NOTICE CONCERNING COPYRIGHT RESTRICTIONS

EFFECTS OF CONTROLLED DISTURBANCE ON FERRUGINOUS HAWKS AS MAY OCCUR DURING GEOTHERMAL ENERGY DEVELOPMENT

C. M. White[1], T. Thurow[1]
and J. F. Sullivan[2]

[1]Brigham Young University, Provo, UT
[2]EG&G Idaho, Inc., Idaho Falls, ID 83401

ABSTRACT

The impacts on the ferruginous hawk of treatments designed to simulate those encountered during geothermal development were assessed at the Raft River Geothermal Test Site. The objective of the study was to ascertain the tolerance limits of the disturbance-sensitive hawks to human- and development-related activities. Various impact treatments were imposed on 10 nests during the 1978 nesting season and on 13 nests during 1979. Three nests were deserted in 1978 and four in 1979; treatment nests that successfully hatched eggs produced statistically fewer young than control nests. Data suggest that "buffer zones" of $\geq$ 1.6 km around each nest be established to minimize deleterious impacts on this hawk species. Utilization of biological systems indicative of ecosystem stress is discussed.

INTRODUCTION

The ferruginous hawk (Buteo regalis) is the largest member of the North American hawk family and is recognized as a species sensitive to disturbance and prone to nest desertion, especially during incubation (Olendorff and Stoddart, 1974; Fyfe and Olendorff, 1976; Woffinden and Murphy, 1977). Because of this sensitivity and its apparent declining numbers over parts of its range, the ferruginous hawk has been placed in a category of special concern by allocating it to the National Audubon Society's "blue list" (American Birds, 1972). This list indicates species that are, or seem to be, substantially reduced in numbers, either regionally or throughout their range, due to any of a number of reasons including habitat reduction and human impact. The U. S. Department of the Interior has placed the ferruginous hawk in the "undetermined status." However, during years when high population densities occur in its food base, the ferruginous hawk can be common and have high reproductive output (Olendorff, 1973; Woffinden and Murphy, 1977). Thus, the ferruginous hawk is potentially a good biological barometer of the effects of disturbance as may occur during development of geothermal resources.

The Department of Energy's Raft River Geothermal Test Site, operated by EG&G Idaho, Inc., is located in south central Idaho where the ferruginous hawk exhibits a dense nesting population. The hawks have been studied for several years in the Raft River and adjacent valleys (Powers et al., 1973; Howard, 1975). Consequently, their population densities and dynamics are known. Such previous baseline data are essential to establishing trends in populations and separating the effects of human factors from environmental vagaries.

With the intensifying demands of multiple land use and the rapidly expanding efforts to diversify the uses of certain renewable and nonrenewable resources, conflicts with wildlife are increasing. The obvious meeting ground for such conflict is in the wise use of each resource and the adjustment of activities to minimize the impact. Such concepts of integrated use of resources to provide minimal effect on any given factor have been addressed elsewhere (Rappoport et al., 1977; Wagner, 1977).

The goals of this study were to: (1) use the ferruginous hawk as a biological indicator of potential impacts of geothermal development, (2) calculate "buffer zones" around nest locations beyond which geothermal development would presumably not impair nesting success, and (3) accumulate information and baseline data that will be useful to other studies aimed at implementing the concepts of multiple land use.

MATERIALS AND METHODS

The study area location is shown in figure 1. The most distant nests are 38 km to the north of the Known Geothermal Resource Area (KGRA) and 19 km to the southwest. From north to south, the study area covered about 49 linear km and from east to west about 33 km. For comparative purposes, nest surveys were also conducted in Black Pine and Curlew valleys on the east and Almo valley to the west.

The habitat is typical of the Great Basin cold deserts (Odum, 1971). A mixture of sage (Artemisia), greasewood (Sarcobatus), rabbit brush (Chrysothamnus spp.), and other low-growing shrubs and forbs cover the valley floor. The gently sloping alluvial fans forming the sides of the valley are covered with junipers (Juniperus). Ferruginous hawks typically nest in the outermost periphery of the juniper tree forests where the trees extend as fingers out into the sagebrush flats.

The hawk disturbance study spanned the 1978 and 1979 nesting seasons. The area was visited in early April of each year to locate occupied territories, at which time the nests were observed from a distance of at least 0.4 km to determine if adults were present. Nests were designed as control and treatment locations, with logistics of the study determining the random sample of treated nest sites.

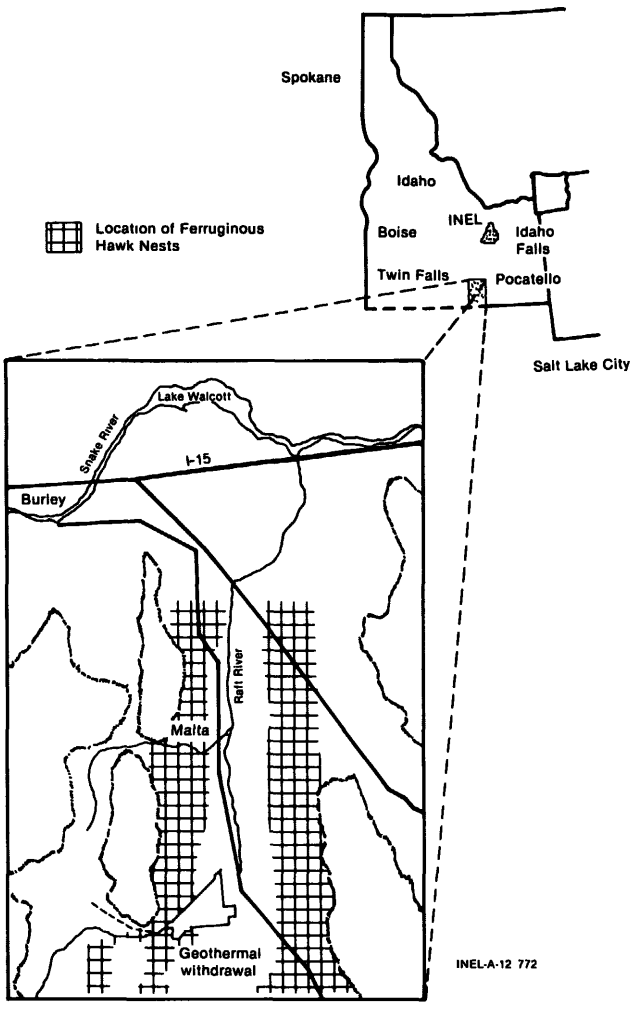

Fig. 1 Study area location.

In early May 1978 and late April 1979, impact treatments were initiated on nests chosen for treatment. During 1978, four treatments were applied: (1) three nests were perturbed by investigators on foot, (2) three were impacted by an approaching vehicle, (3) three were disturbed by discharging firearms in the vicinity, and (4) two were disturbed by placing continuously-operating, 3-1/2 hp gasoline engines near them. The firearm (0.22 calibre rifle) was discharged approximately every 20 m as investigators approached the nest, beginning with an approximate distance of 500 m from the nest, and continuing until the adult flushed.

Treatments were changed in 1979, reflecting difficulty encountered in assessing the 1978 results. Thus, the 1979 treatments were applied as follows: (1) five nests were visited on foot, (2) five nests were visited by vehicle, and (3) four were treated with wind or battery-powered noisemaker devices placed 30-50 m from the nests. Noise intensity at the nest sites was designed to simulate noises common to a geothermal (or other type of development) site.

Each nest was approached to the point at which the adult flushed (left) the nest, regardless of the form of treatment. The distance between the investigator and the nest was estimated and recorded as the level of stress or anxiety at which the hawks could no longer tolerate the presence of the disturbing factor.

All nests contained eggs at the initiation of the various treatments and were perturbed daily until the young hatched, at which time the frequency of visits was reduced. Data collected at each visit included flushing distance, presence or absence of adults, general behavior of adults, and unusual climatic conditions. All young were banded when they were 2-3 weeks of age. Since population dynamics of ferruginous hawks is closely related to the prey base (Woffinden and Murphy, 1977), hawk fecal pellets and the density of the rabbit population were also assessed.

RESULTS AND DISCUSSIONS

The sensitivity of ferruginous hawks to perturbation during the nesting season has been well documented; however, little nest failure was witnessed at Raft River caused by the treatments of this study. During 1978, three pairs (out of 10 total treatment nests) deserted eggs from what appeared to be our impact, while 4 out of 13 treatment pairs deserted during the 1979 season (tables 1 and 2). Approaching the nests on foot resulted in two and one desertions during 1978 and 1979, respectively, while driving to the nests caused one pair to desert during each study season. While neither discharging firearms infrequently in the vicinity of the nests nor placing continuously operating motors near them resulted in nest desertions during 1978, two of the four nests impacted by low intensity noise levels during 1979 were deserted by adults.

Table 1. 1978 treatments and results.

Treatment	Number of Visits	Mean Flushing Distance and Range (m)	Results
Walk	18	31 (14-137)	Fledged 0 (3 young depredated)
Walk	8	110 (23-183)	Deserted
Walk	6	53 (37-91)	Deserted
Motor	8	65 (37-201)	Fledged 4
Motor	8	101 (37-320)	Fledged 4
Gunshots	18	71 (23-230)	Fledged 2
Gunshots	22	96 (5-274)	Fledged 2
Gunshots	19	74 (5-320)	Fledged 4
Drive	7	217 (18-484)	Deserted
Drive	6	221 (137-366)	Destroyed by wind
Drive	25	62 (18-484)	Fledged 1

Individual variability of the hawks and response variability within each set of treatments

were large. Flushing response data during the incubation phase, when evaluated chronologically, indicated that most pairs did not increase in tolerance nor were sensitized by the presence of the investigators. During 1979, attending adults were not present at the nest or flushed at distances > 500 m 24% of the time investigators approached treatment nests on foot and 18% of the time when approached by vehicle.

During 1978, 1 of the original 11 treatment nests was destroyed by wind during egg incubation. Nest failure was thus not due to human impact and the fledging rate of 0 was not included in data analysis. A second treatment nest was affected when the three young were approximately 14 days old; the nest was blown from the tree and the young survived for 4 days prior to apparent loss to avian predators. Since this nest was still intact, the young were unharmed, and ferruginous hawks are documented ground nesters, the adults could still have protected the young had they actively attended the nest; therefore the production data were included in the data analysis. Of the 10 active 1978 treatment nests, 7 were successful in fledging 17 young for a fledging rate of 2.43 young per successful nest (table 3). Including the three nests that were deserted, the fledging rate for the 10 nests was 1.70 young per attempted nesting. The 15 control nests fledged a total of 53 young, for a fledging success of 3.53 young per nest. The controls therefore fledged more young than successful treatment nests; the difference was statistically significant (P=0.10) as evaluated by the independent t-test (Croxton et al., 1967). Of greater importance is the biological significance of control nests fledging an average of one young more than their successful treatment counterparts or twice as many young as all treatment nests (the difference results from the desertion of nests as a result of human insult).

Table 2. 1979 treatments and results.

Treatment	Number of Visits[1]	Mean Flushing Distance and Range[2] (m)	Results
Walk	19 (5)	138 (20-400)	Fledged 3
Walk	21 (7)	66 (20-150)	Fledged 2
Walk	19 (2)	164 (70-300)	Deserted
Walk	26 (10)	196 (10-350)	Fledged 3
Walk	24 (3)	118 (25-255)	Fledged 3
Drive	24 (3)	90 (15-270)	Fledged 3
Drive	28 (1)	162 (35-400)	Fledged 3
Drive	28 (1)	54 (15-180)	Fledged 2
Drive	6 (3)	153 (20-400)	Deserted
Noise	NA[3]		Deserted
Noise	NA		Fledged 2
Noise	NA		Fledged 3
Noise	NA		Deserted

[1]Number in parentheses indicates those visits when the adults flushed at > 500 m or were not present.
[2]Calculated only on values when adults flushed at < 500 m.
[3]Not applicable; nests perturbed by noise were not regularly visited by investigators.

Table 3. Fledging rates for 1978 and 1979 nesting seasons.

	No. of Nests		Fledging Rate	
	1978	1979	1978	1979
All treatment nests	10	13	1.70	1.85
Successful treatment nests	7	9	2.43	2.67
Control nests				
Raft River Valley	15	21	3.53	3.81
Curlew/Black Pine Valleys	5	8	3.00	3.16
Almo Valley	-	3	--	2.66

During 1979, 9 of the 13 treatment nests were successful and fledged 24 young for a fledging rate of 2.67, compared to rates of 1.85 for all treatment nests (successful and unsuccessful) and 3.81 for control nests. The difference of 1.1 young per nesting attempt between successful treatment and control nests was found to be significant (P=0.01). Of particular interest is the trend that appears in the data (table 4); 14 of the 21 1979 control nests (or 71%) fledged either 4 or 5 young per nest while the maximum number of young fledged by any treatment nest was 3.

Table 4. Distribution of the number of young fledged per nest.

Number Young Fledged	Number of Nests 1978				Number of Nests 1979			
	Control		Treatment		Control		Treatment	
5	2	(13)[a]	0	(0)	5	(24)	0	(0)
4	7	(47)	3	(30)	10	(48)	0	(0)
3	3	(20)	0	(0)	4	(19)	6	(46)
2	3	(20)	2	(20)	1	(5)	3	(23)
1	0	(0)	1	(10)	1	(5)	0	(0)
0	0	(0)	4	(40)	0	(0)	0	(31)

[a]Percentage of nests in each category.

Three of the four territories deserted during the 1978 phase of the study were not reoccupied during 1979, an observation that could have long-range population implications if that trend were followed over seval years. Additional study is required to substantiate the 1979 observations.

Behavioral data collected during each visit to the nests suggested that adults became sensitized to the presence of the investigators and were not as attentive to their young. This lowered attentiveness may have contributed to the lowered fledging success of treatment nests. Although flushing distance was used as an indication of the critical stress threshold, and nest desertions as a manifestation thereof, the hawks might well have reached a critical stress level long before they flushed. Busch, deGraw, and Clampitt (1978) recorded a threefold increase in heart rate, as an indication of stress, at the sight of a human approaching a caged ferruginous hawk. Under our field conditions, heart rates might well have increased at much greater distances than that distance at which the hawk flushed.

The food supply variability may also have contributed to the outcome of this study since the threshold of sensitivity may be lowered significantly when the adults are in a poor physiological state as a function of food stress. Woffinden and Murphy (1977) reported that such lowered physiological condition in poor food years is evidenced by smaller clutch sizes and fewer nesting pairs. Food habits of the ferruginous hawk were partly assessed by identification of prey remains in nests. On a biomass basis, 89.4% of the prey in 1978 were rabbits. Based on transects (methods of Hayne, 1949; Gross et al., 1974) within Raft River valley proper (area of about 309 km^2), the rabbit density was high, with about 309 rabbits per km^2 in 1978. The 1978 Curlew Valley density was about 50 rabbits per km^2. This is high by most standards, but includes the year's crop of new juveniles which most counts do not include (Gross et al., 1974) since they are taken when only the adult breeding population is counted in early spring or late autumn. Highs in the adult breeding population at these times are indicated by counts on the order of 100 to 200 individuals per km^2.

Although incubation may be successful and young hawks raised, the presence of humans too near nests may cause the added problem of premature fledging of young, which may increase the mortality rate. At one nest, presence of investigators caused a young hawk, only recently out of the nest, to make an exerted and lengthy premature flight. Within 20 minutes a coyote (Canis latrans) was scouting the area where the young had landed. This coyote may have seen the young in its unstable flight, or its presence might have been a chance event. Greater public utilization of the ferruginous hawk habitat might increase this premature departure rate from nests; mortality factors such as predation on the inexperienced young could exact a substantial toll and ultimately impact population levels.

CONCLUSION

As is often characteristic of biological subjects, there does not appear to be a single standard formula or level of development-related impact that can be applied to the ferruginous hawk. Although a variety of impacts from geothermal development have been suggested (Ermak and Phelps, 1978), little is known about the distance the impact is effective. Under the conditions of this study, it is suggested that normal human activities at distances greater than 0.8 km and construction activity at distances of 1.6 km should not adversely affect the most sensitive pairs of ferruginous hawks. Although data collection and analysis are not yet complete at this writing, the preliminary "buffer zone" suggested is thus 1.6 km.

Continued observation and experimentation are required to adequately understand and predict the long-range impacts that geothermal development may have on the population dynamics of ferruginous hawks in the Raft River Valley. The concept of utilizing biological subjects as "indicator organisms" is not new, and use of such information by developers in selecting locations for future development could mitigate potential problems and/or delays in development associated with destruction of critical habitat. In this study, we have attempted to observe the natural behavior of a sensitive raptor under both disturbed and undisturbed conditions to determine the level of perturbation that they will tolerate without decreasing nesting success or production rates. Utilizing such information as siting criteria for well and/or power plant locations should enable development to take place compatibly with species normally sensitive to such development.

ACKNOWLEDGMENTS

The authors are indebted to Shawn Clark and Dan Johnson, research assistants, for the many months of dedicated field support they gave to this project. The assistance of Richard Howard, U. S. Fish & Wildlife Service, in experimental design, nest site location, and technical advice was invaluable. Roger Olsen, Idaho Department of Fish & Game, provided appreciated assistance in banding.

This work was performed at the Idaho National Engineering Laboratory under the auspices of the U. S. Department of Energy, Division of Geothermal Energy.

REFERENCES

American Birds, 1974, Vol. 27: 943-945.

Busch, D. E., deGraw, W. A., and Clampitt, N. C., 1978, Raptor Research 12: 122-125.

Croxton, F. E., Cowden, D. J., and Klein, S., 1967, Applied General Statistics: Prentice-Hall, Inc.

Ermak, D. and Phelps, P., 1978, An overview of environmental issues in Geysers-Calistoga KGRA: Environ. Sciences Div., Lawrence Livermore Lab.

Fyfe, R. W., and Olendorff, R. R., 1976, Minimizing the danger of nesting studies to raptors and other sensitive species: Canadian Wildlife Service Occ. Paper 23.

Gross, J. W., Stoddart, L. C., and Wagner, F. H., 1974, Wildl. Mongr. No. 40: 1-68.

Hayne, D. W., 1949, J. Wild. Mgmt. 13: 145-157.

Howard, R. P., 1975, Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho, unpublished thesis, Utah State Univ., Logan, UT.

Odum, E. O., 1971, Fundamentals of Ecology: W. B. Saunders Co., Philadelphia, PA, 574 pp.

Olendorff, R. R., 1973, Ecology of the nesting birds of prey of northeastern Colorado: USIBP Grasslands Biome Tech. Report 211.

Olendorff, R. R. and Stoddart, J. W., 1974, The potential for management of grassland raptors in Hamerstrom, F. N., Jr., Harrell, B. E., and Olendorff, R. R., eds., Management of Raptors: Raptor Research Report #2, Vermillion, SD.

Oosting, H. J., 1956, The study of plant communities: W. H. Freeman and Co., San Francisco, CA.

Powers, L. R., Howard, R. P., and Trost, C., 1973, Population status of the ferruginous hawk in southeastern Idaho and northern Utah in Murphy, J. R., White, C. M., and Harrell, B. E., eds., Status of Raptors: Raptor Research Report #3, Vermillion, SD.

Rappoport, A. G., Mitchell, J. G., and Nagy, J. G., 1974, Mitigating the impacts to wildlife from socioeconomic developments, Trans. 42nd N. Amer. Wildl. Nat. Resc. Conf: 169-178.

Wagner, F. H., 1977, Species vs ecosystem management: concepts and practices, Trans. 42nd N. Amer. Wildl. Nat. Resc. Conf: 14-24.

Woffinden, N. D. and Murphy, J. R., 1977, Great Basin Nat. 37: 411-425.