FINAL REPORT

Peregrine Falcon Foraging Study in the Geysers - Calistoga Known Geothermal Resource Area, Sonoma County, California - 1979

James H. Enderson

and

Monte N. Kirven

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Contractor: James H. Enderson

Department of Biology

Colorado College

Colorado Springs, CO 80903

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CONTENTS

Abstract.

Two adults and two young peregrine falcons were radio-tagged to determine foraging behavior near an eyrie in the Geysers-Calistoga Known Geothermal Resource Area. Equipment failure prevented detailed analysis of movements, but tracking data coupled with data from observers near the eyrie permitted analysis of 139 flights by the female and 40 by the male. Flights were categorized as those less than 1 km from the eyrie, extending about 1 km but perhaps proceeding farther, and long flights beyond 1 km. All flights were assigned one of seven vectors, one of which was in the direction of the geothermal area. Long flights on that vector included 9 and 12% of all long flights for the female and male respectively. Long flights for the female were mainly southeast from the eyrie (36%) and for the male they were southwest (35%). The observer data alone in 1979 indicated that 11% and 15% of the flights of the female and male, respectively, were toward the geothermal area. Inbound flights by both sexes with prey from the geothermal area included 17% of all such flights. About 12% of flights made by both sexes observed in another study in 1978 were to or from the development area, and other 1977 results suggest that up to 33% were in that direction. The proposed development site is small and lies 6 km west of the eyrie. The relatively few flights in that direction, the non-selective use by the falcons of flight routes in most other directions, and the general high abundance of prey in the region indicate that development of the geothermal site would not result in significant loss of foraging resource to the peregrines.

Acknowledgements

This study was made possible in large measure by the interest and efforts of T. Cordill of the Sonoma County Planning Office. The field assistants, P. Anderson and B. Braker, often worked under difficult conditions; without their enthusiasm the study would have been far less productive. We have relied on notes taken by other observers including B. Bainbridge, P. Crump, W. Grummer, and R. French, and are grateful for their careful observations and cooperation.

R. Olendorff of the Bureau of Land Management provided administrative direction for the study. The U. S. Fish and Wildlife Service maintained the observers whose field data have been useful. The California Department of Fish and Game approved the study and demonstrated interest in resolving issues relating to impacts on peregrines.

INTRODUCTION

Historical Perspective

The Geysers - Calistoga Known Geothermal Resource Area includes the McMicking Leasehold of Republic Geothermal, Inc., a proposed geothermal development site in the Briggs Creek drainage centering 6 km west of a peregrine falcon (Falco peregrinus anatum) eyrie occupied in the years 1970-73 and 1977 to present. In 1977, M. Kirven and co-workers under contract to Republic Geothermal visually studied the movements of the adults to determine the importance of the development site to foraging peregrines (Kirven 1977). In May, 1978, a research advisory committee, representing the California Fish and Game, the U. S. Fish and Wildlife Service, the Bureau of Land Management, National Audubon Society and the Geothermal Resource Impact Projection Study (GRIPS), was appointed to guide further study. In 1978, visual tracking of the adult falcons was undertaken in a study by M. Kirven for GRIPS. Positions of foraging falcons and headings of hunting flights were obtained, but radio-telemetry studies were indicated because of the limitation of visual range.

The 1979 Study.

The present work sought to reveal the extent of foraging flights, correlate successful hunts with habitat type, and determine the importance of the development area in providing food resource for the peregrines. The movements of adults and young fitted with radio transmitters were to have been monitored throughout flights away from the eyrie by triangulation of bearing data simultaneously obtained by two tracking receivers. Equipment malfunction and breakage prevented completion of

these goals. Useful telemetry data on foraging regions were obtained for the adult falcons and permit an analysis of the relative importance of the Briggs Creek drainage to the birds. This report also includes an analysis of the visual data obtained in 1977 and 1978 in light of the present study and integrates 1979 observations by U.S. Fish and Wildlife Service observers stationed near the eyrie.

METHODS

Equipment

Telemetry receivers were AVM Instrument RB-4 single-channel instruments with three sub-channels. SM-1 transmitters weighing 15g were matched to the receivers in the 148.075 - 148.125 MHz range permitting distinction among six transmitters. Transmitters were fitted with batteries providing power for up to 90 days depending on requirements of each transmitter. Transmitters, coated with dental acrylic, were fitted with 38 cm guitar wire antennas 0.011 inches in diameter.

Tracking station antennas were four-element directional yagis mounted on three-meter rotating masts equipped with bearing discs at the bases. Co-axial cable 4m long linked antenna to receiver. Head phones reduced outside noise. CB transceivers powered by automotive batteries or mercury cells provided communications between tracking stations and the observer near the eyrie. Tracking stations were established on the summit of Mount Saint Helena (MSH) 2 km south of the eyrie, and on Chalk Point (CP) 4 km southwest because they maximized line-of-sight coverage of the region (Fig. 1).

Two separate tests established bearing error on a test transmitter

8 km from receiver. The error was $\pm$ 5°, but one 8° error was obtained. Maximum line-of-sight range exceeded 15 km, but intervening terrain interrupted transmission. Bearings of instrumented birds were taken at 30-second intervals when possible.

Trapping

Adults and young were trapped in the vicinity of the eyrie with nets or snares; they were then hooded, instrumented, and released immediately. The male was to be trapped in April, the female in late May, but the female was caught on 21 April and fitted with a transmitter sewn to a single tail feather. The male was elusive and not caught or instrumented in the manner of the female until 2 June. Both birds behaved normally upon release.

The young were not radio-tagged in the eyrie because of high risk of flushing them from the ledge prematurely. Four young began fledging on 11 June, but only three males were present when trapping began on 24 June. One was caught on 24 June; another was trapped on 25 June. Both were fitted with tail-mounted transmitters. The third young could not be caught because his perching and feeding areas became unpredictable.

Operations

Appendix I provides a summary of field operations from 17 March - 6 July. Prior to 21 April the nesting situation was checked, and equipment was readied. The female's transmitter operated from 21 April to 1 June when the antenna separated. In that period, useful telemetry data (usually without triangulation) was obtained on 14 days. Poor weather and transceiver malfunction

were major and recurring problems. Trapping operations sometimes pre-empted tracking.

The adult male provided only four days of tracking data, some of it involving triangulation, in the period 3-6 June. On the latter date the antenna separated from the transmitter.

The young male instrumented on 24 June provided tracking data on only one day; that transmitter lost useful strength by 3 July. The second young male was equipped with a transmitter on 25 June, but the pulse rate slowed almost immediately, became erratic, and failed within the day.

Interpretation of Telemetry Data

Telemetry information for the female consisted mainly of headings taken on MSH on 14 days in the period 21 April - 31 May. The female was incubating or brooding small young in that period and on only one day were simultaneous headings obtained at MSH and CP. The adult male ranged more widely, and triangulation data were obtained in three of the four days his transmitter operated. One young was tracked from MSH on 1 July, nearly three weeks after fledging.

The field data, consisting of bearings and corresponding times, notations by tracking station operators, and notes taken by the FWS observer near the eyrie were collated in the following way:

1) Bearings were drawn from the tracking station on an overlay of a USGS 7.5 min topographical map. The time the bearing was obtained was noted along the line (Appendix II).
2) Remarks written by the station operators or received from the eyrie observer by transceiver were written on the bearing overlays where they related to movement of the falcon.

3) The notes of the FWS observer were summarized in regard to falcon movements to and from the eyrie for the days when telemetry data were available.

4) The general route of flights made in one day were traced on overlays of the topographic map integrating telemetry bearings, triangulation data when available, notes taken by trackers, and the observers' notes (Appendix III). The resulting routes do not indicate the exact route of each flight, but only its general course based on signal direction, strength, flight courses seen by the FWS observer, and time intervals between sequential bearings. For example, a great shift in bearings 30 seconds apart coupled with a strong signal imply the bird was passing near the station. Sudden loss of signal implied the bird passed behind intervening terrain. Some segments of flights were uncertain; these were indicated by dashed lines.

5) Overlays of the generalized flight routes were then analyzed, flight by flight , in terms of the general regions through which the flight passed. These routes or vectors, are shown in Fig. 1 and are flight corridors normally used by the adults. Several vectors correspond to topographical features:

F1 - westward from eyrie over ridge into Briggs Creek drainage and the region of proposed geothermal development;

F2 - southwest on ridge toward the tracking station at Chalk Point and upper Knight's Valley;

F3 - southwest down canyon to lower Knight's Valley;

F4 - south from the eyrie toward the tracking station on Mount Saint Helena and southward;

F5 - southeast from eyrie on the east side of County Line Ridge

F6 - east from the eyrie toward St. Helena Creek drainage; and

F7 - northeast from the eyrie, past Tom Dye Rock toward Collayomi Valley.

When a flight, or part of a flight on the general route overlays involved a vector, a mark was placed on the vector (Fig. 2). Marks on each vector in Fig. 2 and 3 represent three categories of flights:

1) Marks on vectors plotted near the eyrie, within the 1.0 km radius circle, represent flights in the corridor during which the falcon did not fly farther than 1.0 km from the eyrie.
2) Marks on vectors plotted at the 1.0 km circle represent flights that may or may not have exceeded about 1 km from the eyrie.
3) Marks near the far ends of the vectors represent flights known to have exceeded 1 km from the eyrie in the region of the vector, but the precise extent of the flight was not often determined.

Interpretation of Observer Information

1979. A FWS observer was stationed at a vantage point 350 m south of the eyrie on 52 days in the period 3 April - 19 June. This observer recorded the arrival, departure, and other behaviors of the falcons. This information was used with telemetry data to reconstruct generalized flight routes of the falcons. The observer data were also examined for patterns in the use of flight vectors and for vectors used during arrivals from successful hunts.

1978. From 30 May to 20 August two observers (one 350 m south, the other 760 m southwest of the eyrie) cooperated by radio to determine the flight bearing of adults when finally lost from view (Kirven 1978). The

report provides a map of 65 positions and the direction of flight for each. These data were plotted on the same vector system applied to the 1979 results.

1977. From 9 July to 7 September 1977 observers were stationed at vantage points in the vicinity of the eyrie to determine the direction of flights of the foraging adults (Kirven 1977). Whenever possible, positions of the birds were determined simultaneously by two observers and triangulated. These positions and the data on flight direction are analyzed in this report in terms of the seven flight vectors.

RESULTS

Telemetry Information Augmented by Observer Data

General. Figures 2 and 3 show the distribution of flights, or portions of flights, from the overlays of generalized routes. Marks within the 1 km radius represent round-trip flights and were often substantiated by notes made by the FWS observer stationed 300 m south of the eyrie. These flights, sometimes interrupted by perching, usually of short duration, included a few hunting flights and defense flights.

Marks plotted on the 1 km circle were known to approach 1 km from the eyrie, but may have gone farther because the beacon signal was lost or the falcon was lost from view. These flights, including round-trips and isolated departures and arrivals to the eyrie, are useful in that they suggest the regions where the falcons hunted.

Marks near the ends of the vectors represent round-trip flights, or portions of flights, judged to be in the area represented by the vector. When a flight passed more than one vector, a mark was placed on each vector involved; a single flight is represented by a mark on different vectors in

these cases. When a falcon returned to a vector left earlier in the same flight a second mark was entered. Marks for flights beyond 1 km do not reveal the precise distance from the eyrie or the time spent in the area of the vector.

Adult female. The beacon of the adult female provided useful information on her position for 14 days in the period 27 April - 31 May 1979 (Fig. 2). Flights less than 1 km from the eyrie centered on vectors F1 and F7, both including favored perches and loafing areas. Vector F5 passes an apparent perching area southeast of the eyrie, but often the female's position there was uncertain because a ridge blocked radio reception from Mount Saint Helena.

Long flights, over 1 km from the eyrie are of most interest, especially when they were toward the proposed development site on vector F1. Of 64 such flights recorded on Fig. 2, 6 (9%) were known to have crossed the ridge westward toward Briggs Creek and the development area. Some long flights on F2 may have turned northward to F1; long flights of both these vectors include 25% of all long flights. Long flights with southerly components on vectors F2, F3, F4, and F5 include about 90% of all long flights. Over one-third of all long flights were on vector F5 to the southeast.

Some flights of unknown distance probably exceeded 1 km from the eyrie. If these 41 flights are added to the 64 long flights, 105 flights result; 13 are on vector F1 and are about 12% of all such flights. Long flights and those of unknown distance on vector F5 amount to 35% of all these flights. The telemetry and observer data in Fig. 2 indicate the adult female flew mainly toward the south when she left the area within 1 km of the eyrie, and used the area of the proposed development uncommonly

in the period of observation.

Adult male. The beacon of the adult male provide useful information in the period 3-6 June 1979 (Fig. 3). Long flights on F1 included 12% of all long flights. Flights known not to have exceeded 1 km from the eyrie include two westward along the ridge on F1 and one to a perching area northeast of the eyrie on F7, together comprising 8% of all flights. Flights that may have exceeded 1 km are mainly on F1 (four flights) and on F7 (five flights). These amount to 23% of all flights. Flights exceeding 1 km included all vectors, but 9 of 26 (35%) were on F2 southwest of the eyrie.

Some of the 11 flights of unknown distance probably exceeded 1 km from the eyrie. These added to 26 long flights total 37 flights; 7 (19%) are on vector F1 in the direction of the proposed development, and 9 (24%) of such flights were on the adjacent vector F2. The telemetry data supplemented by observer information in Fig. 3 indicate the male distributed his flights, in this brief period, more or less uniformly on most vectors, but known long flights predominate on F2 southwest of the eyrie.

Nineteen long flights by the adults were tracked beyond about 3 km from the eyrie (Table I). The locations of four of these flights were substantiated by telemetry triangulation; the others are inferred by signal strength and direction from CP or MSH tracking stations. Most of these flights were southwest, and some exceeded 7 km from the eyrie.

Flights by young. Only on 1 July was the young falcon with a functioning transmitter tracked out of the eyrie area. That male made three excursions to MSH: 1) down the ridge SW of the eyrie, south across the canyon to MSH, east to County Line Ridge and NW to the eyrie; 2) south from eyrie to the summit of MSH, probably south around the summit to the north side, circled NE of the summit, passed in view tracking station headed NW;

3) approached MSH from the NW, south and east around the summit, passed the tracking station and probably dropped northward under the summit toward the eyrie.

1979 Observer Data.

A variety of conditions precluded observation of all flights to and from the eyrie by the FWS observer, but 222 were recorded for the male (Fig. 4) and 215 for the female (Fig. 5) in the period 3 April - 19 June. The male showed surprisingly uniform use of all vectors within the visual range of the observer, except that flights on vector F7 to a perching hunting area to the northeast predominated. Flights on F1 in the direction of the proposed geothermal development account for 15% of all flights. Some flights on F2 may have been in that area; F1 and F2 flights collectively include 31% of all flights seen by the observer. The female (Fig. 5) also showed uniform distribution of flights by vector, except she favored F5 to a perching area. Only 11% of her flights were on F1 and 23% were on F1 and F2.

In 92 instances the observer recorded inbound flights by adults with prey (Fig. 6). These flights suggest the regions of hunting success because adults carrying prey probably return directly to the eyrie from the site of the kill. The male was seen inbound 72 times, especially from the northeast and south to west. The female brought in prey mainly from the south to west. Sexes combined, 17% of inbound flights with prey were on F1, and 40% on F1 and F2.

Analysis of the 1978 Observer Data.

The report (Kirven 1978) includes a map of 65 positions and direction of flight when the adults were lost from view. These data can be plotted on the vectors used in 1979 (Fig. 7). Sometimes positions were midway between vectors and in these cases a vector was assigned if the direction of flight was toward the vector. Most importantly, falcons flying on the ridge southwest of the eyrie were assigned vector F1 if their flight direction was toward the development area. The plots in Figure 6 do not distinguish flight distance from the eyrie since many were lost from view while in progress. About 12% of the flights are on F1 and 37% are on F1 and F2 combined. In 1978 the great majority of the flights had a southerly component.

Analysis of the 1977 Observer Data.

Positions of flying adults were determined simultaneously by two observers and triangulated. Directional bearings were recorded for the birds when lost from view. Terrain limited visibility such that 13 of 20 triangulations were within 1 km of the eyrie, 5 were within 2.2 km, and 2 were 4-5 km from the eyrie. Four of the triangulations beyond 1 km were in the direction of the proposed development. About 55% of all triangulations were in the general direction of the development (Kirven 1977).

In 1977, 71 directional bearings were recorded for the adults as they were lost from view. Of these 24, or 33%, were in the general direction of the development area.

DISCUSSION

Flights to the Briggs Creek Drainage and Development Area.

Flights on vector F1, some of those on F2, and perhaps a few involving other vectors may proceed into the Briggs Creek drainage (Fig. 1). The area of the proposed development site is small relative to the drainage; flights to the drainage do not necessarily include the development area.

Not all flights on F1 and F2 extended beyond 1 km from the eyrie in 1979. Of 55 flights determined by telemetry and augmented by observer data, 14 or 25%, did not exceed 1 km.

Table II summarizes the distribution of flights by vector determined by different means 1977-79. Flights on F1 in 1978 and 1979 include less than 20% of all flights. When flights on F1 and F2 are combined, up to 40% of all flights are included, a result not unexpected because F2 is along a ridge providing access to regions west and south. The 1977 data for F1 and F2 include those listed as "towards Briggs Creek" or "from Briggs Creek" (Kirven 1977). About half of the 1977 flights were in this group, a result probably biased upwards by the position of one observer 760 m from the eyrie on F1. Flights on other vectors were less well observed.

The Bureau of Land Management administers about 10.4 km^2 of land extending from about 3 km northwest of the eyrie to about 6 km north of the eyrie (Fig. 1). More extensive BLM lands lie northwest of this tract. BLM land would be encountered along about one-third of all bearings between north and west of the eyrie. Flights on F1 and possibly a few on F2 are within that sector. On that basis, a very rough prediction of use of BLM land by peregrines can be made. If less than 20% of all flights are on F1 (Table II) and 25% of these are less than 1 km from the eyrie, only 15% of all flights could reach BLM land. If these flights extended to 3 km, only about 5% would reach BLM land if no

preference for direction of flight within the northwest sector were shown.

Flights to Other Areas.

The pattern of flights by the adults at this eyrie in the breeding season is spread more or less eveningly among those available. Some vectors, taken together include obvious corridors to hunting areas. Vectors F2, F3, and F4 comprise the northwest slope of Mount Saint Helena, Rattlesnake Canyon, and Knight's Valley to the southwest. Between one-third and one-half of all flights were on these vectors, depending on the year and type of study (Table II.) Similarily flights on F5, F6, and F7 to the east include the vast Collayomi Valley and the east slope of Mount Saint Helena. Between about one-third and one-half of all flights were on these vectors.

The uniformity of distribution of flights, many of which are foraging flights, may be due to the obvious abundance of prey in the region. Bird count transects were made in 1977 by G. Miller and P. Leitner in the McMicking Leasehold (Kirven 1977). They found 324, 550, and 521 birds per mile of transect in two mixed forests and a riparian habitat, respectively. For comparison, averages of 84, 148, and 160 birds were seen per mile of transect in mixed forest, meadow, and riparian habitat, respectively, in Colorado. These represent the richest of 13 habitats sampled near six Rocky Mountain peregrine eyries (Enderson 1977).

Two other studies of radio-tagged breeding adult falcons allow comparisons of the patterns of flight distribution. A female peregrine tracked by triangulation from 7 June - 19 July 1977 distributed her foraging flights in many directions from the eyrie in Colorado (Enderson 1977). That peregrine appeared to favor mixed forest-brushland-meadow habitat and seemed to avoid pure stands of forest, sometimes ranging up to 19 km from the eyrie. Prairie falcons (Falco mexicanus) in Idaho, on the other hand, focused their foraging

flights in limited sectors of the potentially available habitat (Dunstan 1978). Perhaps this use limited to sectors resulted from competition with other adjacent pairs in that region of high prairie falcon density, and from the asymetrical distribution of particularily good foraging habitat. In Colorado, as in the present study, suitable habitat was available in many directions.

It may be reasonable to generalize the results of the present study, and the other radio-tracking studies, to the foraging behavior of nesting peregrines elsewhere in the interior of California. The Mount St. Helena eyrie is located near the top of a divide between distant valleys. There are essentially no high barriers of terrain in almost every direction from the eyrie. In the 1977 Colorado study, the eyrie was on the highest point within 3 km. Both situations allowed foraging adults easy access in every direction. In both situations suitable prey was probably spread throughout the region around the eyrie. Under these conditions peregrines could be expected to distribute foraging flights in all directions. Conversely, where terrain much higher than the eyrie forms a nearby barrier or where prey abundance is strongly irregular as in the Idaho prairie falcon study, peregrines could be expected to show pronounced preference in the use of habitat for hunting.

Geothermal Powerplant Environmental Considerations.

The construction and operation of a geothermal powerplant on the McMicking Leasehold would increase noise, water vapor, hydrogen sulfide levels, and obstructions in the Briggs Creek drainage. Construction equipment can produce up to 95 dBA within 50 feet. Plant operation a full load can produce up to 93 dBA at the steam ejectors, but these high frequency sounds attenuate rapidly with distance. Given the intervening terrain between the

eyrie area and the development site, separated by a distance of 6 km, sound reaching the eyrie would almost certainly be nominal. Peregrines adjust to high noise levels. A nest ledge used for many years in the eastern United States was blackened by nearby steam locomotives, and two eyries active in the 1970's in the Rocky Mountains are within 1 km of coal-fired electric plants.

Increased water vapor content of the atmosphere increases fog likelihood within 2 km of geothermal plants. Fog may hamper peregrine foraging. Predictions of this effect are difficult, but since conditions favoring fog are projected at less than five percent on an annual basis, increase of fog in a significant area of the falcon foraging range seems unlikely.

The possible effects of increased hydrogen sulfide on the avifauna of the Briggs Creek drainage are unknown. Emission by new geothermal power plants are expected to conform to the California ambient air quality standard of 30 parts per billion. The eyrie is 2600 feet higher than the geothermal site, a differential reducing the possible effects of much higher concentrations during temperature inversions.

Power transmission lines are a hazard to peregrines because their attack dives may exceed 150 mph. Collisions with wires are well-known; at least six occurred in California in recent years (Kirven pers. comm.) and in 1978 in Colorado a young peregrine struck a power line 2 km from its eyrie and suffered a broken wing.

It is a mistake to assume peregrines are necessarily sensitive to or intolerant of all types of human activity within the eyrie foraging area. In Colorado, Enderson has studied 13 eyries used by peregrines in the 1970's. Nine were active at least one year in the period 1977-79 and of these 5 had highway traffic below the eyrie within 1 km, 2 had light traffic or pedestrians to within 0.5 km, and 2 were remote from disturbance. Of the four eyries not

active 1977-79, 1 was remote and 3 were often visited by pedestrians or rock-climbers; the latter are probably serious threats to nesting peregrines where the disturbance is continuous.

Management Recommendations

The following recommendations are based on the results of this study and on projections of impacts attending development on the McMicking Leasehold. The present study strongly implies that no significant loss of foraging habitat would result from geothermal power development confined to the leasehold, assuming that present prey abundances and the distribution of flights by the peregrines does not change importantly in the future.

1. The effect of development on prey and falcon use of the Briggs Creek drainage cannot presently be predicted. Careful records should be obtained each year (perhaps by a FWS observer) on flight distribution and the duration of foraging flights, to reveal changes in use of the drainage and apparent ease of obtaining food. Such data can be compared with the results of this and earlier studies.
2. Construction and operational activities associated with power development must not increase human presence within the area designated as Critical Habitat. Traffic on Ida Clayton Road is certain to increase during the construction phase. Access routes to the eyrie from that road should remain closed.

3. Power transmission lines should be routed only down the Briggs Creek drainage westward from the development site; none should be built in Rattlesnake Canyon or adjacent Knight's Valley. Future plans to build transmission lines within about 12 km of the eyrie should be reveiwed on the basis of the flight distribution found in the present study.
4. The Fish and Wildlife Service should continue its observer program at this eyrie, extending the observation period to 1 March - 1 August. A major objective should be to discourage pedestrian and off-road vehicle access to the eyrie.
5. Affected agencies should secure land-owner cooperation or obtain ownership of properties within the designated Critical Habitat to assure no increase in habitat loss or disturbance.
6. The State of California and other affected agencies should develope a Nest Territory Plan for the eyrie as has been done for most Bald Eagle territories in California.

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