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Distribution of nest sites and reproductive success were determined for prairie falcons breeding in Oregon during 1973 and 1974. The study area encompassed a major portion of the eastern half of the state. I located and monitored 63 breeding attempts during the study and found nest sites in a variety of habitats ranging in elevation from 200 feet to 8,300 feet. Pair bonds were formed as early as mid-March. Mean date of initiation of incubation was 16 April. Mean fledging date was 24 June. Incubation period was approximately 30 days; mean nestling period was 41 days. Mean clutch size was 4.03. Mean number fledglings per breeding attempt was 2.49. Analysis of band recovery data from 1928 through 1972 yielded first year and mean adult mortality estimates of 0.65 and 0.35 respectively. Application of a life equation and a structural model to estimates of mortality and observed productivity in Oregon indicated that the

prairie falcon population in Oregon may be decreasing. Estimates of production were 19 percent below that necessary to maintain a stable population.

Status of Prairie Falcons Breeding in Oregon

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

STATUS OF PRAIRIE FALCON POPULATIONS BREEDING IN OREGON

I. INTRODUCTION

Raptorial bird populations have exhibited a generalized decline in numbers, especially pronounced in the past three decades. Their position as predators at the uppermost trophic levels results in a particular sensitivity to environmental disruptions, and these factors, coupled with the enigmatic attraction birds of prey hold for man, have stimulated a recent surge of concern and subsequent study of raptor life histories and population status.

Peregrine falcon (*Falco peregrinus*) populations, previously cosmopolitan in distribution, have shown a drastic suppression in numbers throughout much of their historic range. Once a stable population in Great Britain, peregrines have now decreased to only a fraction of their former numbers (Ratcliffe 1963). The subspecific anatum peregrine (*F. p. anatum*) formerly occupying the continental United States has been virtually eliminated as a breeding population in the eastern states and populations in western states have declined at unprecedented rates (Berger et al. 1969, Nelson 1969). It has been suggested that should the present rate of decline continue unabetted, the once ubiquitous peregrine could be expripated from its historic North American range within this decade (Cade and Fyfe 1970).

The mechanisms involved in these declines have not been completely defined. Evidence exists that indicts the increased usage of chlorinated hydrocarbon pesticides and allied toxic substances, whose persistent residues have been demonstrated as accumulative in the tissues of exposed animals. Not necessarily directly toxic, these residues at sublethal levels can prove disruptive to normal reproductive physiology and behavior. The most common symptom seen is a reduction in eggshell thickness, with accompanying depression in productivity due to egg loses (Ratcliffe 1967, Porter and Wiemeyer 1969, Cade et al. 1971).

Although sympatrically and generically allied to the peregrine falcon, populations of prairie falcons (Falco mexicanus) have apparently not undergone concurrent declines of such severity. Whereas reproductive adult peregrines in many western states were occupying only 10-20 percent of the known traditional nest sites during the past decade (Nelson 1969), prairie falcon populations in the same regions remained relatively stable (Beebe and Webster 1964).

While the prairie falcon has not demonstrated sharp declines and populations have remained static over much of their range, a number of studies have disclosed reduced productivity and cognate effects on reproductive parameters that may forecast future reductions in numbers. Enderson and Berger (1970:356) predicted that prairie falcons in the Rocky Mountain States were "involved in events leading to reduced reproduction. . . ." Productivity of prairie falcons in western Montana during 1970 and 1971 may have been lower than that necessary to maintain the present population (Leedy 1972). Leedy (1972) and Fyfe et al. (1969) have suggested that organochlorine pesticides may have interfered with reproduction in Montana and southern Canada respectively, as evidenced by a reduction in eggshell thickness.

Hickey and Roelle (1969) pointed out that the drastic decline in peregrine numbers was not noted by ornithologists until several years after it began and that other species may be involved in similar declines that are presently unobserved. Gladding and Cade propose that the prairie falcon offers a model species to study with respect to the effects of pesticides and other environmental alterations on raptors, particularly the genus Falco (Hickey 1969).

The status of the prairie falcon population in Oregon was unknown prior to the initiation of this study. Gabrielson and Jewett (1940) considered the species a common resident of the eastern half of the state as recently as the late 1930's. Marshall (1969), however, has subsequently described the prairie falcon as rare in Oregon. Accurate data concerning the status of the population are needed to elucidate the various environmental factors influencing productivity. Effective management of raptorial bird populations has become a possibility, amidst new developments in techniques of habitat manipulation and captive breeding of Falconiformes (Cade 1971, Fyfe 1972, Olendorff and Stoddart 1974). Thus, satisfactory information was needed on the prairie falcon population in Oregon to allow for the development of effective management programs in this state.

During the spring and summer of 1973 and 1974, I collected data appropriate for a determination of the density, habitat selection, productivity and general life history of prairie falcons breeding in Oregon. Productivity data for these two years were analyzed to determine trends in falcon abundance.

III. STUDY AREA

I conducted a generalized survey of prairie falcons breeding in Oregon during the spring and summer field seasons of 1973 and 1974. Because of the generalized nature of the survey, I attempted to search for nest sites in a substantial portion of the state, and limited the extent of my study area only when it proved infeasible to include additional regions The resultant study area encompasses that portion of Oregon east of the Deschutes River and the 122nd West meridian, which generally coincides with the western extent of the xeric, high desert habitats of Central Oregon. The area's northern, eastern and southern boundaries duplicated the state boundaries with Washington, Idaho, and California and Nevada respectively. The extreme northeastern extent of the state was excluded; this area contains Wallowa, Union, Baker and Umatilla counties, and the eastern portions of Grant and Morrow counties.

The study area, comprising approximately 50,000 square miles, included the main stems of several major river systems, and was subsequently partitioned into five subdivisions, each dominated by a major river watershed: the Deschutes, John Day, Columbia, Snake and Klamath Rivers.

Large sections of the study area did not contain appropriate habitat for breeding prairie falcons and the search for nest sites was limited to prospective areas within the larger whole. The continuum nature of habitat suitability, however, negated the possibility of further division or definition of the study area.

Elevations within the study area range from as low as 200 feet above sea level along the flood plains of the Columbia River Gorge to elevations in excess of 8,000 feet in the Steens, Blue and Bly Mountain Ranges. Topographical features vary from level agricultural land contiguous with river bottoms, through rolling foothills, ridges, canyons and buttes to precipitous montane topography. Nearly all terrains searched were characterized by rock outcroppings or rims, which serve as nesting substrates for breeding prairie falcons.

The climate of the eastern half of the state is transitional between the maritime moderation of the western extent of the state and the continental, more severe climate of Idaho, Montana and Nevada. Precipitation is low; a result of the rain shadow effect of the Cascade Mountains, and ranged from 8.58 to 11.76 inches annually during the two years of this study (U.S. Dept. Commerce 1973-74). Spring are mild; summers hot and dry, with temperatures averaging 47.4° F during 1973 and 1974.

Included within the study area, and coincidental with the established distribution of prairie falcons, are vegetational zones extending from Abies grandis (grand fir), Pseudotsuga menziesii (Douglas-fir) and Pinus ponderosa (ponderosa pine) forests at the higher elevations through to the _Juniperus occidentalis_ (western juniper) forests to the _Artemisia tridentata_ (big sagebrush)/grass associations of lower elevations (Franklin and Dyrness 1973).

Montane communities incorporate primarily ponderosa pine and Douglas-fir as the dominant tree species, with subalpine fir (_Abies lasiocarpa_) and lodgepole pine (_Pinus contorta_) at the upper elevational extremes. Associated understory and grass species are sedges (_Carex_ spp.), ceanothus (_Ceanothus_ spp.), bitterbrush (_Purshia tridentata_), bluebunch wheatgrass (_Agropyron spicatum_), fescues (_Festuca_ spp.) and cheatgrass brome (_Bromus tectorum_).

Lower elevations harbor plant communities characterized by big sagebrush and rabbitbrush (_Chrysothamnus_ spp.) associated with bluebunch wheatgrass, Idaho fescue (_Festuca idahohensis_), Sandberg's bluegrass (_Poa sandbergii_) and the alien cheatgrass brome as the dominant grass components. Western juniper, the dominant tree species in the lower xeric regions is replaced by black cottonwood (_Populus trichocarpa_) and _Salix_ spp. upon the mesic sites of the riparian communities.

Land use at lower elevations was predominately irrigated agriculture, livestock grazing and incidental recreation. Most of the high yield agriculture occurred on lands adjacent to major waterways, where irrigation was feasible; the principle crop was alfalfa.

Timber harvest is the most conspicuous use of forested areas in higher elevations, while grazing continues to be a principle use in non-timbered regions. Cereal grain production is a frequent use only in the palous regions of the Columbia River Basin, with wheat the dominant crop during the years of this study.

III. METHODS

The primary task during the study was the location and collection of data from as many prairie falcon nest sites as possible. I attempted to conduct this search and locate a representative sample of nest sites throughout the study area.

The initial location of a nest site usually required the greatest amount of time. The defensive nature of adult falcons in response to human intrusion and the near exclusive propensity for prairie falcons to nest on ledges and cavities on rock escarpments (Skinner 1938) were two critical aids in the location of nest sites.

I began my search for nest sites with the study of topographic maps, communication with individuals knowledgable of prairie falcon biology or nest site locations and an awareness of traditional nesting locations. Travel to and about the suspected areas by vehicle and further search on foot, in conjunction with the use of noise-making devices, usually revealed the presence of a pair of breeding falcons.

Once a pair was discovered and the exact location of the nest noted, I gained access to the nest with the aid of standard rock climbing techniques: nylon ropes, and rapelling and Jumar ascending systems. At each nest, I collected data on: the exposure, height and type of both the cliff and nest; the location, topography, elevation, habitat type and vegetation and land use patterns; and the productivity of the pair at the appropriate stage of the breeding sequence. I also collected any prey items, either in the form of whole or partial remains, or regurgitated pellets encountered in or about the nest.

Unhatched or otherwise obviously non-viable eggs were collected, washed, frozen and later opened; the contents analyzed for residual toxins at the Denver Wildlife Research Center. Equatorial eggshell thickness measurements were made, using a pressure release micrometer (Appendix 1).

Whenever possible, I banded nestlings (age 14 days to fledging) with standard U.S. Fish and Wildlife Service lock-on aluminum bands.

Revisitations were kept to a minimum to reduce the adverse effects of investigator interference. Three visits, including initial site location, were usually sufficient for determining clutch size, hatching success, brood size and fledging success for each pair. A number of breeding pairs were discovered late in the breeding season and only brood size or fledging success was measured at those sites.

Time was spent at each nest site observing behavioral patterns, especially intraspecific interactions, defensive displays and intra-pair sexual behavior. Post-fledging activities were observed when possible, but such observations were limited due to the great dispersal distances involved. Areas suspected of harboring late summer, postfledging juveniles and adults were visited during August and September of 1973 and 1974 to ascertain post-fledging dispersal patterns.

By reason of the cooperation afforded me by the U.S. Forest Service, both in the form of funding and personal contribution on the part of various USFS biologists, I concentrated search activities on or about Forest Service managed holdings whenever appropriate. Beyond such concentration, I made no attempt to survey all regions; my goal was to collect data from a representative sample of prairie falcon breeding in Oregon, not a complete or even partial census.

I was accompanied by one or more assistants during the major phases of field study in both 1973 and 1974.

IV. RESULTS

Distribution and Habitat Characteristics

In 1973 and 1974, I observed 61 breeding attempts by prairie falcons within five major drainages in Oregon (Table 1). Elevations of 52 nest sites ranged from less than 200 feet above sea level to over 8,300 feet, with 39 percent of the sites at elevations of between 2,000 feet and 4,000 feet and nearly one-half of all sites lying between 4,000 and 6,000 feet (Table 2). The lowest nest site was situated on an erosional outcropping of the Columbia River Gorge, in a habitat characterized by a Shrub-steepe vegetational region of the Columbia Basin Province (described by Franklin and Dyrness 1973); the highest site was at the summit of a large fault block in a timbered, montane habitat of whitebark pine (Pinus albicaulis) within an Abies lasiocarpa Zone.

Table 1. Distribution of 61 prairie falcon nesting attempts by major Oregon drainages, 1973 and 1974.

Drainage	No. sites in 1973	No. sites in 1974	Total
Deschutes River	16	13	29
John Day River	4	5	9
Klamath Basin[a]	5	7	12
Snake River[b]	0	7	7
Columbia River	--	4	4

[a]Includes Goose Lake and Abert Lake basins.

[b]Excludes Main Stem of the Snake River.

Table 2. The elevational distribution of 52 prairie falcon nest sites in Oregon, 1973 and 1974.

Elevation (feet)	1973 percent(n)	1974 percent(n)	Combined percent(n)
0-2000	0(0)	8(3)	5(3)
2000-4000	41(11)	38(14)	39(20)
4000-6000	55(15)	46(17)	49(25)
6000-8000	4(1)	5(2)	5(3)
8000 +	0(0)	3(1)	2(1)
Totals	(27)	(37)	(52)

Most (88 percent) nest sites were located in mid-elevation habitats (2,000-6,000 feet) and were typified by relatively undulating topography and moderately xeric to xeric vegetational patterns. Western juniper was the dominant tree species, with a shrub/grass association of big sagebrush in conjunction with bunch grasses, fescues and where overgrazing was evident, cheatgrass brome. The typical nest site thus occupies the transition between the *Artemisia tridentata* associations of Franklin and Dyrness (1973) blending with the *Juniperus occidentalis* Zone as a forest type. Sites were characterized by open terrain, where extended vistas were possible, punctuated with broken ridge systems, rimrocks and isolated buttes with volcanic plugs and extrusions.

Phenology

Although prairie falcons were sometimes present at the nest site in the fall and winter, I found that the first reproductive activity, the establishment of pair bonds, occurred in mid-March. Males were frequently at the nest site prior to the arrival of the females, often exhibiting reproductive behavior and defense responses even before the appearance of their mates. Pair formation is followed by courtship, nest ledge selection and copulation, with these initial behavioral patterns occurring concurrently.

Initiation of incubation, or clutch completion, was observed as early as 2 April 1973 and 1 April 1974 (Table 3). Clutches were not complete at some sites until 8 May 1973, establishing a range of 37 days, and a mean date for initiation of incubation for both years of 16 April.

Cade (1960) suggested that all members of the genus Falco incubate 29 to 31 days. I observed a mean incubation period of 30 days in prairie falcons of Oregon, but found this to vary from 29 to 33 days. Synchronous hatching of the entire clutch resulted from delayed incubation: whereby incubation is initiated only after the final egg is layed.

I found mean dates for hatching and fledging of 16 May and 24 June respectively (Table 3). The sample of observed fledging dates was the more extensive due to the steady increase in the number of nest sites discovered through the course of the field season. Two instances of a pair attempting a second clutch, following the

Table 3. Reproductive phenology of prairie falcons in Oregon, 1973 and 1974.

Phase	1973	1974	Combined
Mean date of clutch completion	19 April (2 Apr-8 May)	15 April (1 Apr-5 May)	16 April (1 Apr-8 May)
Mean date of hatching	19 May (3 May-7 Jun)	15 May (1 May-6 Jun)	16 May (1 May-7 Jun)
Mean date of fledging	27 June (11 Jun-16 Jul)	22 June (9 Jun-13 Jul)	24 June (9 Jun-16 Jul)
Mean incubation period	30 days	30 days	30 days
Mean nestling period	42 days	41 days	41 days

destruction of the first, were found; one 5 May 1974 and the other 3 June 1974. The timing of the breeding sequence was found to be related to elevation of the nest site. Linear regression analysis revealed a significant positive correlation ($P < 0.01$) between elevation and fledging date (Figure. 1).

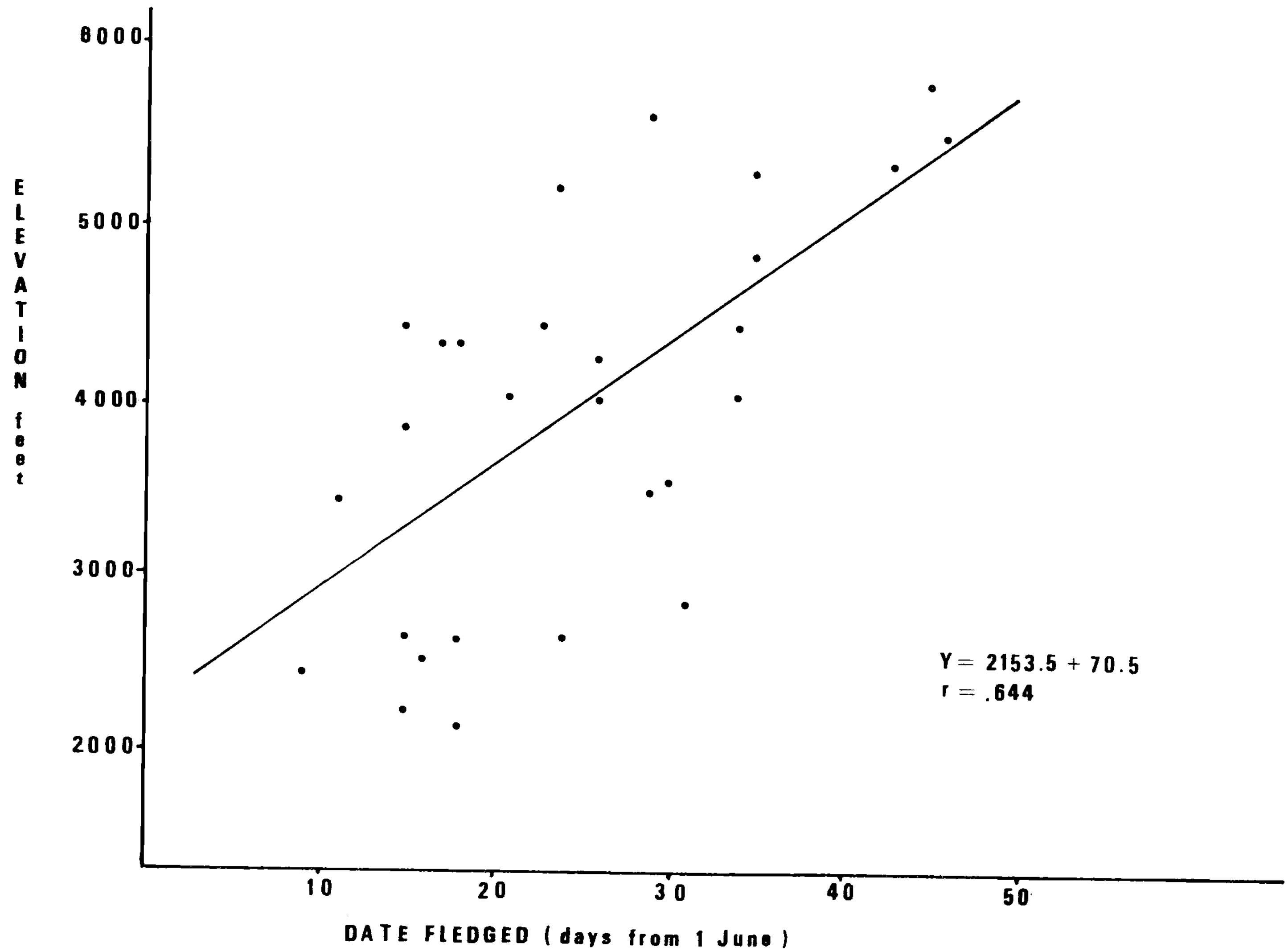
Nest Site Characters

Successfully reproducing pairs of prairie falcons were found in a variety of habitat types and on a wide range of cliff types. Bluffs were the most frequently encountered nest cliff situation (38 percent) where exposed volcanic plugs or fault blocks were used as the nest cliff. Also utilized were ridge systems (29 percent) with associated rimrocks or isolated escarpments, rimrock along canyon walls (24 percent) and solitary monolithic formations (9 percent).

Each cliff was categorized as to geological origin, physiognomy and height. Nearly all nestings occurred on basaltic rock formations (94 percent); in only two instances were sedimentary formations used. All cliffs were nearly vertical and most exhibited a fractured texture offering structures suitable for nest ledges.

Cliff heights were sometimes substantial and some sites were located on cliffs in excess of 400 feet (Table 4). Of the breeding attempts monitored, 59 percent were situated on cliffs less than 100 feet in height, while 14 percent occupied cliffs over 250 feet in height.

Figure 1. Correlation between nest site elevation and reproductive phenology in prairie falcons of Oregon, 1973 and 1974 (d.f. = 31).


8000
5000
4000
3000
2000
ELEVATION feet
10
20
30
40
50
DATE FLEDGED (days from 1 June)
Y = 2153.5 + 70.5
r = .644

Falcons frequently nested on cliffs less than 25 feet high (14 percent) and one pair successfully nested on a cliff under 12 feet in height.

Because the height of nests usually corresponded to cliff height, heights of the nests were equally as varied (Table 4). Seventeen percent of the observed attempts were above 100 feet, while 19 percent were less than 25 feet above the base of the cliff. The difficulty in locating exact nest locations of pairs breeding on extremely high cliffs resulted in a bias toward enumerating lower nest sites. It was not uncommon to find nests less than 10 feet above the base of the cliff and falcons utilizing a nest ledge only 7 feet from the ground successfully fledged three young.

Table 4. Heights of nest cliffs and nests used by prairie falcons in Oregon, 1973 and 1974.

Height (feet)	Cliff percent(n)	Nest percent(n)
0-25	14(7)	19(8)
25-100	43(21)	64(26)
100-200	25(12)	12(5)
200 +	18(9)	5(2)
Totals	(49)	(41)

I placed falcon nests into three major types based on the structure of the substrate. Nests in potholes were the most frequently observed (Table 5). Nests in vertical cracks usually involved a fault in the integrity of the cliff face, with lodged boulders providing the horizontal surface necessary for the building of the nest scrape. Horizontal ledges, the third type, were repeatedly affiliated with remnant and abandoned platform nests previously built and occupied by other raptors or ravens (Corvus corax).

Table 5. Nest site types and percent sheltered of 36 pairs of prairie falcons in Oregon, 1973 and 1974.

Nest type	Percent(n)	Percent sheltered(n)
Pothole	42(15)	10(67)
Vertical crack	39(14)	93(13)
Horizontal ledge	19(7)	57(4)
All types	100(36)	75(27)

The pothole type included both extremes in nest ledge size. Potholes varied from shallow depressions barely 24 inches in diameter and 18 inches deep to extensive caves having entrances over 6 feet high and 10 feet wide, extending into the cliff for as much as 12 feet. The rudimentary nest scapes made by the adults were little more than shallow depressions in the dust of the nest ledge floor, averaging approximately 12 inches in diameter.

A nest site was considered sheltered if the structure of the cavity provided protection from precipitation and direct sunlight when the sun was 45° above the horizon. Shelter was usually provided by a substantial overhang, but functional protection also resulted from angles in the cliffface which reduced the exposure of the nest by a change in aspect. A majority of nests were sheltered (75 percent) and there was a pronounced viability in the degree of protection each nest type afforded (Table 5).

Nests in all categories contained loosely arranged sticks and twigs, yet there was no active nest building by the falcons themselves. Rather, the debris represented the disassociated remains of stick nests left by nest building birds and woodrats (Neotoma spp.). Suitable nesting cavities appeared to be at a premium, and nearly all contained such debris to some extent.

There was frequently a pronounced disparity between the exposure of the cliff and that of the nest (maximum 135°) due to the convolutions inherent in many escarpment systems. I found 61 percent of the nests studied with exposures between 181-360°; of these, 33 percent had exposures of 271-360° (Table 6). Only 14 percent of the nests were oriented towards the northeast (0-90°).

Table 6. Exposure of cliff and nest in 36 prairie falcon pairs in Oregon, 1973 and 1974.

Exposure	Cliff percent(n)	Nest percent(n)
0-90°	11(4)	14(5)
91-180°	22(8)	25(9)
181-270°	22(8)	28(10)
271-360°	45(16)	33(12)
Total	(36)	(36)

For each nest site, I determined the proximity to the nest of various habitat features of potential influence in the selection or reproduction success of the site. Distances were measured along a straight line from the nest to that portion of the feature that lay nearest the nest. Many sites (62 percent) were located within 0.5 miles of some type of road. These were usually graveled or unmaintained access roads, although some were paved. Most roads were well traveled during the spring and summer, frequently by local residents, but sometimes, in the case of the hard-surfaced roads, by substantial transient traffic. One nest was located within 150 feet of a primary state highway.

Somewhat related to road systems was the proximity of nest sites to human habitation. I considered as habitation any man-made structure inhabited as a dwelling or used with weekly frequency, including commercial, mining and agricultural buildings. The prairie falcons were perhaps more sensitive to this type of activity; only 15 percent nested within 0.5 miles of habitation.

Thirty-two percent of the nest sites studied bordered agricultural land, while 24 percent occupied forested habitats. A substantial majority (76 percent) of the sites had water sources within 0.25 miles of the nest lasting throughout the duration of the breeding season. Sixty-eight percent of these were located adjacent to major streams, lakes and reservoirs, while the remainder were near irrigation canals, small creeks or perennial springs.

Nesting Density

No attempt was made to record the densities of breeding prairie falcons throughout the study area. The survey techniques used did not lend themselves to intensive search, and therefore, I determined densities of breeding pairs only in those areas where territories had potentially common boundaries. Densities were measured as a function of straight line distances between nests, in an attempt to reduce the inaccuracies of boundary determination. The minimum distances recorded were 0.25 miles between nesting attempts and 0.5 miles between successful nests. Several sites (20 percent) were located in areas with densities greater than one site per mile. It appeared that the geographical orientation of the adjacent site was a determining factor in the degree of territorial compression allowable. In only one instance were two nests, separated by less than a mile, visible from one another; nest sites in all other adjoining territories were isolated by an intervening ridge or canyon wall. The densities recorded are possibly lower than is actually the case, with the consideration of unobserved nest sites.

Productivity

A breeding attempt was considered initiated when a potential territory was occupied by an adult falcon during the early phases of the breeding sequence and my intrusion illicited a defensive response, or substantial reproductive behavior on the part of the adults could be observed (Fyfe et al. 1969). I further categorized an attempt as successful if the pair fledged at least one young. Discrepancies in the amount of productivity data yielded by different breeding attempts was due to the increase in the discovery of pairs as the field season progressed. Thus, although I measured three criteria to determine productivity: clutch size, hatching success and numbers fledged, I utilized numbers fledged as the indicator of the reproductive output of a breeding pair.

I observed reproductive activity at 51 prairie falcon nest sites during 1973 and 1974. Eighty-two percent of the attempts monitored were successful (Table 7). I was unable to ascertain any production at an additional 14 sites, but because of the infrequency of visitation, they were subsequently considered as unknown and omitted from the analysis of overall productivity. Productivity levels are biased toward higher success rates, in that nest sites locations were found throughout the field season, and failures prior to the discovery of the pair may not have been observed. Most failures (75 percent of the unsuccessful nesting attempts) occurred prior to hatching.

Complete clutches were recorded on 30 occasions; the mean clutch size was 4.10 (Table 7). There was only one instance of a clutch containing a single egg and two clutches contained six eggs.

Table 7. Productivity of prairie falcons breeding in Oregon, 1973 and 1974.

	1973(n)	1974(n)	Combined(n)	Range
Mean clutch size	4.33(9)	4.00(21)	4.03(30)	1-6
Mean brood size	3.30(10)	3.47(19)	3.41(29)	1-5
Mean no. fledged per all attempts	2.33(19)	2.62(24)	2.49(43)	0-5
Mean no. fledged per successful attempts	2.93(15)	3.00(21)	2.98(36)	1-5
Hatching success	0.78	0.76	0.77	
Fledging success	0.88	0.87	0.88	
% successful attempts per known success	83(20)	82(22)	82(42)	
% unsuccessful attempts per known success	17(4)	18(5)	18(0)	
% unknown success	17(5)	25(9)	21(14)	
Sex ratio (males:females)	1:1.5(42)	1.4:1(56)	1:1(98)	

That raptorial birds will renest following the loss of a first clutch has long been common knowledge among oologists (Hickey and Anderson 1969). I recorded two instances of renesting; a clutch of four eggs replacing an original clutch of four and a clutch of one egg replacing a clutch of unknown size. The former attempt was unsuccessful; the latter fledged one young.

Ninety-four percent of the clutches monitored hatched at least one egg and the mean hatching success (number of young per egg) was 0.77 (Table 7). Partial hatching of complete clutches remained infrequent during both years of the study (4 percent).

The observed brood size averaged 3.41 (range, 1-6) for both years. This value may be depressed, as may be clutch size, for some mortality may have occurred prior to my visitations. Young were considered fledglings when they had left the nest or would do so within a few days. Fledging of the entire brood was a gradual process, with siblings leaving at different ages over a period of several days. I calculated a mean nestling period of 41 days (range, 38-47) and nestlings sometimes returned to the nest ledge at night following their initial departure. The mean number of young fledged per all nesting attempts was 2.49 (range, 0-5) and resulted in a fledging rate of 0.88 for all monitored attempts during both years. The mean number fledged per successful attempt was found to be 2.98 (range, 1-5) for both 1973 and 1974 (Table 7).

Sexual size dimorphism is sufficiently developed at 14 days of age to allow sex determination and banding. The sex ratio of observed fledglings was approximately 50:50 (Table 7). I banded 53 nestlings during the two year study.

Mortality Factors

The hatching rates presented earlier implied minimal egg losses. Mortality factors prior to the hatching of the clutch included abandonment of the nest site by the adults before and during incubation, loss of the complete clutch to predation and infertility. I observed six instances of adult abandonment, two of which followed the disappearance of one of the adults. I could not decifer the cause of the abandonment behavior on the remaining occasions.

I collected four infertile eggs during the study and recorded the disappearance of three complete clutches. Egg predation invariably occurred at sites judged accessible to mammalian predators, although no specific occasions of such predation were witnessed and no inference as to the species of predator can be made.

Nestling mortality was even less pronounced than egg loss and only 12 percent of the young that hatched died or disappeared prior to fledging. I could reasonably account for only 55 percent of the nestling mortality: predation accounting for the majority of known causes (60 percent). Harvest by humans was implicated at one site which had been occupied for a number of years previous to 1974.

One young falcon was found alive below a moderately small nesting cavity, apparently expelled by its four siblings. The adults were continuing to feed this nestling, as evidenced by prey remains about the nestling's location.

The occurrence of post-fledging mortality was difficult to observe. Three instances of the loss of fledged young were noted, yet no cause was decifered and I only noted their premature disappearance from the vicinity of the nest.

Nest Site Reoccupancy

The utilization of traditional nest sites by raptors is well documented (Brown and Amadon 1968, Hickey and Anderson 1969). Fifty-six percent of 27 nest sites located during 1973 were reoccupied during the 1974 breeding season. These 15 nest sites, occupied during both years, showed a higher success rate in 1973 than those sites occupied in 1973 only (Table 8). From information conveyed by knowledgable persons, I located 15 nest sites occupying territories used by prairie falcons in the years preceeding this study. Seven sites reported to me as traditionally occupied were not active during 1973 or 1974.

Table 8. Occupancy in 1973, reoccupancy in 1974 and associated success in 1972 of 27 Oregon prairie falcon nest sites.

	No.	Percent	Percent success in 1974[a]
Total	27	100	67
Occupied in 1973 only	12	44	50
Reoccupied in 1974	15	56	80

[a]Denotes percentage of sites that fledged one or more young in 1973.

Food Habits

A quantitative analysis of prairie falcon food habits was not possible, for falcons continually remove partial remains of prey items from the vicinity of the nest (Fowler 1931). Regurgitated pellets were frequently found about the nest site, but were of limited value in ascertaining the identity of a prey species. Falcons do not exhibit the Strigiformes and Buteo spp. habit of engulfing prey items whole, but fragment their food before ingestion. This renders the pellet contents indistinguishable, thereby disallowing identification of prey species.

The frequency of certain prey items in the diet of reproductive falcons was discernible, using all prey material collected from a nest site during each visit as a prey collection unit and qualitatively identifying prey species presence in each collection unit (Ogden 1973). Mammalian prey species identified, in order of decreasing frequency of appearance were: Townsend ground squirrel (*Citellus townsendi*), belding ground squirrel (*C. beldingi*), golden-mantled squirrel (*C. lateralis*) and the least chipmunk (*Eutamius minimus*). Avian species occurring in more than one-half of the collections were: western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), red-winged blackbird (*Agelaius phoeniceus*), mourning dove (*Zenadura macroura*) and the starling (*Sturnus vulgaris*).

V. DISCUSSION

Distribution and Habitat Characteristics

The spatial distribution of prairie falcon nest sites located during this study more closely represents differential search effort than falcon distribution or abundance. However, due to the presence of nest site locations in all the areas surveyed, this distribution pattern does provide evidence for a prairie falcon breeding range in Oregon extending over much of the eastern half of the state. Gabrielson and Jewett (1940) reported breeding pairs throughout much of eastern Oregon, with nest sites recorded as far west as Fort Klamath and The Dalles, and found it common as a breeding species in Harney Lake Valley. Breeding pairs have long been known at locations near Prineville (Skinner 1938).

The relative abundance of breeding pairs within major drainages was almost wholly a function of search effort. In areas where mobility was impaired, topography extreme and access limited, I located few falcon nest sites. The greater number of nest sites within the Deschutes River drainage also reflect personal familiarity and field work conducted in that region prior to the start of this project.

Nest site elevations ranging from 200 feet to 8,000 feet are not unusual for prairie falcons. Leedy (1972) reports finding a breeding pair in Montana above timberline, at 9,000 feet. Sites as high as

11,000 feet have been documented in the Sierra Nevada Range of California (Skinner 1938). However, the frequent occupation of high elevation forest habitats, as observed in Oregon, has not been reported previously. Parker (1972) mentioned the occurrence of prairie falcon nest sites in the montane zones of the Cascade Mountains in Washington, but neglects to describe the specific habitat type. The forest continuity at sites in Oregon was occasionally broken by wet meadows, rocky openings and extensive road systems. I suspect that it was these areas which allowed sufficient foraging and hence, the successful occupation of otherwise densely forested habitats.

Prairie falcon nesting habitat is typically described as open grasslands, interrupted by broken terrain, including escarpments for nesting (Fowler 1931, Skinner 1938, Enderson 1964). The clustering of the majority of nest sites about a median range of elevations indicates that the most common nesting habitat for prairie falcons in Oregon is the same open, broken terrain of the literature. These nesting habitats correspond to the Steepe-shrub Zones of Franklin and Dyrness (1973). Topography was most often gradual, with large expanses of mesas, plateaus and valley floors. Narrow canyons were infrequently utilized, and when occupied, were often situated adjacent to extensive flatlands.

Phenology

Webster (1944) suggests that the male prairie falcon is the first to arrive at the nest site and my own observations in Oregon tend to confirm this, but Enderson's (1964) findings, where nine of eleven first arrivals in a Colorado population were females, confounds the issue.

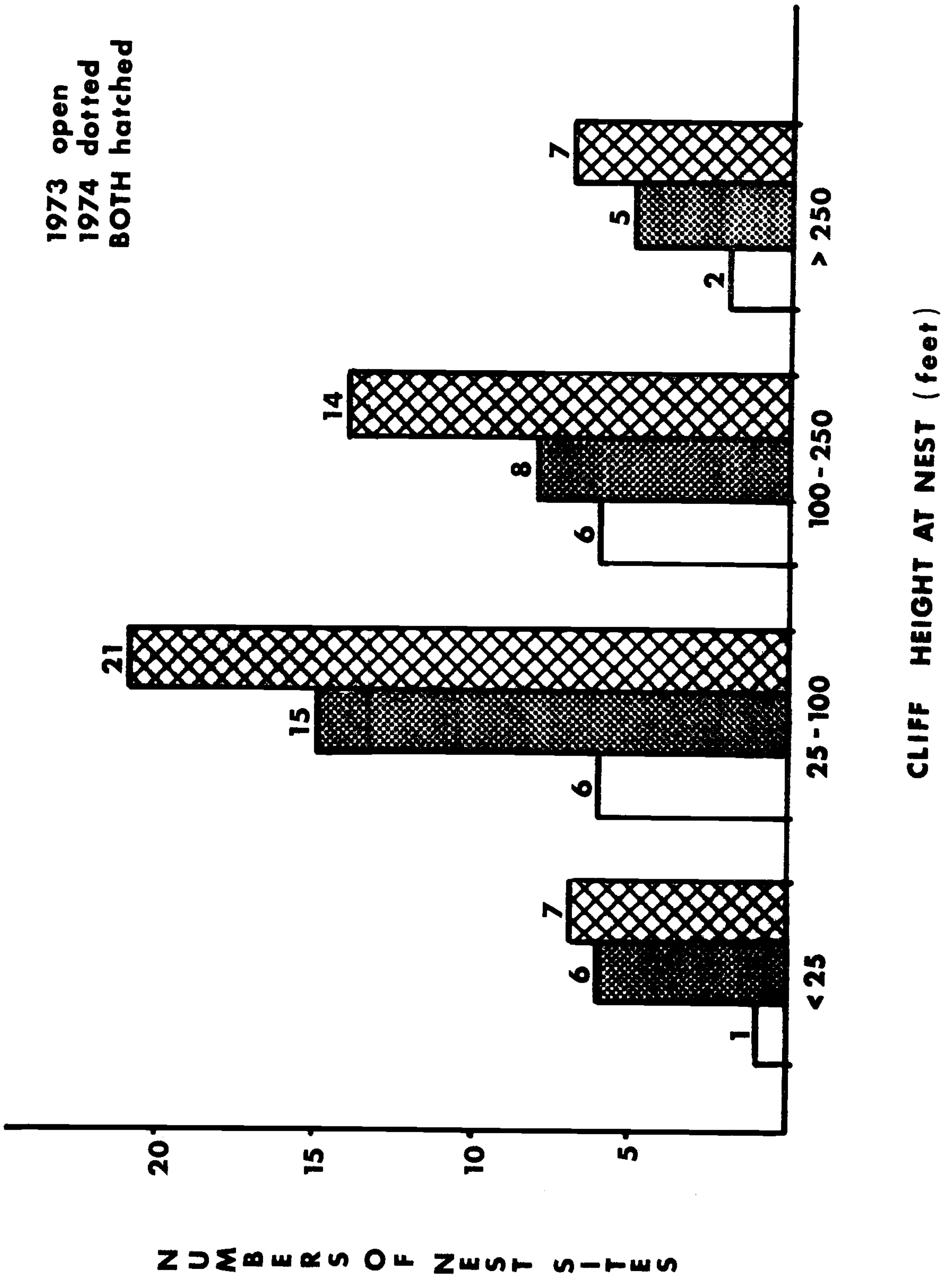
Populations in Colorado and Wyoming (Enderson 1964) and Montana (Leedy 1972) began pair formation in mid-March, while in southwestern Idaho, pairing began as early as mid-February (Ogden 1973). Pair bonds in Oregon were being established in mid-March. The potential for Ogden observing early reproductive behavior was increased over the other studies (his study area was small), and this, coupled with the unusually mild climate unique to his study area could account for this discrepancy in phenology.

Skinner (1938) presented records of eggs observed or collected at prairie falcon nests in Oregon of 28 March to 28 April, with 50 percent occurring within the second week of April. Although Skinner's data suggest a general range, it is not clear whether these dates were recorded when nests were found or eggs were layed. Gabrielson and Jewett (1940) gave collection dates for full clutches of 6 April to 8 May, a period corresponding to dates observed during the current study (mean, 16 April; range, 1 April-8 May). Parker (1972) stated that pairs in Washington begin incubation as early as late March.

All members of the genus Falco incubate 29 to 31 days (Cade 1960). With one exception, all clutches I observed hatched within those limits (mean, 30 days). The nearly synchronous hatching of the entire clutch indicated delayed incubation. Lack (1954) postulates that initiation of incubation at the laying of the first egg may serve as a mechanism for regulation of numbers relative to the existing food base. Although many members of the Order Falconiformes and Strigiformes do exhibit such incubation behavior (Welty 1963), Ogden (1973) found delayed incubation to be common in prairie falcons of Southwest Idaho. Larger clutch sizes in prairie falcons (usually 3+), coupled with the female laying less than one egg daily, would result in a pronounced age difference between siblings of a brood, thereby minimizing the potential for large numbers of fledglings.

New nest site locations were discovered on a continuing basis throughout the breeding season and thus, I monitored a greater number of nests through fledging than through hatching. It should be noted that fledging dates are more variable through the sample than are hatching dates (Figure 2). This is partly due to the difficulty in ascertaining the exact time of fledging. However, since differential development is also responsible for the staggering of fledging dates, a good deal of the variability is the result of situations that induce fledging by any one individual falcon. Males frequently left at an

Figure 2. Histogram of reproductive phenology of prairie falcons in Oregon, 1973 and 1974.


1973 open
1974 dotted
BOTH hatched
NUMBERS OF NEST SITES
5
10
15
20
1
6
7
6
15
21
6
8
14
2
5
7
< 25
25 - 100
100 - 250
> 250
CLIFF HEIGHT AT NEST (feet)

earlier age the did females, perhaps due to their more favorable wing load ratio.

Nest Site Characters

The larger falcons characteristically utilize escarpments upon which to build their nests (Brown and Amadon 1968). Deviations in this nesting pattern by prairie falcons are extremely rare (Skinner 1938). Ground nesting in arctic peregrine falcons and gyrfalcons (Falco rusticolus), in regions devoid of cliffs, is common (Cade 1960, Beebe and Webster 1964, Hickey and Anderson 1969), but ground nesting by prairie falcons has not been reported. The utilization of man-made structures as nesting substrates has also been documented in peregrine falcons (Hickey 1969). There is no reason to discount the possibility that prairie falcons might use artificial sites when appropriate (Fyfe 1972). The close proximity of certain nest sites in Oregon to human habitation and roads may indicate a degree of tolerance to manipulation of nest cliffs, and the management potential is far-reaching.

Basaltic escarpments were the most commonly utilized cliff type and were typically composed of vertical fault blocks or eroded rimrocks. The high frequency of nest sites on bluffs relative to the apparent availability of alternate types stimulates speculation as to the role the elevational component plays in nest site selection. Parker

(1972:2) set forth an example of the ideal nest site as an "old highly eroded lava flow, at the top of a long slope, which overlooks a broad river valley." The advantage of vistas to foraging behavior and the presence of wind currents due to elevational and topographical characters may partially explain any selection for bluff situations.

Declining falcon populations tend to abandon the lower more readily accessible cliffs, utilizing only the highest nest sites available (Hickey 1969). Skinner (1938) contends that prairie falcons select for cliffs of from 50 to 400 feet high, with most nests greater than 30 feet above the cliff base. Prairie falcons in Colorado and Wyoming occupied cliffs with a mean height of 50 feet (Enderson 1964). Enderson (1964) and Leedy (1972) hypothesized that given a protected site overlooking treeless terrain, cliff heights of less than 30 feet can be successfully exploited. The frequent use by prairie falcons in Oregon of cliffs less than 25 feet high conforms with this hypothesis, as does data from Idaho (Ogden 1973). Ogden found several occasions of falcon occupancy of cliffs lower than 25 feet in height. I feel the suitability of a cliff for nesting is primarily a function of accessibility by mammalian predators, which is only indirectly related to cliff height. All successful nesting attempts on cliffs less than 25 feet in height were judged inaccessible to mammalian predators.

The aspect of the nest cavity and cliff may also influence selection of a nest site. Skinner (1938) stated that nest sites with southerly exposures were preferred by prairie falcons, the hot sun causing no apparent discomfort. Leedy (1972) found 72 percent of 49 falcon nests studied in Montana face south or east. Of 36 sites visited by Enderson (1964), 61 percent had southern exposures. Sixty-one percent of the Oregon sample had southwestern and western exposures. I concur with Leedy (1972) that southern exposures may be preferentially selected, where the more direct sunlight would warm the site during the early phases of incubation and brooding.

No evidence of active nest building by the falcons was observed, beyond the simple nest scrape. Prairie falcon nests containing stick debris were, in every case, instances of falcon occupancy of nests abandoned by nest building red-tailed or Swainson's hawks (*Buteo jamaicensis* and *B. swainsoni*), golden eagles (*Aquila chrysaetos*) and ravens. The use of remnant stick nests by prairie falcons has been reported in the past (Dawson 1913, Decker and Bowles 1930, Leedy 1972). The occurrence of woodrat nests on ledges used by prairie falcons has been noted (Beebe and Webster 1964), and it was commonplace during this study to find falcons nesting on the decayed debris of abandoned woodrat nests.

Productivity

I designed the measurements of productivity so that they allowed for: (1) some indication of the actual production of the entire population, (2) the comparison of productivity in Oregon to populations studied in other regions and (3) the application of structural models in a determination of population trends. In this way, I hoped to gain an insight into the reproductive mechanisms that dictate population numbers, thereby allowing a determination of the status of the population.

With the exception of one clutch containing a single egg, clutch sizes in Oregon reflect a distribution exemplified by other populations (Table 9). Mean clutch size of 30 clutches observed in this study was 4.03. Skinner (1938) reported clutch sizes in Oregon, Washington and California averaging 4.70. Of 20 clutches found in western Montana and 68 clutches in Idaho, mean clutch size were found to be 4.3 and 4.4 respectively (Leedy 1972, Ogden 1973).

Table 9. Comparison of frequency of clutch sizes as distributed through four prairie falcon populations.

		Percent of different clutch sizes					
Region and source	n	1 egg	2 egg	3 egg	4 egg	5 egg	6 egg
Oregon, Washington and California (Skinner 1938)	100	0	0	7	21	70	2
Western Montana (Leedy 1972)	20	0	0	20	30	50	0
Southwestern Idaho (Ogden 1973)	68	0	4	15	19	58	4
Oregon (present study)	30	3	0	20	50	20	7

Recent studies of prairie falcons have reported fledging rates both as numbers fledging per all breeding attempts and numbers fledging per successful attempt (Leedy 1972, Ogden 1973). I continue to report fledging numbers in this manner, in the belief that such a dicotomy allows for more specific interpretation of production data (Table 7). Nesting pairs were discovered during all phases of the breeding season, with the result that unobserved desertion of a nest site by adults (failure of an attempt prior to the location of the site) could have occurred. This would introduce a bias toward higher than realized productivity, the observed fledging per all attempts being commensurately higher than the actual rate. This biased measurement is an artifact of fledgings per all attempts only, for in effect, the lack of observation of early failures redefines "all attempts." Rather, what was actually measured was "all attempts monitored."

This argument gives credence to the concept of mean fledging number per successful attempts, in that no bias from unobserved failures is incurred in such a measurement. Yet, a new bias of the same effect, that of an inflated production value, is inherent in any parameter that discounts failures. Mean fledging number per successful attempt, however, does measure a real population parameter, and hence retains its value in comparisons of one population to another.

The significance of various levels of production become meaningful when used as measurements of population status, both as determinants of present status and as indicators of future trends. Because of the essential lack of data on the productivity of prairie falcons in Oregon in the past, there is no opportunity for even gross comparisons with past production levels. Comparisons with data generated from studies in other regions are possible, however, with the realization that such a procedure allows only the crudest indication of population status. The variability in techniques between studies and mortality rates between populations negates the forceful application of such comparisons.

Prairie falcon productivity in Oregon lies well within the range observed for prairie falcon populations studied in other regions (Table 10). Prairie falcons in Oregon fledged a mean of 2.49 young per all attempts and 2.98 per successful attempts. These figures are lower than the means of 3.11 and 3.70 of a population in southwestern Idaho (Ogden 1973), but are elevated relative to recent production in Montana, where mean fledging numbers were as low as 1.9 and 2.9 per all attempts and successful attempts respectively (Leedy 1972). The lower value for Montana included young known to have been harvested by falconers. Such individuals are essentially removed from the population and in an analysis of productivity should be considered as mortalities. This suppresses the Montana productivity per all attempts to below 1.8. Enderson (1964) reported a mean productivity of 1.2 young per attempt in prairie falcons in Colorado.

Table 10. Comparisons of productivity in prairie falcon populations from various regions.

Area and source	Eggs per clutch	Hatchlings per nest	Fledglings per nest
Calif., Ore., Wash., pre-1938 (Skinner 1938)	4.7(100)	--	--
Colorado, 1960-62 (Enderson 1964)	4.5(55)	1.9(67)	1.2(67)
Colorado, 1967-68 (Enderson and Berger 1969)	4.6(35)	1.9(35)	1.6(35)
Saskatchewan, Alberta, 1968-69 (Fyfe 1962)	4.3(85)	2.5(85)	--
California, 1969 (Herman 1969)	4.4(13)	--	1.3(13)
Montana, 1970-71 (Leedy 1972)	4.3(20)	2.4(27)	1.9(48)
California, 1969-72 (Garrett 1973)	4.1(48)	--	2.9(48)
Idaho, 1970-72 (Ogden 1973)	4.4(68)	3.4(85)	3.1(110)
Washington, 1964-72 (Parker 1972)	4.1(25)	--	2.7(23)
Oregon, 1973-74 (This study)	4.1(30)	3.4(29)	2.5(43)

Numbers in parentheses denote sample size.

Mortality Schedules

In order for the production estimates of a population to become valuable as a determinant of population status, something must be known about the mortality rates undergone by each age class within the population. Mortality rates within the Oregon population of prairie falcons were not measured during this study, primarily because of the inability to collect enough data to provide meaningful analysis.

With the assumption that mortality rates of prairie falcon populations throughout their range in North America approximates the mortality schedule of prairie falcons in Oregon, an analysis of 117 band recoveries from 1928 through 1972 was conducted. Banding data used in this analysis were subject to error (for review see Hickey 1952). Inaccuracies in the recording of banding and recovery data could exist and unless discrepancies are acute, they would not be detected. I found few clerical errors in the recovery data and when noted, omitted the record involved from the subsequent analysis. Band loss is a substantial source of error, particularly in large raptors with extended longevity. Bandings made prior to the advent and common use of lock-on aluminum bands have a higher potential for loss or destruction (Hickey 1952). Band loss would cause mortality rates to be overestimated in younger age classes because as older age classes loss their bands, discovered mortalities then become unavailable for reporting. Henny (1972) suggested that band loss is only significant in marine birds, where exposure to salt water causes rapid corrosion. However, the use of corrosive metal, butt-end bands on raptors may have allowed for substantial band loss in prairie falcons.

The composite dynamic life table method was used in estimating mortalities (Hickey 1952, Haldane 1955). Prairie falcons are known to live at least 13 years; some may live longer. Thus, the cohorts banded after 1959 may not have had enough time to live out their potential longevity. This factor could tend to inflate estimates for younger age class mortalities. The composite dynamic life table was used to circumvent the error inherent with incomplete cohorts and allow the inclusion of recent banding data. Rates are expressed as numbers of deaths and the number living per one hundred banded birds. Construction of the life table yielded mortality estimates for the first year (immature) age class of 65 percent and a mean adult mortality of 35 percent (Table 12).

Of critical importance is the date selected as the starting point of the life table. Deevey (1947) suggested that the initial date in life tables based on banded nestlings or juveniles should be the mean date on which the nestlings were banded. However, error is introduced by the selection of this date, in that sampling variables of unknown

Table 11. Band recovery data for prairie falcons banded in North America as nestlings, 1928-1972.[a]

Year banded	Number banded	Recoveries by years after banding 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
1928-1953	492	34	4	4	1										1
1954	7	1													
1955	9														
1956	13	2					1								
1957	4	1													
1958	12														
1959	10	4	1												
1960	25	3	1												
1961	25	3	1	1											
1962	16	1													
1963	25	2		1				1							
1964	19			1	1										
1965	16														
1966	32		2			3									
1967	20					1									
1968	80	4	1		2										
1969	56	1													
1970	66	4	1	1											
1971	124	13	2	1											
1972	150	10	1												
Total	1201 d_x	83	14	9	4	4	1	1	0	0	0	0	0	0	1
No. banded birds available/interval		1201	1051	927	861	805	725	705	673	657	638	613	597	572	547
% banded birds available recovered dead (d'x)		6.91	1.33	.97	.46	.50	.14	.14	-	-	-	-	-	-	.18

[a]Data includes birds banded as 04 and 03 year class codes.

influence are introduced, biasing the immature mortality estimates downward (Hickey 1952). For the analysis presented here, the date of banding is used as the anniversary date of the life table because only data from banded nestlings were included in the table.

Table 12. Composite dynamic life table based on band recoverv data for 117 prairie falcons banded as nestlings, 1928-1972. Mortality rate: 1st year = 0.65, 2nd year and later = 0.35.

Age class	d'_x	ℓ'_x	q'_x		Production at 2.49 yng/female
0-1	6.91	10.63	0.65		--
1-2	1.33	3.72	0.36		--
2-3	.97	2.39	0.41		5.95
3-4	.46	1.42	0.32		3.53
4-5	.50	.96	0.52		2.39
5-6	.14	.46	0.30		1.15
6-7	.14	.32	0.44	0.35	.80
7-8	0	.18	0		.45
8-9	0	.18	0		.45
9-10	0	.18	0		.45
10-11	0	.18	0		.45
11-12	0	.18	0		.45
12-13	0	.18	0		.45
13-14	.18	.18	1.00		.45
Subtotal excluding 0-1 age class		10.53		Total	16.97

The mortality rates estimated in Table 12 for the prairie falcon (0.65 and 0.35) may be compared to rates for the prairie falcon derived by Enderson (1969) of 0.74 and 0.25 for immature and mean annual adult mortality respectively, based on data from bandings made prior to 1951 (Appendix 2). Enderson (1969) also reported mortality rates for the peregrine falcon (prior to 1951) in North America of 0.70 and 0.25. Henny (1972) calculated appropriate immature and adult mortality rates of 0.61 and 0.46 for the American Kestral (Falco sparverius) and 0.59 and 0.30 for the red-shouldered hawk (Buteo lineatus), both based on nestlings banded through 1965.

Population Status

On the assumption that the mortality estimates of 0.65 and 0.35 calculated in Table 12 provide a meaningful estimate of the mortality schedule of the present population of prairie falcons in Oregon, it is possible to apply a life equation analysis to the data in order to establish an estimate of population trends.

Falconiform birds often exhibit second year sexual maturation (Brown and Amadon 1968). Age determinations are made possible in raptorial birds through changes in plumage coloration and pigmentation of the feet and cere. I found no evidence of sexual behavior in first year age classes of prairie falcons in Oregon and no reports of extensive sexual activity in immature prairie falcons have been documented (Webster 1944, Enderson 1964). Hence, for purposes of the status analysis, it is assumed prairie falcons do not breed until the end of their second year.

An estimation of the total number of young produced by the sexually mature birds in the life table can be made by multiplying the figures in the ℓ'_x column (Table 12), starting with age class 2-3, by the production measured in Oregon. Mean annual production of prairie falcons in Oregon during 1973 and 1974 was 2.49 young fledged per breeding attempt. If all sexually mature adults breed each year, the annual recruitment of young fledged per female each year in Oregon can then be calculated (Table 12). Only one-half the resultant value of 16.97 birds are females (assuming an equal sex ratio), thus 8.48 young females are recruited into the population each year to replace the 10.64 females leaving the 0-1 age class. The assumption of a stationary population, upon which the life table model is based, is violated and prairie falcon production in Oregon is representative of a decreasing population. Life equation production estimates were 19 percent below that necessary to provide the 10.63 birds in the 0-1 age class.

The major source of error in this determination is the need for assuming similar mortality schedules between the prairie falcon population in Oregon and those of all of North America, and that mortality rates have remained constant through time. In addition, production estimates for Oregon are valid only for the two years when measurements were made.

In summary, life table analysis of prairie falcons based on North American band recoveries show immature and mean adult mortality rates of 0.65 and 0.35 respectively. These rates, coupled with an annual productivity in Oregon of 2.49 fledglings per nesting attempt indicate a declining population. Major bias includes the assumption of similar mortality schedules between prairie falcons in Oregon and those in North America as a whole.

Population Model

An alternative analysis of the population status of prairie falcons in Oregon is possible with the application of a structural model. Henny et al. (1972) presented a mathematical model for the determination of the production necessary for the maintenance of a stable population (recruitment standard).

The model, as applied here, is a specialized case of a more general model; the case used here (Case II) accommodates populations of species exhibiting delayed sexual maturation, initially producing young only at the end of their second year of life, and where:

$$\bar{m} = 1 - s/s_0 s_1 (1-s+s_2)$$

and:

$$s_0 = \text{immature survivorship} = 0.35$$

$$s_1 = s_2 = s = \text{adult survivorship} = 0.65$$

then:

$$\bar{m} = \text{recuitment standard (females only)} = 1.54$$

Given an equal sex ratio (Table 7)

$2\bar{m}$ = recruitment standard

= 3.08

This predicted value compares to the observed value in Oregon of 2.49, indicating the population is decreasing in number through time.

Although the status determination of this model coincides with that derived by the life equation approach, the Henny et al. (1972) model is inappropriate for use with the data available on the prairie falcon mortality schedules. One of the central assumptions of the model is an equality among age specific adult mortality rates. Examination of the rates derived in Table 12 shows that this assumption is substantially violated, somewhat negating the model's usefulness in this analysis.

VI. MANAGEMENT IMPLICATIONS

The prairie falcon in Oregon is essentially an unmanaged species The program relative to the harvest of production surpluses, should surpluses in fact exist, is limited to one of arbitrary prohibition. Of greater importance, few concerted efforts toward direct prairie falcon habitat management have been made. Both management areas require attention: the former from the Oregon Wildlife Commission: the latter, a far broader and more influential aspect of falcon management, from all agencies, both state and federal, where holdings coincide with prairie falcon presence.

Habitat management, with regard to prairie falcons, can take on two separate designs: (1) the manipulation of those aspects of the habitat that constitute the falcon's immediate environment (including cliff and nest characteristics, vegetation patterns, human interference, etc.) and (2) management of the prey species population. Not necessarily distinct, these two areas are equally influential. Only rarely can one be optimized at the sacrifice of the other without a pronounced detrimental effect on falcon abunance. Recent developments in captive breeding, raptor habitat manipulation and related techniques provide increased potential for effective management (Fyfe 1972, Olendorff and Stoddart 1974).

The present lack of direct management is not wholly detrimental for generalized wildlife management programs often incidentally benefit resident prairie falcons. The low human densities over much of eastern Oregon also allows for a certain buffer effect. However, future land use patterns, agricultural methods and forest management practices by both public and private concerns will undoubtedly have an increasing influence on prairie falcon populations. Then specific programs aimed at select aspects of prairie falcon biology or their environment will eventually become a prerequisite to the continued viability of the species.

The majority of prairie falcons located during this study were found in a habitat exemplified by the shrub/grassland holdings of the Bureau of Land Management (BLM). As a federal agency, the BLM has the potential for effecting the greatest number of falcons in their management programs. Of considerable note, however, was the presence of breeding prairie falcons within relatively timbered habitats, often at high elevations. I found 44 percent of the nest sites studied on or adjacent to U.S. Forest Service lands, and it is apparent the Forest Service should be concerned with the possible influence their management plans could have on the prairie falcon.

Nesting locations were found in a variety of habitat types and on a number of land ownerships. U.S. Fish and Wildlife Service refuges often contain optimum breeding habitat for prairie falcons, and this agency's role in falcon management should be substantial. The incorporation of dedicated lands within the USFWS system allows this agency a unique opportunity for effective and intensive management of resident prairie falcons.

Reservoir construction inundates vast acreages of potential breeding habitat of the prairie falcon, with concurrent responsibility of appropriate agencies, including the U.S Army Corps of Engineers and the Bureau of Reclamation, the result.

Thus, with the growing possibility of conflicts between programs optimizing prairie falcon habitat and other land uses, an awareness of prairie falcon biology, habitat requirements, population trends and perhaps simply the presence of a single pair will be increasingly important. A myriad of means in which to manage prairie falcon populations are available, and specific efforts in this area will become increasingly necessary.

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APPENDIX

Appendix Table 1. Residues of chlorinated hydrocarbons and heavy metals, and eggshell thickness of four prairie falcon eggs collected in Oregon, 1974.[a]

Success of nest[b]	Results (ppm wet weight)						Thickness (mm)
	Hg	DDE	Dieldrin	Hep. Epox.	HCB	PBC[c]	
U	0.21	2.3	.06	.03	0.37	1.1	0.345
U	0.08	2.6	.08	.04	0.50	-	0.352
U	0.16	9.4	.53	.06	14.60	2.3	0.330
S	0.04	1.0	.01	.01	0.06	-	0.379

[a]Residues analyzed at the Denver Wildlife Research Center.

[b]S = successful at fledging at least one young; U = unsuccessful.

[c]Polychlorobenzene-like material: quantities estimated.

Appendix Table 2. Prairie falcon life table based on recoveries of birds banded as nestlings (Enderson 1969).

Age interval[a] (years)	No. of recoveries[b]	No. alive at start of period	Annual mortality rate (%)
0-1	61(53)	81(72)	75(74)
1-2	8(7)	20(19)	
2-3	5(5)	12(12)	
3-4	3(3)	7(7)	
4-5	1(1)	4(4)	
5-6	1(1)	3(3)	
6-7	1(1)	2(2)	26(25)
7-8	0(0)	1(1)	
8-9	0(0)	1(1)	
9-10	0(0)	1(1)	
10-11	0(0)	1(1)	
11-12	0(0)	1(1)	
12-13	0(0)	1(1)	
13-14	1(1)	1(1)	
Subtotal excluding age 0-1	20(19)	55(54)	26(25)
Total	81(72)		

[a]Date of banding taken as beginning of age interval 0-1.

[b]Numbers without parentheses are based on banding data through 1962; thus this part of the table is incomplete. Numbers in parentheses are based on falcons banded prior to 1951.