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INTRODUCTION

The ferruginous hawk (Buteo regalis) is the largest hawk in America 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; Woffinden 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 (Powers 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 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 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.

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.

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 0.4 km 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.

Figure 1

Location of Ferruginous Hawk Nests

Five different impact treatments were originally planned but only four 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 engines 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.

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 and analyzed for chlorinated hydrocarbons.

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).

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 in 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

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	--

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.

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.

It should be emphasized that the control nests as well as those in Black Pine and Curlew Valley were never visited prior to the time the young were 2-3 weeks old.

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 hawk, Swainson's hawk (Buteo swainsonii) and long-eared owl (Asio otus) commonly using the juniper forest and nesting close to the ferruginous hawk had rather complete data gathered on them (Table 2). The one species that was unfortunately neglected but that interacts closely with the ferruginous hawk is the raven (Corvus corax). In decreasing numbers of nests found the nine species are: ferruginous hawk, Swainson's hawk, long-eared owl, red-tailed hawk (Buteo jamaicensis), golden eagle (Aquila chrysaetos), great-horned owl (Buteo virginianus), burrowing owl (Speotyto cunicularia), cooper's hawk (Accipiter cooperii), and prairie falcon (Falco mexicanus). Additionally, the American kestrel (Falco sparverius), harrier (Circus cyaneus), short-eared owl (Asio flammeus, and sharp-shinned hawk (Accipiter striatus) 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 (Table 3).

Table 2. Reproductive data on the three common raptors nesting in the juniper forest.

	Ferruginous Hawk			Swainson's hawk (N=18)	Long-eared owl (N=9)
	Control (N=16)	Treatment (N=11)	Adjacent Valleys (N=5)	Raft River Valley	Raft River Valley
Number of young (y) or eggs (e) per nest	Number of nests			Number of nests	Number of nests
1	0	1 (y)	1 (y)	0	0
2	4 (y)	2 (y)	0	7 (y), 1 (e)	2 (e)
3	3 (y)	0	2 (y)	5 (y), 4 (e)	4 (y), 1 (e)
4	7 (y)	3 (y)	2 (y)	0	0
5	2 (y)	0	0	0	1 (y)
Unknown	0	0	0	1	2

Table 3. Distance between active Swainson's hawk nests and nearest, ferruginous hawk nest whether active or recently inactive.¹

Active ferruginous to active swainson's		inactive ferruginous to active swainson's	
Ferruginous hawks nest number	distance (km)	ferruginous hawk nest number or designation	distance (km)
1	0.70	3	none
1a	0.60	6	none
2	0.30	7	none
4	0.55	11	1.7
17	0.65	20	none
24	none	21	none
28	0.50	24a	none
31	0.70	32	0.50
36	0.80	35	none
37	0.80	38	0.35
40	0.70	38a	none
41	0.30	Kelsaw	none
42	0.75	Rice Spring	none
62	0.35	Cedar Spring	none
66	0.65	Draw	none

(1) distances greater than 0.8 km from the ferruginous hawk nest were not systematically checked.

Most of the other 11 territories, however, had constellations of unused Swainson's hawk nests around them and in most cases also within 0.60 km.

Because 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, of 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 (Table 4). 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.

Data on the synthetic chemical contents of the eggs analyzed and their incubation state are given in Table 5. Analysis were performed by the Intermountain Laboratories Inc., Salt Lake City, Utah.

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.

Table 4. Food remains found in nests of hawks in the juniper forest.

Species	Ferruginous Hawk					Swainson's Hawk				
	No. Individuals	% by number	Approx. wt. (g)	Approx. biomass (g)	% by biomass	No. Individuals	% by number	Approx. wt. (g)	Approx. biomass (g)	% by biomass
Black-tailed jackrabbit	13	28.1	2,300	29,900	79.5	7	17.2	2,300	16,100	67.1
Other rabbits (<i>Sylvilagus</i> sp)	4	10.2	900	3,600	9.5	3	7.2	900	2,700	11.3
Townsend's ground squirrel	3	7.6	191	573	1.5	-	----	-----	-----	-----
Belding ground squirrel	1	2.4	280	280	0.7	-	----	-----	-----	-----
Pocket gopher	8	20.4	170	1,360	3.7	1	2.4	170	170	0.7
Least chipmunk	1	2.4	78	78	0.2	1	2.4	78	78	0.3
Deer mouse	-	----	-----	-----	-----	2	5.0	17	34	0.1
<i>Microtus</i> sp.	1	2.4	38	38	0.1	1	2.4	38	38	0.1
<i>Dipodomys</i> sp.	1	2.4	65	65	0.2	-	----	-----	-----	-----
<i>Perognathus</i> sp.	1	2.4	15	15	tr. (1)	-	----	-----	-----	-----
Long-tailed weasel (Male)	2	4.8	178	356	0.9	1	2.4	178	178	0.8
Mammal total	35	83.1	-----	-----	96.3	16	39.1	-----	-----	80.4
Mallard duck	-	----	-----	-----	-----	1	2.4	1135	1135	4.7
Pintail duck	1	2.4	900	900	2.4	-	----	-----	-----	-----
American kestrel	-	----	-----	-----	-----	1	2.4	140	140	0.6
Ring-necked pheasant (young)	-	----	-----	-----	-----	1	2.4	900	900	3.8
Long-billed curlew	-	----	-----	-----	-----	1	2.4	360	360	1.5
Northern flicker	-	----	-----	-----	-----	3	7.3	175	175	2.2
Black-billed magpie	-	----	-----	-----	-----	3	7.3	173	519	2.2

Table 4 (cont)

Ferruginous Hawk

Swainson's Hawk

Species	Ferruginous Hawk					Swainson's Hawk				
	No. Individuals	% by number	Approx. wt. (g)	Approx. biomass (g)	% by biomass	No. Individuals	% by number	Approx. wt. (g)	Approx. Biomass (g)	% by biomass
Horned lark	3	7.6	30	90	0.5	1	2.4	30	30	0.1
Mountain bluebird	1	2.4	45	45	0.1	-	---	---	---	---
Meadowlark	1	4.8	145	290	0.1	7	17.2	145	1015	4.2
Vesper sparrow	---	---	---	---	---	1	2.4	30	30	0.1
Avian total	7	17.2	---	---	3.7	19	2.4	---	---	19.4
Gopher snake	---	---	---	---	---	1	2.4	tr	tr	tr
Beetles, sp. (remains)	---	---	---	---	---	2	5.0	tr	tr	tr
Unk. Locustidae	---	---	---	---	---	2	2.4	tr	tr	tr
Jerusalem cricket	---	---	---	---	---	1	2.4	tr	tr	tr
Misc. Grasshoppers	---	---	---	---	---	1	2.4	tr	tr	tr
Grand total	42	100.3	---	37,590	100.0	41	99.9	---	28,172	99.8

(1) tr = trace amounts

23,952

Tabel 5. Chemical residues and conditions of eggs when collected or deserted. Values are given in parts per billion, wet weight. Chemicals tested for but not listed on the table are given below¹

Nest Number	hexochloro benzene	heptachlor epoxide	total DDT	dieldrin	Methoxychlor	oxychlordanone	PCB's	Comments
24	2	23	95	8	10	10	10	embryo ca. 8 days old
15	5	115	184	4	10	10	10	embryo three-fourths formed
36	4	107	818	8	10	15	10	embryo ca. 10 days to hatching
17	5	15	59	19	10	7	10	fresh, no embryo detectable
24	2	19	100	12	10	20	10	embryo ca. 10 days old
24	2	19	90	12	10	20	10	early embryo
15	6	92	196	4	10	10	10	embryo three-fourths formed
19	8	15	173	31	10	15	10	ca. 3-4 days from hatching
36	14	67	481	12	10	20	10	embryo ca. one-half formed
41	6	8	176	4	10	10	10	embryo ca. two-thirds formed

(1) lindave, all samples 1; BBHC, all samples 2; endrin, all samples 1;

We are convinced 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 the 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 both 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 78% on a biomass basis. However, the values may be biased in the case of the Swainson's hawk since it will often take carrion road-killed rabbits to the nest.

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, 71.9 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).

This study may offer some data to the current interests in the evolutionary factors involving the reflections of Gloger's Rule in raptors. Color, according to this rule, is a reflection of environmental conditions with dark colors being in humid environment and light in dry climates. This principle has been applied to the ferruginous hawk (Tomback and Murphy MS) but no general uniformity is readily evident in hawks in general. From the data we collected it appears that whatever it is that causes the color polymorphism, if it is on the breeding grounds, is acting independently upon the ferruginous hawk and the Swainson's hawk. This is suggested by the different ratios of color phases between the two hawks (Table 6). This problem merits considerable more work in order to offer

Table 6. Color phases of hawks at nesting sites⁽¹⁾ in the juniper forest.

Color Phase	Ferruginous hawk		Swainson's hawk
	Adults	Young	Adults(2)
light (normal)	62	72	10
dark	2	5	11
intermediate (mottled)	0	0	11
red	1	0	2
chocolate	0	0	1
no. pairs or broods of same phase	30	30	4
no. pairs or broods of different phases	2	2	13

(1) not all adults were seen.

(2) young Swainson's hawks are all somewhat similar and "distinct" color phases can not be distinguished.

an explanation to the data but that work is beyond the scope of this project.

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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