SITING CRITERIA AS A FUNCTION OF SENSITIVITY
OF NESTING FERRUGINOUS HAWKS TO GEOTHERMAL DEVELOPMENT

MASTER

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1. 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 thus prone to nest desertion, especially during incubation (Olendorff and Stoddart, 1974; Fyfe and Olendorff, 1976; Woffiden and Murphy, 1977). Because of this sensitivity and its apparent declining numbers over parts of its range it has been placed in a category of special concern by allocating it to a "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. Further, during years where high population densities occur in its food base the hawk can be common and have high reproductive output (Olendorff, 1973; Woffinden and Murphy, 1977). These facts taken together make the ferruginous hawk a good barometer to the effects of human disturbance as might be found during geothermal development.

The ferruginous hawk has been studied over a number of years in the Raft River Valley area of southcentral Idaho (Power et al., 1973; Howard, 1975) and consequently its 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 the environmental vagaries.

With the intensifying demands of multiple land use and the rapidly expanding efforts to diversify the uses of certain renewable and non-renewable resources, conflicts with wildlife and aesthetic values are increasing. The obvious meeting-ground for such conflict is in the wise use of each resource and the adjustment of activities to minimize

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the impact. Such concepts of integrated use of resources to provide minimal effect on any given factor have been addressed elsewhere (Roppoport et al., 1977; Wagner, 1977).

The goals of this study were to use the ferruginous hawk as a barometer to the limits of impact, determine what sorts of "buffer zones" need to be established around the species to be compatible with the concepts of multiple use, and accumulate information and baseline data that will be useful to other studies aimed at determining similar parameters and rationales.

2. STUDY AREA

The study area surrounds the Raft River Geothermal Test Site in Raft River Valley, Idaho (Fig. 1). The most distant nests extended about 38 km north of the 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.

The habitat is typical of the Great Basin cold deserts. A mixture of sage (*Artemesia* sp), greasewood (*Sarcobatus* sp), rabbit brush (*Chrysothamnus* sp) and other low growing shrubs and forbs cover the valley floor. The gently sloping alluvial fans forming the sides of the valley and ascending to the higher mountains are covered with junipers (*Juniperus* sp). Generally, the outermost periphery of juniper that extend as tongues out into the sagebrush flats contained the nests.

3. MATERIALS AND METHODS

The study area was first visited on 6 - 7 April, 1978, to check for occupied territories. Territories had been located in previous years by Howard (1975). Nests were examined with a spotting scope from a distance of at least 1/4 mile but only long enough to determine if adults were present. Once occupancy was determined, treatment nests were chosen on the basis of accessibility or suitability for the given treatment. The area was then visited again on 3 May to start the impact treatments.

Five different impact treatments were originally planned but only 4 could be executed due to inappropriate conditions to accomplish the fifth. These treatments were undertaken as follows: a) 3 nests were visited on foot; b) 3 were visited by vehicle; c) 3 were disturbed by discharging firearms in the vicinity; and d) 2 were disturbed by placing continuously operating motors near them. Briggs and Stratton 3-1/2 hp gas engines were placed by nests and continuously supplied gas from a 211 l drum connected by a gravity-flow line. The engines were checked from a distance to determine only if they were operating. When they were known to have stopped due to rain or other factors they were then approached in vehicles and restarted. A firearm (0.22 cal rifle) was discharged approximately every 20 m as we approached the nest beginning with an approximate distance of 500 m from the nest and continuing until the adult flushed.

Figure 1

Location of Ferruginous Hawk Nests

Each nest was approached only to the point at which the adult flushed whether approached on foot, in a vehicle or if a firearm was discharged near it. Our distance from the nest when the hawk flushed was then estimated by two or three observers and was recorded to represent the level of stress or anxiety at which the hawk would no longer tolerate the presence of the disturbing factor. Once the hawk flushed we immediately retreated from the nest area.

All nests contained eggs at the initiation of the various treatments. An attempt was made to visit each nest daily through the presumed incubation period. Once nestlings were known to be in the nest, the frequency of visits was reduced. Nests were not climbed to determine clutch size. Once nests were known to be deserted or otherwise destroyed, remaining eggs were removed.

Data recorded included the general behavior of adults, their presence or absence, their time of arrival at nests if not immediately present, time of visit, and conspicuous environmental conditions such as rain, etc. Once eggs hatched, and nests were visited for banding, food remains were recorded and removed from the nests. Data were also taken on nearest nesting raptor of another species. All young were banded with U. S. Fish and Wildlife Service bands in control and treatment nests when about 2-3 weeks of age.

The density of the rabbit population was assessed by walking 10, 1.6 km transects chosen at random using the flushing distance equation of Hayne (1949) and the correction factor and census criteria of Gross, et al. (1974). This technique was used in order to compare with the long-term rabbit population data previously and concurrently taken by Utah State University for the general southern Idaho-northern Utah area adjacent or near to Raft River Valley (Gross, et al., 1974).

4. RESULTS

Unlike previously reported findings of nest desertion as a function of human interference, we witnessed very little nest failure caused by our treatments. Of the 11 treatment nests, only 3 pairs deserted eggs from what appeared to be our impact. These nests were deserted after 14, 10 and 8 days of impact and involved, respectively, two nests that were walked to and one driven to.

Each pair had slightly different responses to our treatment and none seemed to increase tolerance to our presence over time. Several pair did not show any apparent increased sensitivity to the treatment. The results of the treatments are shown in Table 1.

Two of the treatment nests failed due to natural causes and not our interference. One was partially blown from the nesting tree; the eggs could not be incubated and thus were deserted. The second nest was blown from the tree after the young were approximately 14 days old; the young were subsequently lost to predation after 4 days. Two of the young were found dead about 30 m from the nest 2 weeks after their disappearance, and appeared to have been removed from the nest by an avian predator, possibly a raven. The possible mammalian predators in the area would most likely have eaten the young had they removed them from the nest.

TABLE 1
IMPACT TREATMENT AND RESULTS AT EACH NEST

Nest Number	Treatment	Date Treatment Started	Date Treatment Ended	Number Of Visits	Mean Flushing Distance and Range (m)	Results	Comments
1	Walk	May 3	June 2	18	31 (14-137)	Depredated	Hatched ca. May 11, destroyed by predation ca. May 29.
9	Motor	May 13	June 12	8	65 (37-201)	Fledged 4 Young	--
11	Gun shots	May 11	June 21	18	71 (23-320)	Fledged 2 Young	Eggs hatched ca. May 18
15	Drive	May 10	May 18	7	217 (18-484)	Deserted	--
17	Gun shots	May 10	June 22	22	96 (5-274)	Fledged 2 Young	Eggs may have hatched by May 12-13
19	Drive	May 10	May 17	6	221 (137-366)	Destroyed	Nest destroyed by wind
22	Drive	May 10	June 22	25	62 (18-484)	Fledged 1 Young	Eggs hatched ca. May 19
24	Walk	May 4	May 17	8	110 (23-183)	Deserted	--
31	Gun shots	May 10	June 22	19	74 (5-320)	Fledged 4 Young	Eggs may have hatched by May 15.
33	Motor	May 5	May 29	8	101 (37-320)	Fledged 4 Young	Eggs may have hatched by May 10
36	Walk	May 4	May 4	6	53 (37-91)	Deserted	--

Of the remaining 9 active treatment nests in the study, 6 were successful in fledgling a total of 17 young. The fledgling rate is thus 2.83 young per successful nest. Including the three nests that were deserted, the fledgling rate for the nine nests was 1.88 young per attempted nesting. For the entire Raft River Valley we obtained data on 27 ferruginous hawk nests with eggs or young. Of these, 16 were used as controls (one ground nest perhaps should have been eliminated from the sample). These 16 nests fledged a total of 55 young, for a fledgling success of 3.44 young per nest. The controls and successful treatment nests were not significantly different where $P=0.1$ confidence level, as tested by a paired comparison t-test. However, a pattern appeared in that the control nests fledge better than one-half young more per nest. This difference may be nonetheless of biological significance. Considering all treatment nests the difference between the controls and treatment nests is significantly different where $P=0.05$ confidence level. This difference results from the desertion of nests which we view as a result of our insult upon them.

In addition to the nests examined in Raft River Valley we also checked 15 nesting locations in the adjacent Black Pine and Curlew valleys. Only 5 successful pairs and 2 additional nests that had contained eggs but were recently destroyed by wind were found. The 5 nests produced 15 young for a fledgling rate of 3.0 young per pair. Reproduction in these pairs more closely approximates our treatment than control nests. We suggest that the difference in fledgling rate between these two valleys and the controls in Raft River Valley is a result of the lowered food base in the former areas. Data to support this are presented beyond. Woffinden and Murphy (1977) have already shown a correlation between jackrabbit density and nesting success and fledgling rate in the ferruginous hawk.

During the course of this study 78 raptor nests representing nine species were found. Most were found incidental to the study but the three species (ferruginous hawks, Swainson's hawks, and long-eared owls) commonly using the juniper forest and nesting close to the ferruginous hawk had rather complete data gathered on them. The one species that was unfortunately neglected but that interacts closely with the ferruginous hawk is the raven. In decreasing numbers of nests found the nine species are: ferruginous hawk, Swainson's hawk, long-eared owl, red-tailed hawk, golden eagle, great-horned owl, burrowing owl, cooper's hawk and prairie falcon. Additionally, the American kestrel, harrier, short-eared owl, and sharp-shinned hawk nested in the valley, but data were not gathered on them because of lack of time or opportunity.

Two interesting nesting associations exist between the ferruginous hawk and other functional raptors. The raven used old ferruginous hawk nests and in point of fact both species may exchange nests and territories in subsequent years. They appear to defend mutually exclusive territories. Of 15 active ferruginous hawk nests sampled, 14 or 93% had an active Swainson's hawk nest within an average of 0.60 km from it. Of 15 territories used in past years but not occupied by ferruginous hawks in 1978, only three or 20% had active Swainson's nests near them, these within an average of 0.36 km. Most of the other 11 territories, however, had unused Swainson's hawk nests around them and in most cases also within 0.60 km.

Since the juniper forest is in most cases more or less continuous, one would predict that if nests were placed at random about 50% of the active ferruginous territories and 50% of the inactive territories would have active Swainson's nests near them. Since this is not the case, a selection by the Swainson's hawk (which nests later than ferruginous hawks) for placement of a nest near an active ferruginous hawk nest is suggested. Swainson's hawk nests are thus significantly associated ($\chi^2 = 16.41$, 1 df, $P < 0.005$) with an active ferruginous hawk nests sites within a sample radius of 0.80 km. This association was further confirmed when we located two additional Swainson's hawk nests in an area where ferruginous hawk were not known to be. A search around the Swainson's nests revealed an active ferruginous hawk nest within 0.80 km of one and about 1.12 km from the other. The ferruginous hawk in the latter case nested out in an isolated tree (may have been a second attempt nesting) with no other trees closer than 1.12 km. The Swainson's hawk thus used the nearest set of available trees. Reasons for the association as mentioned above are unclear and will be explored and further documented in 1979.

The distribution of the ferruginous hawk with respect to the available habitat is rather uniform. The juniper habitat occupied by the hawk is more or less continuous in a belt along both sides of the valley. Because the hawks, however, occupy the outer periphery of juniper stands, outlying single trees, or small clumps of several trees, one gains the impression of a patchy or clumped habitat and related nesting distribution. Of 8 active nests along the east side of the valley the average distance between them was 3.9 km (range 1.6 to 6.4 km) over 24 linear km. On the west side of the valley, including an extension ridge at the south end of the valley, 17 active nests were separated, on average by 4.7 km (range 0.8 to 8.0 km) over 46 linear km. The closest nests to one another across the valley of unsuitable habitat comprising either brush or farmland was 8 km. This distance was between a tree nest and the only ground nest we located. More characteristically, however, the distance across the valley between nests is about 12.8 km.

Food habits were partly assessed by examination of prey remains in nests. Once it became evident that both species relied heavily on rabbits (89.4% for ferruginous and 81.1% for Swainson's hawk on a biomass basis) rabbits were counted along transects (Hayne, 1949; Gross, et al., 1974). Within Raft River Valley proper (area of about 309 km²) the rabbit density was high with about 1286 rabbits per km². This is high by most standards but includes the year's crop of new juveniles which most counts do not include (cf. 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 km².

5. DISCUSSION

As with most 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 our study we suggest that normal human activities at distances greater than

0.8 km and construction activity at distances of perhaps 1.6 km seem not to adversely affect the most sensitive pair of ferruginous hawk. The "buffer-zone" we suggest is then 1.6 km.

It appears that our data would have been different if we had started our treatments at or just prior to the onset of egg laying, or had the food base been at low density. We suggest that the threshold of sensitivity is lowered significantly when the adults are in a poor physiological state as they would be in food stress situations. Such lowered physiological condition in poor food years is evidenced by smaller clutch sizes and fewer nesting pairs (cf. Woffinden and Murphy, 1977). In 1979 we will start our treatment at the onset of egg laying or incubation to test one of these assumptions.

We are further convinced that the nest desertion process after one visit to the nests can be correlated with food availability. Such correlation seems not to have been attempted in most earlier studies. We made single visits to several different nests not included as a part of this study and climbed to them during incubation; the adults did not desert. We suggest, however, that had we climbed repeatedly to the nests in our study during incubation more desertions would have occurred. Grier (1969) could not demonstrate any effect on productivity at climbed and unclimbed bald eagle nests but he did not carry out his experiment during the incubation phase of the breeding cycle. Simple approach on-foot toward wintering bald eagles shows a significant adverse effect, however, on their flight distance and rooting behavior (Stalmaster and Newman, 1978).

Although we used flushing distance as indications of a critical stress threshold and interpreted the desertion of nests as manifestation of it we are aware that the hawks might well have reached a critical stress level long before they flushed. Busch, deGraw and Clampitt (ms) recorded a 3-fold 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. We suggest that adults in our study became sensitized to us or our presence in the area and were not as attentive to their young as they otherwise would have been. This lowered attentiveness may indeed account for the lowered fledging success noted in this study. This is evidenced by at least two observations: 1) young hawks at one treatment nest were not brooded as they normally would have been during a severe rainstorm, and 2) during banding when the controls and treatment pairs had young 2-3 weeks of age, the treatment pairs were consistently absent from the nest or remained at great distances while the control pairs were close by the nests, appeared more concerned, and occasionally made weak defense gestures at us.

Although incubation may be successful and young raised, the presence of humans too near nests may cause the added problem of premature fledging of young which may increase their mortality. At one nest our presence caused a young, 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 and mortality factors such as predation on the inexperienced young could exact a substantial toll and ultimately impact population levels.

We have already alluded to the availability of a food supply as perhaps being important to the outcome of several findings in this study. Food distribution or preference often plays a prime role in causing closely related animals to partition the available habitat to avoid interaction or even competition. This same food preference or distribution may, on the other hand, act to draw species together. Because the habitat has such uniformity we doubt it would act in causing Swainson's hawks to be closely associated in nesting with ferruginous hawks. At first glance then, we thought food might be the factor causing this association and that Swainson's hawks were cueing in on active ferruginous hawk nests as an indication of an available food supply since both species take a similar amount of rabbit in the diet. In the ferruginous hawk this amount was 89% and in Swainson's hawk 81% on a biomass basis. However, the values are biased in the case of the Swainson's hawk since it will often take carrion road-killed rabbits to the nest. Further, on a biomass basis jackrabbits make up 89% of the total rabbits in ferruginous hawk while only 58% in the Swainson's diet, the remainder being cottontail and pygmy rabbit.

As a measure of the amount of overlap in foods the Kulczynski index in similarity is frequently employed as described by Oosting (1956) (cf. also Ueckert and Hansen, 1971). Using this method an index of 90 shows high or nearly total overlay while an index of 10 is a low degree of overlap. On a biomass basis the 4 most common mammals in the ferruginous hawk diet (94.2% of total) only had an index of similarity of 64.5 with the Swainson's hawk. On a numerical basis of individuals taken in the diets the index of similarity was 55.8 for mammals, 7.9 for birds and 52.4 for the entire diet.

These indices suggest that the degree of overlap is not great and probably the parameters of food are not related to the reasons for the association of the two species. They appear to be associated in nesting proximity, although less closely, even where food overlap approaches 90-95% as it does in Alberta (Schmutz, 1977).

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 industry in selecting locations for future development could mitigate potential problems and/or delays associated with destruction of critical habitat. In this study we have attempted to observe the natural behavior of the raptors under both disturbed and undisturbed conditions to determine the level of perturbation that the organisms 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.

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