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HOME RANGE SIZE AND HABITAT-USE PATTERNS OF NESTING PRAIRIE FALCONS NEAR OIL DEVELOPMENTS IN NORTHEASTERN WYOMING

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Abstract.—Movements and habitat-use patterns were evaluated for a small population (n = 6 pairs) of Prairie Falcons (*Falco mexicanus*) nesting near Gillette, Wyoming. A total of 2462 falcon relocations was documented through telemetry. The average (n = 6) harmonic-mean 95%-contour home-range was 69 km^2, whereas the average 75% contour was 26.6 km^2. The convex polygon average home-range size was 29.4 km^2. The average 95% and 75% foraging-area contours, where points less than 500 m from the eyrie were excluded, were 111.8 km^2 and 57.4 km^2, respectively. The convex polygon foraging area was 74.7 km^2. It is believed that the 95% foraging-area contour best represented falcon home ranges as confirmed through field observations. Habitat analyses showed that falcons selected foraging areas near their nest sites, in areas of open grassland, and did not overtly avoid oil wells. Falcons foraged in areas with an oil well density of approximately 1.4 wells/km^2. These results suggested that falcons could tolerate low levels of oil development on foraging sites when their eyries were insulated from human disturbances.

TAMAÑO DEL TERRITORIO DE VIVIENDA Y PATRÓN DE USO DE HABITAT DE INDIVIDUOS DE *FALCO MEXICANUS* RESIDENTES CERCANOS A DESARROLLOS PETROLEROS EN EL NORESTE DE WYOMING

Sinopsis.—Se evaluaron, cerca de Gillete, Wyoming los movimientos y el patrón de uso de habitat de una pequeña población residente (n = 6) de individuos de *Falco mexicanus*. Mediante el uso de telemetría, se documentaron 2462 relocalizaciones de las aves. El promedio (n = 60) de la media armónica (del 95% del contorno del territorio de vivienda) fue de 26.6 km^2, mientras que el promedio del 75% del contorno lo fue de 26.2 km^2. El promedio del convexo del polígono del territorio fue de 29.4 km^2. El promedio del 95% y el 75% del contorno de forrajeo (donde se excluyeron puntos a menos de 500 m del lugar de anidamiento del ave) resultaron ser de 111.8 km^2 y 57.4 km^2, respectivamente. El convexo del polígono de área de forrajeo resultó ser de 74.7 km^2. Creemos que el 95% del contorno de forrajeo representa adecuadamente el territorio de vivienda, lo cual fue confirmado mediante observaciones de campo. El análisis de habitat mostró que los falcones seleccionan para forrajear, áreas cercanas a sus lugares de anidamiento en pastizales abiertos, y que no evitan los desarrollos petroleros. Las aves forrajearon en localidades con una densidad de pozos petroleros de 1.4 pozos/km^2. Estos resultados sugieren que los falcones pueden tolerar, en sus áreas de forrajeo, niveles bajos de desarrollos petroleros, cuando sus áreas de anidamiento son protegidas de disturbio por parte de humanos.

Many aspects of Prairie Falcon (*Falco mexicanus*) biology have been examined (Evans 1982) including their habitat-use patterns (Haak 1982, Harmata et al. 1978) and the effects of human disturbance on nesting (Boyce 1981, Harmata et al. 1978).

The impacts of human disturbance on nesting Prairie Falcons are variable. For example, Boyce (1981) found the time needed to walk to Prairie Falcon eyries from roads and a composite human disturbance variable were significant predictors of nesting success, and White (1969) found the number of Prairie Falcon and Peregrine Falcon (*F. peregrinus*) eyries was reduced due to housing construction. Holthuijzen et al. (1990) found that nearby blasting had no severe adverse effects on Prairie Falcon behavior, occupancy of nesting territories or productivity.

An estimated 820 Prairie Falcon pairs nest in Wyoming (Oakleaf 1985). Many of these pairs nest in areas that are already developed for energy or have a high potential for development. Our first objective was to document the movements and home ranges of nesting Prairie Falcons. Our second objective was to document Prairie Falcon habitat-use patterns in areas associated with energy developments.

STUDY AREA

The study area, located in northeastern Wyoming, was approximately 1090 km^2 encompassing the Pumpkin Butte formation in Campbell County, Wyoming. This formation was composed of five buttes (North Butte, North-middle Butte, Middle Butte, South Butte and Indian Butte) surrounded by rolling sagebrush (*Artemisia* spp.) prairies. The height of these formations was approximately 244 m above the adjacent prairies (1585 m). The area surrounding the buttes was a mosaic of energy development and undeveloped lands with the majority of oil development occurring east of the buttes. In 1980, there were approximately 258 oil well heads and 454 km of haul roads within the study area.

METHODS

Trapping and radio attachment.—Adult falcons were trapped from May through July 1983 when chicks were 1–2 wk of age. Dho-Gazza nets with a live lure owl were set either above or below the eyrie; below-eyrie sets elicited the best response (Beebe and Webster 1964). The nets were oriented in either a straight or L-shaped configuration depending on site conditions.

Noose carpets were also used to trap falcons and were set within the eyrie (Beebe and Webster 1964). Ambulatory chicks were jessed and tethered to the back of the eyrie to prevent their entanglement in the trap. A fishing reel provided the necessary drag to ground trapped falcons and proved superior to using weighted traps.

Transmitters (AVM Instrument Company, SM1 + Hg625 battery, total weight 18 g) were tied to the proximal end on the ventral side of the third retrix. Both the attachment knots and feather shaft were reinforced with dental acrylic. Two male falcons were fitted with solar, backpack-style radios in place of tail-mounted transmitters. Harnesses were made of Teflon tubing (Bally Ribbon Mills, Bally, Pennsylvania) and were fitted individually to each bird.

Movements and home-ranges.—The movements of each radio-equipped bird were simultaneously monitored by two observers, each using a truck-mounted, null-peak antenna. Forty observation points distributed throughout the study area were used to track foraging falcons. We would electronically orient the null-peak antenna system from each observation point to beacon radios insuring the antenna's accuracy prior to tracking birds. The accuracy of the antennas toward the beacon radios was approximately 2°. Error polygons (Heezen and Tester 1967, Nams and Boutin 1991) were not calculated although relocation accuracy was thought to be sufficient for the scale of our habitat analyses.

Falcon locations were documented at 10-min intervals during daily observation periods that extended from 0700 to 2000 hours. Although early dawn and late dusk movements were not documented, periodic checks of bird locations indicated they remained at their eyries during these periods. A calculator program (Dean Biggins, U.S. Fish and Wildlife Service, Ft. Collins, Colorado) was used to calculate the bird's Universal Transverse Mercator location, angle of intercept and distance from each observer as each data point was collected. This information improved the trackers' efficiency in monitoring falcon movements.

The computer program Home Range (Samuel et al. 1985) was used to calculate both harmonic mean (Dixon and Chapman 1980) and minimum convex polygon (Hayne 1949) home ranges and to identify core areas (Samuel and Garton 1985).

To avoid bias associated with a high number of relocation points near the eyrie, home ranges were recalculated using relocation points that were farther than 500 m from the nest site. These areas were considered foraging ranges. Outlier relocation points were identified by the confidence interval test (Samuel et al. 1985) and were removed from home-range and foraging-area calculations.

Daily movements and habitat analysis.—During hourly intervals (0700–2000 hours), the average distances that falcons were from their eyries were calculated. These values were used to estimate time of day when falcons were away from their eyries, presumably hunting, although birds' exact activities could not be determined through telemetry.

Habitat-use was determined by comparing used versus unused habitat types. Falcon relocation points within the bird's 95% foraging-range contour were considered "used" points. Twenty relocations were randomly selected from the movements of each bird ($n = 6$) for a total of 120 use points. Only successfully nesting falcons were included in this analysis. We realize the use points are not completely statistically independent, but the potential for any one individual bird to dominate the analysis was minimized, and so individual relocation points were considered the sampling units.

Unused, but available, points were defined as 120 random points located within a 15-km radius of the butte but outside all designated home-ranges. Nesting falcons did not typically forage farther than 15 km from the buttes (see Results) so we considered greater distances to be unavailable to nesting falcons. Unused points were restricted to those outside known home ranges because we believed this lessened our chance of selecting an "unused" area that was in fact used by foraging falcons.

A vegetative-base map of the study area was drawn from low-level, aerial photography. A scaled 500-m diameter circle was drawn around each data point and overlaid on the map. Nine variables were measured in each circle. These variables were: area in mixed sage/wheatgrass (Wheat), sage (Sage), grass (Grass), barren soil (Soil), agricultural lands (Agri), forests (Forest), the number of oil wells (Wells), length of haul roads (Road) and draws (Draw). In addition, the distance to oil wells (Dwell) and the distance to the eyrie (Butte) were also quantified. Direct discriminant analysis (SPSS statistical package) was used for comparisons between used and unused habitat types (Nie et al. 1975).

RESULTS

Home ranges.—During the 1983 breeding season, a total of 2462 falcon relocations were documented. The average ($n = 6$) harmonic mean 95% contour home-range was 69 km^2 (range = 11–139 km^2, SE = 19.8), whereas the average 75% contour was 26.6 km^2 (range = 3–48 km^2, SE = 7.0). The average core activity area was 14.0 km^2 (range = 2–28 km^2, SE = 3.5). The convex polygon average home-range size was 29.4 km^2 (range = 5–75 km^2, SE = 10.0).

The 95% and 75% foraging-area contours were 112 km^2 (range = 39–213 km^2, SE = 27.3) and 57 km^2 (range = 25–105 km^2, SE = 13.5), respectively. The core foraging area was 40 km^2 (range = 15–73 km^2, SE = 10.1). The average convex polygon foraging area was 74.7 km^2 (range = 19–125 km^2, SE = 15.6).

One falcon pair was monitored before and immediately after their nesting attempt failed in 1983. Both birds shifted their activity areas immediately after the failure. The female moved 16 km east of the buttes to a powerline, where she would typically roost for the entire day after foraging briefly in the morning. Her mate shifted his activities 41 km southeast of the formation and remained away from the buttes throughout the study. The two pair members did not appear to interact with one another during the summer. In 1984, a telemetered bird also shifted its activity area to the east and away from the buttes following its nest failure. These observations suggest the non-breeding segment of this falcon population used different foraging areas than breeders and did not use the buttes as night-roost sites.

Daily movements.—Movement data from 22 full days, 10 mornings, and six afternoons were used to analyze daily movements. Both male and female falcons increased the average distance they traveled from their eyries from mid-morning through early afternoon (Fig. 1). Usually, they would then remain perched by their eyries for the rest of the day. The degree to which birds traveled from their eyries was variable. For example, two females remained near their eyries while nestlings were present. Both birds were almost entirely cared for by their mates and appeared not to forage for themselves until the young fledged. In contrast, another female made extensive movements throughout the nesting cycle. Male birds traveled farther from the eyries than did females, but statistical significance could not be determined due to the limited sample size.

Several biologists have reported a bimodal activity pattern, with birds active early in the morning and late in the day (Haak 1982, Harmata et al. 1978, Platte 1974). Our falcons did not exhibit this activity pattern.

Habitat-use patterns.—Foraging areas used by falcons could not be predicted by the orientation of the falcon's eyrie. Falcons nesting on North Butte primarily foraged to the east of the butte regardless of whether they had to pass through the territories of other falcons nesting on the eastern exposures (Fig. 2). There was no evidence of territorial behavior toward other Prairie Falcons on foraging or nesting areas.

The discriminant analysis of habitat features was significant ($\chi^2 = 255$, df $= 9$, $p < 0.001$), suggesting separation of "used" and "unused" habitats (Table 1). Strong negative correlations were present between variables Wheat and Grass (-0.84) and the variables Wells and Dwell (-0.71). Therefore, the variables Wheat and Dwell were dropped from the analysis. The variable loadings suggested that the distance from the butte (Butte = 0.853) had the strongest relationship with the function. The mean distance of the "used" group was 3.9 km whereas the mean distance for the "unused" group was 12.1 km. The discriminant analysis correctly classified 91.8% of the relocations as either used or unused.

Of the 819 relocations that were greater than 0.5 km from the falcons' eyries, 97% of these were less than 15 km from the nest site. Ninety-one percent of these relocations were less than 10 km. These data concur with the discriminant analysis suggesting Prairie Falcons typically forage close ($<$10 km) to their eyries throughout the breeding season.

As the strength of the Butte variable (distance to the eyrie) tended to overpower other relationships in the data set, we conducted the discriminant analysis a second time with this variable removed. There were still significant ($\chi^2 = 93.65$, df $= 8$, $P < 0.001$) differences between the groups (Table 1). The overall percentage of correct classifications was 76.8.

The variable Grass (0.704), which indicated the greatest degree of habitat openness among habitat types, had the highest relationship to the

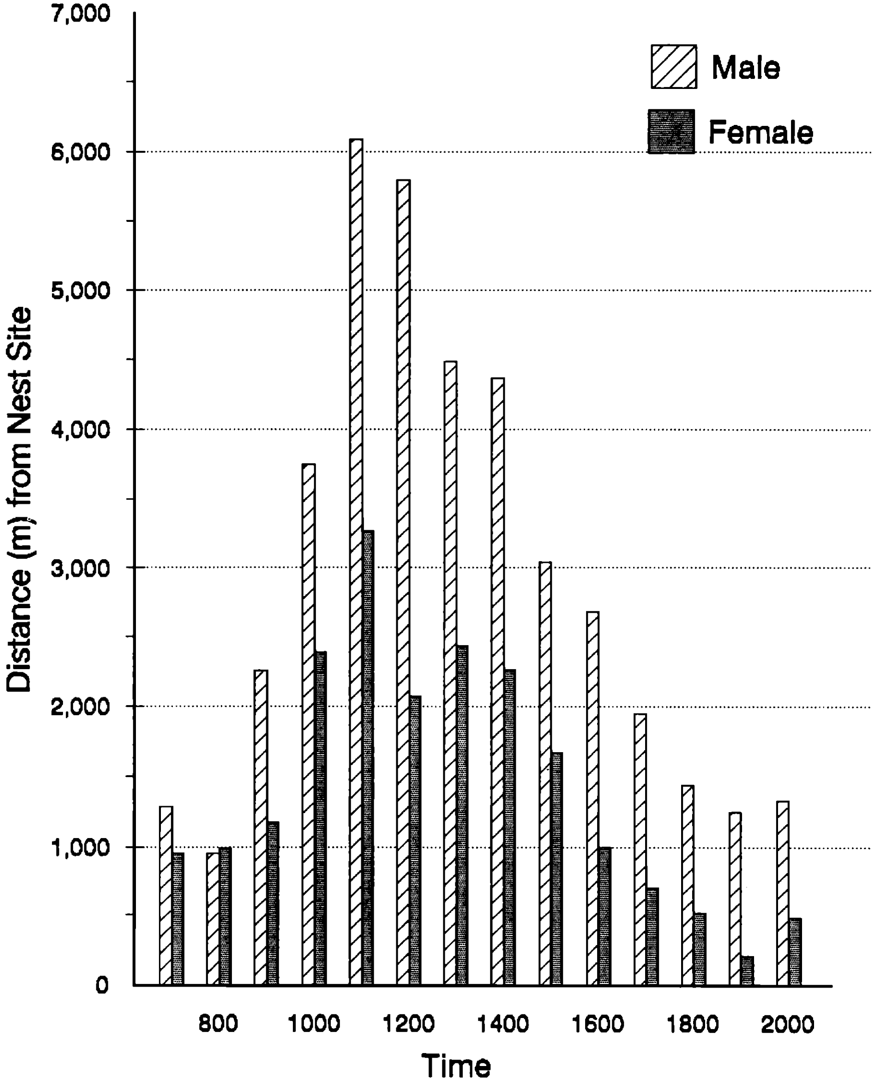

FIGURE 1. The average distance from the nest sites of male compared to female Prairie Falcons according to hourly time intervals.

function. In addition, there was a moderately positive relationship (0.381) between the number of oil wells (Wells) and the function (Table 1). Oil well densities were greatest on the grasslands east of North Butte in the area where falcons typically foraged. Falcons foraged in areas with an oil well density of approximately 1.4 wells/km^2. The results from the second discriminant analysis suggest that falcons selected grasslands as

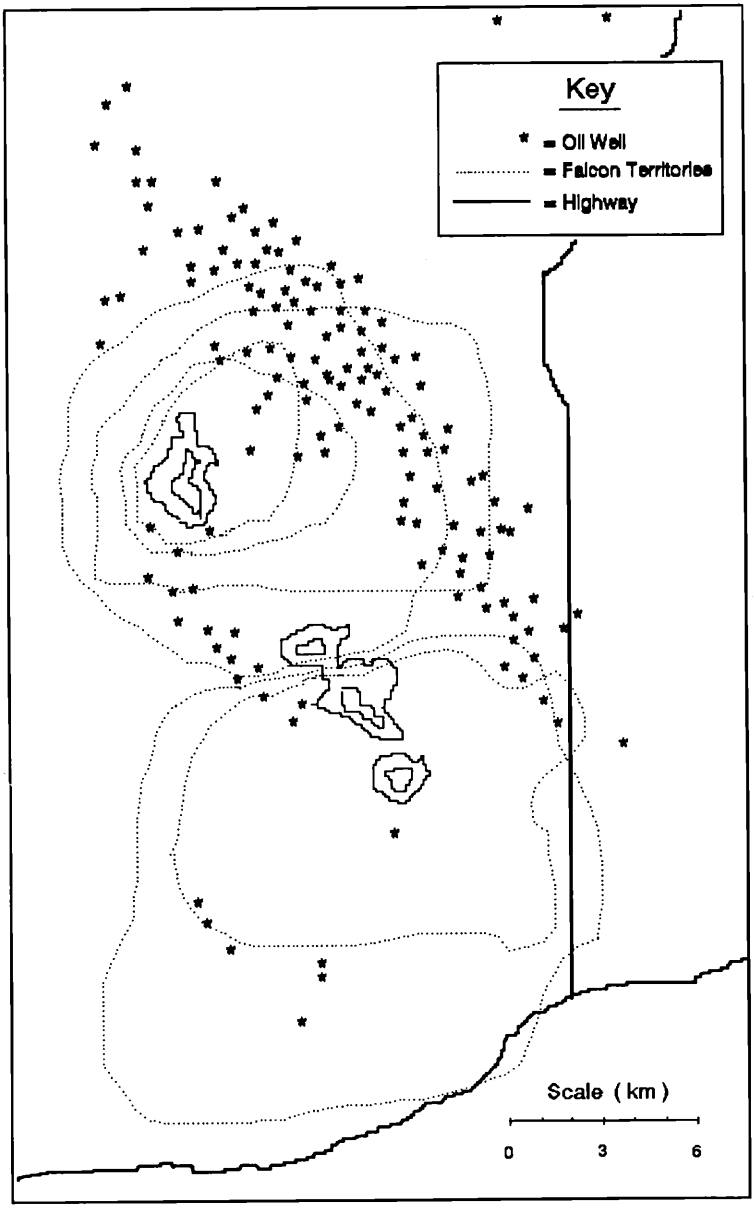

FIGURE 2. Prairie Falcon foraging areas (90% contour) relative to oil wells.

TABLE 1. Summary of direct discriminant analyses of Prairie Falcon habitat use.

	Discriminant function	
	First analyis (all variables)	Second analysis (butte variable removed)
Chi-squared statistic	256.20 (*)	93.65 (*)
Canonical correlation	0.837	0.595
df	9	8
Correct classifications	91.8%	76.8%
Variable loadings (**)		
Area in		
sage	0.038	0.129
grass	−0.344	0.704
barren soil	0.224	−0.653
agricultural	0.192	−0.362
forests	0.078	0.389
Length of		
haul roads	0.084	−0.100
draws	0.213	−0.374
Number of oil wells	−0.387	0.381
Distance to eyrie	0.853	(removed)

* $P < 0.0001$.
** Structure coefficients (Klecka 1980).

their preferred habitat and did not overtly avoid oil wells. The grasslands used by falcons were relatively flat, lacking both steep draws (−0.374) and areas of barren soil (−0.653) compared to random points. This resulted in the negative correlations.

DISCUSSION

Home ranges.—Large areas were included in contour home ranges in which the birds were never observed. This was partly caused by the large number of relocation points near the nest that tended to center the contour. This large concentration of points at the eyrie also caused the computer program to identify many of the foraging relocations as outliers. This concentration, however, was not a problem with the foraging home ranges that were calculated only with relocations that were more than 0.5 km from the eyries. We believe the foraging home range (95% contour, $\bar{x}$ = 112 km^2) most accurately represented the "true" home range used by Prairie Falcons as confirmed by field observations.

The home range sizes determined in this study were within the range of sizes documented in other studies (Craighead and Craighead 1956, Dunstan et al. 1978, Haak 1982, Harmata et al. 1978). Comparisons among studies are difficult, however, and may not be meaningful due to differences in methods, habitat types, and prey abundance, distribution and availability. All these factors may affect the size of home ranges.

Habitat-use patterns.—The discriminant analyses suggested that distance of habitat from the butte was the most important predictor of habitat use. Habitats that were close to the buttes were preferred. Even though this result may be intuitive, we believe it is important because the distance factor may override the importance of other habitat characteristics.

When the effect of distance from the eyrie was removed from the analysis, habitat openness appeared to be the factor best related to habitat use. This result suggests that Prairie Falcons preferentially use grassland habitats that lack sagebrush when given the choice. Thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), Western Meadowlarks (*Sturnella neglecta*), Horned Larks (*Eremophila alpestris*) and Lark Buntings (*Calamospiza melanocorys*) were the dominant prey species used by this population of Prairie Falcons (Squires et al. 1989). Perhaps these prey species were more vulnerable to predation in open grasslands compared to more structured habitat types. Haak (1982) found that most falcon kills occurred in open habitats. On his study area, cropland comprised only 9% of the foraging habitat but was the site of 53% of the kills. Pasture comprised 6% of the foraging habitat but was the site of 21% of the kills. Sagebrush was present on 71% of the foraging areas but the site of only 1% of the kills. Although open areas were preferred in our study, falcons did forage in mixed sage-grasslands when open grasslands were not immediately available.

The current level of energy development did not appear to adversely affect falcon foraging activities. Prairie Falcons did not overfly the entire oil field, but foraged in the undisturbed areas between wells. We never observed falcons hunting or perching on the actual drill pad, but they did perch on powerlines leading to the wells. The potential for energy development to adversely affect falcon foraging might increase if oil well densities were greater, although we cannot predict at what level this may occur.

We believe another reason why these falcons did not appear to be seriously affected by energy development was that their eyries were isolated from human disturbances. Oil developments were not on the actual buttes, but were located on the falcons' foraging areas. Landowners also restricted access to the buttes, which limited human disturbances at the eyries. Platte (1974) found that Prairie Falcons did not tolerate high levels of human disturbance near their eyries. Our results suggest that Prairie Falcons can cope with limited development on their foraging areas if their eyries are secure from human disturbances.

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