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RAPTOR ECOLOGY OF RAFT RIVER VALLEY, IDAHO

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ABSTRACT

Raptor data were gathered in the 988-km^2 Raft River Valley in southcentral Idaho while conducting a tolerance study on the nesting Ferruginous Hawk (*Buteo regalis*) near the Department of Energy's Raft River Geothermal Site. Prior research from 1972 to 1977 on the nesting activity of the Ferruginous Hawk population provided a historical information base. These data are combined with new Ferruginous Hawk data collected between 1978 and 1980 to give a continuous 9-year breeding survey. Information on the distribution, density, and production of the other raptor species found in the study area during 1978 and 1979 is also provided. The following species with active nests were found during this 2-year period: four Cooper's Hawk (*Accipiter cooperii*), one Harrier (*Circus cyaneus*), 66 Ferruginous Hawk (*Buteo regalis*), three Red-tailed Hawk (*Buteo jamaicensis*), 29 Swainson's Hawk (*Buteo swainsoni*), six Golden Eagle (*Aquila chrysaetos*), four Prairie Falcon (*Falco mexicanus*), three American Kestrel (*Falco sparverius*), 15 Great Horned Owl (*Bubo virginianus*), 24 Long-eared Owl (*Asio otus*), nine Burrowing Owl (*Athene cunicularia*), and 16 Raven (*Corvus corax*).

Black-tailed Jackrabbit (*Lepus californicus*) were found to be the major prey for the large raptor species. Peak population levels of 280 to 300 jackrabbits per km^2 were recorded during 1978 and 1979. The high density was responsible in part for the abundant raptor population and the high fledging rates found during these two years. The numbers of active territories and young fledged per nest during the period of 1972 to 1980 suggest that the nesting success of the Ferruginous Hawk is closely tied to the Black-tailed Jackrabbit population, which cycles approximately once every 7 to 10 years.

ACKNOWLEDGMENTS

Dan Johnson and Shawn Clark were key assets to the success of this project; for their enthusiastic field research contributions we offer our sincere thanks. We also thank Leon Powers for insights he offered concerning Ferruginous Hawk migration and Tim and Erica Craig for their perspective on the Burrowing Owl population in Raft River Valley.

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INTRODUCTION

A community approach was attempted in conducting a perturbation study on the Ferruginous Hawk (*Buteo regalis*) population in the Raft River Valley, located in southcentral Idaho. The research project was designed to assess the impact of human activity on the Ferruginous Hawk. While assessing the population dynamics and ecology of the Ferruginous Hawk, the entire raptorial community was observed. Studies reported by Cody and Diamond (1975) used this approach for studying passerine and nonraptorial bird populations; however, few studies have assessed entire raptor communities. Craighead and Craighead (1956) studied complete raptor communities in Michigan and Wyoming. Smith and Murphy (1973) performed the only major study in the Great Basin, but were restricted by fewer numbers of nesting pairs for each species.

Twenty-one raptor species were present in the Raft River Valley, providing an excellent opportunity for an integrated study of the ecology of the raptor community. The Raven (*Corvus corax*) is included as a functional raptor. However, the design and intensity of the perturbation study limited in-depth research on the raptor community to the Ferruginous Hawk, Ferruginous Hawk-Swainson's Hawk nest placement, and Long-eared Owl nesting density and prey. The additional observations that are the basis of this report serve as an overview of a diverse raptor community occurring in a shrub-grassland ecosystem.

Collection of Ferruginous Hawk nesting data was initiated in 1972 (Howard, 1975); detailed data were collected during the 1972 and 1973 nesting seasons. From 1974 through 1977 observations were made on a sporatic basis, with the production of some of the Ferruginous Hawk population being monitored. Intensive observations on the entire raptor community were made on a continuous basis from early April through mid July during both 1978 and 1979. The Ferruginous Hawk and Golden Eagle populations were again thoroughly surveyed in 1980.

A total of 180 active raptor nests were found in the Raft River Valley during 1978 and 1979, with emphasis placed on the Ferruginous Hawk, Swainson's Hawk (*Buteo swainsoni*), Red-tailed Hawk (*Buteo jamaicensis*), Golden Eagle (*Aquila chrysaetos*), and the Long-eared Owl (*Asio otus*). Species known to breed in the study area are as follows with the number of nests located in 1978 and 1979 indicated: Cooper's Hawk (*Accipiter cooperii*) (4), Harrier (*Circus cyaneus*) (1), Ferruginous Hawk (66), Red-tailed Hawk (3), Swainson's Hawk (29), Golden Eagle (*Aquila chrysaetos*) (6), Prairie Falcon (*Falco mexicanus*) (4), American Kestrel (*Falco sparverius*) (3), Great Horned Owl (*Bubo virginianus*) (15), Short-eared Owl (*Asio flammeus*) (0), Long-eared Owl (*Asio otus*) (24), Burrowing Owl (*Athene cunicularis*) (9), Common Raven (*Carvus corax*) (16)—data collected only in 1979. In addition, the Turkey Vulture (*Cathartes aura*), Goshawk (*Accipter gentilis*), Sharp-shinned Hawk (*Accipiter striatus*), Merlin (*Falco columbarius*), Barn Owl (*Tyto alba*), and the Screech Owl (*Otus asio*) have all been sighted and may possibly breed in the valley. The Rough-legged Hawk (*Buteo lagopus*) and the Bald Eagle (*Haliaeetus leucocephalus*) are present in the valley as migrants and winter residents.

The documented high raptor densities make the Raft River Valley an excellent site for studying most breeding raptors which inhabit the Great Basin. The raptors seem to coexist well with the generally moderate grazing practices, range manipulation (removal of some native vegetation and reseeding with crested wheatgrass, *Agropyron spicatum* and *A. cristatum*), and a low human population. However, if human activity and rangeland development increase, some components of the raptor community such as the sensitive Ferruginous Hawk and the ground nesting Burrowing Owl could potentially suffer great losses. In the Raft River Valley, the former has one of the highest population densities and productivity rates known for the species. Such areas are rare. Further changing of rangelands or extensive agricultural development could significantly reduce the remaining sagebrush-greasewood habitat, and jeopardize the current raptor population levels. By maintaining the present land management practices in the valley, the Bureau of Land Management (BLM) will ensure the continued success of these raptor populations.

MATERIALS AND METHODS

Study Area

The study area is located near the Utah-Idaho border in southcentral Idaho, within the Great Basin Region, and is characterized by a cold desert physiogomy and climate (Odum, 1971). Efforts were concentrated in the Raft River Valley proper, which contains the Raft River Known Geothermal Resource Area (KGRA) and is the site for a Department of Energy geothermal test site (Figure 1), operated for the Idaho National Engineering Laboratory (INEL) by EG&G Idaho, Inc. The northern boundary of the valley extends in an open expanse to the Snake River Plain, with the south, west, and east sides of the valley bordered by mountains. The elevation of the valley is about 1500 m. Data on nesting raptors were gathered within the 988-km^2 area of the Raft River Valley (50 km long by 18 km wide with a southwestern extension of 8 km by 11 km). Almo Valley to the west and Black Pine and Curlew Valleys to the east were surveyed to obtain relative comparisons of Ferruginous Hawk production and Black-tailed Jackrabbit (*Lepus californicus*) density.

The vegetation of the valley is characteristic of the northern desert shrub biome as delineated by Cronquist et al. (1972) (Figure 2). Greasewood (*Sarcobatus vermiculatus*) and Shadscale (*Atriplex confertifolia*) are the dominant shrubs on the saline valley soils. On well drained soils or at higher elevations (1500 m) Big Sagebrush (*Artemisia tridentata*) is the dominant shrub, often occuring in monotypic stands. Other major shrub components include Rubber Rabbitbrush (*Chrysothamnus nauseosus*) and Black Sagebrush (*A. nova*). Utah Juniper (*Juniperus osteosperma*) and Pinyon Pine (*Pinus edulis*) are generally limited by lack of moisture to elevations above 1500 m. Ground vegetation is characterized by a variety of forbs and grasses; some of the major species are Squirreltail Grass (*Sitanian hystrix*), Crested Wheatgrass (*Agropyron spicatum*), and Tansy mustard (*Descurainia richardsonii*).

The Raft River Valley has remained relatively free of extensive agricultural and rangeland development until very recently. Bench areas cleared and farmed early in the century reverted back to native vegetation following the droughts of the 1930s (F. Gunnel, personal communication). The Raft River is the only perennial stream in the valley; its flow has been drastically reduced by the water demands of Alfalfa and grain farms on the valley floor. The western immigrants recorded an 11-m-wide river, which has now shrunken to a 5-m-wide shallow creek.

In 1952, the BLM began initial tests of different varieties of Crested Wheatgrass in the valley. Some of these seeding attempts were quite extensive; however, the majority of the land still remains covered by native vegetation. Alfalfa and small grains do not require the intensive farming practices associated with other crops; consequently the fields provide shelter for meadow mice (*Microtus sp.*) and other small prey.

Raptor Survey Methods

Ferruginous Hawk territories were first identified by Powers et al. (1973) and Howard during 1972 and 1973. A sample of these territories were surveyed annually for egg production and fledging data from 1972 through 1977. An intensive study of the Ferruginous Hawk population was initiated in 1978; the area was censused by traveling 13 000 km of road between April and July in both 1978 and 1979. New nest sites were located by traveling along the sagebrush-juniper ecotone and looking for characteristic flat-topped juniper trees which contained the large nests typical of Ferruginous Hawks. Ground nests were found by observing the behavior of pairs that were sighted in areas which did not have suitable tree nest sites; these nests were typically located near utility poles which provided a perch for the hawks. In addition to the ground census, an aerial survey was conducted in late May, 1979 when the young were large downy white chicks, and thus easily visible from the air.

Nests were visited at least twice during the year. On the first visit in late April, the nests were observed from as great a distance as possible using a 15-60X telescope to determine whether the nest was active. The latter visit occurred during the first or second week of June when the chicks were 3 to 4 weeks old. All nestlings were banded with U.S. Fish and Wildlife Service bands. Data were

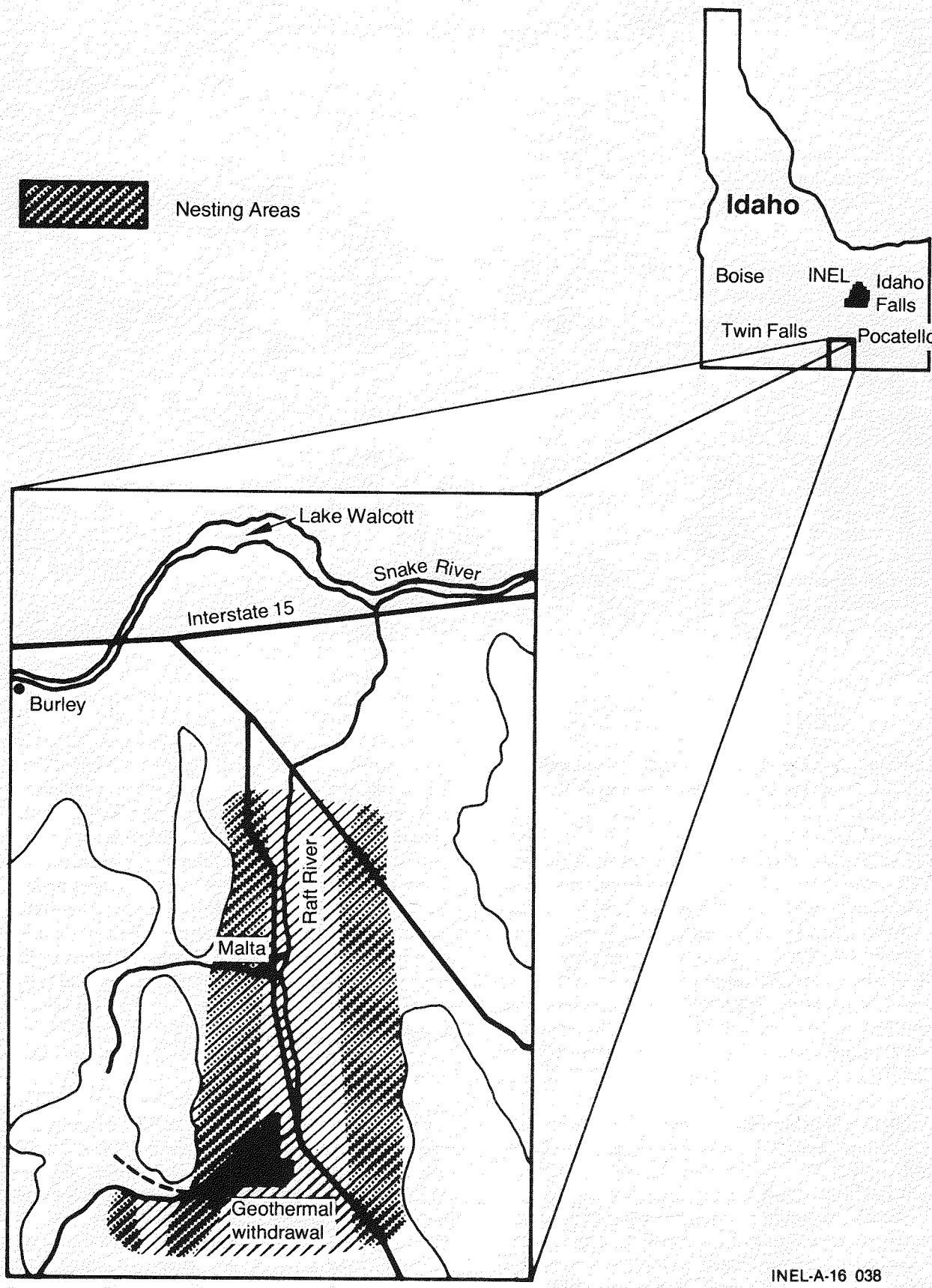

Figure 1. Location of primary raptor nesting areas in the Raft River Valley.

Figure 2. Typical vegetation cover of Raft River Valley.

collected on clutch size, brood size, fledging success, behavior of the adults, and prey items in the nest.

The major objective of the research was to study the Ferruginous Hawk population and determine the response to various types of perturbation. The treatments simulated as closely as possible the types of disturbance which may be associated with increased use of the area that could result from geothermal development. The findings of the Ferruginous Hawk perturbation research are discussed in depth elsewhere (White and Thurow, in preparation).

The population status of most of the other raptor species discussed herein were ascertained in conjunction with the Ferruginous Hawk perturbation study. Nests of these species were censused to the degree that they could conveniently be studied while looking for or traveling to Ferruginous Hawk nests. An organized search for Swainson's Hawk nests was conducted by searching within a 0.8-km radius of 15 active and 15 inactive Ferruginous Hawk nests during both 1978 and 1979. An organized search for Long-eared Owl nests was conducted by surveying 31, 0.5-km sections (14 in 1978; 17 in 1979) along the juniper-sagebrush ecotone. Both Swainson's Hawks and Long-eared Owls frequently used nest sites which were concealed within the canopy of the tree. Since it was essential that no nests be overlooked during these surveys, the census procedure was to walk to and look in each individual tree.

Prey Survey Methods

To conduct a meaningful study of a raptor community, it is essential that dynamics of the prey base be understood. Black-tailed Jackrabbits were the major prey source for all large raptor species. To determine their density, the population was censused by walking 10, 1.6-km transects through habitat types representative of the vegetation composition in the valley. Censuses were conducted in early July, during both 1978 and 1979, when young Ferruginous Hawks fledge. In 1980, 15

transects were run during late March and in early July. The censuses were conducted using the flushing distance equation of Hayne (1949):

$$N_T = \frac{1}{2L}\left(\frac{F_i}{d_i} + \frac{F_2}{d_2} + \ldots + \frac{F_n}{d_n}\right) \quad (1)$$

where

N_T = density estimate

L = transect length

F_i = number of rabbits flushed at corresponding flushing distance

d_i = flushing distance.

The correction factor and census criteria of Gross et al. (1974) that multiplies N_T by 1.14 to reduce the underestimate of the Hayne method was applied. This technique was used in order to compare with the long-term jackrabbit population data previously and concurrently collected by Utah State University for the general southern Idaho-northern Utah area adjacent to Raft River Valley (Gross et al., 1974).

RESULTS

Prey Base

The Black-tailed Jackrabbit (Figure 3) population density, which cycles approximately once every 7 to 10 years, was estimated to be 309 per km^2 in 1978, 287 per km^2 in 1979, and 188 per km^2 in 1980. A pre-reproduction census run in late March 1980 yielded an estimate of 169 per km^2. The Black-tailed Jackrabbit population densities for 1978 and 1979 are high when compared with population estimates in the literature (Lechleiter, 1958; Tiemeier, 1965; Gross et al., 1974), indicating that the population was at or near peak population density in 1978. A qualitative indication of the population was also obtained by counting road-killed jackrabbits. In 1978, 85 dead jackrabbits were counted on an 8-km stretch of the only paved road through the valley. In 1980, at the same time of year and over the same stretch of road as 1978, only 32 dead jackrabbits were counted. These observations support the walk transect data, indicating a substantial population decline over the 3-year period.

The cause for the decline in the jackrabbit population from 1979 to 1980, despite a mild winter for that year, appears in part to be the result of an epizootic outbreak in the population in late 1979. In late summer of 1979, abnormal jackrabbit behavior was observed, evidenced by "dazed" individuals seemingly unaware of the surrounding environment. Jackrabbits were frequently found dead in the field from no apparent external cause. Autopsies revealed tularemia as the probable cause of death. Very few young jackrabbits were present in the 1980 summer population, composing only 19% of the total.

Similar transects were run in Curlew Valley (located about 35 km east of Raft River Valley) during 1978 and 1979, yielding population density

Figure 3. Black-tailed Jackrabbit, the principal prey source for most large raptors of the Raft River Valley.

estimates of 50 per km^2 and 66 per km^2, respectively. The much lower jackrabbit densities in Curlew Valley are probably a reflection of the much more intense agricultural and rangeland development compared to that found in Raft River Valley. The altered environment appears to hold the jackrabbit population in check, so it does not fluctuate as much as populations in large native stands of vegetation. A cycling pattern is evident in population data collected in Curlew Valley by Gross et al. (1974), indicating the last population peak occurred about 1970.

A small mammal investigation in the study valley determined a density of 259 per km^2 (Landeen, personal communication) during 1978. Scattered Townsend Ground Squirrel (*Spermophilus townsendi*) colonies were located in the sagebrush portion of the valley and Richardson Ground Squirrel (*Spermophilus richardsoni*) colonies were in the moister meadows in the aspen and conifer zones higher on the valley sides. Additionally, dead sheep and cattle provide carrion occasionally used by some raptors. The population of nesting desert songbirds was approximately 2.5 pairs per ha based on 1977 data (White, unpublished).

The abundant supply of prey may render direct competition for the existing food supply negligible, and may account for high raptor nesting densities and the large number of immature Golden Eagles that summer in the valley. Additionally, high prey densities stimulate species which can adjust their clutch size (such as the Ferruginous Hawk) to lay more eggs, and enable all raptors to find enough food to feed their young, thus increasing the average fledging success. However, as the jackrabbit population declined in 1980, the availability of prey appears to have become a significant factor affecting the number of young that were successfully fledged.

SPECIES ACCOUNTS

Raptors, often primary consumers at the top of the food chain, are important biological indicators that reflect changes within the ecosystem. Land management policies that effect patterns in land use, habitat, prey densities, or environmental pollution levels are all likely to strongly impact the raptor community. Data generated by this research provide baseline information for southcentral Idaho in a habitat that is representitive of much of the Great Basin. These data can serve as a reference for similar areas within the region and for a historical comparison of effects of future development in the study area. Thus, data are available for use in making wise management decisions. Should adverse changes in the environment begin to occur, they can be quickly assessed and corrective measures implemented.

The objectives of the following species accounts are to provide insight into the habits of the raptor species which occur in the Great Basin ecosystem. The relative abundance, nest site selection, prey, and some of the specific production variables are stressed. The species are generally discussed in their taxonomic order.

Turkey Vulture

Turkey Vultures were first recorded in mid-April and were regularly seen throughout the summer, especially in late June and July when sightings occurred almost daily. The increased frequency of sightings in June and July are probably a function of the parents being more active and traveling longer distances while foraging for food for their young. With the high Black-tailed Jackrabbit densities, dead jackrabbits on the road provided a ready source of carrion.

No Turkey Vultures are known to nest in the Raft River Valley, although there are a limited number of cliffs along the upper rim of the valley which offer potential nest sites. It is likely that the scavanging vultures fly from the adjoining Almo Valley where they nest near City of Rocks.

Goshawk

One positive Goshawk identification was made on June 6, 1980 when an adult female was observed on the sagebrush-juniper ecotone in close pursuit of a Mourning Dove (*Zenaidura macroura*). It is suspected that this species is a breeding resident in the Douglas Fir (*Pseudotsuga menziesii*) forests on the north slopes of heavily wooded canyons because of the nature of the habitat and knowledge of breeding Goshawks in areas adjoining the Raft River Valley.

Cooper's Hawk

Of the three accipiters observed in the valley, the Cooper's Hawk appeared to be the most abundant. This species was a common nester in canyons where large Quaking Aspen (*Populus tremuloides*) and Douglas Fir occur along the creek bottom. Young characteristically fledged at the end of July. Observation of one nest in 1978 and 1980 and two nests in 1979 indicated that four young were fledged for each nesting attempt. The number of nests found is indicative of the limited time spent searching for nests rather than an actual representation of the population density. Cooper's Hawks were frequently seen in most canyons and are considered common in areas with suitable habitat. Prey found at the nests consisted entirely of small passerines and young Richardson Ground Squirrels.

Sharp-shinned Hawk

No active Sharp-shinned Hawk nests were found during this study although the species was occasionally sighted in the Aspen and Douglas Fir forests of the canyons. It was also infrequently observed soaring in the valley. Undoubtedly, Sharp-shinned Hawks nested in the study area but time was not spent to actively search for them.

Rough-legged Hawk

Rough-legged Hawks begin to arrive in the valley from their northern nesting areas in mid October and are the most numerous hawk in the valley during winter. The seasonal abundance of the species seems to be related in part to the snow cover in the valley, with the birds being most numerous when 1 to 4 inches of snow are on the ground interspersed with bare patches. This type

of patchy snow cover probably allows easier hunting for meadow mice as their runways are partially exposed and the mice must travel above ground part of the time.

Most of the individuals sighted throughout the winter were immature birds. The latest spring record for this species in 1978 was June 5 when a juvenile female was found freshly killed on the road. The last sighting in 1979 occurred on June 11 when an immature female was sighted south of Malta perched on a power pole.

Ferruginous Hawk

The Ferruginous Hawk is the largest and perhaps most specialized buteo in North America. The breeding range of this species is restricted primarily to the semiarid rangelands of western United States and Canada where it relys upon high jackrabbit and ground squirrel prey densities. A minimum number of breeding pairs has recently been estimated at between 2810 and 3590 over its entire range (Call, manuscript). The species is recognized as being sensitive to human disturbance and consequently is prone to nest desertion, especially during incubation (0lendorff and Stoddart, 1974; Fyfe and Olendorff, 1976; Woffinden and Murphy, 1977). Because of this sensitivity and its apparent declining numbers over some parts of its range, the Ferruginous Hawk has been put in a special area of concern by allocating it to the "blue list" (American Birds, 1979). This list indicates species that are, or seem to be, substantially reduced in numbers either regionally or throughout their range. From historical data it appears that in many regions throughout the west the Ferruginous Hawk was regarded as the most abundant raptor of the region (cf. Cameron, 1914).

The Ferruginous Hawk still remains the most common buteo in the Raft River Valley. This abundance strongly contrasts with other regions of the Great Basin (Murphy et al., 1969) and the Snake River Plain where habitat seemingly similar or of identical makeup supports a much lower population density. The moderate land use history (primarily domestic hay farming) of Raft River Valley may have affected in a positive fashion the prey base, which in turn has benefited the Ferruginous Hawk (compare Howard and Wolfe, 1976). Pocket gophers from irrigated farmlands form an important part of the prey at some nests and serve to dampen the effects of the cyclic jackrabbit population abundance. It appears that the Ferruginous Hawk is able to maintain original population densities in areas where they are not molested either directly or through loss of critical nesting habitat.

In Raft River Valley, Ferruginous Hawks typically favored nesting sites in large juniper trees along the juniper-sagebrush ecotone (Figure 4). These trees are usually located in small drainages which traverse the rangeland. Nest locations that are typical for the species are shown in Figure 5. Nest trees typically have a characteristic flat-topped appearance; when located in isolated trees they are particularly vulnerable to high winds. During our studies in 1978 and 1979, four active nests were blown from trees. Olendorff (1973) also found that high winds caused the destruction of hawk nests, but in his Colorado study, such damage primarily involved the Swainson's Hawk.

Ground nests, comparable in structure to the type built in trees, are constructed in areas of rangeland where no suitable nest trees are available. Ground nests are usually located near a small hill or along a utility pole line which provies a perch. The ability to use both trees and ground nest sites allows nesting pairs to more fully exploit the available prey source by providing a uniform nesting distribution. One nest was built on the crossbeam of a utility pole where no trees were available. Spacing between nests was fairly regular in those areas which were thoroughly searched. Spacing along the juniper-grassland ecotone averaged 4.3 $\pm$ 1.0 km for 19 nests in 1978 and 3.8 $\pm$ 0.8 km for 25 nests in 1979. Each nesting territory usually had two or three alternate nests, within about 0.3 km of each other. Historical nesting territories were almost all occupied, suggesting that maximum nesting density was observed, reflecting the high prey densities previously discussed. In two areas where a pair theoretically should have occurred old auto tires were placed in trees and filled with sticks to form a platform; neither was used by hawks in 1979 or 1980.

Because of the Ferruginous Hawk's sensitivity to human disturbance, nests were not approached by investigators until the young were ready to fledge; therefore, clutch size and hatching success were not recorded. The Ferruginous Hawks had begun incubation by late April when the study was initiated. In 1978, an approximate average

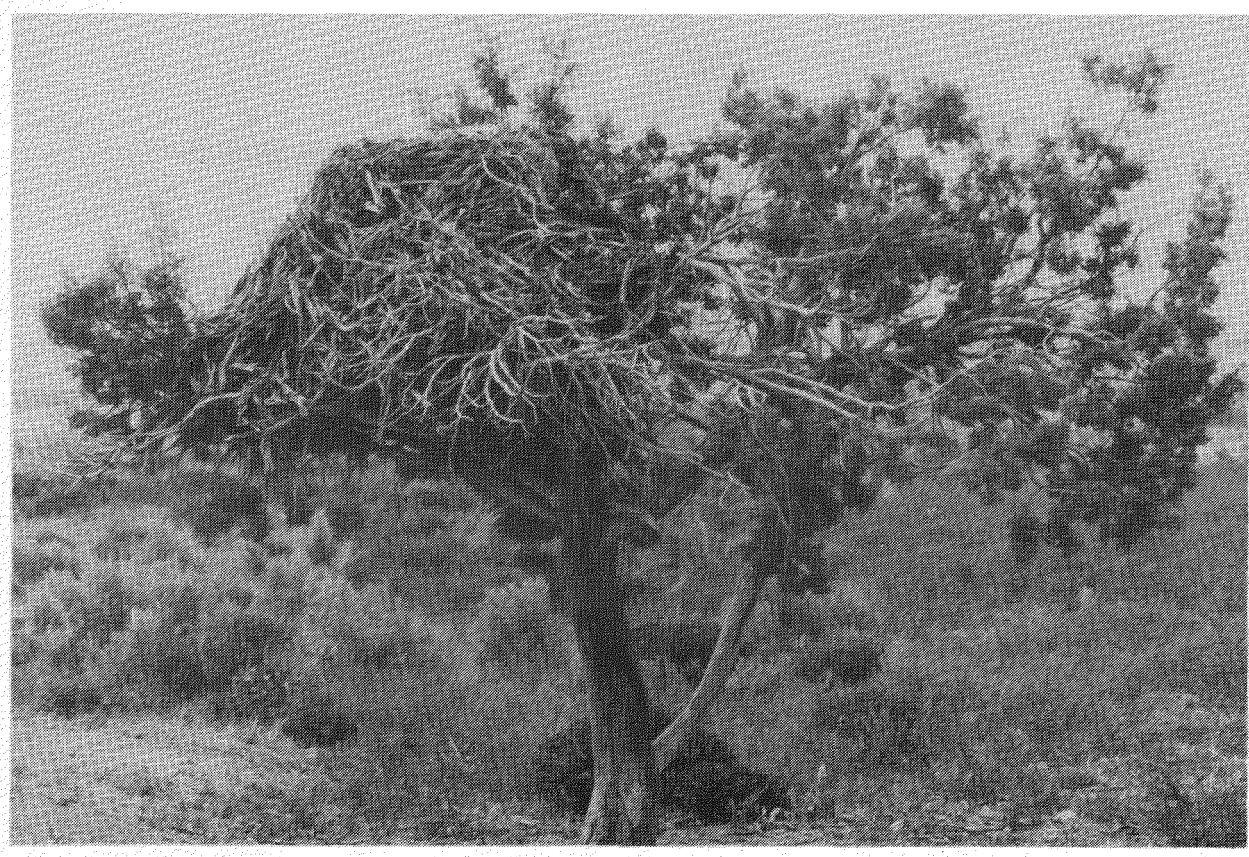

Figure 4. Ferruginous Hawk nest in typical nest tree.

hatching date was May 16. This compares to observations by Howard (1975) when the median hatching dates in 1972 and 1973 were May 18 and May 21, respectively. In 1979, the approximate average hatching date was May 8. In 1980, the median hatching date was May 15. The variability in median hatching dates during the 2 years of this study corresponds with the laying patterns of other raptors which were concurrently studied. In 1979 the early hatching date was due to the early spring. In 1978, the hatching date in one nest was about July 1; and was probably attributable to a renesting attempt. Despite the unusually late hatching date, two young were fledged.

For the 15 control nests which were not disturbed during the perturbation experiments the average fledging rate was 3.53 per nest in 1978. In 1979, the average fledging rate was 3.62 from 24 control nests. These data indicate some of the highest fledging rates recorded in the literature. Olendorff (1976) found 53 nests fledged 1.81 over a 2-year period as an example of general fledging rates. Fledging occurred during the last week of June and the first week in July. A history of the nesting success in the study area, so far as is known since 1972, is shown in Appendix A. Table 1 shows the distribution and average number of young fledged per nest for the years 1972 through 1980.

The data indicate that the fledging success varied over the 9-year period, following a very marked cyclic pattern (Figure 6). This pattern clearly illustrates that Ferruginous Hawk fledging success is very closely tied to the cyclic Black-tailed Jackrabbit population. Unfortunately, jackrabbit population data are not available from Raft River Valley prior to 1978. It is known, however, that the last peak in the jackrabbit population occurred about 1970 (Gross et al., 1974). The declining Ferruginous Hawk fledging rates from 1972 through 1975 apparently reflect the decline period of the jackrabbit cycle. Prey data collected at Ferruginous Hawk nests show to what extent total prey biomass is composed of lagomorphs (Table 2). Quantification of the relative importance of prey based on biomass may

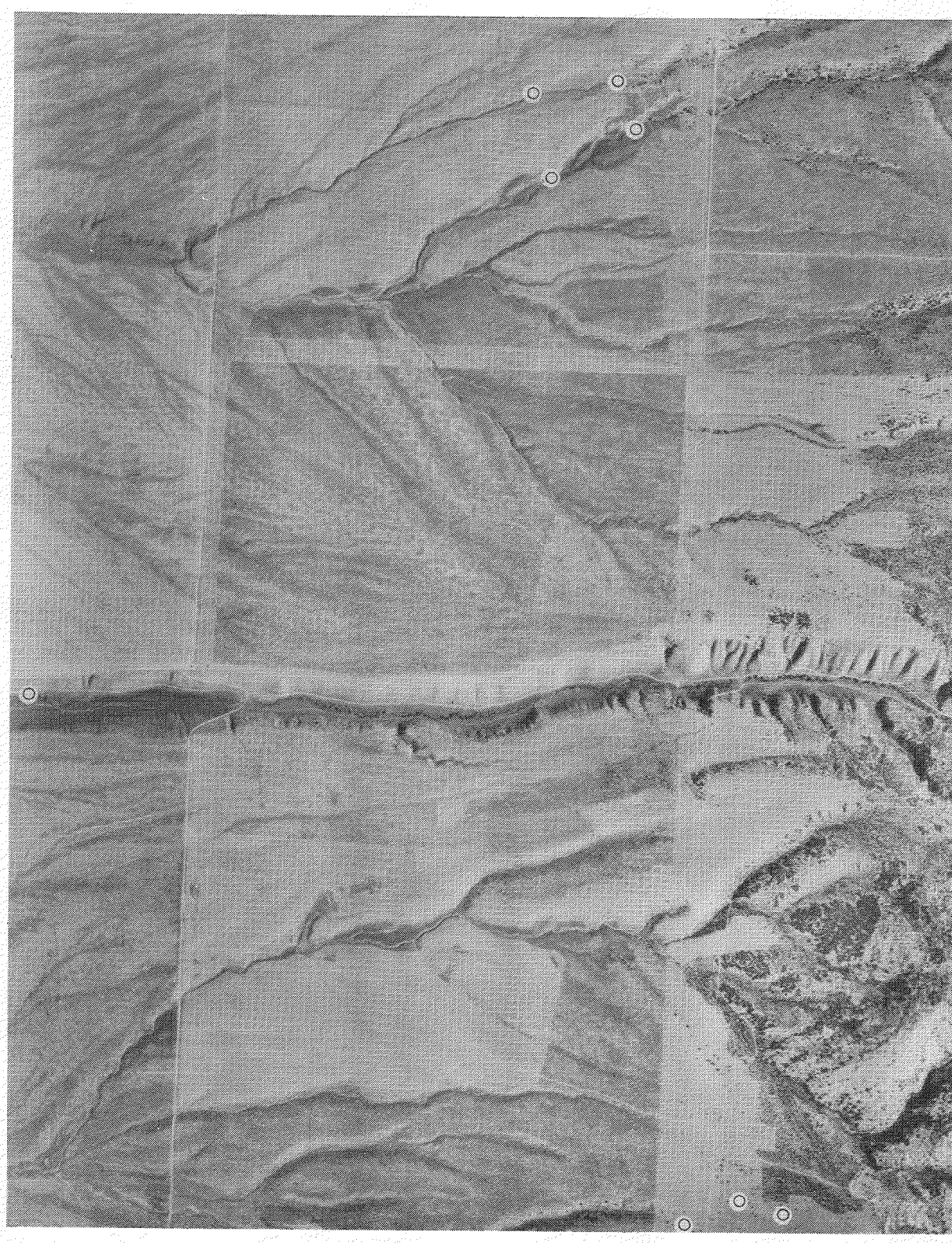

Figure 5. Location of three Ferruginous Hawk territories illustrating the typical location along the sagebrush-juniper ecotone.

Table 1. Ferruginous Hawk fledging rate in Raft River Valley

Number of Young Fledged per Nest	Total Nests that Fledged Young (number of young indicated in far-left column—percentage of yearly total in parentheses)								
	1972	1973	1974	1975	1976	1977	1978	1979	1980
5	1 (6)	0 (0)	0 (0)	0 (0)	1 (9)	0 (0)	2 (12)	5 (24)	0 (0)
4	5 (29)	9 (0)	3 (23)	2 (15)	1 (9)	1 (13)	8 (47)	10 (48)	5 (21)
3	6 (35)	10 (67)	2 (15)	3 (23)	3 (27)	5 (62)	4 (23)	2 (9)	10 (42)
2	4 (24)	3 (20)	6 (47)	6 (47)	3 (27)	2 (25)	3 (18)	2 (9)	5 (21)
1	0 (0)	2 (13)	2 (15)	2 (15)	3 (27)	0 (0)	0 (0)	1 (5)	2 (8)
0	1 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5)	2 (8)
Average number of young fledged per nest	3.0	2.53	2.46	2.38	2.45	2.87	3.53	3.62	2.58

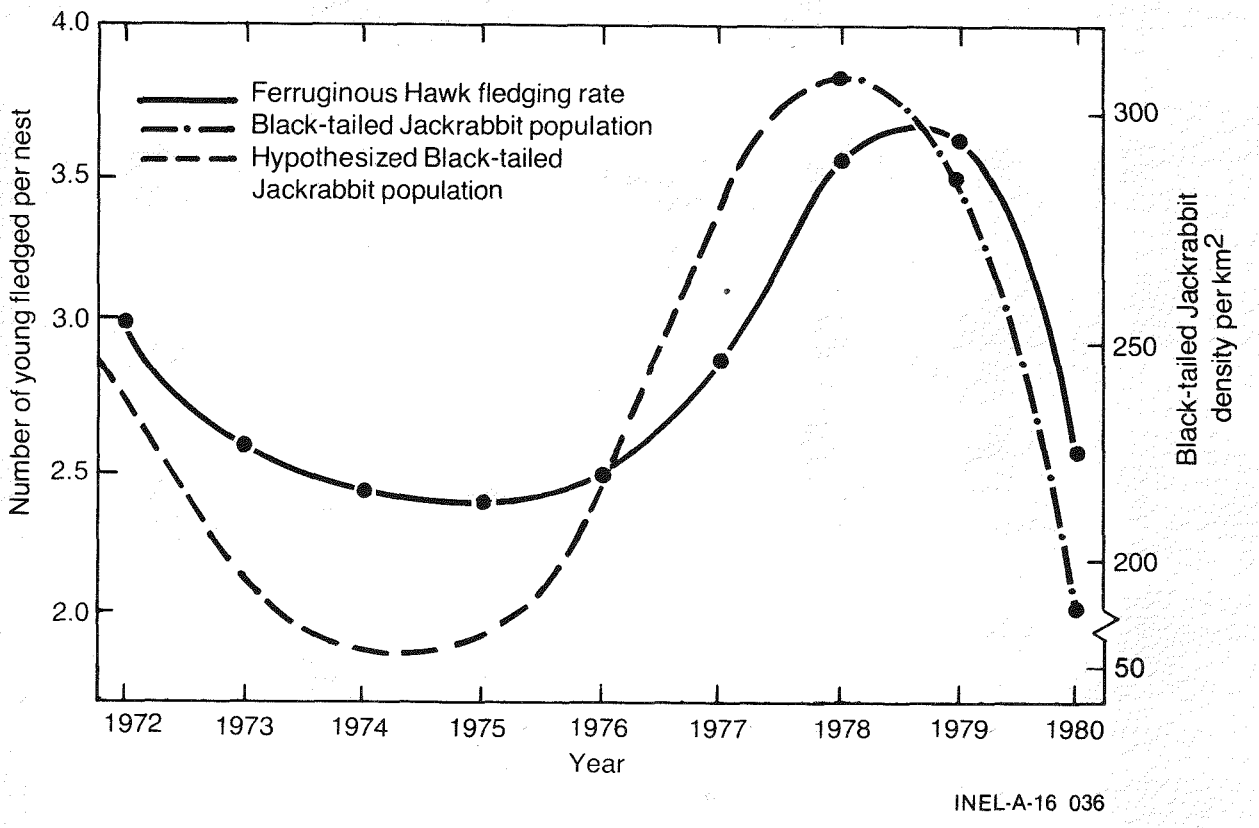

Figure 6. Comparison of Ferruginous Hawk fledging rate with the Black-tailed Jackrabbit cycle over a 9-year period.

be misleading for predators that eat prey which leave no remains. However, in the case of the Ferruginous Hawk, biomass provides a realistic estimate of the importance of prey in the diet if consideration is given to wasteage, thus not overemphasising the importance of large prey items that cannot be swallowed whole. To minimize some of these problems the data are presented as both percent frequency and percent biomass.

The number of young successfully fledged per nest also appears to be tied to the prey base density (Figure 7). In 1978, the jackrabbit population was at its peak density; in 1975, the population would have been near its low. Therefore, 1972 represents a transition year. Figure 6 illustrates that most nests produce four and five young in an abundant prey year; however, in a year when the jackrabbit cycle is low (such as 1975), two young were most commonly fledged, and no nests produced as many as five young.

Both the number of nesting attempts and the clutch size appears to be adjusted downward during the low years of the jackrabbit cycle. The percent of surveyed territories occupied (Figure 8) indicates a close feedback between prey abundance and the initiation of a nesting attempt. Over 80% of the traditional Ferruginous Hawk nesting territories were occupied during high jackrabbit population years, but only 50 to 60% of the territories were used in years when the jackrabbit density was low.

It appears that certain Ferruginous Hawk territories are core sites which are occupied regardless of the density of the prey base in the valley. Other territories are evidently marginal sites which are occupied on an irregular basis during years of low prey abundance. Although not all of the 45 historical territories in Appendix A were visited every year, at least 23 were visited in 5 of the 9 years during which data were collected. Of these 23 territories, nine (39%) were occupied in 7 of the 9 years and only four (17%) were occupied every year. This suggests that about 15 to 20% of the territories are core sites which will be occupied every year. One of these nests has been consistantly used for about 30 years according to a

Table 2. Prey remains found in Ferruginous Hawk nests from 1978 to 1980

Species	Approximate Weight (g)	Number of Individuals	Percentage of Individuals	Percentage of Biomass
Black-tailed Jackrabbit (*Lepus californicus*)	2300	41	36.6	83.5
Mountain Cottontail (*Syvilagus nuttalli*)	1000	8	7.1	7.1
Pygmy Rabbit (*Brachylagus idahoensis*)	750	1	0.9	0.7
Northern Pocket Gopher (*Thomomys talpoides*)	170	21	18.7	3.3
Townsend Ground Squirrel (*Spermophilus townsendi*)	190	8	7.1	1.3
Richardson Ground Squirrel (*Spermophilus richardsoni*)	280	1	0.9	0.2
Least Chipmunk (*Eutamias minimus*)	80	2	1.8	0.1
Ord Kangaroo Rat (*Dipodomys ordi*)	65	6	5.4	0.4
Great Basin Pocket Mouse (*Perognathus parvus*)	15	1	0.9	Tr[a]
Deer Mouse (*Peromyscus maniculatus*)	30	1	0.9	Tr
Mountain Vole (*Microtus montanus*)	35	2	1.8	0.1
Long-tailed Weasel (*Mustela frenata*)	180	2	1.8	0.3
Mammal total		94	83.9	97.1
Pintail Duck (*Anas acuta*)	900	1	0.9	0.8
Gray Partridge (*Perdix perdix*)	480	1	0.9	0.5
Mourning Dove (*Zenaidura macroura*)	155	1	0.9	0.2
Pinyon Jay (*Gymnorhinus cyanocephalus*)	180	1	0.9	0.2
Black-billed Magpie (*Pica pica*)	175	2	1.8	0.3
Horned Lark (*Eremophila alpestris*)	30	5	4.4	Tr
Mountain Bluebird (*Sialia currucoides*)	45	1	0.9	Tr
Western Meadowlark (*Sturnella neglecta*)	145	6	5.4	0.8
Avian total		18	16.1	2.8
Overall total		112	100.0	99.9

a. Tr = trace amount.

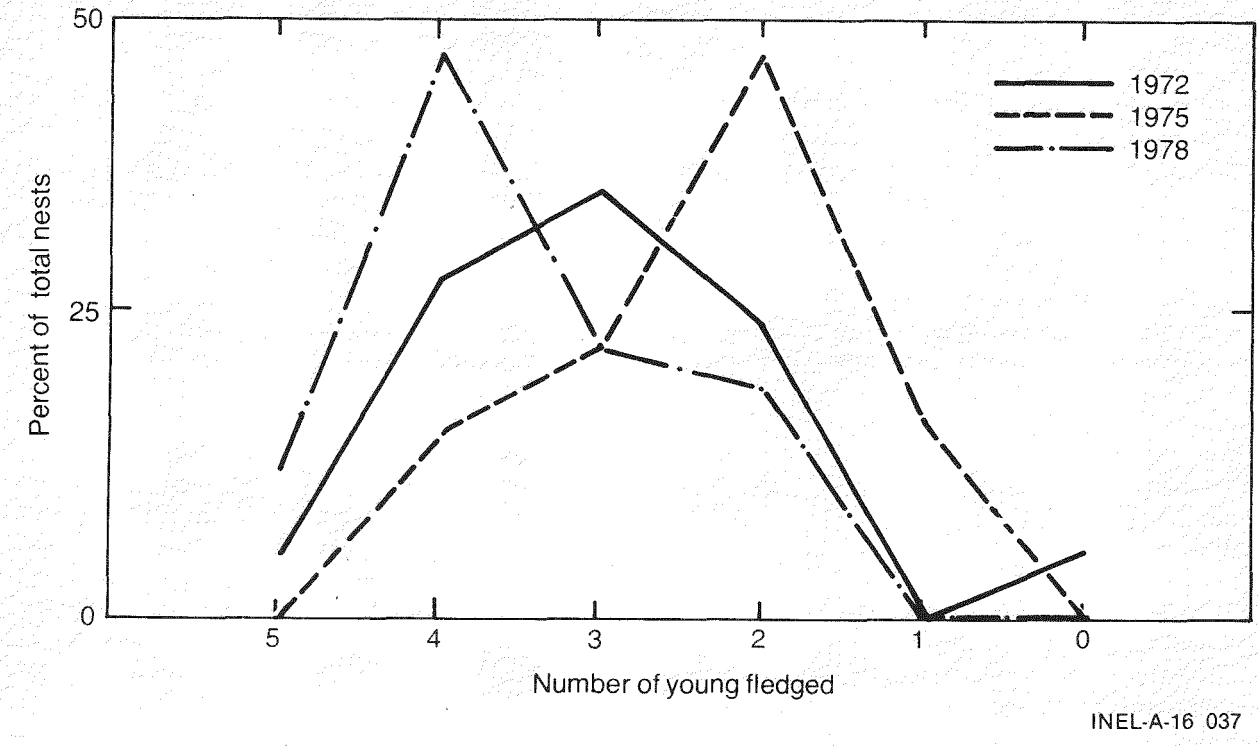

Figure 7. Ferruginous Hawk fledging rate per nest as a percent of total nests throughout the Black-tailed Jackrabbit cycle.

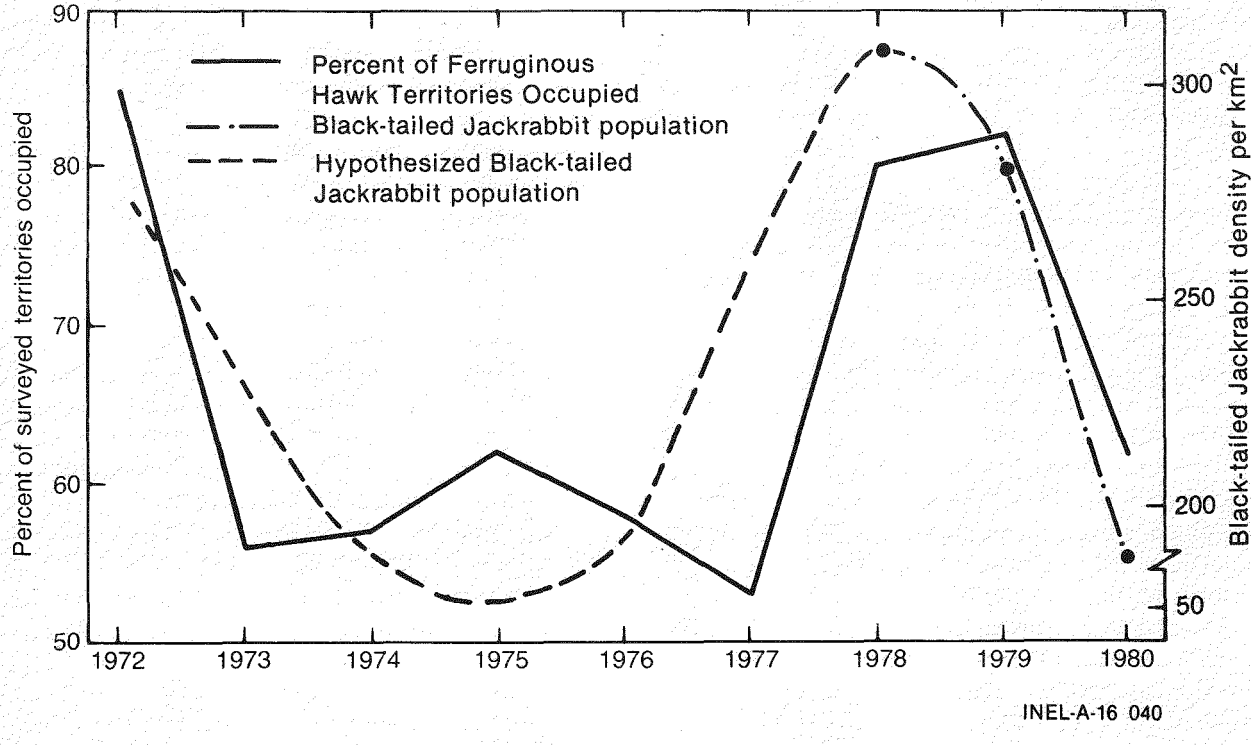

Figure 8. Percent of Ferruginous Hawk territories occupied compared with the jackrabbit population cycle over a 9-year period.

rancher that had taken interest in a particular nest. The core nests are not clumped, nor are they located in areas with similar vegetation cover.

This type of nesting pattern has been documented in other raptor species. The Peregrine Falcon (*Falco Peregrinus*) is a good example of a species that occupy preferred sites year after year. Another explanation may be that particular adults had good pair bonds and were members of the same pair returning to the same nest site year after year. Ferruginous Hawks can be long lived; the longevity record for a wild bird is 19 years (Newton, 1979). At nests where there is a low turnover rate of adults, greater consistant occupancy and production success would be expected.

Clutch size does not appear to respond to a jackrabbit population decline as quickly as the number of territories occupied. In 1980, a total of 23 hatched chicks from the 25 control nests disappeared or were found dead in the nest. A similar die-off was noted by Howard (1975) in Curlew Valley in 1973. The chicks that were successfully raised seemed smaller than would be expected for their stage of development. On one occasion in 1980, two dead Ferruginous Hawk chicks were found partially eaten, apparently having been fed to the siblings.

Three distinct color phases of Ferruginous Hawks (light, black, and red) were observed in the study area . The light phase is characterized by all the underparts being whitish with the exception of the dark V formed by the rufous legs. The black (melanistic) phase has a completely dark body with whitish flight feathers and tail. The red (erythristic) phase is similar to the black phase except the color of the body is rufous. Figure 9 shows the difference between light and dark phase young from the same nest. The percentage of dark phase birds remained fairly stable in the valley from 1972 through 1980 (Table 3); composing approximately 4% of the population compared to a similar melanistic population of 3% recorded in northeastern Colorado (Olendorff, 1973). Populations as high as 30% dark phase have been recorded in southwest Saskatchewan (Lokemoen and Duebbert, 1976). During the 5 years of observation, all dark phase adults in the study area were paired with light phased birds. No pairs of light phased adults produced a dark phase young. Of the young hatched from pair having one dark phase adult, 57% were dark phase.

To determine drift and migration, nestling Ferruginous Hawks in the Raft River Valley and adjoining areas were banded with U.S. Fish and Wildlife Service bands. Between 1972 and 1974, 146 young were banded. This effort was renewed from 1978 through 1980, resulting in 293 nestling Ferruginous Hawks banded. Additionally, in 1972 and 1973, 84 nestlings were banded with patagial markers (Powers, in preparation). Five patagial observations and eleven band returns from outside the breeding area have been obtained so far (Figure 10). Data indicate that the young Ferruginous Hawks remain in the valley 3 to 4 weeks after they fledge from the nest. Nest site checks and road censuses reveal that most of the Ferruginous Hawks leave the valley by late July. For the period of mid-August through late September, four sightings and four band returns recorded from near the continental divide from Gray's Lake, Idaho north to the Henry's Lake region indicate that once the birds leave their natal valleys they drift northeasterly about 150 to 250 km. This pattern of movement may be explained by considering prey availability and the prevailing wind direction. Apparently, food availability on the nesting areas becomes limited in mid-summer due to the change in diel activity of the Black-tailed Jackrabbit. To escape the high temperature during the summers, jackrabbits become relatively inactive during the day; foraging mainly at night. This reduces their vulnerability to diurnal avian predators.

Ferruginous Hawks apparently react to the decline in jackrabbit availability by drifting on prevailing windcurrents, which move primarily in a northeasterly direction, until they find a stable food source. Montane meadows, which support large populations of Richardson Ground Squirrels, are encountered by following the wind patterns. However, the formidable physical barrier of the Rocky Mountains hinders further easterly migration. The ground squirrels in these high mountain meadows remain active throughout the late summer and fall. These squirrels serve as major prey for recently fledged immature birds that are in the process of breaking familial bonds with their parents. It is during this period that the young birds of the year gain predatory skills.

In early October, at the onset of cold weather, the ground squirrels begin hibernation and thus become unavailable to avian predators. Ferruginous Hawks begin their migration south during this time. Hawks that have drifted east of the

Figure 9. Dark and light color phases in sibling young Ferruginous Hawks.

Table 3. Ferruginous Hawk color phases in Raft River Valley

	Breakdown of Color Phases in Ferruginous Hawks (percentage in parentheses)				
Color Phase	1972	1973	1978	1979	1980
Adults					
Light (normal)	59 (95)	41 (98)	63 (95)	69 (96)	60 (97)
Dark	3 (5)	1 (2)	2 (3)	3 (4)	2 (3)
Red	—	—	1 (2)	—	—
Young					
Light	81 (91)	55 (95)	72 (94)	98 (94)	68 (97)
Dark	8 (9)	3 (5)	5 (6)	6 (6)	2 (3)

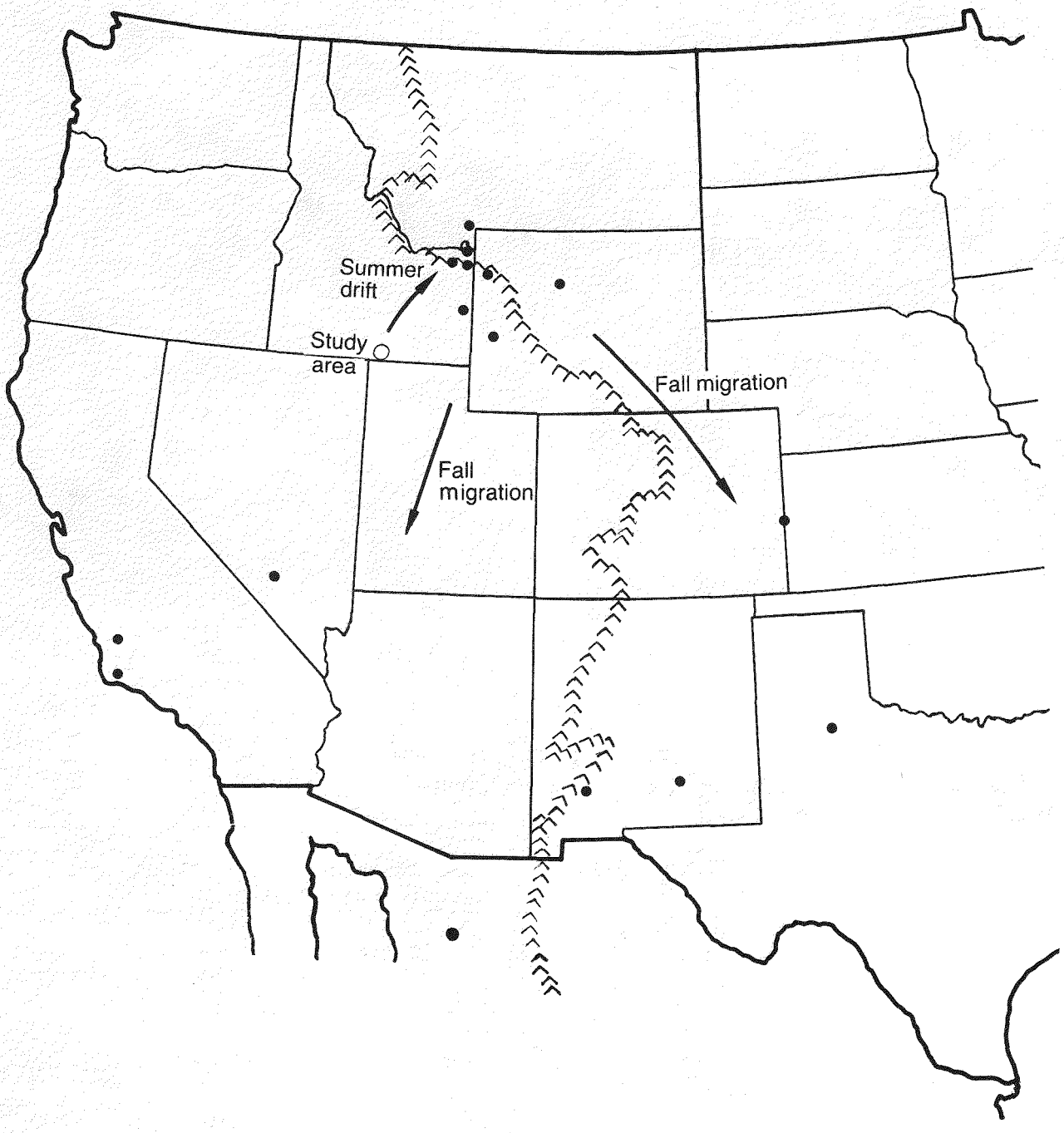

Figure 10. Location of band recoveries and patagial observations of birds raised in Raft River Valley.

continental divide through some of the low passes near the Henry's Lake, Idaho area probably remain on the eastern side of the mountains during their winter migration. Hawks which remain on the western side of the continental divide probably migrate on the western side. This speculation concerning the pattern of migration is supported by studies of Ferruginous Hawks banded in Alberta (Salt, 1939).

During our studies from 1972 to 1980, no patagial marked birds were seen in the study areas as breeding adults. We speculate that either the construction material of the markers did not sustain the weathering process or the markers may have contributed to higher than normal mortality. The latter scenario is unlikely since immature birds with markers were observed from 2 to 6 months after fledging, and there was not a differential return in band returns from marked birds.

As noted by other researchers (Weston in Murphy, 1969; Platt, 1971; and Howard, 1973), dry cow dung was deposited annually in each active Ferruginous Hawk nest. A hypothesis to account for this behavior may be that Ferruginous Hawks do not have elaborate courtship or territory boundary displays. The bulky, large nest structure (often over 1 m in depth and 1 m across) perhaps serves as a territory display marker visible for several kilometers to an airborn hawk. Deposition of dry cow dung may better enable the occupying bird to attract a mate to its territory and at the same time warn potential competitors that the nest territory is occupied. A similar hypothesis has been proposed by Newton (1979) to account for greenery which lines the nests of many raptor species.

Red-Tailed Hawk

Nowhere when the Ferruginous Hawk, Swainson's Hawk, and Red-tailed Hawk are sympatric do they all appear to be relatively equally abundant. One species always seems to be rarer than the other two. In the Raft River Valley, the Red-tailed Hawk was the least abundant of the three buteos. Two active nests were found in 1978, with only one active nest found in both 1979 and 1980. An additional pair of Red-tailed Hawks was observed during both 1978 and 1979, and was known to have fledged at least one chick in 1979; but the nest site was never located. The three nesting territories, and the birds associated with them, account for all the Red-tailed Hawk sightings in the valley. Within an expanded area of 1000 km^2 surrounding the valley seven additional pairs were located; two nests were built in juniper trees, one on a cliff, and the others were in Lombardy Poplar (*Populus nigra*). Areas where Red-tailed Hawks nested were generally more moist than the valley, and usually some sections of land within the vicinity of the nest had at one time been cleared for pasture or hay production. Most nests were in large deciduous trees, agreeing with Platt's (1971) observation. In one case, a Red-tailed Hawk pair moved from their poplar nest site used in 1978 to a juniper tree in 1979 because Great Horned Owls usurped the nest in the poplar. The Red-tailed Hawk pair returned to a different poplar tree nest in 1980.

Three young fledged from one of the two nests in the study area in 1978, and two young from the other. Fledging dates averaged the third week of June, coinciding with the Ferruginous Hawk fledging period. In 1979 the active nest which had contained three eggs failed during incubation, apparently due to nest predation. In 1980, the one active nest that was found fledged three young. Prey identified at the nests consisted primarily of the Mountain Cottontail (*Sylvilagus nuttalli*), Northern Pocket Gopher (*Thomomys talpoides*), and other small mammals in addition to one Bull Snake (*Pituophis melanoleucus*).

Swainson's Hawk

While conducting the Ferruginous Hawk perturbation study, it was consistantly observed that Swainson's Hawks appeared to select nest sites within the vicinity of active Ferruginous Hawk nests. A 0.8-km radius around 30 randomly chosen active Ferruginous Hawk nests was searched over a 2-year period for proximity to Swainson's Hawk nests. A relationship was found in 25 of 30 cases, indicating location of the nest sites of these species to be significantly associated ($X^2 = 16.41$, 1 df, $P < 0.005$). As a control, a 0.8-km radius around 30 inactive Ferruginous Hawk nests was searched; only seven active Swainson's Hawk nests were found (Table 4). The nesting relationship and associated behavioral interactions between the species are discussed in more detail elsewhere (Thurow and White, in preparation).

Table 4. Distance relationship between Ferruginous Hawk and Swainson's Hawk nests

1978

Nest[a] Number	Distance from Active Ferruginous Nest to Active Swainson's Nest	Nest Number	Inactive Ferruginous Nest with Active Swainson's Nest
1	0.72	11 N	yes
1a	0.64	3	no
2	0.32	6	no
4	0.56	7	no
17	0.64	20	no
24	no	21	no
28	0.48	Kelsaw	no
31	0.72	Rice Sp.	no
36	0.80	Cedar Sp.	no
37	0.80	24	no
40	0.72	32	yes
41	0.32	38	yes
42	0.72	38a	no
62	0.32	37a	no
66	0.64	25	no

1979

Nest[a] Number	Distance from Active Ferruginous Nest to Active Swainson's Nest	Nest Number	Inactive Ferruginous Nest with Active Swainson's Nest
16	no	1	no
11	0.64	4	yes
17	0.80	6	no
17a	0.40	7	no
9a	0.56	11 N	yes
5	no	18	no
22	no	Kelsaw	no
25	0.32	Highway	yes
30a	no	B.P.	no
31	0.80	20	no
31a	0.72	21	no
37a	0.64	24	no
40	0.32	30	no
41	0.32	36	yes
42	0.72	37	no

a. Study number assigned to Ferruginous Hawk nests.

Like the Ferruginous Hawk, the Swainson's Hawk nested primarily along the juniper-sagebrush ecotone which ran along both sides of the valley. In 1978 and 1979, 16 and 13 Swainson's Hawk nests were found, respectively. Clutches were composed of either two or three, and in one case, four eggs. In 1978, the average clutch size was 2.56 eggs, and in 1979 it was 2.38 eggs. Fledging success was remarkably close for 1978 and 1979 with 2.13 and 2.15 young per nest being fledged, respectively. In 1980, little effort was made to relocate Swainson's Hawk nests. Four nests were visited containing an average of 2.5 eggs and fledging an average of 2.25 young. The color phases of the adults on the study area were 29% light phase, 34% dark phase, and 37% with an intermediate or mottled coloration.

Of the 41 prey items identified in the nests during 1978 (Table 5), Black-tailed Jackrabbits and Mountain Cottontails composed 78.8% of the prey biomass. The percentage of prey individuals taken was 39% mammals, 46% birds, 12% insects, and 2% reptiles. The percentage of bird prey is high compared with the summary of prey taken by Swainson's Hawk throughout the rest of North America, which reported 37% mammals, 13% birds, 26% reptiles, and 21% insects (Fitzner, 1979). Kulczynski's Index of Similarity (cf. Ueckert and Hansen, 1971) was used to measure the amount of overlap in prey taken by the Swainson's Hawk and Ferruginous Hawk. With this method, an index value of 90 shows a very high degree of similarity while an index of 10 denotes a low degree of overlap. On a biomass basis the four most common mammals in the Ferruginous Hawk diet (94.2% of total) had an index of similarity of 64.5 when compared with the main four prey items of 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 the variable of food is not the reason for the association of the two species. They appear to be associated in nesting proximity, although less closely, even where food overlap approaches 90 to 95%, as it does in Alberta (Schmutz, 1977).

Golden Eagle

The Golden Eagle is the largest breeding raptor in the study area. Four historical eyries are located within the valley, three on cliffs and one approximately 15 m high in a large Lombardy Poplar. Three nests were active in both 1978 and 1979, and two were active in 1980. In 1978, one additional nest was attended by two immature birds.

The eggs had already hatched when observations began in late April. A total of five young were raised in 1978 with two chicks produced in each of two nests, and the remaining nest producing one chick. In 1979, one chick was raised in one nest, two chicks were raised in another, and three chicks were successfully fledged from the third nest. In 1980, the two active nests both fledged two young. Thus the average fledging rate in 1978 was 1.67 chicks per nest, and 2.0 chicks per nest in 1979 and 1980. Fledging occurred in early June.

In addition to the nesting pairs, a large population of immature Golden Eagles summered in the valley, undoubtedly drawn to the area by the high Black-tailed Jackrabbit prey base. A subjective estimate of the number of immature eagles in the valley ranges from 20 to 35. Two observations serve to illustrate the high population of summering immature Eagles on the study area. On one occasion, five immature Golden Eagles were seen to be perched on five out of six consecutive utility poles. On another occasion, six immature eagles were found roosting in the same canyon.

Prey recorded in the nests were exclusively lagormorphs; primarily Black-tailed Jackrabbits, with the exception of one Ring-necked Pheasant (*Phasianus colchicus*). Field observations of prey being captured or consumed also indicated the primary prey was jackrabbits. On two occasions, immature birds were observed to be feeding on cattle that had recently died.

Bald Eagle

This species was regularly observed during migration and throughout the winter. No major roosts were located in the valley, however, a winter roost is located about 30 km northeast near the Snake River. Five Bald Eagles were the maximum number observed at one time in the valley. It is of interest that relatively few have been seen during migration since they are not uncommon 160 km southward in Utah, and presumably some may pass over Raft River Valley. On two occasions, Bald Eagles were observed to be feeding on road-killed jackrabbits. It is presumed that jackrabbits were the main prey source for birds

Table 5. Prey remains found in Swainson's Hawk nests in 1978

Species	Approximate Weight (g)	Number of Individuals	Percentage of Individuals	Percentage of Biomass
Black-tailed Jackrabbit (*Lepus californicus*)	2300	7	17.2	66.4
Mountain Cottontail (*Sylvilagus nuttalli*)	1000	3	7.3	12.4
Northern Pocket Gopher (*Thomomys talpoides*)	170	1	2.4	0.7
Least Chipmunk (*Eutamias minimus*)	80	1	2.4	0.1
Deer Mouse (*Peromyscus maniculatus*)	30	2	5.0	0.3
Mountain Vole (*Microtus montanus*)	35	1	2.4	0.1
Long-tailed Weasel (*Mustela frenata*)	180	1	2.4	0.7
Mammal total		16	39.2	80.7
Mallard Duck (*Anas platyrhynchos*)	1135	1	2.4	4.7
American Kestrel (*Falco sparverius*)	140	1	2.4	0.5
Ring-necked Pheasant (juv.) (*Phasianus colchicus*)	900	1	2.4	3.8
Long-billed Curlew (*Numenius americanus*)	360	1	2.4	1.5
Northern Flicker (*Colaptes cafer*)	175	3	7.3	2.2
Black-billed Magpie (*Pica pica*)	175	3	7.3	2.2
Horned Lark (*Eremophila alpestris*)	30	1	2.4	0.1
Western Meadowlark (*Sternella neglecta*)	145	7	17.2	4.2
Vesper Sparrow (*Pooecetes gramineus*)	30	1	2.4	0.1
Avian total		19	46.2	19.3
Gopher Snake (*Pituophis melanoleucus*)	40	1	2.4	Tr
Grasshoppers (*Locustidae*)	Tr[a]	2	5.0	Tr
Beetles (*Coleoptera*)	Tr	2	5.0	Tr
Jerusalem Cricket (*Stenopelmatus* sp.)	Tr	1	2.4	Tr
Overall total		41	100.0	100.0

a. Tr = trace amount.

wintering in the area as they are for eagles wintering in the Great Basin deserts of Utah (Platt, 1976).

Prairie Falcon

Of the three falcons which breed in the study area, the Prairie Falcon is the largest. No concerted attempt was made to find Prairie Falcon eyries because the time constraints, and the types of census areas to be searched were not compatible with the primary emphasis of the principal raptor studies. Prairie Falcons nest on rock cliffs which border part of the valley. Nevertheless, one active nest was found in 1978, three active nests were found in 1979, and two active nests were visited in 1980. One of the breeding females in 1979 still had many immature feathers, suggesting a year-old bird.

At the nests found in 1978, four eggs were layed and three young were fledged. In 1979, five young were fledged from one nest, and four young were fledged from the other. The third nest found during 1979 had its first clutch destroyed by unknown causes, but another four egg clutch was layed by May 15. However, this clutch of eggs also failed. In 1979, five young were fledged from both eyries that were visited. Fledging dates ranged from the second to fourth week in June.

Avian prey recorded at the nest were primarily the Western Meadowlark (*Sturnella neglecta*) and Horned Lark (*Eremophila alpestris*). Mammalian prey consisted primarily of Townsend Ground Squirrels.

Merlin

Three Merlin sightings were recorded from the study area. In 1977, one pair of Merlins were consistantly observed (Devine, personal communication). It was assumed that they were nesting in one of several Black-billed Magpie (*Pica pica*) nests which were located in a line of Boxelder trees (*Acer negundo*) near an abandoned schoolhouse.

During 1978 and 1979, two other Merlin sightings were recorded. One female of undetermined age on May 15, 1978, and the other was an adult female on May 23, 1979. No Merlins were sighted in 1980. There are several records, all based on museum specimens and egg clutches from southeastern Idaho, of nesting Merlins in Idaho prior to 1913 and one record by Craig (1979) of nesting on the Idaho National Engineering Laboratory (INEL) Site near Arco, Idaho. It is thus possible that this species may occasionally nest on the study site.

American Kestrel

American Kestrels were abundant in the valley and were a common sight along telephone lines and fences. As many as 25 individuals were counted along a 10-km stretch of road. On one occasion, of 18 birds seen along this stretch in mid-May, females outnumbered males two to one. On the open rangeland the number of suitable nesting sites appears to be a limiting factor for population productivity. Indeed, many of the individuals observed never appeared to nest. It is possible that some may have nested in holes along the sides of the gullies cut deep by erosion but we have no observations to confirm this.

In the course of our field observations, four American Kestrel nests were found; one in 1978, two in 1979, and one in 1980. The 1978 nest was in a cavity of a large cottonwood tree from which four young were fledged. In 1979, one nest was found in an old Black-billed Magpie nest which was last visited on June 7, when it still contained five eggs. The other nest was in a juniper tree cavity in which five young had hatched about June 14. In 1980, one nest with five recently hatched young was found in a juniper cavity on June 11.

Observation of prey taken in the field consisted of several Mountain Voles and several insects.

Harrier and Short-eared Owl

Both of these ground nesting species were common breeders in the study valley. No effort was made to locate active nests. Nevertheless, one Harrier nest was found in 1977 on a sagebrush covered hillside 0.4 km from the Raft River. Field observations suggest a minimum of 12 Harrier pairs and four Short-eared Owl pairs present in the valley. This number of Short-eared Owl pairs is undoubtedly much less than the actual nesting population density. Both species appeared to nest in both sagebrush and meadow habitat.

Harrier young born that year were observed at several locations learning to fly. Based on these sightings, the fledging dates approximate June 25. Short-eared Owl chicks were found dead on the blacktop road which ran through the valley on two occasions. In both instances, judging from the development of their flight feathers, they were killed before they had fully mastered flight. The fledging period for these owls appeared to be in late May or early June.

Harriers were observed carrying prey on eight occasions. Seven of the prey items appeared to be Mountain Voles and one item was a grasshopper caught on the road. Two fledgling Horned Larks were found as prey at the nest in 1977.

Barn Owl

Only two observations were made of this species in the valley. Both sightings were of roosting individuals one in an abandoned wooden shed and one in a silo. A quick examination of the casts indicated that meadow mice were the major prey. The species is probably not an uncommon nester in the valley where it may utilize suitable cliff cavities or abandoned farm structures as nesting sites.

Screech Owl

This species was sighted once and heard on several occasions in the Aspen and Douglas Fir forests located in the canyon creekbottoms and on the north facing slopes. No estimates of relative abundance can be made.

Burrowing Owl

Very little information is available concerning the life history and population dynamics of this species. For this reason the Burrowing Owl's current status is listed as undetermined by the U.S. Department of the Interior. No concerted effort was made to find the nests of this species; but in the course of daily fieldwork a total of nine nests were found (three nests in 1978 and six nests in 1979). Most nests were found by chance while driving across open rangeland. Because of their inconspicuous habits and the wide expanses of suitable Burrowing Owl habitat available, it is felt that this species is probably a fairly common nester in the study valley. Platt (1971) also stated that they appeared to be a very common raptor in southeastern Idaho. These observations are being verified by a study begun in 1980 designed to more accurately assess the population of this owl. Organized transect surveys throughout the valley yielded a total of 23 active Burrowing Owl nests; thus a minimum estimate of 80 pairs is plausible (T. Craig and E. Craig, personal communication).

In some areas of the valley, the species appears to be limited by the number of suitable nesting sites, especially in areas where large portions of rangeland have been plowed and seeded with grass. All nests found were located in abandoned Badger (*Taxidea taxus*) burrows; these nests were located in areas of low vegetation. In some areas, virtually all the vegetation was grazed to the ground by livestock. This observation on the characteristic low amount of vegetation cover may be because the owls were more likely to be seen if there was little vegetation cover to block the observer's view.

Production could not be determined prior to the emergence of the chicks from the burrows; thus accurate data of this parameter was not collected, with the exception of one nest that could be easily observed. In 1978, four young emerged from the nest hole, but only three successfully fledged; the fourth chick was hit on the road before it could fly. It appears that the young of both this species and the Short-eared Owl wander away from the nest before they are ready to fly and if their nests are located near a road, mortality from being hit by cars is not uncommon. The young and adults remained around the nest burrow until mid-July. In 1979, the nest failed for an undetermined reason.

In 1978, around the burrow entrance a total of 31 Kangaroo Rat (*Dipodomys sp.*) collected in addition to one Emberizidae mandible, one Horned Lark wing, one Deer Mouse (*Peromyscus maniculatus*) skull, and several pellets composed entirely of insect remains.

Long-eared Owl

The Long-eared Owl was one of the most abundant breeding raptors in Raft River Valley (Figure 11). All nesting sites found were located along the juniper-sagebrush ecotone. Thirty-one, 0.5-km^2 randomly chosen sections of juniper

Figure 11. Young Long-eared Owls.

ecotone were methodically searched for Long-eared Owls over 2 years. Nesting densities determined from this census indicated that there was an average of one pair of breeding birds per 0.65 km^2 with a high of three nesting pairs found in one of the 0.5-km^2 search areas, indicating a density of one breeding pair per 0.17 km^2.

A total of 24 nests were located, with 10 nests found in 1978 and 14 nests found in 1979. From this sample 20 nests were located in old Black-billed Magpie nests and the other four were in what appeared to be old Common Raven nests. The predominate use of Black-billed Magpie nests was also observed by Craig and Trost (1979).

Laying dates varied by over a month during both years of the study. In 1978, laying dates ranged from April 19 through June 2, with a mean laying date of May 3. In 1979, laying dates ranged from April 12 through May 17, with a mean laying date of April 24. These laying dates correspond to those reported elsewhere (Armstrong, 1958; Bent, 1938; Craig and Trost, 1979).

A total of 1000 prey items were identified during the 1978 and 1979 breeding seasons. Mammals accounted for 95.2% of the prey items and 98.2% of the biomass. Deer mice were the most abundant prey items (43.9%), but the Ord Kangaroo Rat composed the greatest percentage of biomass (30%). An extensive analysis of the prey and nesting habits will be presented in a separate paper (Thurow and White, in preparation).

Great Horned Owl

Great Horned Owls were the third most common owl found in the study area; being less abundant than both the Long-eared Owl and Burrowing Owl. The unexpected low Great Horned Owl population is a paradox in that much of the prey used by this species is abundant and diurnal predators with similar prey requirements prosper. A wide diversity of nest sites included pot holes in cliffs, tree nests, and abandoned buildings. The owl chicks were already hatched by the time investigators arrived on the study site. It is

interesting to note that all three cliff nest sites used by Great Horned Owls, the first raptor to begin nesting each year, had a southern exposure.

In 1978, seven nests were found. Eight nests were found in 1979. Fledging data were collected from all but one of the nests each year. In 1978, two young fledged from five nests, and three young fledged from one nest (for an average fledging rate of 2.15 birds per nest). In 1979, one nest failed for an undetermined reason, one young was fledged fom each of two nests, two young were fledged from three nests, and three young were fledged from one nest (for an average fledging rate of 1.57 chicks per nest). In 1980, three nests fledged two young, and one nest fledged three young (for an average fledging rate of 2.25).

Prey collected at the nests were mainly lagormorphs and pocket gophers; although prey items such as an American Kestrel, Western Meadowlark, Black-billed Magpie, and a Striped Skunk (*Mephitis mephitis*) were also found. One interesting observation was that a Northern Pocket Gopher was caught and brought to a nest during daytime between 1500 and 1700 hours, when the owls usually don't hunt.

Common Raven

Of all the raptors in Raft River Valley, the Raven is perhaps the most versatile and adaptable. Like the Great Horned Owl, the Raven is able to use a great variety of nest sites such as cliff ledges, utility power poles, or trees. A Raven's prey ranges from small rodents and immature birds to insects, grain, and carrion. Perhaps due to its versatile diet, the raven also has the greatest production potential of the predators on the study area.

Nest production data were gathered only in 1979 when sixteen active nests were visited. The actual nesting population in the valley was estimated to be at least three times this number. An average of 4.37 young were fledged per nest (range 0 to 7). However, three nests failed as a result of human destruction, and if these three nests are eliminated from the calculations the natural productivity of the 13 remaining nests average 5.38 (range 3 to 7). Young were fledged from most nests during the last week of May and the first two weeks of June. In mid-summer, the Raven family groups congregated in loose flocks ranging from 20 to over 60 individuals and remained together through August.

At seven different locations, the Raven used Ferruginous Hawk nests that had been used by hawks the previous year. In turn, the hawk built a new nest on top of an existing Raven nest within 0.6 km of its former nest. Both species appeared to defend mutually exclusive territories near their respective nest sites. Ravens were circumstantially implicated in the failure of at least three hawk nests. Ferruginous Hawks were the victims on two occasions. In one instance, a Ferruginous Hawk nest that apparently failed due to Raven activity, was refurbished and actively defended by a Ferruginous Hawk pair. A dead Raven with a broken wing was found hanging in the nest tree. In the other case, three 14-day-old Ferruginous Hawk chicks were found near their ground nest, apparently pecked and malled to death. In addition, a Swainson's Hawk was usurped from its nesting attempt. On the first visit to the nest, the Swainson's Hawk was incubating three eggs. Two weeks later, a Raven was found on this nest incubating six of its own eggs.

DISCUSSION

In any community of birds using similar ecological strategies (food habits, nest sites, etc.) there may be the dependance of one species upon another. The sequence of nest site construction can be used to illustrate the interrelationship of the raptor community. The Black-billed Magpie appears to be responsible for initial construction of most nest platforms found in parts of the valley. The domed nests, constructed of small sticks and a mud base, are used directly by many species after the magpie no longer occupies the nest. Long-eared Owls, Kestrels, and Merlins all have been known to use the nests while the dome is still partially intact. The Raven and Swainson's Hawk commonly use collapsed magpie nests to serve as initial platforms for their larger nests. These larger nests, in turn, provide a structure which can be modified and used by the Ferruginous Hawk, or used directly by the Great Horned Owl. Both these latter species rarely begin nest structures in trees without a previously existing platform base. Thus it appears that construction of a large percent of raptor nests built in trees can be traced to the mud and stick platform base first made by the magpie.

At least two key factors affect the composition of the raptor community; juniper trees for nest sites and jackrabbits for food. The current favorable combination of these two critical elements is certainly responsible to a large degree for the density and diversity of the raptors in the study area. The alteration of these factors would yield different effects. Removal of junipers would essentially eliminate the Swainson's Hawk, reduce the Ferruginous Hawk population to a few ground nesting pairs, and restrict other raptors to the limited number of suitable cliff nest sites. Practices that would affect the jackrabbit population would reduce the Golden Eagle and Ferruginous Hawk breeding densities, but would have little effect on the densities of generalist species such as the Raven.

Within this community of raptors, some species will respond more quickly to changes than others and some will be benefited by human alteration of the environment, while other species will be harmed. As discussed by Howard and Wolfe (1976), the Ferruginous Hawk population in Black Pine and Curlew Valleys has already shown a response to the changing nature of the vegetation. Moderate grazing practices may increase songbird populations (Skinner, 1975). Nonintensive agricultural crops such as Alfalfa may increase the pocket gopher population, creating an additional prey source which would otherwise be unavailable in the undisturbed ecosystem. Grazing practices and rangeland alteration also help to create open spaces that may be colonized by ground squirrels. Both pocket gophers and ground squirrels provide a stabilizing factor as a prey source. Thus the raptor population has a more diverse prey base and is not dependant solely on the cyclic jackrabbit population. Therefore, moderate rangeland and agricultural development may actually help the raptor population over the short term. Jackrabbits, however, remain the prime food source for large raptors such as the Golden Eagle and Ferruginous Hawk. If the vegatation of the region is altered to such an extent that the jackrabbit population is seriously limited, the populations of these larger raptors will probably decline. This may be the case in Curlew Valley where the jackrabbit population was five to six times lower than in Raft River, probably due to the extensive rangeland development and agricultural activity. Westoby and Wagner (1973) show that jackrabbits use relatively little area of the large Crested Wheatgrass seedings that are more than 300 m away from the sagebrush borders. Changes in the raptor community of the Raft River Valley should be carefully documented as the character of the valley continues to change in the face of agricultural, rangeland, and potential geothermal development. To this end, the reproductive data for the major raptor species are presented (Tables 1 and 6).

Conversion of extensive tracts of native vegetation to monotypic grassland or intensive agriculture may result in potentially significant changes to the ecosystem. Rangeland development programs should be designed to coexist with the requirements of the raptor community. Habitat manipulation should not take place during the critical incubation and nesting period from early March through mid-July. Juniper trees which are actual or potential nest sites, particularly lone trees which grow in the sagebrush-grassland zone, need to be preserved. If rangeland development is initiated, a pattern of developing small areas rather than extensive blocks is encouraged. Howard and Wolfe (1976) suggest that edge be

Table 6. Raptorial species reproductive data in Raft River Valley from 1978 through 1980

Species[a]	1978			1979			1980		
	Number of Nests	Mean Clutch Size	Mean Number Fledged	Number of Nests	Mean Clutch Size	Mean Number Fledged	Number of Nests	Mean Clutch Size	Mean Number Fledged
Swainson's Hawk	16	2.56	2.13	13	2.38	2.15	4	2.50	2.25
Raven	—	—	—	16	—	4.37	—	—	—
Long-eared Owl	10	3.90	3.40	14	4.28	4.00	—	—	—
Golden Eagle	3	—	1.67	3	—	2.00	2	—	2.00
Prairie Falcon	1	4.00	3.00	3	4.33	3.00	2	5.00	4.50
Cooper's Hawk	1	4.00	4.00	3	4.00	4.00	1	4.00	4.00
Great Horned Owl	7	—	2.16	8	—	1.57	4	—	2.25
Red-tailed Hawk	2	—	2.50	1	3.00	0.00	1	—	3.00

a. Exclusive of the Ferruginous Hawk and Burrowing Owl.

maximized in these operations and that a minimum of 20% of the total area remain as existing shrubby vegetation in the form of small islands scattered throughout the treatment area. This practice provides cover required by prey species, upon whose population densities the raptor community depends.

As a unique part of the study of this raptor community, the Ferruginous Hawk in particular was studied. The prime reason for the decline of this species throughout its range must be related to direct human impact (i.e., disturbance or habitat alteration) and not to indirect impacts (i.e., chemical poisoning). Ten eggs of this species were analyzed for agricultural chemicals in 1979. The data from these analyses are presented in Table 7. None of the chemicals present in the eggs could be considered at dangerous levels.

To quantify the behavior and tolerance level of the Ferruginous Hawk, a study was initiated to simulate the types of disturbances that may be anticipated with increased development in the region. These data may provide a scientific basis for establishing protective zones which must be preserved around nest sites during critical periods of the year. The results and conclusions of this study will be presented in detail elsewhere (White and Thurow, in preparation), however, the following text will briefly summarize these findings as they have a direct bearing on the success of Ferruginous Hawk nesting in raptor populations where human use of rangeland increases. While the Ferruginous Hawk is perhaps most known for its sensitivity to human activity, other species such as the Swainson's Hawk and Red-tailed Hawk may also show similar trends.

Unlike previous reports of nest desertion as a function of human activity, very little nest failure was caused by the perturbation treatments. The treatments consisted of either positioning noise makers designed to simulate sounds that would be associated with geothermal development (e.g. pump noise), or of walking or driving near the nest to the point at which the attending adult flushed. When this occurred, the investigator approached no further and immediately left the area. The distance between the investigator and the nest was estimated and recorded as the level of stress or anxiety beyond which the hawks could no longer tolerate the presence of the disturbing factor.

Many factors may affected the results obtained in this study. A few of the obvious variables that cannot be controlled, in some cases measured, that may make individual pairs more or less sensitive include:

1. Clutch size
2. Frequency of total disturbances
3. Inability to measure stress or anxiety in hawks
4. Weather
5. Stage of breeding cycle
6. Presence or absence of mate
7. Different responses in individual hawks to disturbance
8. Familiarity or accommodation
9. Health state of individual
10. Previous experience
11. Number of people
12. Time of day
13. Other undocumented disturbances.

Each pair had slightly different responses to our treatments, but none showed an increased tolerance over time. In fact, most became sensitized to the treatments, flushing at increasing distances until just before the egg hatched (Figure 12). Desertions occurred as late as 19 days after treatment had begun. The development of the eggs in the deserted nests ranged from having just been layed to several days prior to hatching. The reason the initial flushing distances in 1979 were higher than in 1978 is probably because four of the 14 treatment nests had been used as treatment nests in 1978. Those nests were presumably occupied by the same pairs and were perhaps already sensitized from the previous year.

Once the chicks hatch, there is the establishment of a security zone where adults appear to feel safe, within a 100-m radius of the nest. As long as the zone is not entered, adults will not flush 60% of

Table 7. Ferruginous Hawk egg chemical residues and developmental conditions

Nest[b] Number	Chemical Residues[a] (µg/l) Hexochlorobenzene	Heptachlorepoxide	Total DDT	Dieldrin	Methoxychlor	Oxychlordone	PCBs	Comments
15	5	115	184	4	10	10	10	Embryo three-forths formed
15	6	92	196	4	10	10	10	Embryo three-forths formed
17	5	15	59	19	10	7	10	Fresh, no embryo detectable
19	8	15	173	31	10	15	10	About 3 to 4 days from hatching
24	2	19	90	12	10	20	10	Early embryo
24	2	23	95	8	10	10	10	Embryo about 8 days old
24	2	19	100	12	10	20	10	Embryo about 10 days old
36	14	67	481	12	10	20	10	Embryo about two-thirds formed
36	4	107	818	8	10	15	10	Embryo about 10 days to hatching
41	6	8	176	4	10	10	10	Embryo about two-thirds formed

a. Other chemicals tested for but not given in the table are lindane, all samples = 1; BBHC, all samples = 2; endrin, all samples = 1.

b. Study number assigned to Ferruginous Hawk nests.

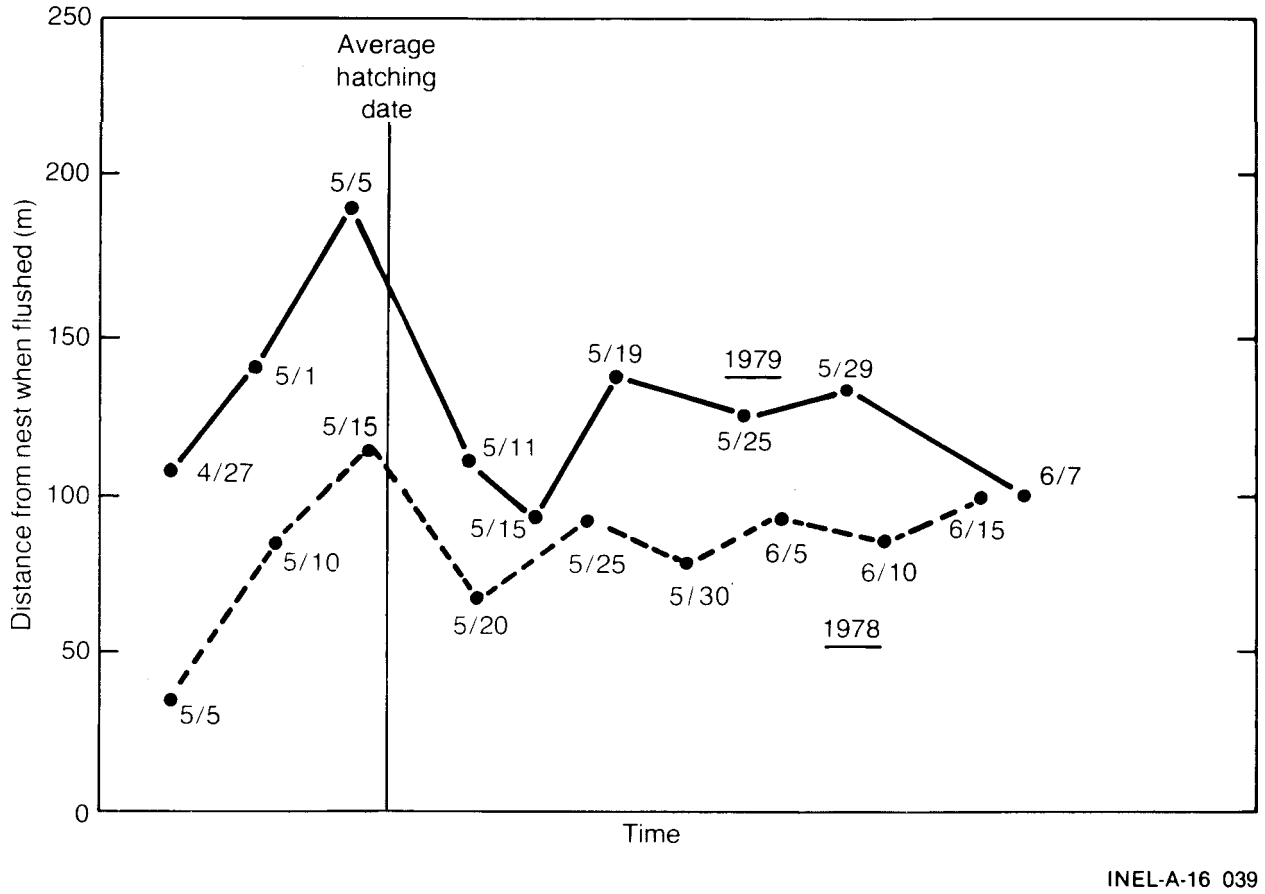

Figure 12. Average 5-day interval flushing distance throughout the nesting cycle.

the time. The average flushing distance throughout the nesting season appears to be about 120 m. About 84% of the flushing could be avoided if direct human activity is restricted within 200 m of the nest; 90% of the flushing could be avoided if that activity is restricted to greater than 250 m of the nest.

Of the four treatment nests that failed in 1978, only one of the territories was occupied in 1979. In that territory, the occupied nest was in another tree 300 m away. Of the five treatment nests that failed in 1979, none were active in 1980. Thus, of the nine nests that failed due to disturbance, only one was active in the following year. However, three of the four nests deserted in 1978 were active in 1980.

Both the hatching and fledging rates were significantly different from the control nests ($P = 0.01$) as tested by a paired comparison T test. Of particular interest was the trend that 15 (71%) of the 21 control nests in 1979 fledged either four or five young, while the maximum number of young fledged from any of the 14 treatment nests was three. In 1978, three (30%) of the 10 treatment nests fledged four young, and none fledged five young; conversely 10 (59%) of the 17 control nests fledged either four or five young. This lower fledging rate and the relative absence of large broods (four or five young) being fledged in the treatment nests reflects the inattentive behavior of nesting pairs exposed to the treatments. The lowered attentiveness is illustrated by the fact that during banding, when both the controls and treatment pairs had young 2 to 3 weeks of age, the treatment pairs were consistantly absent from the nest or remained at great distances, while the control nest pairs were close to the nests and were more defensive. The treatment pairs appeared to stay away from the nests as long as possible, returning only to deliver prey. The young were often not shaded or brooded during rainstorms.

The tolerance displayed by the species appears to have resulted because the investigators did not

actually climb into the nest, and the prey base was high enough that the hawks were in a good physiological state. It is suggested 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. This seemed to be the case in 1980 when telemetry studies were conducted by placing an egg containing a transmitter in the nest to determine adult heart rate as a measure of stress. The jackrabbit prey base was declining and inclement weather prevailed throughout May, causing a lowered physiological state. Fewer young were raised on the average, and the parents seemed less tolerant of human presence, flushing on the average at greater distances and abandoning more readily.

The data suggest that nest desertion, after one visit to the nests, can be correlated with food availability. This correlation had not been attempted in most earlier studies. Several different nests, not included as a part of this study were visited once and climbed to during incubation; however, the adults did not desert. We suggest, however, that had we climbed repeatedly to the nests in the study during incubation, more desertions would have occurred. In 1980, when prey was scarce, this was not the case. On two occasions nests were deserted after approaching and flushing the adult just once.

Although incubation and raising of young may be successful, the presence of humans too near nests may cause the added problem of premature fledging, which may increase their mortality. At one nest our presence caused a young bird, 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.

An interesting aspect of the Raft River Valley raptor community is that many of the large birds of prey appear to belong, in a general sense, to the same type of guild. Guilds are defined as groups of species that exploit the same type of environmental resources in a similar way; usually in reference to prey (Phelan and Robertson, 1978). The Raft River Valley raptor guild appears to be comprised of the Golden Eagle, Ferruginous Hawk, Swainson's Hawk, Red-tailed Hawk, Great Horned Owl, and perhaps the Raven. All rely to a significant degree upon the lagomorph population. The Golden Eagle and especially the Ferruginous Hawk are species which clearly fluctuate in nesting attempts and reproductive output along with the jackrabbit population cycle. Other species such as the Raven and Swainson's Hawk are more general in their food habits, but jackrabbits remain the primary source of prey.

Generally, guilds of birds within a community which use the same types of prey are of a similar size, or a direct correlation between predator and prey weight exists (Hespenheide, 1975). Within some raptor guilds this correlation holds to the extent that mean prey weight is the same as the predators weight. This relationship has been clearly shown for accipiters (Opdam, 1975). Such a relationship does not exist for the guild of raptors in the Raft River Valley. Among this guild, there are approximately four different male size classes:

1. Golden Eagle—3700 g
2. Raven—1200 g, and Great Horned Owl—1140 g
3. Ferruginous Hawk—1060 g, and Red-tailed Hawk—1030 g
4. Swainson's Hawk—900 g.

Despite this significant size difference, the major prey source of each species is the jackrabbit. This pattern may reflect a functional response to an abundant prey base; that is, the raptor community is keyed in to hunting jackrabbits due to their abundance and availability. Nevertheless, the diets of the larger members of the guild were composed of a greater percentage of jackrabbits than were the smaller members.

A form of partitioning or dividing of the lagomorph resource among the raptor population apparently exists, and this partitioning is more temporal than spatial. Smith and Murphy (1973) showed that the hunting activity patterns of the large raptors on their Utah study area were spread throughout the day among the different species. Partitioning also occurs throughout the year since the heaviest use of the lagomorphs takes place

during the nesting and postfledging periods. Of the raptor species discussed, the onset of incubation, length of incubation, and nesting periods occur over a range of dates rather than simultaneously. An approximate sequence of these variables occurs as follows (incubation periods from Newton, 1979):

1. Golden Eagle, onset of incubation March 1, nesting period mid-April to early June

2. Great Horned Owl, onset of incubation March 5, nesting period early April to mid-May

3. Raven, onset of incubation March 10, nesting period early April to late May

4. Ferruginous Hawk, onset of incubation April 5, nesting period early May to late June

5. Red-tailed Hawk, onset of incubation April 15, nesting period late May to late June

6. Swainson's Hawk, onset of incubation May 1, nesting period early June to mid-July.

Ravens and owls have fledged young prior to the hatch of Swainson's Hawks, and the nesting period of Red-tailed Hawks and Ferruginous Hawks only overlaps the Swainson's Hawks for about 2 weeks.

Much of the staggering of the breeding cycle depends on when the species arrives on the breeding grounds and the size of the bird. Golden Eagles, Ravens, and Great Horned Owls are resident and can start breeding early while the Swainson's Hawks migrate as far south as northern Argentina, and thus are only arriving back on the breeding grounds when some species have freshly hatched young.

CONCLUSION

The raptor community in the Raft River Valley is essentially unchanged by human development. It is unique in that few geographical areas remain in North America where the sensitive Ferruginous Hawk is the primary diurnal bird of prey and the Long-eared Owl is the most common nocturnal raptor. Unaltered raptor communities characteristically are found in remote areas unsuited for human development, in contrast to the marginally productive Raft River Valley, which is somewhat representative of the Intermountain Sagebrush Province.

The density and productivity of the Raft River Valley raptor community, supported by a high natural prey base and an abundance of suitable nesting sites, is a remnant region that represents a portion of the Great Basin which has long since been cultivated in most areas.

Areas of future recommended study include:

1. Responses of Ferruginous Hawks and Burrowing Owls to rangeland and agricultural changes

2. Effects of an expanding, decreasing, or stable Raven population on other raptors

3. The nesting ecology relationship of the Raven and Ferruginous Hawk

4. The effects of a changing prey base (primarily lagomorphs) on the large raptors of the region

5. The relationship of nest-site selection, density, and distribution of the three Buteo species.

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APPENDIX A

TABULAR HISTORY OF FERRUGINOUS HAWK NESTING SUCCESS IN THE RAFT RIVER VALLEY

Table A-1. Nine-year nesting history of Ferruginous Hawks in Raft River Valley

Nest Number		1972	1973	1974	1975	1976	1977	1978	1979	1980	Comments
0	E[a]	4	3	3	3	2	NV[c]	?[d]	5	4	
	F[b]	4	3	2	3	1		4	4	3	
1	E	I[e]	I	2	I	I	NV	?[f]	I	I	Three young depredated in 1978
	F			2				0			
1a	E	NV	NV	NV	NV	NV	NV	?	?	4	
	F							3	3	4	
2	E	NV	NV	NV	NV	NV	NV	?	4[f]	I	
	F							3	3		
3a	E	NV	NV	NV	NV	NV	NV	?	3[f]	5	
	F							2	2	3	
4	E	4	I	I	I	I	I	?	I	I	Nest blown out in 1979; pair present in territory
	F	4						3			
5	E	2	I	2	I	I	NV	I	3[f]	I	Eggs deserted in 1979 due to perturbation study
	F	2		2					0		
6	E	3	I	2	3	3	I	I	I	I	Nest blown out in 1977; territory never reoccupied
	F	3		2	2	1					
8	E	NV	NV	NV	NV	NV	NV	I	NV	4	
	F									1	
9	E	4	3	3	2	I	NV	5[f]	?[f]	4	Deserted during perturbation study in 1979
	F	4	3	3	1			4	0	2	
9a	E	NV	NV	NV	NV	NV	NV	NV	5	I	
	F								4		

Table A-1. (continued)

Nest Number		1972	1973	1974	1975	1976	1977	1978	1979	1980	Comments
10a	E	NV	NV	NV	NV	NV	NV	NV	5	4[f]	Ground nest. Deserted during 1980 telemetry study
	F								5	0	
10b	E	NV	NV	NV	NV	NV	NV	NV	4[f]		Ground nest
	F								3	I	
11	E	3	I	2	3	3	2	?	?[f]	5	At least two young killed by invasion of nest by ants in 1979
	F	3		2	2	3	2	2	2	3	
11a	E	NV	NV	NV	NV	NV	NV	NV	5		Nest blown out in late 1979
	F								4	I	
15	E	5	I	4	2	5	3	5		5[f]	Nest deserted in 1978; female found shot on nest in 1980
	F	5		4	2	5	3	0	I	0	
15a	E	?	I	I	NV	NV	I	NV	?		
	F	3							4	I	
16a	E	NV	NV	NV	NV	NV	NV	?	?	?	
	F							4	4	3	
16b	E	NV	NV	NV	NV	NV	NV	NV	4	[f]	
	F								3	I	
17	E	NV	3	I	3	2	NV	3	4[f]	4[f]	
	F		3		3	1		2	3	3	
17a	E	4	3	3	4	NV	NV	NV	?	3	Eggs depredated in 1979
	F	4	3	3	4				0	2	
19	E	3	2	I	I		2	3	4[f]	3[f]	
	F	3	2				2	0	3	2	

Table A-1. (continued)

Nest Number		1972	1973	1974	1975	1976	1977	1978	1979	1980	Comments
20	E	3	I	I	I	I	I	I	I	I	Eggs depredated in 1972; territory never reoccupied
	F	0									
21	E	2	I	I	I	NV	NV	I	?	4	Male adult disabled in 1980
	F	2							1	0	
22	E	3	I	I	I	I	I	?[f]	?[f]	4	
	F	3						1	2	4	
24	E	4	I	3	2	4	3	3[f]	I	4	Deserted during perturbation study in 1978
	F	4		1	2	3	3	0		3	
25	E	NV	NV	NV	NV	NV	NV	I	?[f]	I	Deserted during perturbation study in 1979
	F								0		
26	E	2	3	2	2	2	3	?	?	4	
	F	2	2	2	1	2	3	5	4	3	
27	E	NV	2	NV	NV	NV	NV	NV	3	?	
	F		2						2	3	
28	E	NV	NV	NV	NV	NV	NV	?	?[f]	I	
	F							4	3		
30	E	NV	NV	NV	NV	NV	NV	?	?[f]	5	Cause for failure in 1980 undetermined
	F							3	2	0	
31	E	NV	NV	NV	NV	NV	NV	?[f]	?	?[f]	Deserted during telemetry study in 1980
	F							4	4	0	
31a	E	NV	NV	NV	NV	NV	NV	NV	?	5	
	F								3	1	

Table A-1. (continued)

Nest Number		1972	1973	1974	1975	1976	1977	1978	1979	1980	Comments
32	E	NV	3	NV	I	I	NV	?	5[f]	I	Ground nest deserted during perturbation study in 1979
	F		3					2	0		
33	E	I	1	4	3	3	3	?[f]	?	4	
	F		1	4	3	2	3	4	4	4	
33a	E	NV	NV	NV	NV	NV	NV	I	?[f]	I	
	F								4		
34	E	I	3	2	3	2	NV	I	3[f]	?	Nest destroyed by wind in 1979
	F		3	1	2	2			0	2	
36	E	2	I	I	NV	NV	NV	3[f]	I	?[f]	Deserted during perturbation and telemetry studies in 1978 and 1980, respectively
	F	2						0		0	
37	E	NV	NV	NV	NV	NV	NV	?	I	4	
	F							2		2	
38	E	3	1	NV	3	3	NV	?	?	4	
	F	3	1		2	3		4	4	3	
39	E	NV	3	NV	NV	NV	3	?	?	4	
	F		3				3	5	5	3	
40	E	NV	3	I	NV	NV	I	?	?	I	
	F		3					4	5		
41	E	NV	3	I	NV	NV	I	?	?	4	
	F		3					4	5	4	
42	E	NV	3	4	4	?	4	?	?	I	
	F		3	4	4	4	4	4	5		

Table A-1. (continued)

Nest Number		1972	1973	1974	1975	1976	1977	1978	1979	1980	Comments
43	E	NV	NV	NV	NV	NV	NV	?	?	4	
	F							4	4	4	

a. E row is number of eggs per nest.

b. F row is number of fledged young per nest.

c. Nest not visited.

d. Question mark indicates nest was active but not approached.

e. Nest inactive.

f. Indicates treatment nests (disturbed).