Nest site selection, productivity, and food habits of ferruginous hawks in southeastern Montana
by John Thomas Ensign

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Ferruginous hawks (Buteo regalis) were studied on 492 km of public land in southeastern Montana during the 1981 and 1982 nesting seasons. Nest sites were significantly removed from roads and areas of continual human activity. Ninety-one nests were located, 97% were situated on the ground in association with hills and ridges encompassing broad, flat valleys. Sixty-seven percent of all nests were located on the ends of side-ridges, knobs on ridgetops or lone knolls. Eighty-three percent of all nests were on slopes which were oriented in a 180° arc from southwest through north to northeast with 24% possessing a southwest orientation. Nests which were occupied in the 2 years possessed significantly more vantage from the nest than unoccupied nests. Bare ground and grass-forb cover within a 5 m radius of all nests differed significantly between the years while big sagebrush (Artemisia tridentata) cover averaged 15% in both years. Occupied nests in both years had similar levels of grass-forb cover (32.7 and 36.8%, respectively) adjacent to the nest, in spite of the significant differences noted at all nests. Increases in grass-forb cover measured at a nest were accompanied by decreases in sagebrush cover. Twelve and 11 nest territories were occupied during the 2 years of study, out of a potential of 25. Two-year average clutch size was 2.69, and 26% of all occupied nests were successful. Five juveniles were fledged each year, for an average of 1.67 juveniles per successful nest and 0.34 per nest attempt. Predation and sibling fratricide were the major causes of nestling mortality, accounting for 34 and 27%, respectively, of the total progeny loss. White-tailed jackrabbits (Lepus townsendii) represented the greatest frequency (24.4%) and biomass of prey items collected from nests. Other important prey items and their frequency of occurrence included western meadowlarks (Sturnella neglecta) 18.3%, thirteen-lined ground squirrels (Spermophilus trideoemtineatus) 12.7%, and northern pocket gophers (Thomomys tatpoides) 11.7%. Low prey densities and decreased prey vulnerability are implicated as major factors contributing to the dearth of nesting pairs and poor reproductive output. Notes are included concerning relative abundances of potential prey, the raptor community, and the behavior of adult and juvenile ferruginous hawks.

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APPROVAL

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John Thomas Ensign

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES--Continued

LIST OF FIGURES

ABSTRACT

Ferruginous hawks (*Buteo regalis*) were studied on 492 km^2 of public land in southeastern Montana during the 1981 and 1982 nesting seasons. Nest sites were significantly removed from roads and areas of continual human activity. Ninety-one nests were located, 97% were situated on the ground in association with hills and ridges encompassing broad, flat valleys. Sixty-seven percent of all nests were located on the ends of side-ridges, knobs on ridgetops or lone knolls. Eighty-three percent of all nests were on slopes which were oriented in a 180° arc from southwest through north to northeast with 24% possessing a southwest orientation. Nests which were occupied in the 2 years possessed significantly more vantage from the nest than unoccupied nests. Bare ground and grass-forb cover within a 5 m radius of all nests differed significantly between the years while big sagebrush (*Artemisia tridentata*) cover averaged 15% in both years. Occupied nests in both years had similar levels of grass-forb cover (32.7 and 36.8%, respectively) adjacent to the nest, in spite of the significant differences noted at all nests. Increases in grass-forb cover measured at a nest were accompanied by decreases in sagebrush cover. Twelve and 11 nest territories were occupied during the 2 years of study, out of a potential of 25. Two-year average clutch size was 2.69, and 26% of all occupied nests were successful. Five juveniles were fledged each year, for an average of 1.67 juveniles per successful nest and 0.34 per nest attempt. Predation and sibling fratricide were the major causes of nestling mortality, accounting for 34 and 27%, respectively, of the total progeny loss. White-tailed jackrabbits (*Lepus townsendii*) represented the greatest frequency (24.4%) and biomass of prey items collected from nests. Other important prey items and their frequency of occurrence included western meadowlarks (*Sturnella neglecta*) 18.3%, thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) 12.7%, and northern pocket gophers (*Thomomys talpoides*) 11.7%. Low prey densities and decreased prey vulnerability are implicated as major factors contributing to the dearth of nesting pairs and poor reproductive output. Notes are included concerning relative abundances of potential prey, the raptor community, and the behavior of adult and juvenile ferruginous hawks.

INTRODUCTION

Throughout its breeding range populations of ferruginous hawks (*Buteo regalis*) are stable or declining slowly, with habitat loss posing a serious threat to any stability (Evans 1982). In 1973 the U.S. Fish and Wildlife Service (USFWS) classified the ferruginous hawk as "status undetermined" (USFWS 1973). This bird has been listed on Audubon's Blue List as a species that displays noncyclical population declines or range contractions either locally or on a more widespread level (Tate 1981).

The present status of breeding populations of ferruginous hawks in Montana is uncertain. Nesting concentrations occur in the extreme southwest in Beaverhead County and in the extreme southeast in Carter County (D. Flath pers. comm.). In addition, scattered nesting has been reported along the northern tier of counties east of the town of Havre.

My study was established in 1981 on a large, nearly contiguous block of public lands in the Carter County area. Preliminary reconnaissance of this area in 1977 and 1979 by personnel of the U.S. Bureau of Land Management indicated a substantial nesting population of ferruginous hawks. My study objectives were to investigate the distribution and habitat use of all raptors, with special consideration given to characteristics of nest sites, food habits, productivity and behavior of ferruginous hawks. The field season in 1981 began in

early April and terminated in mid-September and extended from mid-April to mid-August in 1982.

STUDY AREA

The study area was located in the southeastern corner of Montana beginning approximately 21 km (13 mi) south of Ekalaka and continuing in a southerly direction for 24 km (15 mi) (Figure 1). At its greatest east-west width the area spanned 34 km (21 mi), extending roughly from Box Elder Creek on the east to the Chalk Buttes Road on the west. Land ownership of the 492 km^2 (190 mi^2) study area was 84% federal (BLM), 5% state, and 11% private. The private land was largely located along Cabin Creek which traversed the study area from northwest to southeast. Studies were concentrated north of Cabin Creek in an area encompassing the Buffalo, Lone Tree, Dead Boy, and Chito Creek drainages. This segment was approximately 240 km^2, or roughly half of the entire study area.

The study area is located at the north end of a broad relatively flat horseshoe shaped basin. Virtually treeless, this sagebrush-grassland basin is confined on three sides by sandstone buttes and hills that rise approximately 200 m (650 ft) above the surrounding landscape. The basin includes broad gentle drainages which gradually slope up towards narrow, bare shale ridges that finally rise abruptly 15-30 m (50-100 ft) from the surrounding landscape. Although all drainages are ephemeral, occasionally heavy runoff from spring thaws or local thunderstorms has cut and furrowed the steep ridgesides and valley bottoms.

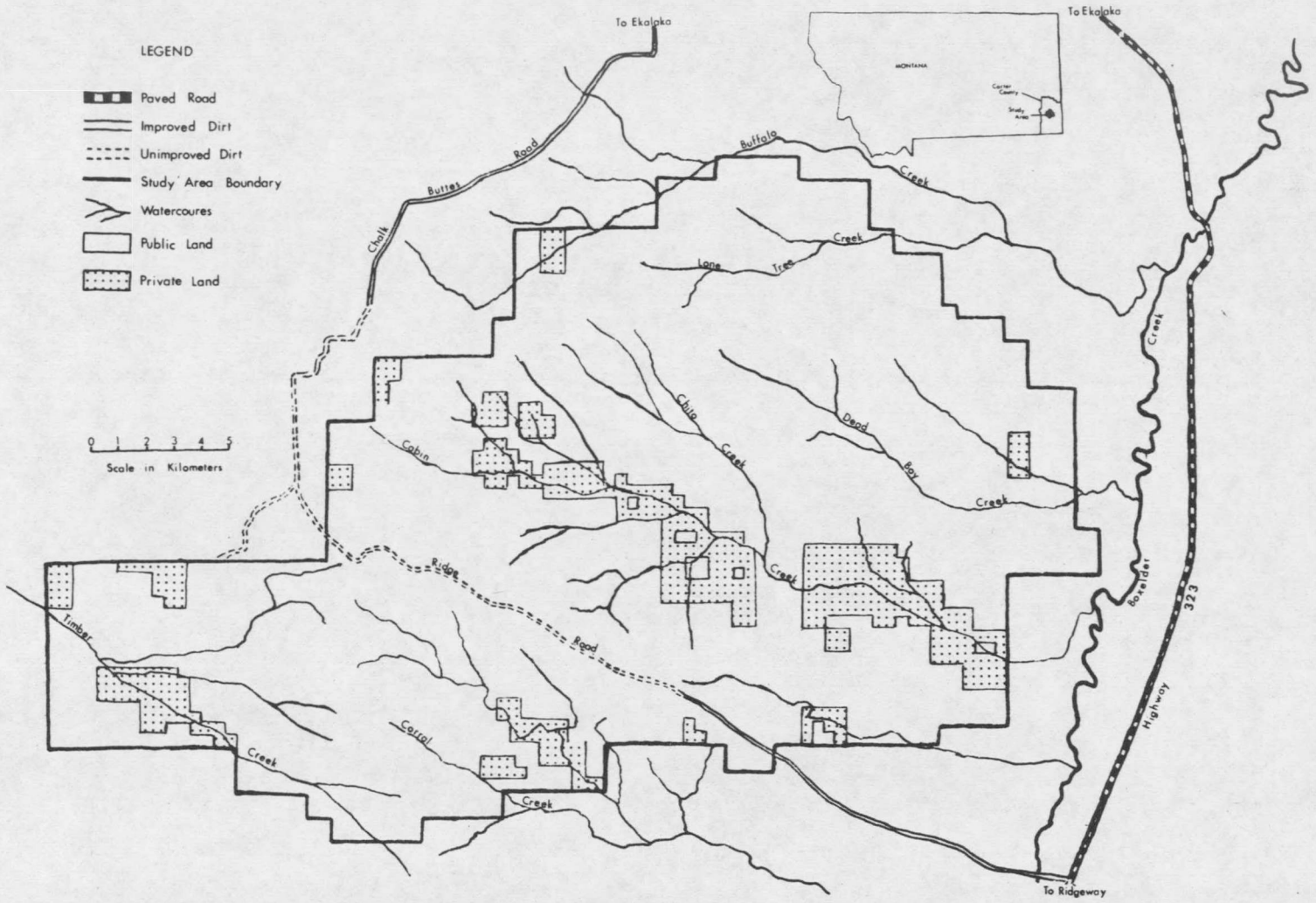

Figure 1. Study area showing land ownership and major drainages.

The lowest elevations on the study area occur in the southeastern corner on Timber Creek (945 m above MSL) and along the eastern perimeter adjacent to Box Elder Creek (975 m). The highest elevations range from 1082 m in the northwest to 1097 m along Ridge Road in the southeast.

Geology and Soils

The study area was part of an inland oscillating sea during the late Cretaceous Period at which time sediments of varying thicknesses accumulated. Interspersed within these sediments were deposited lenses of light colored volcanic ash. Today these ancient sediments result in extensive beds of thick (610-820 m), soft, grey-black Pierre shales with thin lenses of bentonitic material interspersed throughout. Pierre shale consists of 65-80% clay particles and has a sodium rich montmorillonite component (Veseth and Montagne 1980). In areas where ancient seashores occurred, accumulations of sand produced formations known as Fox Hills sandstone (Bauer 1924, Veseth and Montagne 1980, Roger Colton pers. comm.). Pierre shale exerts by far the greatest influence upon the area's soils. The Fox Hills sandstone is associated only with alluvially-colluvially derived soils in the northern reaches of the study area (Bauer 1924).

Inherent in their bentonitic-montmorillonitic mineralogy, soils derived from Pierre shales characteristically have a high shrink-swell potential and high exchangeable sodium percentage. The heavy clay consistency, high sodium content, and low organic content of the soils,

together with the lack of available moisture makes the study area best suited for rangeland with little if any potential for agriculture.

There are no springs on the study area and small accumulations of precipitation slowly percolate into the soil or are evaporated. Large accumulations of precipitation that cannot be absorbed into the soil flow over the ground surface to be caught as surface runoff in depressed areas along drainage ways or accumulate in numerous stock-ponds that dot the landscape.

Climate and Weather

The study area is characterized by wide seasonal and annual fluctuations in temperature and precipitation. Summers are generally hot and short while winters are cold and long. Annually an average of 39 cm (15 in) of precipitation falls on Ekalaka, slightly more than half of which accumulates from May through July (Table 1). Wide spatial and temporal variations in precipitation, characteristic of central Carter County, are a result of orographic differences and the vagaries of localized summer thunderstorms. As a result, the study area probably receives less moisture than Ekalaka and would have moisture and temperatures more similar to Ridgway (Table 1).

July, with a mean temperature of 21.4 C, is the warmest month with temperatures frequently exceeding 38 C. January is the coldest month with an average temperature of -8.1 C. Record high and low temperatures recorded at Ekalaka are 42 C and -42 C (NOAA 1981, 1982).

Prevailing northwesterly winds are a dominant climatic factor throughout the year and are especially strong and frequent in the

Table 1. Monthly precipitation totals in centimeters.

Station	Year	April	May	June	July	August	Yearly
Ekalaka[1]	1980	0.66	7.39	7.52	6.27	4.55	34.65
	1982	3.96	19.61	8.10	3.53	3.56	62.00
	Ave.	3.30	5.72	9.32	4.80	3.81	38.66
Ridgway[1]	1981	0.74	6.65	5.82	3.10	1.55	24.28
	1982	2.06	18.01	8.51	4.45	5.75	55.92
Research station[2]	1981	0.84	5.33	6.55	8.64	--	--
	1982	--	12.57	8.89	6.53	--	--

[1]NOAA recording stations
[2]Collected by the author.

spring. Several consecutive days of high winds are not uncommon and the rolling treeless landscape offers little shelter.

Weather conditions differed between the 1981 and 1982 field seasons. Prior to the spring of 1981, the area had suffered several years of drought. Spring 1981 saw some alleviation but neither the timing nor the amounts of precipitation was sufficient to totally reverse the drought conditions. Localized thunderstorms in the summer of 1981 provided rainfall both in excess and far short of normal levels in different locales on the study area. The area around the field station at the head of Lone Tree Creek received above normal rainfall while areas 8 km distant received little or none.

In the spring of 1982, the weather was unseasonably cold and wet. Several substantial snows fell in late April and precipitation in May greatly exceeded the normal. Previously dry stockponds filled, barren shale ridges became carpeted with rillscale (*Atriplex dioica*) and hillsides became covered with sweetclover (*Melilotis officinalis*). The

summer of 1982 was hot with below-normal precipitation, lacking both the number and the intensity of thunderstorms characteristic of 1981.

Vegetation

The study area can be categorized as a mixed grass prairie with big sagebrush (*Artemisia tridentata*) or greasewood (*Sarcobatus vermiculatus*) communities occurring on alluvial soils of drainageways and in rolling uplands. Big sagebrush was the predominant shrub throughout the area. Greasewood was virtually absent north of Timber Creek. Table 12 lists the dominant plant species found on the study area.

Small clumps of juniper (*Juniperus scopulorum* and *J. horizontalis*) and stunted ponderosa pine (*Pinus ponderosa*) occurred in the steep, narrow canyons of some Timber Creek tributaries. A few large singular cottonwoods (*Populus deltoides*) and mature box elder (*Acer Negundo*) trees were found along some of the major drainages. Groves of these species provided a riparian aspect to private inholdings along Cabin Creek. Spindly willows (*Salix* spp.) lined some water impoundments in the Dead Boy and Lone Tree drainages.

Ground cover on shale ridgetops and adjacent steep slopes was sparse, confined primarily to small widely dispersed clumps of alkali sacaton (*Sporobolus airoides*) and Nuttall saltbrush (*Atriplex nuttallii*). Mats of rillscale covered washes and the swales of steep slopes. Erosion resistant knolls and singular hills that occur on the perimeter of and subtend the ridge systems were often rocky or gravel capped and supported growths of junegrass (*Koelera cristata*),

wheatgrass (*Agropyron* sp.), phlox (*Phlox hoodii*), fringed sagewort (*Artemisia frigida*), cactus (*Opuntia polycantha*) and sagebrush at their apexes. Ground cover on these sites averaged 20-50% and declined rapidly downslope. On the more gentle midslopes, vegetative cover increased and was dominated by a grass-forb complex. On flat areas where erosion has resulted in a braided drainage pattern of islands of topsoil interspersed between hardpan areas, loamy hummocks supported dense growths of big sagebrush with a moss (*Selaginella densa*)-blue gramma (*Bouteloua gracilis*)-green needlegrass (*Stipa viridula*) understory.

Mammals and Birds

Fifteen mammalian species were observed on the study area, 11 of which were considered residents (Table 13). The remaining 4 (striped skunk, longtail weasel, raccoon and beaver) were characteristic of the more mesic habitats along Box Elder Creek and the wooded draws off the study area and thus were considered transients whenever observed on the study area.

Thirty-eight avian species were either regular users of or resident breeders on the study area; at least 12 additional species were transients (Table 14). Five species of dabbling ducks were known to utilize stockponds and sheetwater areas as brood rearing and loafing areas in the spring and 3 species of diving ducks plus Canada geese used deeper stockponds during migration. Eight species of wetland birds bred and/or were commonly sighted. Upland sandpipers were occasionally seen in shortgrass habitats on gently

sloping sidehills of the narrower drainages. Mourning doves were residents of the study area in the spring and summer and were especially prevalent during 1982. Sage grouse were yearlong residents; sharp-tailed grouse, Merriam's turkey, and Hungarian partridge which more commonly are associated with forested, brushy, or agricultural areas were seen in such habitats peripheral to the study area.

Human Impacts

The region is sparesely populated, the 1980 Federal census reporting only 1800 people as residents of Carter County (USDOC 1982). Approximately one third of these reside in Ekalaka. Excluding the residents of Ekalaka, Carter County, which encompasses 8580 km^2 (3313 mi^2), had a population density of roughly one person per 7.41 km^2 (1/2.86 mi^2) in 1980. The economy of the county is dominated by cattle and sheep ranching and small grain farming. In 1974, roughly 73% of the total county landmass was farmland of which 9% was cropland and 91% rangeland. The remaining 17% of the county was largely national forest land (USDOC 1977).

The study area currently is subdivided into grazing allotments managed as five-pasture rest rotation grazing systems. Owing to the inherently poor quality soils and the lack and/or irregular distribution of moisture, the rangelands can support only moderate levels of grazing.

Some small-scale wheat farming and grass-alfalfa hay cropping are practiced on deeded land along Cabin Creek and adjacent to the boundaries of the study area.

Past attempts by the BLM to bolster range condition and rehabilitate frail lands on the area have included extensive diking in low lying areas along Lone Tree and Dead Boy Creeks to retard runoff and increase water infiltration. Most drainages north of Cabin Creek include some areas which have been contour furrowed to impede runoff and break up impervious sodium caps. Several experimental areas have been reseeded to crested wheatgrass (*Agropyron cristatum*) and alfalfa (*Medicago sativa*). Success of these practices has varied.

Drill hole caps and effluent holding ponds attest to past exploratory drilling for gas and oil. The area has no producing wells. Seams of bentonite on the study area are generally too thin and discontinuous to be economically mined and no strippable reserves of coal underlie the area (Roger Colton pers. comm.). Some uranium exploration has occurred in the Long Pine Hills to the east of the study area but large scale recovery has not been attempted.

Recreational activities in the area, including sport hunting and shooting, fossil digging, and dirt biking, have been limited by the area's remoteness from urban centers and the sparse resident population.

METHODS

Initial investigations centered on reconnaissance of the study area to locate as many ferruginous hawk nests as possible. Raptor nests found in 1979 by BLM personnel were relocated. A motorcycle was employed to systematically search potential nest habitat. Helicopter searches supplemented ground searches but were of little value in locating new nests. Nest locations were individually coded and plotted on 1:24000 scale topographic maps. Isolated nests were discovered throughout the course of study.

When a nest was located, the general area and the physiography of the site were described. Measurements included aspect, exposure, elevation and percent slope of the terrain subtending the nest, and long distance exposure (LDE) or the degrees of sight-line from the nest that is unobstructed within a 200 m radius. The elevational rise was measured from the adjacent valley floor to the nest and from the nest to the highest point of land in the vicinity of the nest. I also made linear measurements from the nest to the nearest neighbor nest, road and area of continual human activity.

The material composition, substrate type and linear dimensions of each nest were also recorded.

Nest condition was determined for both years and assigned one of five classes:

New - A nest completely constructed during the present nesting season. Nest appeared haphazardly thrown together with little bulk or accumulated material; the bottom of the nest bowl was directly in contact with the ground.

Remnant - Nest appeared to have been unoccupied for several nesting seasons. Only slight indication of a nest remained; e.g., an accumulation of circularly placed sagebrush sticks at a typical nest location.

Poor - Definite nest, large accumulation of nest material but rather amorphous in structure; extensive rebuilding would be required before nest could be used.

Fair - Nest usable but in disrepair or flat-topped and trampled from use in previous years.

Good - Nest well constructed with a definite nest bowl; showed signs of repair and new material.

Percent ground cover was determined for vegetation within a 5 meter radius of the nest. Measurements employed line transect methods similar to those outlined by Canfield (1941). Four line transects, each 5 meters long, were established at right angles from the nest. Linear intersections of various cover types with these four lines were recorded and converted to a percentage of ground covered. Sagebrush cover adjacent to the nest was measured taking the height of each plant, summing them and deriving an average value.

The habitat in which a nest was located was described within a 100 m radius of each nest by estimating the percent of ground that was covered by grass-forbs, sagebrush or was bare.

Observations of occupied territories began with the sighting of the first ferruginous hawk each spring. Subsequent observations of single or paired birds in the same vicinity and defensive activities by these birds towards intruders were taken as indications of occupied territories. Further observations plus the presence of a hawk or pairs of hawks perched on or in the vicinity of a nest or a hawk in incubating posture on a nest were taken as positive signs of territory occupancy. Nests were considered active if eggs were laid, an adult bird was observed in an incubating posture on a nest, or if young were raised. A nest was considered successful if at least one young fledged. These terms (occupied, active, and successful) are similar to those proposed by Postupalsky (1974) for describing raptor nest status.

Clutch sizes and dates when eggs were first observed were obtained from nests either by helicopter reconnaissance or by finding active nests early in incubation when both adults were absent. Dates of hatching were determined by systematic observation of active nests, noting changes in adult behavior from incubating to brooding and shading. Determination of hatching success was delayed 5 to 10 days post-hatching to minimize exposure of newly hatched chicks that had not gained full thermoregulatory abilities. Active nests were then revisited every 2 to 4 days to observe nestlings, determine the cause of nestling loss and to collect prey remains.

Prey items, prey remains and cast pellets were collected or their presence recorded at nest and perch sites. Feeding debris removed from nests and perches was air dried and stored in glassine bags. Whole prey items and prey remains that could constitute a meal were

recorded as present and left at the nest. Prey remains collected on subsequent visits to a nest were checked against previously collected items to minimize duplication. Where possible, weights and ages of whole or partial prey items were procured. A reference collection of potential prey items was assembled.

Relative densities of white-tailed jackrabbits were compared between the 2 years of study using a series of headlight surveys similar to those described by Flinders and Hansen (1973). Numbers of jackrabbits visible in the headlights of a vehicle were tallied along three 16 km routes driven at speeds of 32-40 km/hr beginning 45 minutes after sundown. Each route was travelled 3 times from mid-April into June.

To survey relative abundance of potential prey species, 15 transects, each 1.6 km long, were established through representative habitats on the study area during the spring of 1982. All surveys were conducted between dawn and 9:00 a.m. Techniques similar to those described by Reid et al. (1966) were used to census pocket gophers and thirteen-lined ground squirrels. I counted the number of active pocket gopher mounds within a 6 m belt and active thirteen-lined ground squirrel burrows within a 3 m belt along the 1.6 km transects. Passerine bird abundance was estimated by making 2 minute stops every 79 m along transects where I tallied individual songs and the actual sightings of passerine birds in a 180° arc ahead of the line of travel.

Small mammal populations were censused with traplines consisting of 25 livetraps spaced at 10 m intervals. From June through

mid-August 10, traplines were set out in representative habitats and monitored for 3 day periods. In 1981, 20 active northern pocket gopher mounds were surveyed and measurements made of physiography, slope and aspect.

Individuals of a nesting pair of ferruginous hawks could be sexed and distinguished from each other on the basis of the size and the degree of melanism. During visits to specific nests, the behavior and habits of both sexes of a mated pair were differentiated and noted with respect to the stage of nesting.

Prior to fledging, juvenile ferruginous hawks were banded with USFWS lock-tight leg bands. Two fledglings from 2 different nests in 1982 were outfitted with backpack radios (Dunstan 1972) and tracked up to 4.5 weeks postfledging to observe their daily activity patterns, the progression of their range expansion, and their habitat usage.

Records on the observations of all raptors encountered on or in the vicinity of the study area included the time of day, date, location and activity of each bird sighted. The occurrence and nature of interspecific raptor interactions was also noted.

The effects of human intrusion and disturbance on nesting birds were quantified by recording a bird's reaction, flushing distance and any aftermath effects of human-raptor interactions in relation to the stage of nesting.

Unless specifically noted, all statistical analyses herein reported are two-tailed t-tests (Snedecor and Cochran 1980). Tests were considered significant at $P<0.05$.

RESULTS AND DISCUSSION

Nest Site Locations and Characteristics

Ninety-one ferruginous hawk nests were located during the study representing an estimated 95% of all nests present on the study area (Figure 2 and Table 11). Four-fifths of these were considered supernumerary (Weston 1969, Fitzner et al. 1977), while the remaining one-fifth were within single nest territories. Where two or more nests occurred within a single territory, only one was used for incubation and brooding purposes; the others (supernumerary nests) may be refurbished and/or utilized as feeding and loafing perches. Supernumerary nest complexes on the study area included up to 6 nests, with groups of 3 being the most common.

In 3 years of observation, the number of territories occupied ranged from 11 to 13. During this time no individual nest was active and successful more than 1 nesting season. Seven nest territories were occupied 2 out of 3 seasons and 1 all 3 years. Supernumerary nests were occupied in the same ratio as their occurrence on the study area.

The mean observed distance between all nests (Clark and Evans 1954) was 0.634 km or about half the distance expected if nests were randomly located ($R=0.54$, $P<0.001$). "R" value equals the ratio of observed to expected distance as a measure of distance from randomness. Nests tend to be aggregated in hilly areas; only 5 nests were located in areas with less than 15% slope (Figure 3).

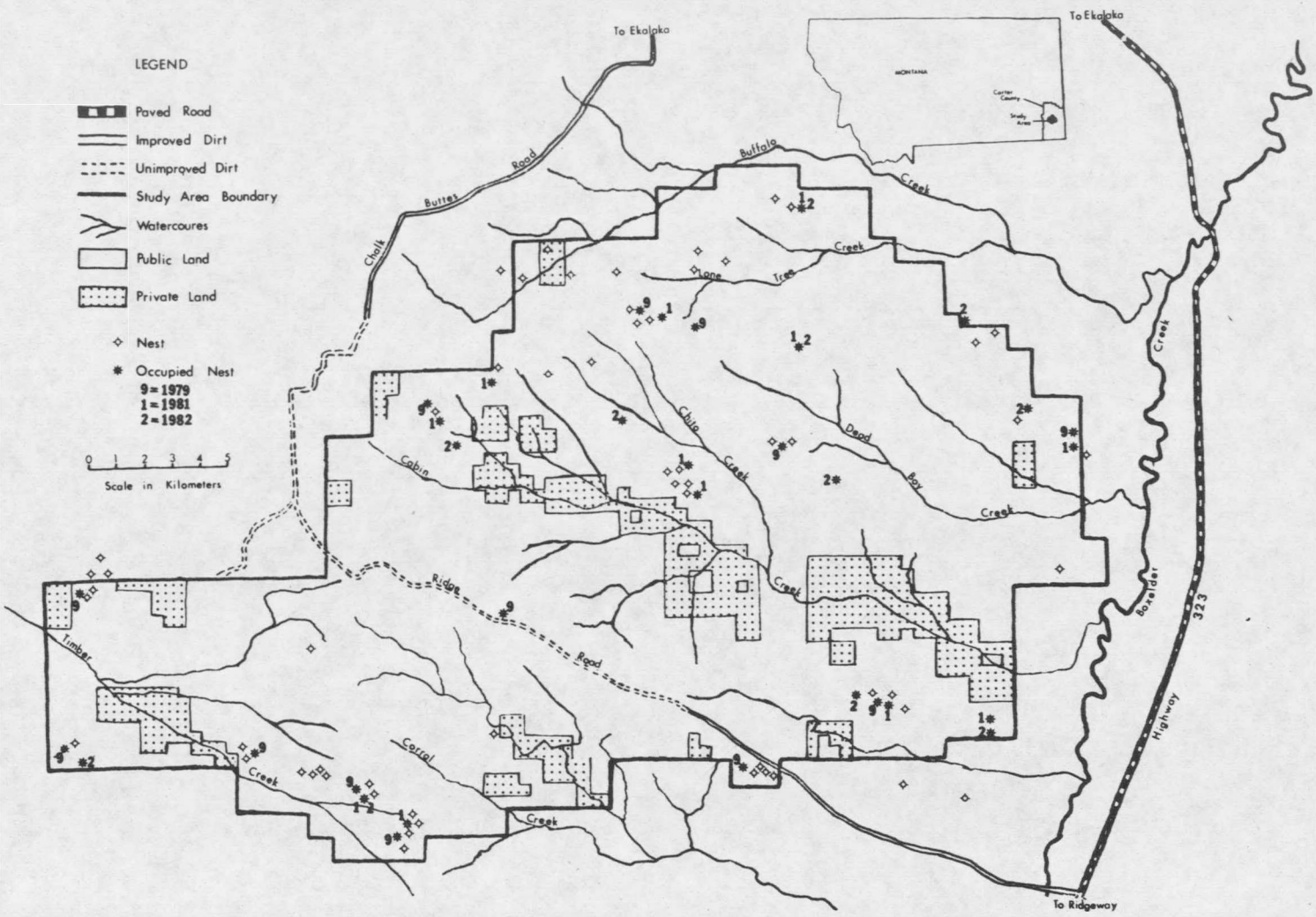

Figure 2. Study area in southeastern Montana showing locations and activity status of ferruginous hawk nests, 1979, 1981, and 1982.

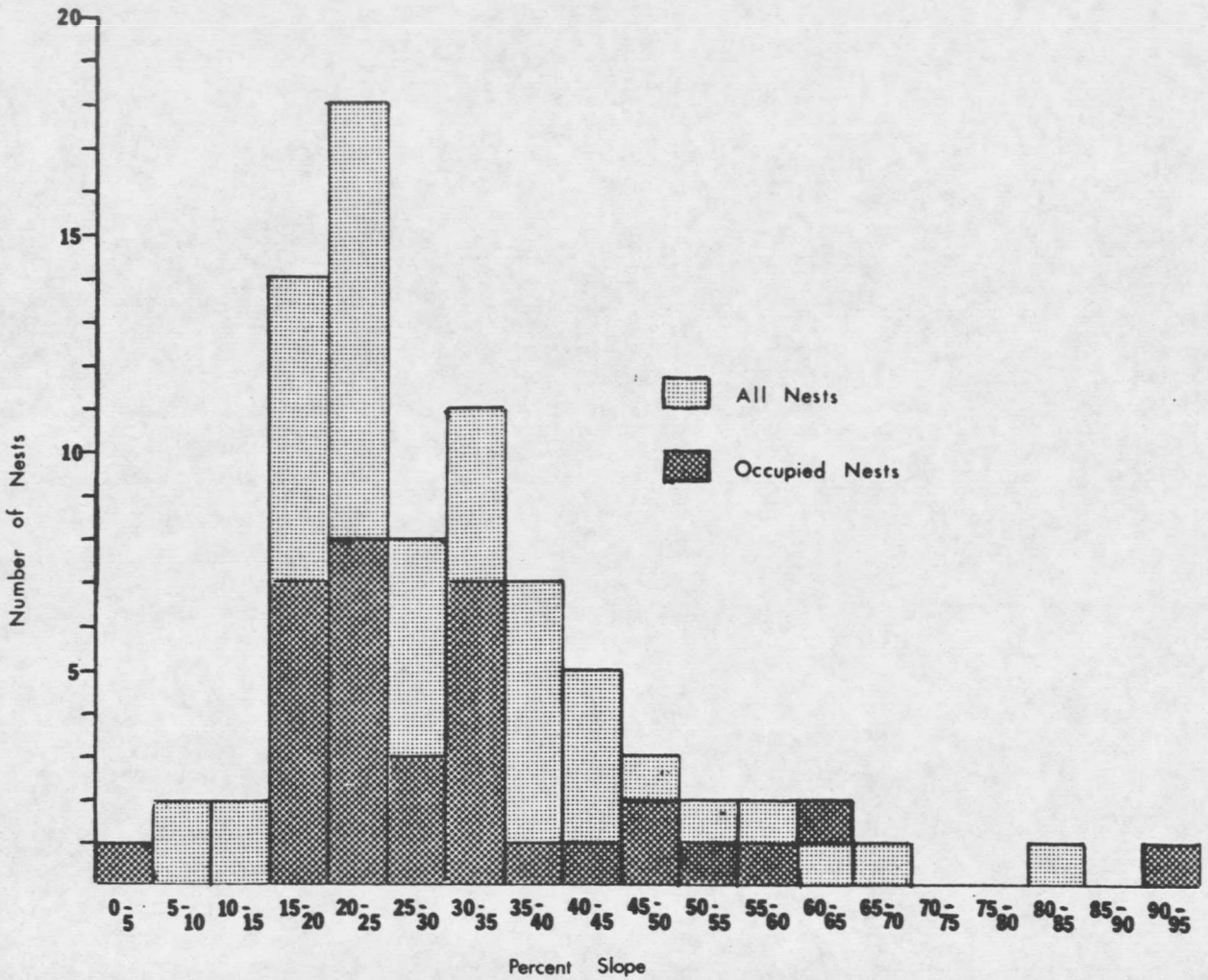

Figure 3. Distribution of ferruginous hawk nests in relation to slope of terrain, 1979, 1981, and 1982.

Several aspects of nest density are presented in Table 2. Crude densities were based on the entire 492 km^2 study area while ecological densities relate to only the 202 km^2 of the study area that was hilly and thus considered suitable nesting habitat. I had difficulty classifying several nests into supernumerary or singular nest categories. If considered supernumerary, densities and the number of territories would decrease.

Table 2. Crude and ecological density for all nests, maximum possible nest territories and occupied nests on the study area, 1979, 1981 and 1982.

	Crude density		Ecological density	
	km^2/nest	mi^2/nest	km^2/nest	mi^2/nest
Individual nests (N=91)	5.41	2.09	2.22	0.86
Maximum possible nest territories (N=37-42)	11.71-13.3	4.52-5.14	4.80-5.45	1.85-211
1979 occupied nests (N=13)	37.85	14.62	15.52	5.99
1981 occupied nests (N=12)	41.00	15.83	16.81	6.49
1982 occupied nests (N=11)	44.73	17.27	18.34	7.08

Crude densities derived for occupied nests on this study area were similar to those noted by Weston (1969) in central Utah and by Howard and Wolfe (1976) in northern Utah. Blair (1978) found a much lower density for ground nesting ferruginous hawks in northwestern South Dakota roughly 60 km due east of my study area. On that area, crude density ranged from 292-412 km^2 per pair and ecological density ranged from 99-104 km^2/pair.

Distinct differences became apparent when several characteristics of all 91 nests were compared to similar features for 99 randomly selected points. Nests were located an average of 4060 m (range= 112-11220 m, SD=2798 m) from roadways where traffic was greater than 3 vehicles per week. In comparison, random points averaged 1366 m closer to such roads ($P<0.001$).

When the slope of terrain on which nests were located was related to comparable data from random points, highly significant differences were revealed ($P<0.001$). The slope at nest sites averaged 21.3% compared to 6.1% at random points.

A preference for direction appeared to be associated with nest site selection (Table 3). Eighty-two percent of all nests had aspects directed within a 180° arc from 225° SW through 0° N to 45° NE. When nest aspect was compared to the aspects at random points and to an even distribution of aspects at all 8 compass points, active choice and preference for certain aspects was indicated ($x^2=29.44$, df=7, $P<0.005$; $x^2=19.64$, df=7, $P<0.01$, respectively). Other researchers (Weston 1969, Lokemoen and Duebbert 1976, Lardy 1980, Smith and Murphy 1982, Gilmer and Stewart 1983, Woffinden and Murphy 1983) have indicated that nesting ferruginous hawks have preferential and often quite specific slope aspects to their nests.

Areas of continual human activity and habitation were, in general, located peripheral to the study area and thus had little direct influence upon nest site selection. No significant statistical differences were found between the distance that nests and

Table 3. Orientation of all nests located on the study area.

Direction of orientation	All nests		Occupied nests	
	N	%	N	%
North	14	15.4	8	22.2
Northeast	12	13.2	6	16.7
East	2	2.2	0	0
Southeast	6	6.6	1	2.8
South	8	8.8	2	5.6
Southwest	22	24.2	9	25.0
West	13	14.3	4	11.1
Northwest	14	15.4	6	16.7
Total	91		36	

statistical differences were found between the distance that nests and random points were located from these areas. Nests averaged 5100 m (range=122-11220 m, SD=2657 m) from areas of human habitation and activity while random points averaged 4995 m.

All nests were located on some discontinuity of landform (Table 4); 88 nests were on the ground and 3 were located atop rock chimneys that rose 1-2 m above the surrounding terrain. Selection for nest site was indicated from comparisons of actual locations with random points and an even distribution of nests at the 8 described locales (x^2=78.59, df=7, P<0.005; x^2=26.59, df=7, P<0.005, respectively). Nest placement at a particular physiographic locale appears to be an active process in nest site selection.

The preferred topography for nest sites appeared to be the ends of side-ridges and knobs on ridgetops. Conversely, the least preferred seemed to be long, slight rises and midslope positions. The

Table 4. Physiographic location of nests located on the study area.

Physiographic location	All nests		Occupied nests	
	N	%	N	%
End of side-ridge	24	26.7	9	25.0
Knob on ridgetop	16	17.8	7	19.4
Lone knoll at basin head	9	10.0	6	16.7
Lone knoll subtending ridge	11	12.2	5	13.9
Lone hilltop	12	13.3	3	8.3
Long, slight rise	7	7.8	3	8.3
Rock chimney	3	3.3	2	5.6
Mid slope	8	8.9	1	2.8
Total	90		36	

paucity of nests on rock chimneys can probably be attributed to the lack of such structures on the study area.

Nest sites were easily accessible from at least 3 and often 4 sides. The 4 slopes radiating away from the nest were downhill at all but 14 nests. At these nests, the slope opposite the direction of nest aspect often was directed uphill at a 1-17% slope (mean=9.4%, SD=5.5%). At 3 of these nests, 2 slopes were directed uphill. During the 3 years of study, 9 nests with uphill slopes were occupied.

Several differences were detected between nests occupied at least once and those that showed no use during the 3 years of observation. Although the difference was not significant (P=0.103), occupied nests tended to be located at higher elevations than unoccupied nests relative to the next highest point of land. Occupied nests averaged 4.1 m lower than the highest point while unoccupied nests averaged 5.9 m lower.

Also, though not statistically significant, occupied nests tended to be located higher above valley floors than unoccupied nests. Occupied nests averaged 12.6 m (SD=6.4 m) above adjacent valley floors while unoccupied nests averaged 10.5 m (SD=6.3 m).

Long distance exposure (LDE) was greater (P=0.014) for occupied than for unoccupied nests. LDE for occupied nests averaged 231.6° (SD=100°) while unoccupied nests averaged 169.8° (SD=105.7°). At physiographic locales with low LDE (ends of side-ridges and midslope positions), occupied nests had anywhere from 33-97° more LDE than their unoccupied counterparts. Locations with greater LDE (lone hilltops and knobs on ridgetops) showed little difference between occupied and unoccupied nests.

Occupied nests were located an average of 4164 m (SD=2710 m) from major roads and 5210 m (SD=2660 m) from areas of human activity. Unoccupied nests averaged 160 m closer to such features. These differences were not statistically significant.

Distance to nearest neighbor nest, distance to nearest occupied nest, LDE, height above valley, distance to roads and distance to areas of human activity for occupied nests are presented in Table 5. The average distance between occupied nests and their nearest neighbor nest in 1981 was significantly less than in 1982 (P=0.023). This suggested that in 1981 nesting hawks may have chosen territories that encompassed a larger area (e.g., nests within a territory were located further apart).

The average distance between occupied nests in 1981 was significantly less than comparable data gathered in 1979 or 1982 (P=0.039). This occurred with no substantial increase in population density.

Table 5. A summary of nest site parameters for ferruginous hawk nests occupied during 1979, 1981, and 1982 in southeastern Montana.

Year	Nearest neighbor nest (meters)				Nearest occupied nest (meters)				LDE (degrees)		Height above valley (meters)		Dist. to road (m)		Dist. to human (m)	
	mean	min.	max.	SD	mean	min.	max.	SD	mean	SD	mean	SD	mean	SD	mean	SD
1979	808	91	4175	1071	5420	1935	10210	2870	220	114	13.7	7.0	4250	2677	5360	3054
1981	449	109	1119	279	3418	1076	5020	2373	241	89	11.2	5.5	4315	2732	4717	2592
1982	956	182	2316	602	5460	3657	9394	2034	235	100	13.7	5.9	3905	2598	5384	2406

Minor differences, none of which were statistically significant, were noted between years in LDE, heights above valley floors and distance to roads and/or areas of human activity. Slope of terrain and height of occupied nests relative to the highest point of land were similar in all 3 years.

Relationships between nest characteristics and nest condition were examined to detect any differences between recently utilized nests and those left unused for several years (remnant nests). Remnant nests were located an average of 840 m from nearest neighbor nests while all other nests were located approximately 300 m closer. This suggested that remnant nests were more likely to be singular rather than part of a supernumerary complex. Also, remnant nests were found at significantly different physiographic locations than would be expected (x^2=16.08, df=7, P<0.025). Fewer remnant nests than expected were found on the ends of side-ridges and knolls at basin heads, while more than expected were found on knobs on ridgetops and lone hilltops. Remnant nests tended to be located 600 m closer to major roads than all other nests, but this difference was not significant. Remnant and newer nests were similar with respect to LDE, nest orientation, slope of terrain, height above valley and elevational difference from the highest point.

Study area vegetation varied greatly between 1981 and 1982. Measurements of vegetation within a 100 m radius around 53 nests in 1981 showed the average grass-forb cover as 50.8%, sagebrush 21.0%, and bare ground 31.5%. Measurements around 78 nests in 1982 showed average cover to be 64.6% grass-forb cover, 19.0% sagebrush, and 16.0%

bare ground. The differences in grass-forb cover and bare ground between the 2 years were highly significant ($P<0.001$ for both) while the difference in sagebrush cover was not.

Grass-forb cover around occupied nests averaged 46.8 and 64.1% in 1981 and 1982, respectively. This difference was significant ($P<0.05$). Nests chosen for occupancy in 1982 averaged 7.3% less sagebrush cover than the 25.2% noted around nests in 1981. The amount of bare ground cover decreased from 32.7% in 1981 to 17.5% in 1982. The differences in sagebrush and bare ground were not significant. The differences in grass-forb and bare ground cover probably were an artifact of weather variation between the 2 years, whereas the difference in sagebrush cover was probably real. When all nests were considered, sagebrush cover differences between the two years were small (2.0%) while differences between occupied nests were more measurable.

Vegetative trends within a 5 m radius of the nest were similar to those noted within the larger 100 m radius. At 48 nests where vegetation was measured in both years, average grass-forb cover increased from 26.0% in 1981 to 42.5% in 1982. Bare ground decreased from 60.9 to 46.5% and sagebrush increased from 15.5% to 15.9% between 1981 and 1982. The annual changes in grass-forb and bare ground were significant ($P<0.001$), changes in sagebrush were not.

In spite of the 16.5% increase in grass-forb cover at all nest sites from 1981 to 1982, occupied nests had similar grass-forb cover each year, 32.7 and 36.8%, respectively. Also, though sagebrush cover at all nest sites increased 0.4%, the amount of sagebrush at occupied nests declined from 19.1% in 1981 to 13.4% in 1982.

Shrub height was measured immediately adjacent to 21 nests at which shrubs occurred. Skunkbush sumac (*Rhus trilobata*) was the dominant shrub at one site; the remaining 20 sites were dominated by big sagebrush. Shrubs obstructed view from the nest at 9 of the 21 nests, 7 of which were occupied. Shrub height averaged 19 cm (SD= 7.7 cm) at the 21 nests and 21 cm (SD=6.7 cm) at the 9 obstructed nests. At 4 of the obstructed nests, shrubs were 1-14 cm ($\bar{X}$=7 cm, SD=7.16 cm) taller than the highest side of the nest; 3 of these were occupied. At the 9 obstructed nests, shrub vegetation ranged from 2-22 cm ($\bar{X}$=10 cm, SD=6.9 cm) taller than the lowest side of the nest; 6 of these were occupied.

Nests were primarily constructed of dead sagebrush, greasewood or green rabbitbrush branches. Ungulate bones, antlers and lumber scraps were occasionally incorporated into the nest. Nest bowls were lined with grass culms and clumps and cow chips while in several bowls were found bits of paper, plastic and deer hide.

Morphologically, nests consisted of 3 parts: a base, the main nest, and a bowl. The base portion was relatively flat and sprawling, averaging 124 X 140 cm (SD=33.0 X 33.5 cm) across. The main nest was circular, of more distinct dimensions and showed a vertical buildup of material. Main nests averaged 94 X 105 cm (SD=23.6 X 22.6 cm) across, 30 cm (SD=16.0 cm) tall on their high side and 20 cm (SD=11.4 cm) on their low side. Nest bowls averaged 35 X 39 cm (SD=9.1 X 9.6 cm) across and 6.1 cm (SD=5.5 cm) deep. Nest bowls as deep as 15 cm at the initiation of incubation were trampled flat by the end of the nestling period.

Nest refurbishing involved reconstructing a bowl on a flattened main nest. At 2 nests completely new main nests were constructed on top of older nests. These "double" nests rose to 71 cm. At several sites remnant nests were adjacent to better structured nests that had a different aspect. Nests on the study area were generally broader and lower in stature than those ground nests described by other investigators (Weston 1969, Lokemoen and Duebbert 1976, Fitzner et al. 1977).

Reproduction

Adult ferruginous hawks were present on the study area at the initiation of each field season in early April. Their date of arrival probably corresponded with the late March arrival reported by Blair and Schitoskey (1982) for ferruginous hawks in northwestern South Dakota. Eggs were first observed early in the third week of April in 1981 and at the end of April in 1982. In 1981 hatching peaked the first week in June; in 1982 incubation was protracted 10 days and hatching occurred approximately June 15th. Fledging occurred in early July, 1981 and mid-July in 1982. Adults and juveniles were regularly observed on the area in late August and probably remained past this time. The lateness of the initiation of egg laying and the extension of the incubation period noted in 1982 was probably a result of the relatively cool, wet spring (Table 1).

The number of occupied nests observed on the study area declined slightly from 1979 to 1981 and 1982. BLM raptor files indicated 13 occupied ferruginous hawk nests were present on the study area in

1979, compared with 12 and 11 in 1981 and 1982, respectively. It is possible that more than 13 nests were occupied in 1979 as data were gathered late in the nesting season after some earlier occupied territories may have been abandoned. Nest locations recorded in 1979 represented 49% of the number of nests located through 1982.

In 1981, 83% of the pairs initially occupying territories remained to egg laying stage (Table 6); in 1982, 73% remained. One territory in 1981 and 2 in 1982 were occupied by paired ferruginous hawks early in the season but vacated before eggs were laid. One nest, in both years, was occupied for several weeks early in the season; but no effort was made either year to refurbish the nest or lay eggs. In 1982, one additional nest was refurbished but vacated before eggs were laid. Here, the pair continued to defend the area for several weeks after other pairs had begun incubation.

During each of the 2 years, 1 territory was occupied and maintained by unpaired birds throughout the nesting period. In neither case was any effort made to construct or refurbish a nest. The territory occupied by a single bird in 1981 was occupied by a pair in 1982 and a chick was fledged. The unpaired bird occupying a territory in 1982 was joined late in the nest season by another ferruginous hawk and both exerted defensive postures around the nest after chicks from other nests had fledged and normal parental nest defense had waned.

In 1981, 2 hastily constructed nests were found to contain single, infertile eggs. Although single ferruginous hawks were observed perched in the vicinity of both nests, incubation posture

Table 6. Productivity data for occupied territories and active nests of ferruginous hawks in southeastern Montana, 1981 and 1982.

		1981	1982
I)	Nests		
	Total occupied territories	12	11
	Territories abandoned pre-laying	1	2
	Territories occupied but no eggs laid	1	1
	Total nests with eggs laid	10	8
	"Laid" nests abandoned pre-incubation	2	0
	"Laid" nests abandoned or destroyed during incubation	2	1
	Total nests hatching	6	7
	Nests abandoned pre-fledging	3	4
	Total nests fledging (successful nests)	3	3
II)	Eggs*		
	Total eggs laid*	26	19
	Total eggs incubated*	24	19
	Eggs lost pre-hatching	7	2
	Infertile eggs	3	1
	Infertile eggs brought to term	1	1
	Total hatchlings*	16	16
	Hatchling lost pre-fledging*	11	11
	Total fledglings	5	5
	Fledglings dying	1	2
	Possible recruitment	4	3
Statistics			
	% nests w/clutch that hatched	75.0	87.5
	% of occupied nests successful	25.0	27.3
	Average clutch size**	2.78	2.57
	Average hatch (of nests that hatched)**	3.00	2.50
	Average fledge per successful nest**	1.67	1.67
	Eggs per occupied territory*	2.17	1.73
	Hatchlings per occupied territory*	1.33	1.45
	Fledglings per occupied territory	0.42	0.45
	Percent of eggs laid that hatched*	62	84
	Percent of eggs laid that fledged	19	26
	Percent of eggs hatched that fledged	31	31

*Numbers represent minimal values, 1 nest each year disrupted before counts could be made

**From nests with known clutch size

was not observed nor was the nest defended. These eggs were probably laid by subadult hawks. In 1982, one of these nests was reoccupied and 2 chicks fledged.

In 1981, all clutches (except the aforementioned nests with single infertile eggs) contained either 3 or 4 eggs. Omitting the 2 single egg nests, the average clutch size was 3.29. In 1982, all clutches comprised either 2 or 3 eggs and averaged 2.57. Three egg clutches predominated in both years, and the 2 year average clutch size was 2.69 eggs per active nest.

Smith and Murphy (1978) found average clutch sizes of 2.5 and 2.9 for 1967 and 1970, respectively, in central Utah. Their 4 year (1967-1970) average clutch size was 3.2 with a high of 3.8 in 1969. The 2 years of lowest average clutch size were those when the number of breeding pairs was the lowest and nest desertion and failure were highest. Olendorff (1973) reported an average clutch size of 2.5 in northeastern Colorado during 1970, a year when nest success was poor and clutch size adversely affected by cool, wet spring weather; the 3-year average clutch size for that area was 3.14. Woffinden and Murphy (1977) reported minimum clutch sizes of 2.1 and 2.4 in north-central Utah during 1973 and 1974, years characterized by low prey numbers. They stated that 1 and 2 egg clutches were prevalent in areas of low prey numbers and that average clutch sizes were larger in years of high jackrabbit numbers.

Caution should be exercised in making direct comparisons of clutch sizes between my study and those cited above as clutch size data are not directly comparable. Gilmer and Stewart (1983) found

clutches of ground nesting ferruginous hawks to be slightly larger (0.5 egg/clutch) than clutches in elevated nests. Nearly all (97%) of the nests on my study area were ground nests. In contrast, Smith and Murphy (1978) reported only 19.4% ground nests. Average clutch sizes for ground nesting ferruginous hawks in northwestern South Dakota were 3.4 (1976) and 3.3 (1977) (Blair 1978). Ground nesting hawks in east-central Oregon averaged 3.2 eggs per clutch (Lardy 1980). Nest success exceeded 72% during both of those studies.

The percentage of nests which hatched eggs during my study was more than double the 33% reported by Lokemoen and Duebbert (1976) for ground nesting hawks in South Dakota. I compared productivity parameters between my study and 2 other studies in which similar average clutch sizes were observed (Table 7). My data indicated a greater number of chicks hatched per nest and a comparable number of fledglings per successful nest. Discrepancies are apparent in the number fledged per nest attempt and the percentages of nests that successfully fledged at least 1 chick. In both cases, values from my study were lower. Individual nest success in southeastern Montana was at least comparable to that found in Utah and Colorado during years of similar clutch size but nest failure, desertion and hatchling mortality were greater. The percent nest success reported in this study is the lowest yet reported in the literature.

In 1981, the greatest loss of eggs resulted from nest desertion precipitated by human disturbance at the nest site while predation was the major cause of nestling loss (Table 8). In 1982, predation was the major cause of egg loss while sibling fratricide (and

Table 7. Productivity data for ferruginous hawks nesting in southeastern Montana, central Utah, and northeastern Colorado. (Similar average clutch sizes.)

Area	Year	Eggs hatched per nest where eggs were laid	Young fledged per successful nest	Young fledged per nest attempt	% nests successful
Montana[1]	1981	1.60	1.67	0.30	25
	1982	2.00	1.67	0.38	27
Utah[2]	1967	1.30	1.20	0.80	67
	1970	1.00	1.40	0.70	54
Colorado[3]	1970	1.22	1.83	1.22	67

[1]Present study

[2]Smith and Murphy, 1978

[3]Olendorff, 1973

Table 8. Egg and nestling losses of ferruginous hawks nesting in southeastern Montana, 1981 and 1982.

	1981	Total % eggs	Total % loss	1982	Total % eggs	Total % loss
Pre hatching						
nests abandoned - human caused	2			0		
eggs lost - human caused	7	26.9	33.3	0		
nests abandoned - predator	0			1		
eggs lost - predator	0			2	11.1	12.5
nests - subadult abandonment	2			0		
eggs lost - subadult abandonment	2	8.0[1]	9.5[1]	0		
infertile eggs	3	12.0	14.3	1	5.6	6.3
Post hatching						
nests abandoned - human caused	0			1		
hatchlings lost - human caused	0			2	11.1	12.5
nests abandoned - predator caused	3			1		
hatchlings lost - predator caused	9	32.0[2]	38.1[2]	1	5.6[2]	6.3[2]
nests abandoned - cause unknown	0			1		
hatchlings lost - cause unknown	0			2	11.1	12.5
hatchlings lost - fratricide	2	8.0	9.5	6	33.3	37.5
Post fledging						
fledglings lost - fratricide	0			1	5.6	6.3
fledglings lost - predator	1	4.0	4.8	1	5.6	6.3

[1] Eggs infertile, also tallied under infertile eggs

[2] One nest disrupted each year before counts could be ascertained, values given are minimal values

related losses due to starvation and exposure) was implicated in the majority of hatchling loss. Fratricide and predation accounted for 43.8 and 25.1%, respectively, of the total progeny loss in 1982.

Two major periods of predation were identified, one during the week following hatching and the other in the week preceding and following fledging. Isolated cases of predation occurred throughout the nesting period. The predators responsible were not ascertained but badger, red fox and golden eagle were suspect.

The peak of hatchling loss due to fratricide occurred approximately 2-3 weeks posthatching in 1981 and 1 week earlier in 1982. In 1982, a second minor peak occurred just prior to fledging. A casting from an adult hawk suggested that hatchling carcasses were cannibalized.

In 5 of 10 cases of nestling mortality resulting from fratricide, there was evidence to indicate that prior to offspring death the adult male had abandoned the nest and left the female to feed and fend the progeny. In one instance of abandonment, an adult male left approximately one-third through the nestling period followed by the female 10 days later, leaving 1 chick dead from exposure and the other near death. The live chick was transferred to a surrogate nest where 3 chicks had hatched but 1 disappeared 2 weeks after hatching. The orphan chick was accepted at the surrogate nest and within 6 days had usurped the smallest original chick's position in the peck and feeding order. The latter died shortly thereafter presumably from starvation and injury inflicted upon it by its nest mates. In the 2 weeks prior to fledging the adult male of this surrogate nest abandoned the nest, leaving

only the female to care for the young. Within 5 days of the time the male was last seen, the orphan chick was found dead at the nest, presumably dying from exposure and/or malnutrition, leaving only 1 chick to fledge.

In another unique case of hatchling loss, a fully feathered chick approaching fledging died at the nest several days after its siblings had moved from the nest and were being fed by the adults at a perch site approximately 20 m from the nest. The dead chick showed no sign of abuse and appeared to have simply failed to leave the nest when its nest mates did and died of exposure and/or starvation while waiting for adults to bring food.

A 30% loss of juveniles occurred within 2 weeks postfledging. Two losses were attributed to predation and one to fratricide. The carcass of one predator loss, a radioed juvenile, was found 180 m from the nest. It had been plucked at the base of a greasewood bush, where presumably it was perched when killed. Other remains from which a leg and breast muscles had been removed were found 6 m away near the den of a badger which was presumed to have been the predator.

In the fratricide loss, the unmolested carcass was found 40 m from the nest. This juvenile was a sibling of the fully feathered chick that was found dead at the nest after presumably failing to move to a feeding perch at the time its nest mates did. Apparently both of these chicks failed to make critical shifts in feeding behavior with exposure or starvation the result.

Food Habits

A total of 149 prey items and 131 pellets were collected from 14 active nests and associated perch sites. Identified from this collection were 504 individuals, representing 8 mammalian and 11 avian prey species (Table 9). In 1981, 3 mammalian and 1 avian species occurred regularly in collected debris; an additional 2 mammalian and 5 avian species were common in 1982.

Glading et al. (1943) found pellets cast by hawks to be unreliable quantitative and questionable qualitative indicators of food habits. The osseous structures of passerine birds and mice are small, delicate, easily digested and less apt to accumulate in a casting than the heavier bones of larger mammals such as the white-tailed jackrabbit, northern pocket gopher, and thirteen-lined ground squirrel. Prey specimens in the former category tend to be underestimated relative to the latter. The effects of this bias on the tally of small mammals and passerines may not be as great as sometimes stated because the lack of osseous remains may be counterbalanced by the presence of hair and feathers in cast pellets.

Remains of small mammal carcasses were conspicuously absent at nests and perch sites. The only evidence of small mammals as prey occurred in cast pellets. This may introduce slight additional underestimation of the numbers of small mammals preyed upon. The lack of remains at nests could result from hawks taking small mammals opportunistically rather than from active search. Also, small mammals may be immediately injested and not carried back to the nest. In terms

Table 9. Prey items collected at ferruginous hawk nests and perch sites in southeastern Montana, 1981 and 1982.

Species	1981 N	1981 %	1982 N	1982 %	Total N	Total %
Mammals						
White-tailed jackrabbit (*Lepus townsendii*)	32	19.3	91	26.9	123	24.4
Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)	29	17.5	35	10.4	64	12.7
Northern pocket gopher (*Thomomys talpoides*)	41	24.7	18	5.3	59	11.7
Sagebrush vole (*Lagurus curtatus*)	0	0	16	4.7	16	3.2
Deer mouse (*Peromyscus maniculatus*)	1	0.6	5	1.5	6	1.2
Northern grasshopper mouse (*Onychomys leucogaster*)	1	0.6	1	0.3	2	0.4
Black-tailed prairie dog (*Cynomys ludovicianus*)	0	0	1	0.3	1	0.2
Bat (*Myotis* sp.)	0	0	1	0.3	1	0.2
Unidentified small mammals	8	4.8	14	4.1	22	4.4
Total mammals	112	67.5	182	53.8	294	58.3
Birds						
Western meadowlark (*Sturnella neglecta*)	35	21.1	57	16.9	92	18.3
Sage grouse (*Centrocercus urophasianus*)	2	1.2	11	3.2	13	2.6
Horned lark (*Eremophila alpestris*)	0	0	13	3.8	13	2.6
Lark bunting (*Calamospiza melanocorys*)	1	0.6	4	1.2	5	1.0
Mallard (*Anas platyrhynchos*)	0	0	5	1.5	5	1.0
Blue-winged teal (*Anas discors*)	0	0	3	0.9	3	0.6
Brewer's sparrow (*Spizella breweri*)	1	0.6	1	0.3	2	0.4

Table 9. Continued.

Species	1981 N	1981 %	1982 N	1982 %	Total N	Total %
Birds (Continued)						
Short-eared owl (*Asio flammeus*)	0	0	2	0.6	2	0.4
Mourning dove (*Zenaidura macroura*)	0	0	1	0.3	1	0.2
Wilson's phalarope (*Steganopus tricolor*)	0	0	1	0.3	1	0.2
Ferruginous hawk (*Buteo regalis*)	1	0.6	0	0	1	0.2
Unidentified passerines	12	7.3	33	9.8	45	8.9
Unidentified Anatidae	0	0	9	2.7	9	1.8
Other unidentified birds	2	1.2	16	4.7	18	3.6
Total birds	54	32.5	156	46.1	210	41.7
Total prey items	166		338		504	

of biomass, small mammals appeared to represent only a trace fraction of the total hawk diet.

White-tailed jackrabbits, which constituted 41.8% of the total mammalian prey frequency, represented the greatest source of prey biomass for nesting hawks. About 75% (N=49) of the jackrabbit remains on which age determination could be made (Bear 1966, Woffinden and Murphy 1982) were from individuals less than 1 month old and 6% were from individuals older than 4 months (adults). Woffinden and Murphy (1977) found that 44% of the black-tailed jackrabbits (*Lepus californicus*) taken by ferruginous hawks in westcentral Utah were 2-6 weeks old while only 10% were greater than 13 weeks old.

A definite shift in mammalian prey frequency was apparent between the 2 years (Table 9). Thirteen-lined ground squirrels and northern pocket gophers collectively represented 62.5% of the mammalian prey frequency in 1981 but declined to 29.1% frequency in 1982. The bulk of this change can be attributed to the decline in the number and frequency of use of the northern pocket gopher. Conversely sagebrush voles, white-tailed jackrabbits and deer mice prey numbers showed increased use in 1982. These yearly trends may indicate changes in prey population densities and/or the vulnerability of prey to foraging hawks. Such interpretations, however, are confounded by the apparent tendency of ferruginous hawks to be locally opportunistic in exploiting available prey. The bulk of northern pocket gopher remains in 1981 were recovered from 2 nests; birds at the remaining nests showed little utilization of this species. The increased use of sagebrush voles in 1982 was apparent at all active nests.

Passerine birds accounted for 90.7% of the total avian component in 1981 and 69.2% in 1982 (Table 9). Western meadowlarks were the most frequently taken avian species, comprising 82.1% of all identified passerines, 57.9% of all passerines and 43.8% of all birds taken as prey. The frequency of western meadowlark remains exceeded the combined frequency of all other avian prey identified to species.

Juveniles represented 78% of all meadowlarks for which age could be determined (N=18). Blair and Schitoskey (1982) found juvenile western meadowlarks accounted for 82% of all meadowlark remains recovered during their study in northwestern South Dakota.

The number of birds larger than passerines increased notably among prey remains found in 1982. In 1981, sage grouse were the only large birds known to be taken. In 1982, the remains of two species of dabbling ducks plus sage grouse were regularly found at nests. The frequency of large birds identified increased from 9.3% of all avian prey in 1981 to 30.7% in 1982. Gilmer and Stewart (1983) reported that 3 species of dabbling ducks were regularly taken as prey by ferruginous hawks in North Dakota during a year when a large increase in the utilization of avian prey was apparent. Lokemoen and Duebbert (1976) found 1 unidentified *Anas* in prey remains in South Dakota.

Insect remains, primarily Hymenopterons and Coleopterons, were common components of regurgitated pellets and probably reflected food habits of other prey species or items injested incidentally to prey consumption rather than food sought by the hawks.

Overall, the frequency of occurrence of mammalian prey was low and that of avian prey high when compared with other studies (Weston 1969, Smith and Murphy 1973, Howard and Wolfe 1976, Lokemoen and Duebbert 1976, Blair and Schitoskey 1982, Gilmer and Stewart 1983). The major mammalian prey species in southeastern Montana were similar to those reported by other researchers in North and South Dakota but the relative importance of individual species varied. Blair and Schitoskey (1982) found thirteen-lined ground squirrels occurring more frequently than white-tailed jackrabbits, which in turn were found more frequently than northern pocket gophers. Blair also stated that western meadowlarks were the greatest component of identified

avian prey in South Dakota. Gilmer and Stewart (1983) found Richardson's ground squirrels (*Spermophilus richardsoni*) the most frequently encountered prey item in North Dakota, followed in decreasing order of frequency by northern pocket gophers, thirteen-lined ground squirrels and white-tailed jackrabbits. Lokemoen and Duebbert (1976) found white-tailed jackrabbits to be unimportant in frequency of occurrence as prey for ferruginous hawks in central South Dakota.

Prey Populations

White-tailed jackrabbit population indices suggest that jackrabbit numbers were 30% greater in 1981 than in 1982 (Figure 4). During May, the initial stages of ferruginous hawk nesting, jackrabbit numbers were a significant ($P<0.025$) 68% greater in 1981 than in 1982. Indices for June, during the hatchling stage show the opposite trend.

At least 2 factors influenced the results of headlight surveys and the jackrabbit population indices. First, in early May jackrabbits tended to congregate in the vicinity of culverts and barrow pits where succulent vegetation first appeared. As greenup progressed jackrabbits dispersed and were more evenly distributed throughout the study area. As a result, the May indices were inflated relative to those derived during June. Secondly, May headlight routes were conducted before vegetative growth was sufficient to reduce jackrabbit visibility. Increased vegetation along routes in June 1982 probably resulted in a decrease in jackrabbit visibility during that period as compared with June 1981 routes. Thus, Figure 4 underestimates jackrabbit numbers for all routes and June routes for 1982.

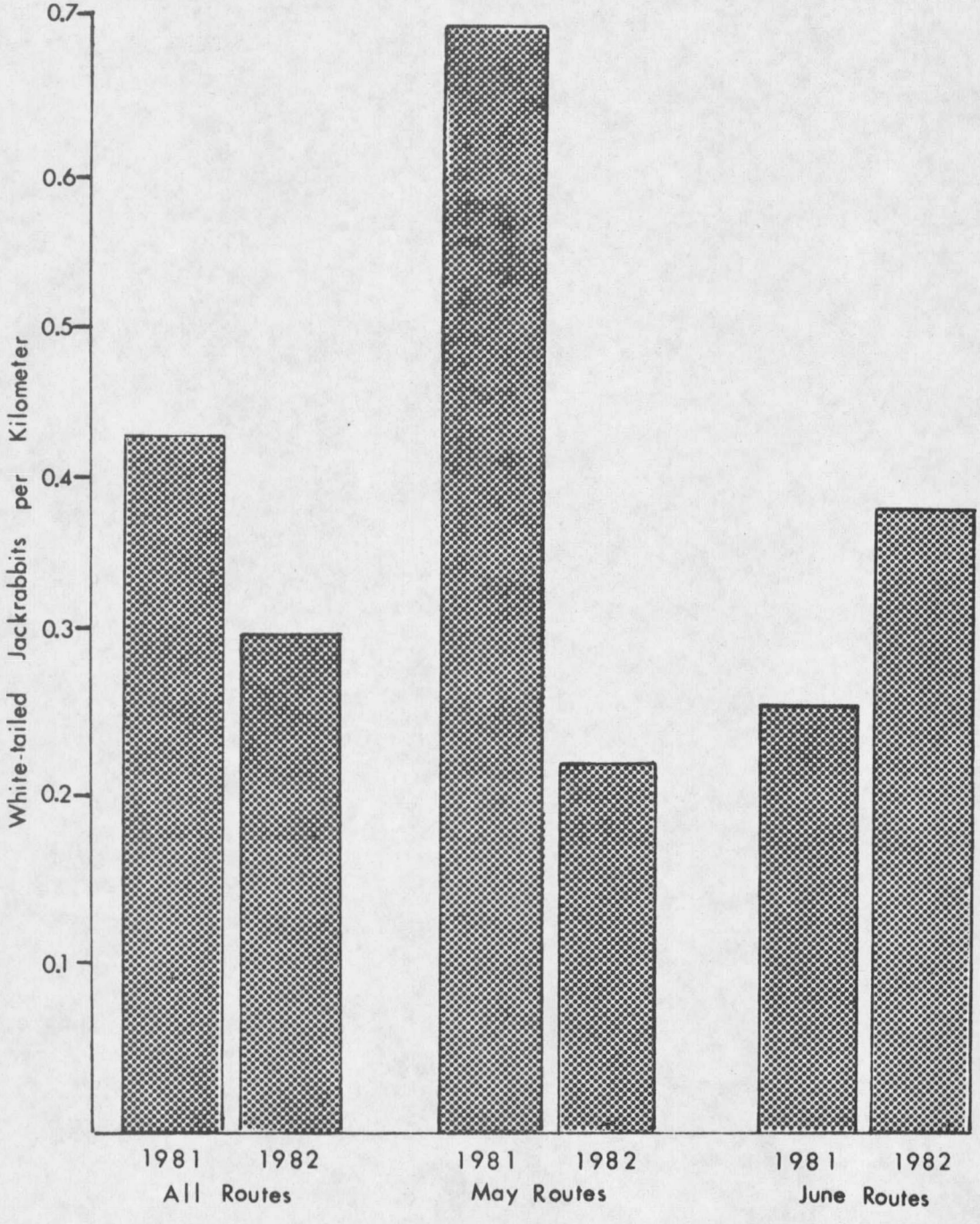

Figure 4. White-tailed jackrabbits observed per kilometer of headlight survey in southeastern Montana, 1981 and 1982.

In 1981, 145 small mammals were trapped in 719 trapnights (Figure 5). During 1982, 114 small mammals were captured in 742 trapnights. Sample sizes for all species except *Peromyscus maniculatus* were too small to make valid statistical comparisons between relative numbers trapped in each year. There were no statistically significant differences between 1981 and 1982 in total small mammals or deer mice captures per 100 trapnights.

Four mammal species were captured on the study area. Deer mice, common in all habitats, represented a composite total of 91.1% of all small mammals trapped. Thirteen-lined ground squirrels, trapped predominantly in shortgrass areas with less than 15% sagebrush overstory, represented 5.0% of all small mammals captured. Northern grasshopper mice, trapped predominantly where the ground was extensively bare and sagebrush cover was less than 10%, represented 3.1%. Sagebrush voles, found where sagebrush cover exceeded 20%, represented 0.8%.

Numbers of deer mice trapped declined 21.2% from 1981 to 1982; captures of northern grasshopper mice declined 66.3% for the same period. The number of thirteen-lined ground squirrels captured increased 4.6% from 1981 to 1982. No sagebrush voles were trapped in 1981; 2 were caught in 1982.

An average of 0.63 active pocket gopher mounds and 8.83 active thirteen-lined ground squirrel burrows were located per ha of survey route traversed in 1982. Northern pocket gopher mounds were predominantly restricted to swale areas in rolling hills. In these habitats an average of 12 active mounds per ha of survey route were

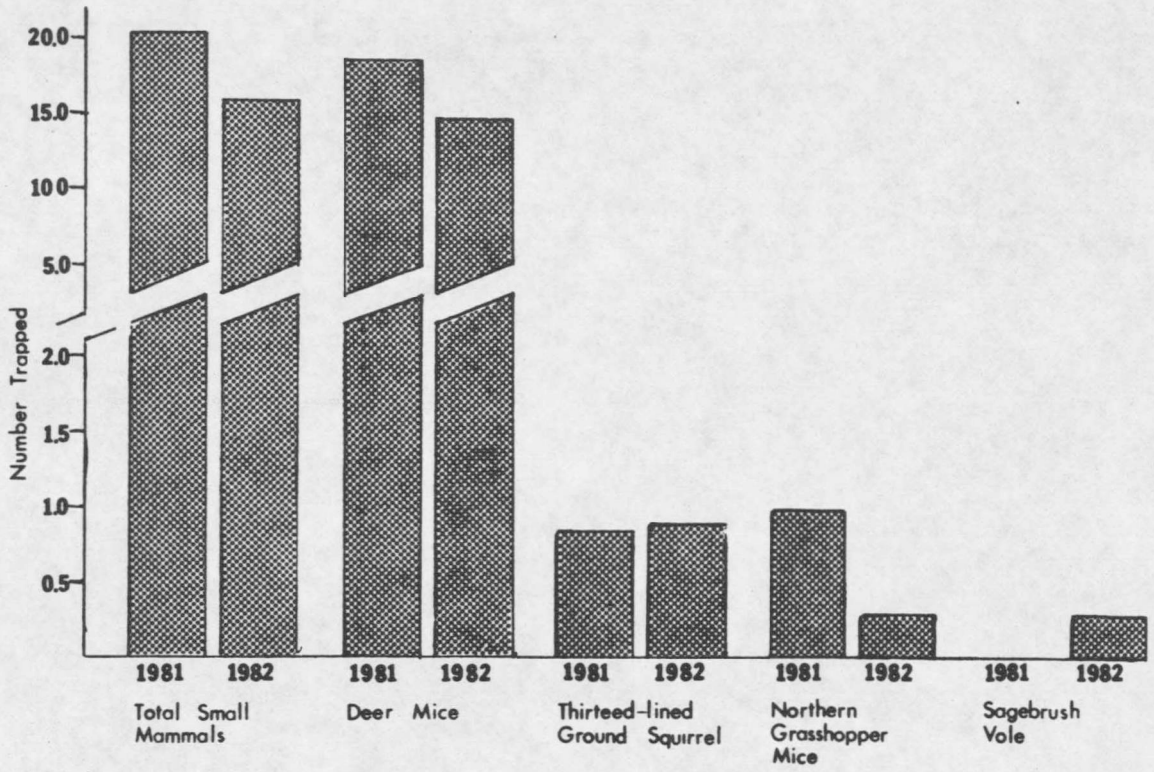

Figure 5. Number and species of small mammals trapped per 100 trapnights in southeastern Montana, 1981 and 1982.

located. The only other habitat where pocket gopher mounds were found in abundance was in association with loamy hummocks that dot hardpan areas along creek bottoms. In those locations, 2-5 active mounds per ha were observed. With the exception of hummocky areas, pocket gopher mound sites were located in areas where the slope ranged from 10-45%, averaging 30%. Pocket gopher mounds displayed orientations similar to those noted for ferruginous hawk nests: 90% of all active pocket gopher mounds had aspects directed towards 5 equidistant compass points from 225° SW through 0° N to 45° NE. Southwest orientation was the most common; 30% of all surveyed mounds possessed this aspect.

Thirteen-lined ground squirrels were present in all habitats except unvegetated mud hills and upland hills where sagebrush cover exceeded 70%. The greatest densities were found in shortgrass areas adjacent to grassy creek bottoms (38 burrows/ha) and in association with shortgrass- sagebrush cover (20 burrows/ha).

Five species of passerine birds were abundant (Figure 6). Red-winged blackbirds, killdeer, mourning doves and upland sandpipers were also observed, but sightings of these species were few and thus not included in tabulation.

Western meadowlarks were the largest and most visible passerines on the study area. Meadowlarks were common in all habitats except extensively bare areas or those on which sagebrush cover exceeded 80%. The most preferred habitat for this species appeared to be mid-slope hills with 60-80% grass-forb cover understory and 15-25% sage-brush overstory.

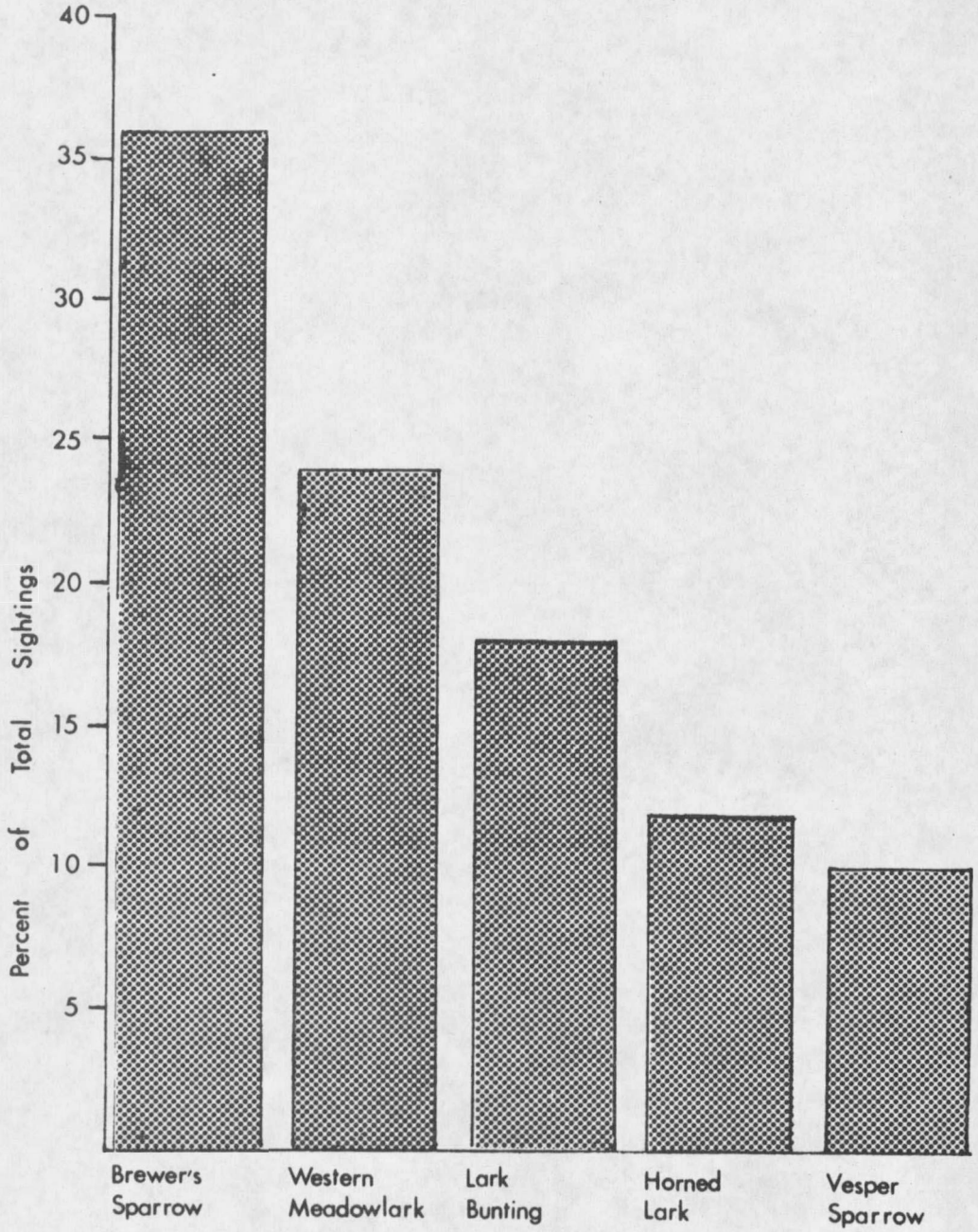

Figure 6. Relative abundance of 5 most common passerines encountered along survey routes in southeastern Montana, 1982.

Lark buntings, vesper sparrows and Brewer's sparrows appeared similar in their habitat preferences. These species were abundant in rolling hill and hilltop habitats with a grass-forb understory that averaged less than 70% ground cover and sagebrush overstory with greater than 20% ground cover. As the sagebrush overstory increased above 20% and the grass-forb understory decreased below 70%, the habitat gradient appeared to favor these passerines in this order: lark buntings, vesper sparrows and Brewer's sparrows.

Horned larks were most prevalent in shortgrass/bare ground habitats where sagebrush cover was less than 10%.

The Raptor Community

Five species of diurnal and 2 species of nocturnal raptors were observed regularly on the study area during the field season; an additional 4 diurnal species were occasionally or rarely sighted (Table 10).

Two and possibly three species of raptors, in addition to the ferruginous hawk, nested on the study area. Two Swainson's hawk nests were located, one in a singular box elder tree on Cabin Creek, the other, which was active in 1982, in one of a group of 3 mature cottonwoods along Timber Creek. Singular and pairs of Swainson's hawks were often sighted in the juniper breaks north of Timber Creek.

No short-eared owl nests were located during the study and only single birds were sighted. However, prey remains of ferruginous hawks indicated that this species did nest in the area.

Table 10. Raptors observed, their abundance based on average number of sightings per day of observation, and their status in southeastern Montana, 1981 and 1982.

Species	Number sighted per day of observation 1981	1982	Total	Status on study area
Golden Eagle (*Aquila chrysaetos*)	0.67	0.45	0.57	common-nonnester
Ferruginous hawk (*Buteo regalis*)	0.28	0.32	0.30	common-nester
Swainson's hawk (*Buteo swainsoni*)	0.07	0.26	0.16	common-nester
Marsh hawk (*Circus cyaneus*)	0.05	0.19	0.15	common-nester?
American kestrel (*Falco sparvarius*)	0.05	0.19	0.11	common-nonnester
Great horned owl (*Bubo virginianus*)	0.02	0.07	0.04	common-nonnester
Short-eared owl (*Asio flammeus*)	0.00	0.07	0.04	common-nester
Red-tailed hawk (*Buteo jamaicensis*)	0.02	0.10	0.06	uncommon-transient
Prairie falcon (*Falco mexicanus*)	0.00	0.05	0.03	uncommon-transient
Merlin (*Falco columbarius*)	0.02	0.03	0.03	rare-transient
Cooper's hawk (*Accipiter cooperii*)	0.01	0.02	0.01	rare-transient
Burrowing owl (*Athene cunicularis*)	0.00	0.00	0.00	rare

Recurrent observations of paired marsh hawks at specific locations indicated that this species may nest on the study area although this was not substantiated.

Golden eagles were the most common and visible raptor to inhabit the study area. Perched and soaring individuals and groups were prevalent over the entire study area. The most frequent sightings

occurred in association with the steep narrow canyons of the juniper breaks north of Timber Creek. Observations of golden eagles increased through the spring, peaked in June, and declined in July. Most birds appeared transient and not attached to any specific area. Several nest territories abandoned by ferruginous hawks at various stages of nesting were occupied by golden eagles within several days of the hawk's departure. Eighty-one percent of all golden eagles for which age was determined were considered subadults. American kestrels were common in early April, decreased in early May and increased in mid- to late July after ferruginous hawk juveniles had fledged.

Direct observations of nocturnal raptors (Table 13) were not representative of true great-horned owl and short-eared owl population levels. The frequency of crepuscular and nocturnal calling by these species suggested that these birds were more common than indicated by direct observations. The sighting of a single burrowing owl on the study area in 1980 (D. Goldan pers. comm.) and rare sightings of this species in surrounding areas in 1978 and 1979 (Becker 1980) have been reported. No burrowing owls were observed during the course of my study.

Becker (1980) reported that golden eagles, marsh hawks, American kestrels, great horned owls, red-tailed hawks, prairie falcons and merlins were common nesters in the forested hills and sandstone cliffs located peripherally to my study area. He also reported Cooper's hawks rarely nest in these areas.

Three interspecific contacts were observed between ferruginous hawks and golden eagles. In all cases, the hawk initiated the

interaction, apparently to expulse the eagle from the hawk's territory. These altercations occurred in April or early May during the early stages of ferruginous hawk nesting. In one case, a golden eagle was perched 3600 m from the nearest active ferruginous hawk nest. The ferruginous hawk stooped on the eagle and apparently caused the eagle to take flight. At this point, the hawk again dove at the eagle, the eagle flipped and presented its talons to the oncoming hawk and after a brief contact the eagle flew off and the hawk perched on a nearby hill. In another incident, a golden eagle was flying 500 m from the nearest active ferruginous hawk nest, the male ferruginous hawk, which was originally perched within 200 m of the nest, flew toward and then above the oncoming eagle. After stooping on the eagle several times, coming closer at each stoop, the eagle diverted flight to one perpendicular to its original course; and the hawk continued soaring for several minutes before returning to its perch. Soon after the male hawk had taken pursuit of the eagle, the female hawk flew from the nest and circled above the altercating birds but never joined the conflict. Similar behavior was noted in relation to another altercation except that it occurred roughly 4000 m from the nearest active nest and only a single hawk was observed. Upon the hawk's third dive, the eagle rolled and presented its talons to the hawk and brief contact was made between the 2 birds.

Ferruginous Hawk Behavior

The behavior of adult ferruginous hawks appeared to change in relation to breeding chronology. Adult ferruginous hawks demonstrated little affinity to the nest site upon arrival and in the initial stages of courtship. Observations of ferruginous hawks were of single birds and all were at some distance from the eventual nest sites. As the season progressed, single birds were noted in the vicinity of a nest, often perched on a prominence and on occasion were observed to evert or billow their chests. As egg laying approached pairs rather than single hawks were observed perched in the nest areas. Members of a pair perched alone, choosing adjacent perch sites separated by tens of meters. Little activity was apparent in the vicinity of occupied nests from early morning until mid-afternoon. After this time, paired birds perched for long periods in the vicinity of a nest, apparently loafing. Such activity was especially prevalent as dusk approached. Adults were not observed to perch on the nest prior to incubation. This is contrary to the findings of Fyfe and Olendorff (1976). Such activity could have occurred but the lack of constant nest observation during the period precluded verification. A lack of twilight movements by adults indicated that adults chose to roost near their last daylight perch. The inability to observe adult movements after dark leaves the possibility of roost shifting open to question. Roost sites were on the ground.

Adult attentiveness at the nest increased as incubation progressed. During the 10-14 days after egg laying, adults were absent

from the nest for 15-30 minute intervals and possibly longer. These periods of absence were prevalent in the late afternoons of temperate days. After the first 2 weeks of incubation, an adult was present on the nest during all periods of observation. Stints on the nest lasting several hours were interrupted with breaks from incubation of less than 5 minutes, during which the adult would fly and/or perch within 200 m of the nest before returning to incubate. Feeding and defecation occurred away from the nest during incubation; nests were neat and orderly and harbored little evidence of whitewash, prey remains, or cast pellets.

The female was the only bird observed to incubate. However, the lack of constant nest observation and an inability to sex incubating birds precludes definite statements.

Lone incubating birds crouched as I approached to about 450 m of the nest on foot. Birds allowed me to approach to about 170 m (N=9) when I was on foot and about 95 m when I was on a motorcycle (N=10). Two approaches by pickup truck elicited flushing responses at 75 and 200 m. Helicopter approaches as close as 30 m above the nest with stationary hovering for 10-20 seconds resulted in little apparent adverse reaction from incubating birds. In three such approaches, 10 days after egg laying, no birds were flushed and all eggs were carried to term.

Motorized approaches that were characterized by starting and stopping elicited a flushing response at a distance further from the nest ($\bar{X}$=140 m) than nonstop approaches ($\bar{X}$=90 m). For indirect motorized approaches, the incubating bird flushed at an average

distance of 65 m, direct approaches prompted flushing at an average of 144 m.

Approaches from below the nest were less disturbing to an incubating bird than those from the same level or above. Approaches below the nest resulted in flushes at an average of 100 m while approaches from level with or above the nest an average of 142 m.

When flushed, the lone incubating bird would rise from the nest, fly briefly before settling within 200 m of the nest, and demonstrate no defensive postures. Upon my departure from the area the bird would return to incubate within 5 minutes. When an incubating bird and her mate were present, the female would again fly off the nest and her mate would either circle and call at the intruder or join his mate. On 1 occasion as a nest was approached closely, the male circled, called and stooped once. I immediately left the area. In several cases where only the incubating bird was apparently present, the rise of this bird from the nest seemed to act as a signal to the mate which appeared within 2-3 minutes.

With 2 exceptions, all approaches to nests from the ground occurred within the first 2 weeks after egg laying and were limited to 1 or 2 approaches per nest; no abandonments resulted. The first exception elicited the defensive stoop by the male related above and occurred about 3 weeks into incubation. This was the only known human disturbance to the nest and may have been the direct cause for the abandonment.

The second exception related to a nest that was disturbed a total of 7 times, twice weekly, to set out and retreive a time lapse

camera. Disturbance was limited to crepuscular hours and the nest was never approached closer than 100 m. My approach to the nest was concealed up to the point where the bird flushed. In all 7 instances the only reaction was flushing, even when both adults were present. Abandonment of this nest occurred after the seventh intrusion, 1.5 weeks prior to the anticipated hatching.

Constant presence of an adult at the nest waned approximately 1 week after hatching. After this point adults were present at the nest only to supply food or to brood or shade the offspring during adverse weather.

The females role appeared to shift after the eggs hatched. Previously passive and secretive, she became more aggresive. The male was less intense in nest defense and would often only circle above the female as she initiated and carried out defensive postures. Ironically, the male was the only bird observed to stoop on me.

During all nest visitations, the female was observed hunting, soaring or perched in the vicinity of the nest. She would nearly always escort me, circling and screaming as I proceeded towards the nest. The male was generally away from the nest and came into visual or auditory range within 5 minutes after I disturbed the female. After 5-10 minutes of harassing me, the male typically lost interest and flew off while the female either continued circling and calling or perched a short distance away and continued calling weakly. Perch sites were defended as adamantly as the nest.

In most cases, nest defense by the male waned as the nestling period progressed; defense by the female remained high. Towards the

termination of the nestling period, several males failed to appear regularly or they made their presence known only by weakly calling from distant points.

On several visits to a particular nest, a single ferruginous hawk soared above the defending pair but this bird was never observed to directly participate in defense. This bird was probably the same individual that inhabited a territory centered 1850 m from the active nest.

Defense in the area of the nest waned postfledging as family groups moved their centers of activity away from the nest area. Defensive postures were elicited at several active nests up to 2.5 weeks after the young had fledged, but displays were weak and inconsistent. At nests abandoned or disrupted prior to hatching, defense of the nest site terminated immediately. At nests disrupted after hatching, adults remained defensive of the nest site up to a week after nest destruction.

Definite family groups were commonly observed up to 3 weeks after fledging. These groups consisted of the female and offspring, which hunted and perched together. In some cases the male remained in the vicinity of the family group but was never observed to hunt or perch with them. Two adult and one juvenile ferruginous hawk were observed flying together 2 months after fledging.

One paired male, whose mate was inadvertently killed in a trapping accident midpoint in the hatchling stage, successfully raised the 2 offspring produced by the pair. The chicks fledged and I subsequently followed them for 4.5 weeks after fledging. No behavioral

changes were noted in the male as a result of the loss of its mate. In successive visits to the nest after the female was killed, the male was present in the vicinity of the nest only on rare occasions. Defense of the nest and young by this single adult was virtually absent, limited to weak calling from a distance. Fresh food items were always present at the nest and/or feeding perches through the remainder of the nestling period into the first 10 days after fledging. The adult male was never observed to directly interact with the offspring and was last observed in the vicinity of the juveniles 2 weeks postfledging.

Juvenile attachment to the nest declined at approximately 10 days before fledging about the same time juveniles became aggressive. During this period juveniles were found at adult feeding perches or hunkered in thick stands of sweet clover or sagebrush up to 40 m from the nest; juveniles demonstrated great adeptness at running and hopping as a means of escape.

The first observed flights consisted of downslope glides from stationary positions. As young birds became more agile, flight was initiated by a short run and simultaneous wing flapping until enough lift was gained to become airborne. These early flights were wobbly, labored, and direct from 1 point to another and the bird seldom rose more than 2 m off the ground.

During the first week after fledging, juveniles remained in the vicinity of the nest, making only 40-200 m flights, either downslope or across slopes. No uphill flights were observed. Landings were

crude, shaky, and generally overshot with birds losing balance and appearing to stumble upon landing.

Flight was mastered in the second week. Take-off from flat surfaces was accomplished with only 2-3 preliminary hops. Flight articulation improved to the point that juveniles could easily gain altitude, wheel and turn and demonstrate aspects characteristic of buteo soaring. Flights up to 500 m long were accomplished. Landing technique became refined and graceful, birds would alight upon a perch rather than crash into it.

A radioed juvenile and its sibling nest mate provided information on post fledgling behavior and movements. During the latter half of the second week, juveniles demonstrated a major shift away from the nest site and were often observed at distances up to 1000 m from the nest. During this period, these birds inhabited an area that was extensively bare, broken only by patches of cactus, shortgrass and stunted sagebrush plants; sagebrush or bare ground were used as perches. The last observation of the single male parent was made during this period as he perched on a fencepost 50 m from the offspring.

During the third week, activity shifted to an area roughly 1600 m from the nest where, for the next 10 days, they occupied an ecotone between the previously used bare area and a lush, grassy creekbottom. Perching shifted from the ground and sagebrush plants to fenceposts.

Major periods of activity, flight, and hunting by the juveniles occurred in the early morning and declined substantially 3 hours after sunrise. During the remainder of the day, the hawks perched

on fenceposts alternating short flights or hunting forays between extensive periods of perching. Following these flights the juveniles frequently shifted perch sites.

Activity increased near dusk when the birds demonstrated what can best be termed uneasyness; they flew briefly, perched for several minutes, then resumed flying. No hunting was observed to occur during this time. Fifteen minutes to one-half hour after sunset, the birds would roost on the ground in moderate to heavy stands of sagebrush on level ground. Little shifting occurred at night as the first observations of the birds before daybreak were similar to the last observed location of the previous evening. Siblings roosted alone.

Food items collected from the juveniles during this period consisted of 2 juvenile jackrabbits, 1 thirteen-lined ground squirrel, 1 juvenile sage grouse, 1 horned lark and the remains of 4 unidentified birds.

Four and one-half weeks after fledging, the juveniles moved up the creek approximately 3400 m from the nest. Large shifts in the area of daily activity were noted. Juveniles continued perching together. At this time, the radioed juvenile was recaptured by night-lighting and the radio was removed.

CONCLUSIONS

Ferruginous hawks select a wide variety of natural and man-made nest sites (Olendorff and Stoddart 1974). Natural sites include cliffs, rock outcrops, cutbanks, ground, and trees (Weston 1969, Olendorff and Stoddart 1974, Smith and Murphy 1982). Man-made structures include haystacks, power poles, utility line towers, and artificial nest platforms (Lokemoen and Duebbert 1976, Gilmer and Wiehe 1977, Call 1979, Howard and Hilliard 1980).

Nest sites on my study area were limited largely to ground and rock outcrops. Although mature box elder and cottonwoods occurring along several drainages have potential as nest sites, these predominantly singular trees would be sites vulnerable to wind damage. In addition, nest sites along nearby ridges offer a more commanding view than those in trees along creek bottoms. Since ferruginous hawks select nest sites with greater vantage, this factor apparently outweighs the loss of security inherent in ground nesting.

Juniper trees found along the steep-sided canyons north of Timber Creek offer potential nest sites. However, I found no nests nor did I see any ferruginous hawks utilizing this area probably because as a plains buteo, they cannot efficiently utilize habitats characterized by steep narrow canyons.

Many variables, including nest security, prey availability and past nesting experience of individual hawks, act in concert to

influence ferruginous hawk nest site selection. Nest site parameters assessed in this study can only give indications as to which of these variables, among others, may have selective influence upon nesting hawks. Information gathered in this study can be used to ascertain broad habitat preferences of ferruginous hawks in southeastern Montana, but actual selective pressures that may influence nest site selection are less tangible and can only be inferred.

Ferruginous hawks select nest sites associated with hills and ridge systems that separate broad, flat valleys. Nests, generally located on the periphery of these elevated areas, are exposed to expanses of prairie. Nests tended to be more prevalent at drainage heads rather than further downstream. The landscape here was more broken and varied than that found further downstream and possessed more potential nest sites, more "edge", interspersion, and possibly higher prey densities.

Local thermals are more readily spawned on the periphery of elevated areas, as a result of differential heating of flat valleys and adjacent hills and ridges. These thermals increase lift capabilities giving large soaring buteos greater efficiency at becoming airborne, allowing these birds to devote less energy to flying and more to prey search (Pennycuick 1980, Smith and Murphy 1982). Nests in elevated areas would allow incubating adults and older juveniles a downslope means of escape when confronted by predators.

The lack of consensus concerning preferred slope aspects of ferruginous hawk nests in any 2 studies in the literature indicate that nest orientation is dictated by vagaries of a given geographic

area. Smith and Murphy (1982) stated "raptors tend to select exposures that offer optimum microclimate within reasonable variations." Lokemoen and Duebbert (1976) felt nest orientation was directed towards aspects that allowed nesting hawks to rise easily into the wind. Lardy (1980) felt orientation was directed towards the most xeric and vegetatively barren direction, thus increasing vantage from the nest. In my study, preferred aspects of ferruginous hawk nests are similar to the aspects of areas utilized by northern pocket gophers. This similarity could be a response by both species to a common environmental variable, probably incident solar radiation. Ferruginous hawks may select nest aspects that allow optimum exposure to a potential prey population (pocket gophers). Nesting ferruginous hawks in southern Montana appear to select aspects that provide greatest LDE from the nest proper, thereby increasing vantage from the nest.

Ferruginous hawks in southeastern Montana apparently prefer a level of vegetation growth at nest sites that does not prevent surveillance from the nest, yet provides adequate security. Even though there was a substantial increase in grass-forb cover at all nests in 1982, nests selected for occupancy showed levels of vegetative cover similar to those levels found at occupied nests in 1981. Nest sites selected by ferruginous hawks in 1982 had less sagebrush cover than those selected in 1981, possibly compensating for the increase in grass-forb cover in 1982.

Selection of nests with adjacent shrub cover indicates the desirability of such growth. Shrub growth may help conceal incubating birds or chicks from potential predators. Although such shrub

growth may limit short range vision from the nest, it would not necessarily detract from an incubating bird's long range vantage.

Olendorff and Stoddart (1974) report that active ferruginous hawk nests were more frequently located in remote and posted areas than in areas of free access; hawks occupying remote nests fledged more young than their free access counterparts. My findings indicate that ferruginous hawks selected nest sites that were removed from areas of vehicular traffic and/or constant human activity. No nests were located in potential nest habitats adjacent to the study area that are close to areas of human activity.

Vehicle trails are present on nearly all ridgetops and prominent points on the study area. These trails, used by ranchers and BLM personnel, are often located within 100 m of ferruginous hawk nests; several are within 10 m. Although these trails are used less than once weekly, such disturbance could be disruptive if occurring at a critical point in the nesting sequence. Fyfe and Olendorff (1976) indicate that ferruginous hawks are prone to desert the nest if disturbed in early stages of nesting.

Restricted use of trails from March through mid-July would benefit nesting ferruginous hawks and is highly recommended. An alternative would be for competent personnel to aerially reconnoiter identified nest areas sometime before grazing commences in mid-May. Areas utilized by incubating ferruginous hawks should be posted and human activity within 450 m (point at which nest approaches elicited response from hawks) of the nest restricted.

More than expected numbers of remnant nests have been found on knobs on ridgetops and lone hilltops. These two physiographic locations were observation points used by humans, as evidenced by the truck trails that lead up and over them. In the past, such locales were probably prime nest sites, but an increase in vehicular traffic over these areas forced ferruginous hawks to shift from these to more secure nest sites.

The optimum ferruginous hawk habitat is unbroken prairie grassland that is ungrazed or slightly grazed (Olendorff and Stoddart 1974, Lokemoen and Duebbert 1976, Gilmer and Stewart 1983). This habitat is felt to provide sanctuary for ground nesting hawks and the relative stability of these areas fosters populations of jackrabbits and ground squirrels that are important prey sources. My study area has remained unbroken prairie as a result of its poor quality soils, related lack of intensive agriculture and public ownership. Grazing intensity is moderate. Range improvement practices such as contour furrowing and crested wheatgrass seedings have been practiced on the study area, but these activities were conducted over limited areas and were not consistently implemented on a yearly basis. Several years after their implementation, any impacts from these practices become lessened as the area reverts back to native condition. Howard and Wolfe (1976) emphasize the need to maximize edge and interspersion in vegetation management, to optimize the prey base for ferruginous hawks and other raptors. They indicate the desirability of treating small tracts of land, creating more interspersion, rather than treatments that encompass large tracts of land with relatively less edge and

interspersion. I feel the size of vegetation treatments on my study area are of proper size (generally less than 10 ha) but future treatments should incorporate an irregular boundary to increase interspersion.

Call (1979) indicates that moderate to heavy levels of grazing remove rodent cover, thereby benefiting birds of prey during the nesting season by increasing prey vulnerability. This short-term increase in prey availability must be weighed against a possible long-term decrease in prey density that may result from cover and habitat loss.

Grazing levels on the frail lands of the study area are moderate and have left the range in fair condition. Sustained levels of grazing during the drought years previous to and including the first year of this study may have increased the severity of prey declines on the area and thus helped to depress numbers of nesting ferruginous hawks.

Lower levels of grazing, under presently implemented rest-rotation systems should benefit nesting ferruginous hawks by bolstering food and cover for prey species, especially during dry years of low vegetation production. Rotation of pastures, whether within or between grazing management units, should provide for a checker-board distribution of heavy, moderate, light, and ungrazed pastures. Moderate and heavily grazed areas increase prey availability for hawks while prey populations increase in adjacent ungrazed and lightly grazed areas and disperse into more heavily grazed areas. This juxtaposition of heavy and lightly grazed pastures around nest

areas may allow more constant prey densities to occur within the foraging range of nesting hawks.

I observed 2 cases of nest territory reoccupancy that suggest mechanisms involved in recruitment of birds into breeding population. Two territories in 1981, 1 occupied by a single, unpaired bird and another with a nest in which a single infertile egg was laid but not incubated, were both reoccupied in 1982 and were successful. Assuming that the birds occupying these territories in 1981 returned in 1982, this behavior may represent prenest "probing" of a potential territory by subadult hawks to ascertain the adequacy and availability of the territory before actually attempting to nest the following year.

Certain nests within territories seem to be preferred and showed repeated use, as indicated by the amount of accumulated nest material; other nests within the territory appear to be less preferred and deteriorated through several seasons of non-use. Prenesting assessment of the territory and its potential nest sites by ferruginous hawks is apparent. Hawks may refurbish several nests within a particular territory and thereby assess each nest in relation to its security, vantage, and exposure to hunting areas.

Statistical analysis indicates that remnant nests are more apt to be singular rather than supernumerary nests. The presence of supernumerary nests suggests traditional territories that are of higher quality than territories with only 1 nest. Conversely, the presence of singular, remnant nests indicates that these territories occur in marginal habitat and are used only in years when conditions for nesting are best and/or when the nesting population is high.

Adequate ground nesting sites were available for ferruginous hawks during the 2 years of study. Based on relative numbers on supernumerary and singular nests used in 1981 and 1982, I believe the area could potentially support approximately 25 nesting pairs of ferruginous hawks. Only half of this potential was realized during the 3 years of observation.

Nest site and prey availability are the two basic factors limiting the number of diurnal raptors within a given area (Newton 1979). Since adequate nest sites were available on this area during the years of study, density and vulnerability of potential prey prevented increase in the number of breeding pairs of ferruginous hawks. Unusual prey items, numerous unoccupied territories, low average clutch size, nest desertion and failure, poor nest success, predation and sibling fratricide implicate low prey availability as the major limiting factor.

Mobile, nomadic raptor species can adjust their numbers in accordance with densities of available prey (Galushin 1974). Such behavior would be advantageous, if not essential, to the well-being of a species such as the ferruginous hawk that inhabits arid, sagebrush-grassland, and grassland areas that are relatively poor in prey species diversity. This hawk frequently depends upon a limited number of prey species (Bent 1937, Evans 1982) that demonstrate wide annual fluctuations in population densities.

In comparison to other studies, the frequency of mammalian prey items was low in this study, perhaps because densities and availability of staple prey populations (jackrabbits, ground squirrels and

pocket gophers) were low during 1981 and 1982. This paucity of usual prey items forced nesting hawks to respond functionally by shifting their foraging efforts to alternate more available prey (i.e., birds). In addition, ferruginous hawks that normally nest on this area probably demonstrated a numerical response to a declining prey base and shifted to other areas where prey population densities were more suitable.

Smith and Murphy (1978) indicate that populations of breeding pairs of ferruginous hawks in central Utah fluctuated widely between years from a high of 34 in 1969 to a low of 13 in 1970. These changes were felt to be directly related to fluctuations in the hawk's major prey, the black-tailed jackrabbit. This population of hawks demonstrated numerical responses to increases and declines in their major prey, illustrating the ability of large, mobile raptors such as the ferruginous hawk to concentrate their numbers in areas of high prey abundance.

Ferruginous hawks in north-central Utah responded to low prey densities by either failing to nest or by producing smaller clutches (Woffinden and Murphy 1977); both of these responses were noted on my study area. These researchers also indicate that nestling mortality increased during these periods because adults had to forage further from the nest and for longer periods of time to supply adequate food for the offspring. As forage time and distance increased, nest predation increased as nest attentiveness and defense decreased. In southeastern Montana, I found predation to be the primary cause of nestling loss in 1981 and the second most important cause in 1982.

The decline in male attentiveness of the nest and nestlings as brood rearing progressed may have been a direct result of the male having to forage further and longer to supply food for the growing offspring. Woffinden and Murphy (1977) found average nestling mortality of 49.5% for years characterized by low prey numbers; nestling mortality on my study area averaged 69%.

The decline in the number of nestlings as the brood rearing period progressed and the prevalence of fratricide in my study indicates that adult hawks were unable to supply adequate food for their young. Ingram (1959) felt that the brood size of raptorial birds is constantly adjusted throughout the nestling period in accordance with the amount of food adults are able to supply.

The number of single ferruginous hawks that occupied territories in north-central Utah increased during the periods of low prey numbers (Woffinden and Murphy 1977). Smith and Murphy (1978) report that the ratio of single to paired hawks in central Utah varied from 1:19 and 1:31 in years of high prey abundance to 1:9 and 1:5 in years of low prey numbers. I found that the ratio of single to paired birds ranged from 1:3 in 1981 to 1:10 in 1982.

The series of drought years into the 1981 nesting season probably contributed to depressed prey populations during that year and induced fewer hawks to nest on the area. In 1982, the wet spring may have again depressed prey populations by flooding burrows of ground squirrels and pocket gophers. Later in the nesting season, an increase in vegetation reduced prey vulnerability to foraging hawks. Trapline captures of thirteen-lined ground squirrels

increased 4.6% from 1981 to 1982 while the frequency of these mammals in prey analysis declined 7.1% for the same period. The increase in moisture in 1982 also resulted in the filling of stockponds and sheetwater areas which in turn increased waterfowl numbers and productivity. As a result, nesting ferruginous hawks were opportunistic on this unusual but abundant prey resource. In addition to the cool, wet spring in 1982, lower relative jackrabbit numbers during early stages of nesting may have caused ferruginous hawks to lay smaller clutches. The increased density of jackrabbits later in the season was probably offset by decreased vulnerability of this species. Foraging hawks were unable to exploit the increased jackrabbit densities and were forced to rely on less preferred but more available prey resources.

Clark (1975) found a positive correlation between vole density and short-eared owl numbers; voles constituted the greatest percentage of any single prey item for these owls even when these mammals were scarce. He also noted that these owls congregate in areas of high microtine numbers. No sagebrush voles were captured on traplines in 1981 nor were any short-eared owls observed. During 1982, trapline captures included these voles, and short-eared owls were observed on the study area. During 1981, no sagebrush vole remains were recovered from ferruginous hawk prey remains or castings. In 1982, these voles, which were the least common mammals captured on traplines, were the most common small mammal identified in prey remains and castings. The use of sagebrush voles as prey may indicate that the vulnerability of these voles to foraging hawks is greater than that of the much more abundant deer mice.

Ferruginous hawks did not prey on passerine birds in proportion to their abundance but instead focused on the larger, second most abundant passerine, the western meadowlark. This use is probably related to the cost-benefit ratio of capturing larger but less abundant prey species and to the relative conspicuousness of meadowlarks. The larger meadowlarks are probably less agile than smaller species of passerines and thus easier to catch. In relation to the fact that 82% of meadowlark prey remains were juveniles, ferruginous hawks appear to be capitalizing upon an abundant and vulnerable prey resource as juvenile meadowlarks disperse from the nest. Horned larks were the second most common passerine in prey remains and the fourth most abundant passerine on the area. Ferruginous hawks are probably more efficient at foraging for small passerines present in habitats that are relatively more barren (horned larks) than for passerines that are associated with well-vegetated habitats (Brewer's sparrows, lark buntings).

Nests occupied in 1981 were closer together than those in 1982. Since densities during these 2 years were essentially the same, nesting birds were probably concentrating their efforts in areas of higher prey abundance.

The relative size of male and female hawks appears to relate to the distinct behavioral patterns of the sexes. The greater size and bulky physique of the female would make her the logical pair member to incubate and defend the nest while the trimlined physique of the smaller male would make him the more efficient and adept hunter of the pair. In my observations, the female was the only bird

identified incubating. Defense of the nest and young was initiated and carried out primarily by the female. The bond between hen and offspring is probably stronger than the bond between cock and offspring. The hen's defense would thus logically be more adamant than the cocks. In my visits to the nest, the male was generally observed off away from the nest area, presumably foraging while the female was always found in the close vicinity of the nest. At nests which the male deserted, defense of the young by the female remained high; but these nests appeared to have a higher incidence of sibling fratricide and nestling mortality, as the lone female seemed unable to supply offspring with adequate food. At the nest where the female was killed, defense became nonexistent, no fratricide or nestling mortality was observed, and food was always present. These observations reinforce the idea of distinct roles of the sexes, the female role of incubation and defense, the male role of forage and food supply.

APPENDIX

Table 11. Locations and activity status of ferruginous hawk nests in southeastern Montana, 1979, 1981 and 1982.

Legal description	BLM code	Activity[1] 1979	1981	1982
T2S R57E				
S10 NW¼SW¼	FH-41	-	-	-
S10 NE¼NE¼	n/a	-	-	-
S9 NE¼SE¼	n/a	?	?	-
S11 SW¼SW¼	n/a	?	-	-
S12 SW¼NW¼	n/a	?	-	-
S13 SW¼NE¼	FH-19	+	-	-
S13 NW¼SE¼	FH-17	-	-	-
S13 NW¼SE¼	FH-18	-	-	-
S21 SW¼SE¼	n/a	?	-	-
S21 SW¼SE¼	n/a	?	+	-
S22 SE¼SE¼	n/a	?	-	-
S23 NW¼SE¼	n/a	?	-	-
S25 NW¼SW¼	n/a	?	-	+
S29 SW¼NW¼	FH-6	+	-	-
S29 NW¼SW¼	FH-30	-	+	-
S29 SE¼SW¼	FH-31	-	-	-
S32 SE¼NE¼	n/a	?	-	+
T2S R58E				
S3 SW¼NW¼	n/a	?	+	+
S4 SE¼NE¼	n/a	?	-	-
S4 NE¼NW¼	n/a	?	-	-
S7 SE¼NE¼	n/a	?	-	-
S7 SE¼SE¼	n/a	?	-	-
S8 NW¼SE¼	n/a	?	-	-
S18 SW¼SE¼	FH-4	+	-	-
S18 NW¼SW¼	n/a	?	+	-
S21 SE¼NE¼	FH-15	-	+	+
S31 SE¼SW¼	n/a	?	-	-
S31 SW¼SE¼	n/a	?	+	-
S31 SW¼SW¼	n/a	?	-	-
S33 SE¼NW¼	FH-5	+	-	-
S33 SW¼NE¼	n/a	?	-	-
S33 SE¼NW¼	n/a	?	-	-
T2S R59E				
S17 SW¼NW¼	n/a	?	-	+
S17 SE¼SW¼	n/a	?	-	-
S17 NE¼SE¼	n/a	?	-	-
S27 SW¼SW¼	FH-1	+	-	-
S28 SW¼NE¼	n/a	?	-	+
S28 SE¼NW¼	FH-14	-	-	-
S34 SE¼NW¼	n/a	?	+	-
S34 SW¼SE¼	n/a			-

Table 11. Continued.

Legal description	BLM code	Activity[1] 1979	1981	1982
T3S R55E				
S13 NE¼NE¼	FH-37	+	–	–
S13 NE¼NE¼	n/a	?	–	–
S13 NE¼NE¼	FH-36	–	–	–
S36 SE¼SE¼	n/a	?	–	+
S36 NE¼SW¼	FH-45	+	–	–
S36 SW¼NE¼	FH-44	–	–	–
T3S R56E				
S7 SE¼NW¼	FH-32	–	–	–
S7 SW¼SW¼	FH-34	–	–	–
S7 SE¼SW¼	n/a	?	–	–
S23 NE¼SE¼	n/a	?	–	–
S34 SW¼SW¼	FH-27	–	–	–
S34 SE¼SW¼	FH-29	+	–	–
S34 NW¼SW¼	FH-28	–	–	–
T3S R57E				
S16 SW¼SE¼	FH-7	+	–	–
S33 SE¼NW¼	FH-30	–	–	–
T3S R58E				
S3 SW¼NE¼	n/a	?	–	+
S6 NE¼NW¼	n/a	?	–	–
S6 NW¼NE¼	n/a	?	–	–
S6 SW¼NE¼	n/a	?	–	–
S6 NE¼SE¼	n/a	?	+	–
S25 SW¼SW¼	n/a	?	–	–
S26 NW¼SE¼	n/a	?	–	–
S26 NE¼SE¼	n/a	?	–	–
S26 SW¼SE¼	FH-3	+	–	–
S26 SE¼SE¼	n/a	?	+	–
S26 NW¼SW¼	n/a	?	–	+
T3S R59E				
S9 SE¼NE¼	n/a	?	?	–
S29 SE¼SW¼	n/a	?	+	–
T4S R56E				
S1 NW¼SE¼	FH-23	+	–	–
S1 NW¼SE¼	n/a	?	+	+
S1 NE¼SE¼	FH-22	–	–	–
S1 NE¼SE¼	n/a	?	–	–
S2 NE¼NW¼	n/a	?	–	–
S2 NE¼NW¼	n/a	?	–	–

Table 11. Continued.

Legal description	BLM code	Activity[1] 1979	1981	1982
T4S R56E (Continued)				
S2 NW¼NE¼	FH-26	-	-	-
S2 NW¼NE¼	FH-25	-	-	-
T4S R57E				
S7 NE¼NE¼	n/a	?	+	-
S7 SW¼NE¼	n/a	?	-	-
S7 SW¼NE¼	FH-20	+	-	-
S7 NW¼SE¼	FH-21	-	-	-
S7 NE¼NE¼	n/a	?	-	-
S7 NE¼NE¼	n/a	?	-	-
T4S R58E				
S1 NW¼SW¼	n/a	?	-	-
S4 NW¼NW¼	n/a	?	-	-
S4 NW¼NW¼	n/a	?	-	-
S4 NE¼NW¼	n/a	?	-	-
S4 NE¼NW¼	n/a	?	-	-
S5 NE¼NE¼	FH-2	+	-	-
T4S R59E				
S6 NE¼SE¼	n/a	?	-	-
S32 NE¼NW¼	n/a	?	-	+
T2S R57E				
S13 NE NW	n/a	?	-	-

[1]Activity: ? = activity unknown
- = activity none
+ = active nest site

Table 12. Dominant plant species found on the study area in southeastern Montana, 1981 and 1982.

	Common name	Scientific name
Grasses	Western wheatgrass	*Agropyron smithii*
	Thickspike wheatgrass	*Agropyron dasystachyum*
	Prairie junegrass	*Koeleria cristata*
	Green needlegrass	*Stipa viridula*
	Blue gramma grass	*Bouteloua gracilis*
	Sandberg bluegrass	*Poa sandbergii*
	Alkali sacaton	*Sporobolus airoides*
Forbs	Rillscale	*Atriplex dioica*
	Common yarrow	*Achillea millifolium*
	Yellow wild parsley	*Lomatium foeniculaceum*
	Tansy mustard	*Descurainia sophia*
	Hood's phlox	*Phlox hoodii*
	Fringed sagewort	*Artemisia frigida*
	Scarlet globemallow	*Sphaeralcea coccinea*
	American vetch	*Vicia americana*
	Yellow sweetclover	*Melilotus officinalis*
	Prickly pear cactus	*Opuntia polycantha*
Shrubs	Nuttall saltbush	*Atriplex nuttallii*
	Broom snakeweed	*Gutierrezia sarothrae*
	Green rabbitbrush	*Chrysothamnus viscidiflorus*
	Big sagebrush	*Artemisia tridentata*
	Greasewood	*Sarcobatus vermiculatus*

Table 13. Mammalian species observed on the study area in southeastern Montana, 1981 and 1982.

Common name	Scientific name
Longtail weasel	*Mustela frenata*
Striped skunk	*Mephitis mephitis*
Raccoon	*Procyon lotor*
Badger	*Taxidea taxus*
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Beaver	*Castor canadensis*
Deer mouse	*Peromyscus maniculatus*
Northern grasshopper mouse	*Onychomys leucogaster*
Sagebrush vole	*Lagurus curtatus*
Northern pocket gopher	*Thomomys talpoides*
White-tailed jackrabbit	*Lepus townsendii*
Mule deer	*Odocoileus hemionus*
Pronghorn antelope	*Antilocapra americana*

Table 14. Avian species observed on the study area in southeastern Montana, 1981 and 1982, including their relative abundance and status on the area.

Common name	Scientific name	Abundance	Status
Eared grebe	*Podiceps caspicus*	common	unknown
Canada goose	*Branta canadensis*	rare	transient
Mallard	*Anas platyrhynchos*	common	breeder
Pintail	*Anas acuta*	common	breeder
Gadwall	*Anas strepera*	common	breeder
Northern shoveler	*Anas spatula*	common	breeder
Blue-winged teal	*Anas discors*	common	breeder
Redhead	*Aythya americana*	rare	transient
Canvasback	*Aythya valisineria*	rare	transient
Ruddy duck	*Oxyura jamaicensis*	rare	transient
Cooper's hawk	*Accipiter cooperii*	rare	transient
Red-tailed hawk	*Buteo jamaicensis*	uncommon	transient
Ferruginous hawk	*Buteo regalis*	common	breeder
Swainson's hawk	*Buteo swainsoni*	common	breeder
Marsh hawk	*Circus cyaneus*	common	breeder
Prairie falcon	*Falco mexicanus*	rare	transient
Merlin	*Falco columbarius*	uncommon	transient
American kestrel	*Falco sparverius*	common	nonbreeder
Golden eagle	*Aquila chrysaetos*	common	nonbreeder
Sharp-tailed grouse	*Pediocetes phasinellus*	uncommon	transient
Sage grouse	*Centrocercus urophasianus*	common	breeder
Hungarian partridge	*Perdix perdix*	uncommon	transient
Meriam's turkey	*Meleagris gallopavo*	uncommon	transient
Great blue heron	*Ardea herodias*	rare	transient
American coot	*Fulica americana*	common	unknown
Killdeer	*Charadrius vociferus*	common	breeder
Long-billed curlew	*Numenius americanus*	common	breeder
Willet	*Catoptrophorus semipalmatus*	common	breeder
American avocet	*Recurvirostra americana*	common	breeder
Wilson's phalarope	*Steganopus tricolor*	common	breeder
Upland sandpiper	*Bartramia logicauda*	common	breeder
Mourning dove	*Zenaidura macroura*	common	breeder
Short-eared owl	*Asio flammeus*	common	breeder
Great-horned owl	*Bubo virginianus*	common	unknown
Burrowing owl	*Speotyto cunicularia*	rare	unknown
Common nighthawk	*Chardeiles minor*	common	breeder
Common flicker	*Colaptes cafer*	uncommon	transient
Horned lark	*Eremophilia alpestris*	common	breeder
Barn swallow	*Hirundo rustica*	uncommon	transient
Common crow	*Corvus brachyrhynchos*	uncommon	transient
Black-billed magpie	*Pica pica*	common	unknown
Sage thrasher	*Oreoscaptes montanus*	common	breeder
Loggerhead shrike	*Lanius ludovicianus*	common	unknown
Eastern kingbird	*Tyrannus tyrannus*	common	unknown
Red-winged blackbird	*Agelius phoeniceus*	common	breeder
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	common	breeder
Western meadowlark	*Sturnella neglecta*	common	breeder
Lark bunting	*Calamospiza melanocorys*	common	breeder
Brewer's sparrow	*Spizella breweri*	common	breeder
Vesper sparrow	*Poocetes gramineus*	common	breeder

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