposure	.460	-
	Nest exposure	.072	
	Overhang	--	
	Vegetation type	.417	
	Closest raptor nest	.146	-
	Closest nest of same species	.310	-
	Closest water	.264	-
	Closest disturbance	.471	
	Type of disturbance	.277	-
	Probability of disturbance	.062	-



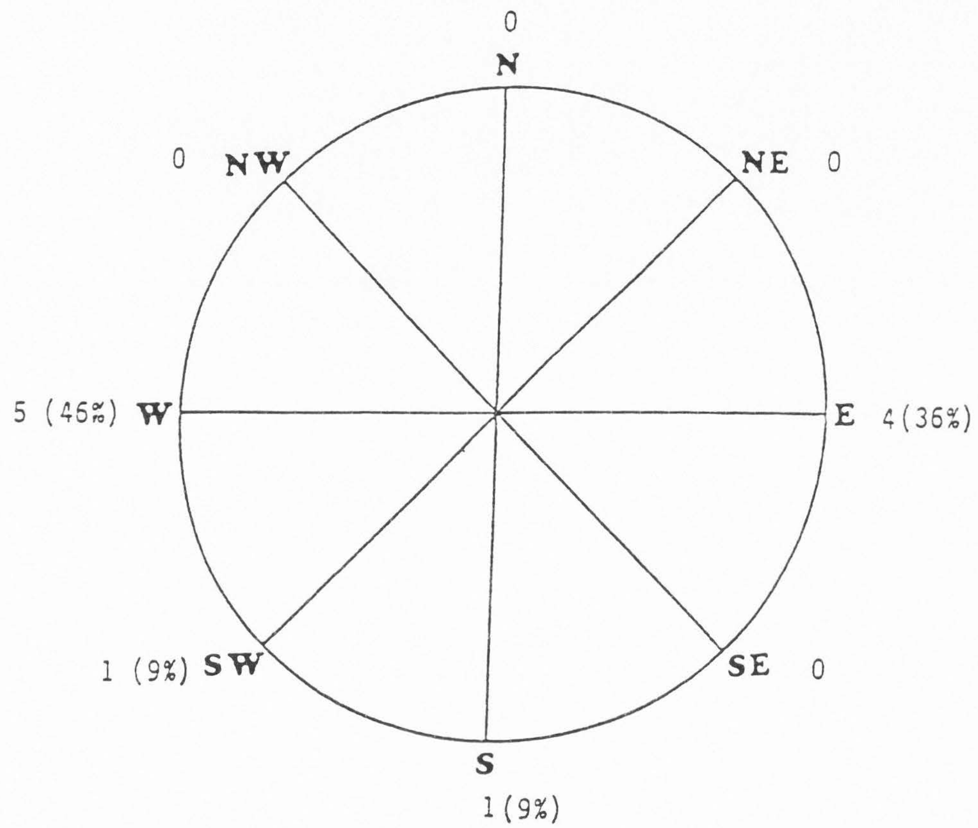
Total sample size = 29
Same exposure as cliff = 20 (69%)
Different exposure than cliff = (9) (31%)

Figure 10. Nest site exposure of prairie falcons.



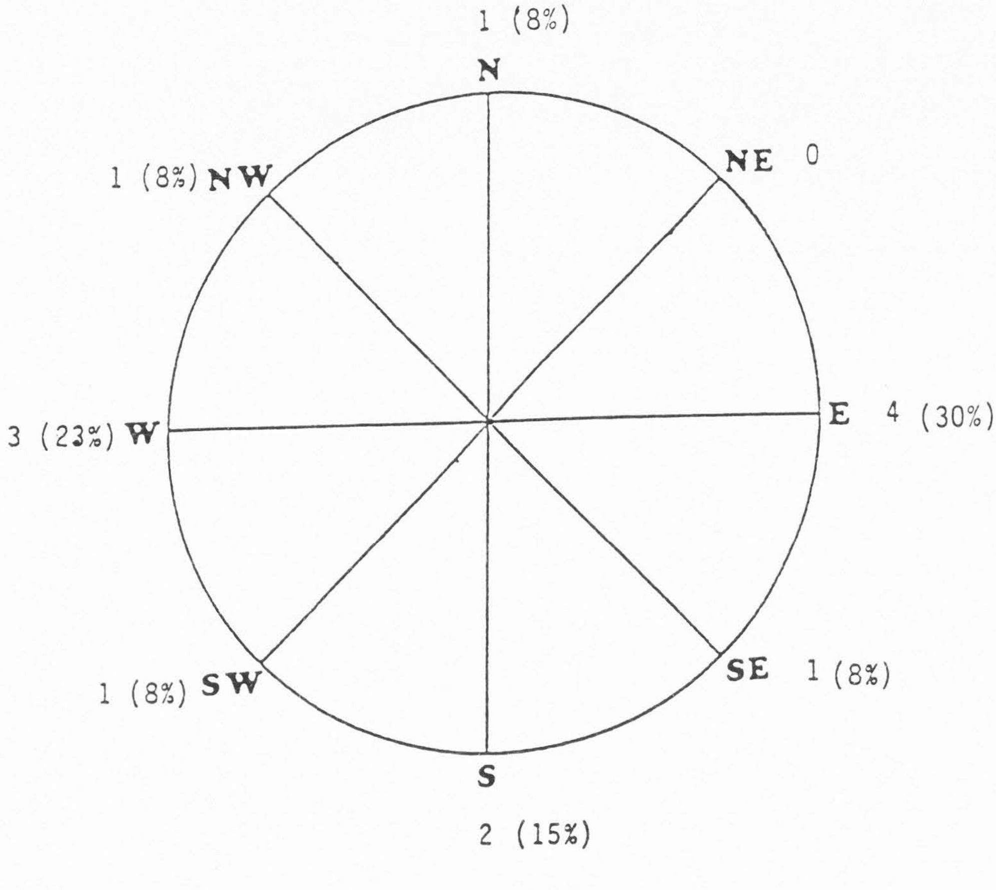
Total sample size = 15
Same exposure as cliff = 15 (100%)

Figure 11. Nest site exposure of golden eagles.



Total sample size = 11
All nest sites exposed 360°
Slope exposure is shown

Figure 12. Nest site exposure of ferruginous hawks.



Total sample size = 13
Same exposure as cliff = 10 (76.9%)
Different exposure than cliff = 3 (23.1%)

Figure 13. Nest site exposure of red-tailed hawks.

indicates that no preference was shown when nest site exposure was compared to cliff site exposure.

Hunting Methods

Prairie falcons secure most of their prey by the hunting method of flying at a moderate height and then diving at the potential prey (Brown and Amadon 1968). Enderson (1964) described the typical hunting pattern of the prairie falcon. It consists of a shallow dive from a perch with a series of rapid wing beats close to the ground for a distance usually less than 400 m (437 yds), with the final approach accomplished in a swift glide.

White (1962) observed prairie falcons exhibiting accipitrine and circinine hunting methods. He observed one falcon pursuing starlings, diving from a height of 30 m (98.4 ft) to a level of just above the tops of the sagebrush and fences of the area. Flying rapidly, it passed under some small trees along a fence row and then emerged directly below the starlings. On the first capture attempt the falcon flew into the flock to seize one but missed. After perching, she repeated the techniques again and was successful. White also observed a juvenile falcon flying slowly at a very low height above the ground and occasionally hovering above small clumps of brush like a harrier.

When a prairie falcon attempts to take larger ground prey, such as a pheasant or rabbit, it may make repeated passes until it is able to injure or dispatch its quarry. It will then land and finish off its prey with a bite to the neck just below the skull (per observation).

Prairie falcons were observed soaring, although few prey attempts were observed during this type of activity. The early morning and late afternoon hours are their primary hunting activity periods and soaring is seldom done at these times. When young need to be fed, adults may have to hunt throughout the day to meet the increased demand for prey by the rapid growing young.

The golden eagles' common hunting techniques on the study area were soaring or hunting from a perch, usually a power pole or rocky outcropping. In hunting areas where trees are present, they often will perch on or near the top of the tree if large dead limbs are present. Golden eagles do not appear to make many attempts to hunt while flying at low altitudes.

Golden eagles and ferruginous hawks have very similar hunting styles, probably due to sharing many of the same prey species, the black-tailed jackrabbit being the most important. They are the two largest avian predators found on the study area. Bald eagles are considered primarily carrion feeders, although they can take live prey.

Eagles and large hawks do not normally engage in active pursuit chases. If they miss on their first attempt, they seldom make a second. Smaller hawks and falcons engage in pursuit activities and often make repeated attempts to capture prey. In fact, these raptors commonly use low-altitude, ground-hugging flight which is designed to surprise prey and allow capture after a short pursuit.

Quartering flight is a common prey search method for buteo hawks. Johnson (1986) described three types of flights used in hunting activities: (1) perch/quarter--indirect flight between elevated perches during which birds engaged in random quartering flight within 3-15 ft (1-5 m) of the ground; (2) quarter/ground--indirect flight to the ground during quartering flights; and (3) perch/ground--direct flight from an elevated perch to the ground. These appear to be the most common type flights of juvenile red-tailed hawks. Direct flights to the ground from elevated perches comprise most of the hunting-related activity. Three weeks after fledging, direct flights comprise 76 percent of the hunting techniques. Aerial versus stationary searching has been found to result in more successful hunting attempts for the ferruginous hawks.

Migration

In a temperate region like northern Utah, some raptor species leave for the winter while others move, primarily from the north, into this zone for the winter. East-west movements are common in some species; for example, prairie falcons which breed in the mountains and deserts of western North America move eastward across the prairie each autumn (Enderson 1964).

The reason breeding areas become unsuitable during the colder part of the year is lack of food. Such food shortages occur for raptors because many avian prey species migrate from the area for part of the year, while other kinds of prey hibernate or become hidden under snow (Newton 1979). The migratory habit can thus be regarded as a product of natural selection, ensuring that in the long term individuals adopt whatever pattern leads them to survive and breed most effectively. The role of food supplies in controlling the movements of raptors is evident from: 1) regional and annual variations in the proportions of birds that leave for the non-breeding season, 2) locations of the wintering areas, and 3) to a lesser extent timing of the movements and other factors (Newton 1979).

In a regional population, more raptors stay when prey is plentiful than in years when prey is scarce. More will remain in mild winters than in colder, more severe ones and in good habitat than in poor habitat, implying an influence of food on the number of raptors that stay or leave an area (Craighead and Craighead 1956).

There are also annual changes in raptor movements. In some temperate zones, distance moved may vary from year to year, with the majority of individuals staying in the northern part of the wintering range in years when prey are plentiful and moving further south in years when prey is scarce. This is more prominent in raptors that depend on fluctuating (cyclic) prey (Lack 1954).

Raptors, like other birds, move so as to keep themselves in the most optimal habitat for as much of the year as possible. Regional, seasonal, and annual variations in movement patterns can all be broadly linked with variation in feeding conditions and the location of their wintering areas.

Migration corridors of raptors are often along major mountain ranges and ridges. These produce thermal updrafts, which are important and beneficial to migrating raptors. Raptors are very adept at soaring and gliding when necessary. A thermal draft may induce an almost imperceptible air movement at the earth's surface. They may travel at 56.3 km using a current of air that is rising vertically at less than 3.2 km. If the bird coasts at a slightly descending angle it can attain even higher speeds (Lincoln 1979). Many hawks have been timed with the speedometer of an automobile and have been found to fly at 35.4-45.1 km per hour. This speed, maintained over 10 hours, would move these birds approximately 402.3 km per day (Lincoln 1979).

The speed or rate of migration therefore depends mainly upon the duration of flight, tail wind velocity, and thermal conditions. It has been shown, through comprehensive radar studies, that 95 percent of bird migratory movement occurs under 914.4 m. Records of the U.S. Civil Aeronautics Administration show that over two-thirds of all the bird-aircraft collisions occur below 609.6 m and practically none occur above 1,829 m (William 1950). However, birds can and do fly over 4,572 m without apparent ill effects. A Himalayan mountain climber at 4,877 m was rather amazed when a flock of geese flew north 3 km over his head, honking as they went (Swan 1970); they were flying at about 8,230 m and calling while they traveled at this tremendous height.

Eagles, hawks, and falcons are day migrants and have not been known to migrate after dark. Birds such as broad-winged, red-tailed, and ferruginous hawks can only migrate during the day because their soaring mode of flight makes them dependent on updrafts created by heat from the sun for long-distance traveling (Lincoln 1979).

Weather conditions can also have a great impact on raptor migrations. In the fall, often the best day to observe hawk migrations in the eastern United States is on the second day after a cold front has passed, providing there are steady northwest winds and sun for production of thermals (Pettingill 1962). This also appears to be the case for migrations through Utah. Large bodies of water can influence migration routes, especially on raptors that are dependent on thermals and air currents. A good example of this includes the Great Lakes in the northeastern United States. The Great Salt Lake in Utah also influences the migration pattern of raptor species. While this body of water is not a barrier, it does influence raptor movements in the study area. Water areas do not create good thermals and many migrants will travel along the shoreline, where updrafts are created as the cooler water meets the warmer land. These conditions often concentrate buteos, such as red-tailed, rough-legged, and Swainson hawks, into restricted areas where numbers may be quite high.

Some evidence has been gathered (Workman 1985, pers. comm.) that juvenile accipter hawk species tend to follow the shoreline of the Great Salt Lake southward while most adults will continue over the lake. They follow the two islands south of Promontory Point, which extend on a north-south axis to the southern shore of the lake.

Mountain ridges, as previously mentioned, are often very conducive to migratory travel, especially if parallel to the line of migration. Apparently the highest and longest ridges deflect the horizontal winds upward better than the lower ridges, and more birds are seen, on the average, along the higher ridges (Robbins 1956). Hence, the influence of topography may help or hinder bird migration considerably, especially for raptors, depending upon the factors involved.

During the spring migration, weather conditions conducive to strong movements of birds are opposite from those in the fall. Migrants will often move north on the warm front of an incoming low, just after a high pressure area has passed through and the influx of warm moist tropical air in a low pressure front is extended and intensified (Bagg et. al. 1950). However, when a fast-moving cold front approaches from the northwest, the movement of migrants will be sharply curtailed or even stopped until more favorable conditions occur.

The spring migration of raptors appears to follow the same corridors as the fall migration. Many raptors not common in the study area, such as the goshawk (*Accipiter gentilis*), Cooper's hawk (*Accipiter cooperii*), and sharp-shinned hawk (*Accipiter striatus*), were observed during mid- to late April 1986, soaring north over the study area along the higher ridges and mountain ranges.

Rough-legged hawks began moving back to their northern breeding grounds during the second and third weeks of February 1986. Extremely heavy rainfall occurred from February 8 through 24. Weather reports said as much as ten inches of rainfall fell from February 14 through 20 in the general study area. This rainfall was usually accompanied by high winds from the south. A new record of 110 mph winds was reported in western Wyoming during this same period. Waterfowl numbers increased dramatically after February 18. Many swans, ducks, and geese were observed passing through northwestern Utah on their way to their northern breeding grounds during this period.

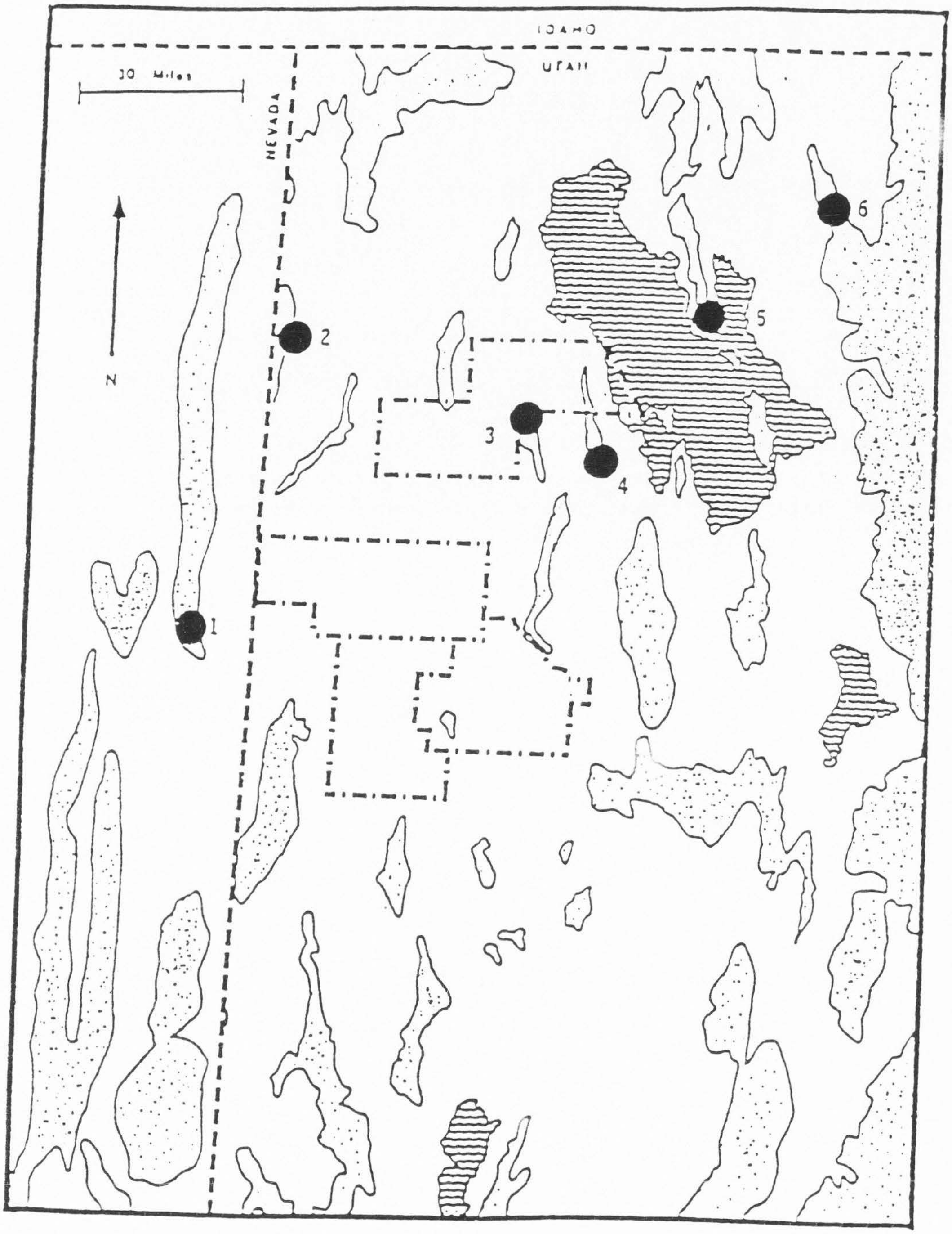
The following table and map (Table 27 and Figure 14) indicate that the primary migration corridors are along the Goshute Mountains in eastern Nevada, the Promontory Range in Utah, which extends into the Great Salt Lake for over twenty miles, and the Wellsville Mountains, which are part of the Wasatch Mountains which lie along the eastern edge of the Great Salt Lake Basin.

Table 27. September 1985 raptor migration data for northwestern Utah.

	Observations by location					
Date	Goshute Mtns	Pilot Mtns	Grassy Mtns	Lakeside Mtns	Promontory Mtns	Wellsville Mtns
19	207	12	0	6	101	2
20	367	17	0	8	175	77
21	93	0	0	1	108	0
22	68	28	9	9	224	41
23	345	20	7	19	110	85
24	218	37	12	53	211	155
25	218	58	0	5	128	79
26	592	65	3	14	91	49
27	243	44	2	28	314	244
28	263	7	1	2	148	8
Totals:	2377	288	34	145	1610	740
	45.8%	5.5%	.7%	2.8%	31.0%	14.2%

Grand total of observations: 5,194

Note: Thirteen species of raptors observed.



Legend

● Raptor migration observation sites

—·—·— U.S. Military Test and Training Ranges

1. Goshute Mountains
2. Pilot Mountains
3. Grassy Mountains
4. Lakeside Mountains
5. Promontory Mountains
6. Wellsville Mountains

Figure 14. Map of area migration observation points in northwestern Utah.

Other Findings

Peregrine Falcons

Peregrine falcons and bald eagles are the endangered raptor species that occur in the study area. Peregrine falcons are present in greater numbers during spring and summer reproductive periods, and most leave northern Utah to winter further south. Approximately 1,200 bald eagles spend the winter in Utah.

The peregrine falcon population increased from two to four nesting pairs in the study area during 1985 and 1986. Three of these pairs were on tower hack sites (release sites of captive-produced birds) located on the eastern edge of the Great Salt Lake. A pair of peregrines were at the Hotel Utah in downtown Salt Lake City. This pair produced three young, two males and one female, in 1985.

Dr. Gar W. Workman, Utah State University, reported observing an adult peregrine falcon between Logan and Smithfield in northcentral Utah (1985, pers. comm.). It was observed approximately six times in this same general area by Dr. Workman in the spring and summer of 1985.

It is possible that there are additional peregrine pairs that have not been located nesting in some of the remote cliffs in northern Utah. There are 30 known pairs of peregrines nesting in southern Utah. Many nest sites have just been located in the last three years. Researchers involved with the peregrine falcon in Utah feel that it will only be a few years before the peregrine falcon will reach pre-pesticide (DDT and DDE) population levels in northern Utah.

Bald Eagles

An annual bald eagle survey in the study was conducted by helicopter in January 1985 and 1986 in cooperation with the Air Force Rescue Squadron stationed at Hill Air Force Base. Biologists of state and federal agencies, including Utah State University, were observers. The number of bald eagles counted during both the air and ground annual search remained relatively stable through 1985 and 1986. Additional counts are also conducted in cooperation with state, federal, and private organizations.

Utah is one of the top three areas in the United States which have wintering bald eagle populations. The area along the Missouri and Mississippi rivers in Missouri is the number one area, followed by areas of Washington and Utah. Numbers of bald eagles were stable during 1985 and 1986 on the study area.

Bald eagles congregate at specific wintering sites from late October through March. Open water on major river systems or impoundments usually attracts bald eagles; however, they will also use arid desert valleys, as in Utah, in winter.

Bald eagles are usually fish-eating species. However, in Utah they usually rely on avian and mammalian carrion (Murphy 1974). Due to the rise in the water level of Great Salt Lake over the last four years, almost all of the marsh areas around the lake, especially on the eastern side, have been destroyed. Consequently, carp- and water- related avian species (waterfowl mortality) are no longer available in previous quantities as food during the winter months in the Great Salt Lake area. Many eagles have shifted to other places in the Great Basin area of Utah, along most stream courses and even into sagebrush vegetative zones.

Food supply and suitable habitat, followed by disturbance factors, are the most critical factors influencing wintering bald eagles. Because preservation of winter habitat may become a critical component of bald eagle management, an understanding of habitat requirements of wintering bald eagles is essential (Steenhof 1978).

Communal roosts are focal points for wintering activity. The same sites are used for years if conditions remain the same. Utah's bald eagles return to their roosting areas in early afternoon, frequently flying several kilometers in a slow, labored flight (Edwards 1969). These flights are usually below 1,000 feet and are direct flights from feeding areas to roosting areas. Utah eagles leave roosts as early as one hour and 50 minutes before sunrise. They sometimes glide and soar above canyon walls just before returning to their roost site (Platt 1976).

Proximity to a food source is probably the most important factor influencing perch selection by bald eagles (Steenhof 1978). Bald eagles in Utah prefer the more protected mountain valley roosts during winter, especially during periods of high winds and storms (Edwards 1969, Platt 1976). Large trees with strong branches are preferred by this large raptor, particularly trees with horizontal branches such as conifers.

Eagles will tolerate more disturbance at feeding sites than at loafing or roosting areas (Steenhof 1978). Airplanes flying at altitudes of 100 to 300 feet above wintering sites rarely disturb eagles (Krauss 1977).

Rough-legged Hawk

The rough-legged hawk (*Buteo lagopus*) is the most common breeding species of hawk in the North American arctic. Rough-legged hawks migrate south for the winter. They are found wintering from southern Canada all the way to the Gulf Coast. Utah has a very large number of this species from mid-October to March. It is the most numerous raptor species that winters in Utah. Rough-legged hawk numbers and productivity fluctuate greatly in response to variations in prey density (Zarn 1975, Brown and Amadon 1968, White and Cade 1971).

These raptors exhibit distinct diurnal activity patterns. They hunt or move little during the mid-day period from 1000 to 1500 hours; however, they can be seen perched on power poles or trees during this time. Rough-legged hawks generally hunt while in flight rather than from a perch. Their prey in the study area is usually voles and mice. While hunting, they fly slowly, quartering the ground. At times they may hover in place, turning their heads from side to side while looking down (Bent 1938, Brown and Amadon 1968, Belkap 1966, Schnell 1968). Rough-legged hawks seldom fly at altitudes above 100 to 200 feet, except during migration when they can be as high as to 2,500 to 3,000 feet above the ground. Highway mortality may be high for wintering rough-legged hawks due to their habit of feeding on road-killed prey, such as jackrabbits (White 1969).

Weather and food supplies regulate the onset of migration. In the spring, rough-legged hawks tend to follow the melting snow line as it recedes northward. The rate of movement is influenced by the rate of the snow melt (Kessel 1967, Brown and Amadon 1968). If prey becomes scarce in one area during the winter, the hawks will move to a different area.

DISCUSSION OF QUESTIONS OF INTEREST

Following is a brief summary of the findings that relate to questions of interest.

1. Is there a difference in productivity caused by human disturbance? The study area is quite remote and, aside from off-road vehicle users and an occasional livestock operation, there is little use of the area by humans. There is a need to regulate and control the amount of vehicle traffic that occurs in the off-road areas. The probability of disturbance was found to be a significant factor in the ferruginous hawk reproductive success. This was not found to be the case for the other three species examined.

2. Is there a difference in nest sites for the four raptor species? The golden eagle was found to select cliff nest sites with the greatest height. The mean is found to be 15 meters. The mean for the prairie falcon is 12.5 meters and was found to be a significant factor when related to productivity. The prairie falcon prefers a high nest site on the steepest portion of the cliff, but will use a low cliff if a higher one is not available in a good hunting territory. Nests on these lower cliffs (under 4.6 m) have a much greater probability of failure. The red-tailed hawk has a mean nest site height of 7.3 meters, but height does not appear to be a significant factor for reproductive success. The ferruginous hawk has a mean nest height of 3 meters, due to its practice of nesting on very low cliffs. Some are only rock outcroppings, less than 1.5 meters in height. It also

nests directly on the ground, usually on a ridge or point. The low height of the nest site was also due to the use of juniper trees, which are seldom over 8 meters, for nest sites. The probability of disturbance was found to be significant, possibly due to the habit of using such low and conspicuous nest sites.

3. Is there a difference in production of young due to predator accessibility to nest site? The golden eagle has no failure due to terrestrial predator access, probably due to its large size and its ability to defend its nest more successfully. However, only two sites had predator access. The prairie falcon and red-tailed and ferruginous hawks do show a difference in their productivity. Two out of six attempts at prairie falcon sites with predator access failed. Three out of eleven with access failed for ferruginous hawks and one out of one failed for red-tailed hawks. There were no failures of the 45 nesting attemps at sites without predator access.

4. Is there a difference in the diet of selected raptors due to seasonal availability? The seasonal diet is affected by availability of prey. The prey selected are those that are most abundant during each season. The ground squirrel is the most common prey item during spring and summer when it is active above the ground. Rabbit remains were not found as prey items at nest sites in the study area. Horned larks were found to be important year round for prairie falcons, but especially during the fall and winter

when ground squirrels are not available. Red-tailed hawks use ground squirrels and reptiles during the warmer months. Most red-tailed hawks leave for the winter, and the few that stay appear to feed primarily on mice and voles.

5. Does prey density and availability have an effect on raptor productivity within the study area? Prairie falcons are reproducing at a comparable rate with those found in other studies. This is probably due to their two main prey species, ground squirrels and horned larks, being readily available. The other three raptor species were found to be adversely affected because their usual prey items, the lagomorphs, are not available in sufficient numbers.

6. Is there a difference in raptor species or numbers present over the year? It was found that indeed there are large differences in both numbers and species present during the breeding and nonbreeding seasons.

SUMMARY

Habitat and nest site characteristics were examined for the golden eagle, ferruginous hawk, red-tailed hawk, and prairie falcon. Rocky outcropping and cliff faces are the most important locations for nest site selection by these species. Ferruginous hawks also use juniper trees for their nest sites. They prefer lone trees or small scattered stands of mature trees. Nest sites are commonly found on ledges in crevices and potholes located on the higher portions of rocky outcropping and cliff faces. Nests are located in the steeper portions of the nest cliffs, and direction of exposure is usually the same direction the cliff faces. When juniper trees are used by ferruginous hawks, the nest is constructed in the highest part of the tree where the trunk and larger branches support a stick nest.

The reproductive success of the prairie falcon is normal when compared to other stable populations. The number of chicks fledged was 2.5 young per successful site. The percent of prairie falcon nest sites active each year was approximately 70 percent which also is within the normal range of prairie falcons. The prairie falcon breeding activity is similar to that of other studies and may be normal for this salt desert community.

The density of golden eagles, ferruginous hawks, and red-tailed hawks breeding on the study area is considerably below that found in other studies (Smith and Murphy 1979).

This is believed to be a direct result of the extremely low rabbit population on the study area during 1984, 1985, and 1986 (Knowlton 1986, pers. comm). The jackrabbit is considered the major prey species of ferruginous hawks, comprising 80 percent of the total food biomass in some years (Howard and Wolfe 1976). The rabbit population was at the bottom of its cycle, and transects conducted near this study area indicate numbers are the lowest recorded in the past twenty years. The prairie falcon is able to use the avian prey species (primarily horned larks) to maintain normal reproduction success, while the larger, slower raptor species studied are less able to use this resource.

The movement patterns of these raptors were investigated and the normal daily hunting methods described. Seasonal and annual movements were also investigated and found to be similiar to those in other studies in the western United States. The use of ridges and mountain ranges where thermal updrafts create a favorable current of air for the raptors are of great importance as migration corridors. The passage of storm fronts was found to be of major importance, as the raptors would use these winds, if favorable, to assist them. Large numbers of migrating raptors were counted passing during periods when conditions were optimal, and few birds were observed moving when unfavorable conditions were recorded.

RECOMMENDATIONS

Effective raptor management requires collection and storage of information on nest site concentration areas and movement patterns of the raptors. This information is essential, but at the same time poses a threat to some raptor species if made public. Legal and legitimate uses of the falconiform resource, including bird-watching, research, falconry, and photography, may cause nest abandonment and failures. Off-road vehicles users and curiosity seekers are an increasing threat in the western United States. Accordingly, adequate means of protecting sensitive data, especially locations of nest sites, should be addressed by the state and federal agencies involved. A workable system for data storage and authorized use should be established.

The literature indicates that raptors will frequently desert their nests if disturbed during the incubation period. Some ferruginous hawks are especially sensitive to disturbance and have been found to desert their nests after only one case of human intrusion. Once the young have hatched, the probability of desertion decreases considerably. However, undue harassment may cause the desertion of fledglings by adults. The significant parameters found should be considered in future management plans. Disturbances must be kept at a minimum, especially during the nesting periods for the ferruginous hawk. Cliffs are an important parameter for all species, due to the lack of trees for nest sites within the study area. The higher cliffs are of greatest value for nesting by prairie falcons and golden eagles.

Human activity should be restricted in areas of known nest sites during the reproductive period from February 1 through July 1. Potentially disruptive land-use actions should not be scheduled within one kilometer of nest sites during this time. Roads, power lines, and other easements should be placed along the valley floors avoiding the top and sides of ridges, hills, and mountain ranges where most nesting activities are located.

Power lines, if constructed aboveground, should be designed to protect the raptor species from electrocution. When these lines cross terrain with few natural perching sites for raptors, they will be heavily used by raptors for hunting and resting perches. Power lines may be a factor in the mortality rate. Guidelines on modifications or new constructions are available in "Suggested Practices for Raptor Protection on Power Lines" (Steenhof 1978).

The use of pesticides and poisons to contol insect and rodent populations should be carefully controlled, and only environmentally approved products should be used. Even then, the use of this type of control may still be harmful to the raptor species present, as it will adversely effect their prey populations. Careful consideration and study should be done before any of these products are used.

One of most important factors for the four species of raptors investigated were limited nest sites. This included cliff faces, rocky outcroppings and in the case of the ferruginous hawks, juniper trees. There appeared to be a preference for isolated trees and small scattered groups of junipers. These are the most sensitive and important areas during the reproductive period.

The prey base for these raptors is another important factor that affects raptor populations. Domestic livestock grazing and use of the water resources have a great effect on the small avian and mammals prey species. Water tanks should be left full for wildlife when livestock are removed from the range. In practice, this is seldom the case, and the water resource is only present when the livestock are. Some livestock operations do make an attempt to leave water; however, other persons may leave the valves open and drain the tanks, causing wildlife to do without water. This loss of water is especially critical to most wildlife species during their reproductive periods. Increasing water resources would benefit both wildlife and domestic animals on this dry desert range.

The vegetation cover should not be so overgrazed that it reduces or adversely affects prey numbers. Throughout much of the desert, perennial grass and forb cover has been over-utilized by livestock. This has resulted in large communities of cheatgrass (Bromus tectorum) that is subject to annual range fires, which may cause this plant species to be a climax community for this dry desert range.

All camping sites should be located at least 1 km from any water source. All water sites should be posted "No camping within 1 km, except when snow is present." This would allow wildlife undisturbed access.

Management of habitat for wintering bald eagles should consist of protecting winter roost areas, habitat, and food sources. Physical disturbances should be kept at a level that does not interfere with eagle use of an area.

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APPENDICES

Appendix I . Data Form for Cliff Nest Sites of Raptors

CLIFF NEST SITES

ACTIVE:______ SITE#:____________
INACTIVE:______ OBSERVER:__________

SPECIES OF BIRD:____ DATE:____________
LOCATION: T________________ R__________________ S________________
DESCRIPTION OF LOCATION:____
____
NEST CLIFF HT:__________ FACING DIRECTION:__________ LENGTH:__________
NEST HT:__________ NEST SITE FACING DIRECTION:___________________________
NEST SITE DIS. FROM TOP OF CLIFF:__________ FROM BOTTOM OF CLIFF:________
DESCRIPTION OF NEST SITE:____
ELEVATION:__________
____
NEST SITE OVERHANG:________________________ IN CREVICE:______________
DIRECTION OF SLOPE:_________________________ DEGREE OF SLOPE:________
CLIFFS SITE ON SLOPE:_______________________ LENGTH OF SLOPE:________
TYPE OF ROCK PRESENT:____
ALTERNATE NEST SITES:____
NUMBER OF YEARS OCCUPIED:________ VEGETATION AROUND CLIFF:____________
____
PREDATOR GROUND ACCESS:____
MISC. NEST OR SITE INFO:____
____
____
NESTING ATTEMPT MADE:____
RENESTING ATTEMPT MADE:____
NUMBER OF EGGS:________ NUMBER HATCHED:________ NUMBER ADDLED:________
NUMBER OF YOUNG:________ MALE:________ FEMALE:________ UNKNOWN:________
MORTALITY IF NOTED:__________ CAUSE OF MORTALITY:____________________
____
EST. HATCHING DATE:______________ EST. FLEDGING DATE:_________________
DATE YOUNG BANDED:________________ NUMBERS ON BANDS:__________________
ADULT BEHAVIOR:____
____
PREY SPECIES AND NUMBER:____
DISTANCE AND DIRECTION FROM NEAREST RAPTOR NEST:______________________
SPECIES:____
DISTANCE AND DIRECTION FROM NEAREST NEST OF SAME SPECIES:______________
____
DIS. TO NEAREST WATER:__________ TYPE OF WATER:_______________________
DIS. TO NEAREST DISTURBANCE:__________ TYPE OF DISTURBANCE:___________
____
PROBABLITY OF DISTURBANCE:____
DATE THE SITE WAS REVISITED AND COMMENTS:_____________________________
____
____
____
COMMENTS:____

Appendix II. Data Form for Cliff Nest Sites of Raptors

TREE NEST SITES

ACTIVE:______ SITE#:____________
INACTIVE:______ OBSERVER:__________

SPECIES OF BIRD:____________________________________ DATE:____________
LOCATION: T__________________ R____________________ S_______________
DESCRIPTION OF LOCATION:____

TREE SPECIES:__________________________ HT:___________ DIA. @ 5':________
NEST HT.:________ DIA. OF TRUNK OR MAIN BRANCHES @ NEST SITE:_________
COMPOSITION OF TREES WITHIN 100 YDS:______________________________________

SIZE OF TREE STAND:________ AVE. HT. OF STAND:________ ELEV.:________
AVE. DIA. OF TREE STAND:_________ TYPE OF GROUND COVER WITHIN 100 YDS.
OF NEST TREE:____
DENSITY OF GROUND COVER %:_______ NEST TREE CANOPY AT CROWN %:________
NEST TREE CANOPY AT NEST SITE %:____
NEST TREE ON SLOPE:Y/N ____ UPPER 1/3:___ MID. 1/3:___ LOWER 1/3:___
NEST TREE DIS. TO EDGE OF STAND:_________ DISTANCE TO WATER:__________
DIS. TO NEAREST DISTURBANCE:_____________ TYPE:__________________________
FREQUENCY OF DISTURBANCE:____
DIRECTION SLOPE IS FACING:______________ DEGREE OF SLOPE:_____________
NEST CONSTRUCTION AND PLACEMENT IN TREE:__________________________________

DIRECTION FROM TRUNK:____
HOW LONG OCCUPIED:________________ ALTERNATE NESTS:______________________

NUMBERS OF EGGS PRESENT:___________ YOUNG PRESENT:_______________________
ESTIMATE HATCHING DATE:______________ ESTIMATE FLEDGING DATE:___________
MORTALITY IF NOTED:____
NUMBER OF YOUNG BANDED:_______ SEX:MALE_____ FEMALE_____ UNKNOWN____
PREY SPECIES PRESENT____
PREDATOR GROUND ACCESS:____
ADULT BEHAVIOR:____

DATE THE SITE WAS REVISITED AND COMMENTS:__________________________________

COMMENTS:____

Appendix III. Raptor Observation Form

Date ________ Temp. ________

Wind ________

Conditions ________

Observer ________

Mileage end ________

Mileage start ________

Time	Species	Number	Activity	Flight Direction	Altitude	Location of Observation	Comments

Appendix IV. Raptor Migration Data Form

General Information Sheet

DAY MONTH YEAR ____ __ ____ LOCATION ____________

START __:__ BUT. ___

STOP __:__ ACC. ___

LEADER ____________ OBS. ___ TOT.HRS. __.__ EAG. ___

OBS. ____________ OBS. ___ TOT.RAPTORS ___ FAL. ___

OBS. ____________ OBS. ___ RAPTORS/HR. __.__ HAR. ___

Time(Std.)	-	-	-	-	-	-	-	-	-
Max. Visib.									
Air Temp., °C									
Sky Code									
Wind Speed									
Wind From									
Alt. Flt.									
Flt. Direct.									
# Observers									
Min. Obs'd.									
Tot. Birds									

COMMENTS

GENERAL INFORMATION SHEET INSTRUCTIONS

Time(Std.)-record the inclusive time of observation in one hour blocks and in Standard Time(i.e. 5-6,6-7)
Max.Visib.-indicate atmospheric clarity by judging your longest view and entering that distance in kilometers
Air Temp.,°C-record temperature in degrees Celsius
Sky Code- using table, enter number which best describes the predominant conditions
Wind Speed-using table, describe the average wind speed
Wind From-enter direction in degrees from which wind is blowing
Alt.Flt.-using table, enter average height of most migrants
Flt.Direct.-record heading in degrees of most migrants
Observers-only those actively involved in counting migrants
Min.Obs'd-amount of time actually covered per hourly block
Tot.Birds-total raptors observed per hourly block

METRIC CONVERSIONS

Yards	Miles	km	°F	°C
25		.02	10	-18
50		.05	20	- 7
100		.09	32	0
250		.23	40	4
500		.46	50	10
1000	.6	.91	60	16
1500	.9	1.37	70	21
2000	1.1	1.83	80	27
	2.0	3.22	90	32
	3.0	4.83		

WIND SPEEDS

0 less than 1 mph, calm
1 1-3 mph, smoke drifts with wind
2 4-7 mph, wind can just be felt
3 8-12 mph, just rustles leaves
4 13-18 mph, raises dust & leaves
5 19-24 mph, small trees will sway
6 25-31 mph, larger branches sway
7 32-38 mph, whole trees swaying
8 39-46 mph, branches broken off
9 greater than 46 mph

SKY CODE

0 clear, 0-15% clouds
1 partly cloudy, 16-50%
2 mostly cloudy, 51-75%
3 overcast, 76-100%
4 wind-driven sand, dust, or snow
5 fog or haze
6 drizzle
7 rain
8 snow
9 thunderstorm-rain

ALTITUDE OF FLIGHT

0 below eye level
1 up to 30 meters overhead
2 seen easily with unaided eye
3 at limit of unaided vision
4 visible with 10X binoculars
5 at limit of binoculars
6 requiring greater than 10X magnification (spotting scope)
7 no predominant height

IF POSSIBLE FOR MORE PRECISE WEATHER INFORMATION, PLEASE ATTACH CLIPPED OUT NEWSPAPER WEATHER REPORT

OBSERVATION FORM INSTRUCTIONS

Bird#: Assign consecutively
Std.Time: 24-hour clock (0900, 1430, etc.)
Species:

TV - turkey vulture	UE - unid. eagle
UA - unid. accipiter	GE - golden eagle
GO - goshawk	BE - Bald eagle
SS - sharp-shinned hawk	NH - northern harrier
CH - cooper's hawk	OS - osprey
UB - unid. buteo	UF - unid. falcon
RT - redtail hawk	PF - prairie falon
BW - broadwing hawk	PG - peregrine falcon
SW - swainson's hawk	ML - merlin
RL - roughleg hawk	AK - American kestrel
FE - ferruginous hawk	UR - unid. raptor

Age: A - Adult
I - Immature
- - Unknown

Sex: M - Male
F - Female
- - Unknown

Color ph.: D - Dark
L - Light
- - Unknown

Flt.Dir.: Flight direction or heading (N, NE, SW, etc.)

Flt.Hgt.: In first column record + or - for above or below observer, then record approximate vertical distance in meters (0200, 1500, etc.)

Lat.Dist.: Record horizontal distance away from observer meters, followed by letters denoting direction (0200NE, 1500S etc.)

Comments: Record strange plumage characteristics, unusual behaviors, aggressions, full crop, etc.

Appendix V. Observation Form

Page ________

Location	yr mo dy	Bird #	FL. dir.	Time	Species	Age	Sex	Col. ph.	Crop	OH	Int.	TR	I+ FL.Ht.	Lateral distance	direction	Comments

8/20/80

Appendix VI. Checklist of Plants Potentially Occurring on the Utah Test and Training Range (after Fisher 1978).

Class Gymnospermae

Family Cupressaceae

Utah Juniper	Juniperus osteosperma

Family Ephedraceae

Nevada ephedra*	Ephedra nevadensis

Family Pinaceae

Single-leaf pinyon pine	Pinus monophylla
Douglas fir	Psedotsuga menziesii
Englemann spruce	Picae englemannii
White fir	Abies concolor
Alpine fir	Abies lasiocarpa

Class Angiospermae

Subclass Monocotyledonae

Family Cyperaceae

Bulbrush*	Scirpus sp.
Sedge*	Carex sp.

Family Juncaceae

Rush	Juncus sp.

Family Poaceae

Cheat grass*	Bromus tectorum
Foxtail barley*	Hordeum jubatum
Needle and thread*	Stipa comata
Red tree-awn*	Aristida longiseta
Great Basin wildrye*	Elymus cinereus
Salina wildrye*	Elymus salinus
Blue wildrye	Elymus glaucus
Bluebunch wheatgrass*	Agropyron spicatum
Crested wheatgrass*	Agropyron cristatum
Tall wheatgrass*	Agropyron elongatum
Western wheatgrass*	Agropyron smithii
Galletagrass*	Hilaria jamesii
Indian ricegrass*	Oryzopsis hymenoides
Sandberg bluegrass*	Poa sandbergii
Nevada bluegrass*	Poa nevadensis
Kentucky bluegrass	Poa pratensis

Family Poaceae (cont.)

Sand dropseed*	*Sporobolus cryptandrus*
Alkali sacaton*	*Sporobolus airoides*
Squirrel tail*	*Sitanion hystrix*
Salt grass*	*Distichilis stricta*
Common reed*	*Phragmites communis*
Bentgrass*	*Argostis stolonifera*

Subclass Dicotyledonae

Family Amaranthaceae

Tumbling pigweed	*Amaranthus albus*

Family Anacardiaceae

Squawbrush*	*Rhus trilobata*

Family Apiaceae

Desert parsley	*Lomatium* sp.

Family Asclepiadaceae

Milkweed*	*Asclepias* sp.

Family Asteraceae

Rock goldenrod	*Petradoria pumila*
Pussytoes	*Antennaria* sp.
Dusty maiden	*Chaenactis* sp.
Common sunflower*	*Helianthus annuus*
Budsage*	*Artemisia spinescens*
Big sagebrush*	*Artemisia tridentata*
Black sagebrush*	*Artemisia nova*
California bricklebush	*Brickellia californica*
Tasselflower	*Brickellia microphylla*
Rubber rabbitbrush*	*Chrysothamnus nauseosus*
Little rabbitbrush*	*Chrysothamnus viscidiflorus*
Curlycup gumweed*	*Grindelia squarrosa*
Broom snakeweed*	*Gutierrezia sarothrae*
Slender rushpink	*Lygodesmia juncea*
Spiny rushpink*	*Lygodesmia spinosa*
Spiny horsebrush*	*Tetradymia spinosa*
Gray horsebrush*	*Tetradymia canescens*
Littleleaf horsebrush*	*Tetradymia glabrata*
Low fleabane*	*Erigeron pumilus*
Stemless goldenweed*	*Haplopappus acaulis*
Aster	*Aster* sp.
Small wire-lettuce*	*Stephanomeria exiqua*
Thistle*	*Cirsium* sp.
Graylocks	*Hymenoxis acaulis*
Salisfy*	*Tragopogon dublis*

Family Asteraceae (cont.)

Yarrow*	Achellia millefolium

Family Borginaceae

Dwarf catseye	Cryptantha humilis
White stoneseed	Lithospermum arvense
Yellow stoneseed	Lithospermum ruderale

Family Brassicaceae

Rockcress	Arabis divaricarpa
Tansy mustard	Descuriania pinnata
Western wallflower	Erysimum asperum
Pepperweed*	Lepidium perfoliatum
Tumbling mustard	Sisymbrium altissimum
Arrowleaf thelypody	Thelypodium sagittatum
Pricky lettuce*	Lactuca serriola

Family Cactaceae

Prickly pear*	Opuntia polyacantha
Great Basin fish hook cactus*	Sclerocactus publispinus
Hedgehog cactus*	Echinocereus sp.

Family Capparaceae

Rocky Mountain beeplant*	Cleome serrulata

Family Caprifoliaceae

Mountain snowberry	Symphoricarpus oreophilus

Family Chenopodiaceae

Picklewood	Allenrolfia occidentalis
Annual Samphire	Salicornia europaea
Fourwing saltbush*	Atriplex canescens
Shadscale*	Atriplex confertifolia
Nuttall's saltsbush	Atriplex gardneri
Gardner saltbrush	Atriplex gardneri
Winterfat*	Ceratodies lanata
Spiny hopsage*	Atriplex grayia
Halogeton*	Halogeton glomeratus
Gray molly*	Kochia americana
Russian thistle*	Salsola iberica
Greasewood*	Sarcobatus vermiculatus
Bush seepwood*	Suaeda torreyana
Smotherweed*	Bassia hyssopifolia
Goosefoot	Chenopodium sp.

Family Fabaceae	
Woolypod milkvetch*	*Astragalus purshia*
Timber milkvetch*	*Astragalus miser*
Wooly milkvetch*	*Astragalus mollissimus*
Family Geraniaceae	
Fremont's geranium	*Geranium fremontii*
Cutleaf filaree*	*Erodium cicutarium*
Family Loasaceae	
Smoothstem blazingstar	*Mentzelia laevicaulis*
Family Malvaceae	
Munro golbemallow*	*Sphaeralcea munroana*
Scarlet globemallow*	*Sphaeralcea coccinea*
Family Onagraceae	
Tufted eveningprimrose*	*Oenothera caespitosa*
Family Polemoniaceae	
Hood's phlox*	*Phlox hoodii*
Longleaf phlox*	*Phlox longifolia*
Granite pricklygilia*	*Leptodactylon pungens*
Family Polygalaceae	
Milkwort	*Polygala acanthoclada*
Family Ploygonaceae	
Buckwheat*	*Eriogonum* sp.
Family Ranunculaceae	
Columbine	*Aquilegia* sp.
Larkspur	*Delphinium* sp.
Family Rosaceae	
Cliffrose*	*Cowania mexicana*
Curlleaf mountain mahogany	*Cercocarpus ledifolius*
Serviceberry	*Amelanchier alnifolia*
Bitterbrush	*Purshia tridentata*

Family Salicaceae	
Narrowleaf cottonwood*	Populus angustifolia
Quaking aspen	Populus tremuloides
Coyote willow	Salix exigua
Family Santalaceae	
Bastard toadflax	Comandra umbellata
Family Saxifragaceae	
Wax current	Ribes cereum
Family Scrophulariaceae	
Penstemon*	Penstemon sp.
Indian paintbrush	Castilleja sp.
Flannel mullein*	Verbascum thappus
Family Solanaceae	
Wolfberry	Lycium andersonii
Family Tamaracaceae	
Tamarisk or salt cedar*	Tamarix ramosissima

* These plants have been identified in plant inventories of the Utah Test and Training Range area.