Nesting ecology of raptorial birds in central Utah

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NESTING ECOLOGY OF RAPTORIAL BIRDS IN CENTRAL UTAH

by

Joseph R. Murphy, Franz J. Camenzind, Dwight G. Smith, and J. Bradford Weston

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Frontispiece. Thirty-four-day-old Ferruginous Hawks, Thorpe Hills, Utah County, Utah, June 21, 1968. The brood consists of 3 dark-phase individuals and one light (“normal”) phase (see p. 34). Photo by J. B. Weston.
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Joseph R. Murphy, Franz J. Camenzind, Dwight G. Smith, and J. Bradford Weston
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AN INTRODUCTION TO
NESTING ECOLOGY OF RAPTORIAL BIRDS IN CENTRAL UTAH

by

Joseph R. Murphy

In contrast to many areas of North America, the sparsely-settled Great Basin deserts of Utah still support large and diverse raptor populations. For the past several years these predatory birds have been the subject of intensive studies by personnel of the Department of Zoology, Brigham Young University. The present report deals with the nesting ecology of three of the largest and most conspicuous species. Other studies in progress, to be the subjects of future publications, deal with behavior and ecology of wintering Bald Eagles, causes and influence of raptor mortality, economic relations of Golden Eagles, and factors which control total raptor densities and population dynamics.

DESCRIPTION OF THE STUDY AREA

The research has been conducted within a maximum area of roughly 3000 square miles, involving portions of six counties in central and western Utah. The majority of the field work, however, has been restricted to a smaller area of about 600 square miles at the eastern edge of the Great Basin, lying approximately between North latitudes 40°00' and 40°20', and West longitudes 111°55' and 112°25'. The area includes, from east to west, the following physiographic features (see map, Fig. 2): Lake Mountains, Cedar Valley, southern end of the Oquirrh Mountains and northern portions of the East Tintic Range with intervening groups of hills (Thorpe Hills and Topliff Hills), and a large part of Rush Valley. Elevations range from some 4500 feet above sea level at the west margin of Utah Lake (east edge of study area) to nearly 8000 feet in the Oquirrh and Tintic Mountains. Local relief varies from 3200 feet at Lake Mountain to 1600 feet (maximum) in the Thorpe and Topliff hills.

Geology

The geology of major portions of the study area has been treated by Bullock (1951) for the Lake Mountain vicinity and by Bissell et al. (1959) for the southern Oquirrh Mountains, Thorpe Hills, and adjacent areas. The structural geology of the area is characterized by synclinal folds and a series of anticlines developed in a thick series of Paleozoic rocks ranging in age from Lower Cambrian to Upper Pennsylvanian. These strata are folded, faulted, and subsequently eroded in such fashion as to expose numerous cliff lines of resistant limestones alternating with softer shales and sandstones (see Fig. 1). Small exposures of Tertiary volcanic materials, mainly basalts and ignimbrites, are scattered through the area. Quaternary alluvial materials, lacustrine and fluvial in origin, form aprons around the bases of the hills and in the stream valleys and passes. Pleistocene sediments and fan gravels of ancient Lake Bonneville comprise the bulk of these deposits. Most of the present stream drainage in the study area is intermittent or ephemeral; as a result, only thin mantles of recent alluvium are visible.

As is typical of most valleys in the Great Basin, there is very little outside drainage of surface water. For the most part, the surface water is either absorbed by the soil or flows over the surface to the lowest part of the valley, where it is slowly absorbed or evaporated.

Climate

Climatic features of the study area are characteristic of the northern or cold desert regions (Fautin, 1946; Shelford, 1963). Mean annual precipitation is generally less than 15 inches (38 cm) for most of the region, with larger amounts at higher elevations. Distribution of precipitation is very uneven in both space and time. Moisture graphs for the area indicate that most of the precipitation comes during two periods: early spring (March through May) and midsummer (July and August). Significant variations in annual and monthly precipitation patterns are characteristic.

The annual range in temperature may be as great as 65°C in some parts of western Utah, with maxima of 45°C and minima down to -30°C. July is generally the hottest month, with a mean temperature of about 23°C in an "average" year. Wide daily fluctuations in tempera-

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ture are also to be expected, amounting to as much as 30° or more in the summer months.

As is true of most arid regions, wind is an important climatic feature in the Great Basin deserts, and combined with the prevailing low relative humidity and dry atmosphere, accounts for the observed high rates of evaporation (Fautin, 1946). The dominant southwesterly winds are particularly strong during the spring months; superimposed upon these and occurring at all seasons, are shallow diurnal mountain and valley winds.

**Biotic Communities**

A variety of soil types occurs within the area of study ranging from well-drained, gravelly soils on higher ground to fine-textured soils of moderate to high salinity in the lower valleys. This diversity in edaphic conditions is reflected in the plant and animal communities present. In terms of plant dominants, the high ridges and hills support a dwarf conifer community consisting primarily of *Juniperus osteosperma* with smaller amounts of pinyon pine (*Pinus monophylla*) and associated shrubs (e.g., *Cercocarpus, Covania, Purshia*). Big sagebrush (*Artemisia tridentata*) is dominant on the well-drained soils of the uplands and lower slopes, while shadscale (*Atriplex confertifolia*) and greasewood (*Sarcobatus vermiculatus*) communities cover large areas of the valley floors. Other prominent shrubs, becoming dominant under certain edaphic and biotic conditions, include rabbitbrush (*Chrysothamnus nauseosus*), four-wing saltbush (*Atriplex canescens*), winterfat (*Eurotia lanata*), horsebrush (*Tetradymia glabrata*), and bud sage (*Artemesia spinescens*). Originally there were significant quantities of perennial grasses, especially *Oryzopsis hymenoides*, intermixed with the shrubs, but overgrazing and other forms of abuse have drastically altered this situation (see next section).

The principal herbivorous vertebrates include the mule deer, jack rabbit, ground squirrels, kangaroo rats, wood rats, deer mice, pocket mice, grasshopper mice, a number of herbivorous birds (mainly passeriforms), and lizards. Vertebrate carnivores, other than raptors, include coyote, badger, kit fox, bobcat, gopher snake, whipsnake, and Great Basin Rattlesnake. The raptors are particularly well-represented; principal nesting species are the Golden Eagle, Ferruginous Hawk, Red-tailed Hawk, and Great Horned Owl. Represented by smaller nesting populations are the Swainson’s Hawk, Harrier, Cooper’s and Sharp-shinned Hawks, Prairie Falcon, Kestral, Burrowing Owl, Sereech Owl, and Long-eared Owl. Of these, the conspicuous permanent residents are the Golden Eagle, Harrier, Prairie Falcon, and Great Horned Owl. Important winter residents are the Bald Eagle and Rough-legged Hawk. Little information is available regarding population cycles in prey species and how these may in turn affect the raptor populations.

**Human Utilization**

Intensive human use of the area extends back a little over a century, and involves three major
activities: livestock grazing, farming, and mineral extraction. Although the main line of the Union Pacific Railroad between Salt Lake City and Los Angeles extends the length of Rush Valley, the four or five towns existing within the study area are all small, with populations of less than 1000.

Important events in western history have influenced the area. Camp Floyd, which supported the largest troop concentrations of any United States military post in the 1850's, was located at Fairfield in Cedar Valley. The route of the Pony Express ran through Cedar and Rush Valleys with relay stations in each valley. Later the booming mining towns of Ophir and Mercur were established in the nearby Oquirrh Mountains. Mining activity has drastically waned in recent years, and the only significant mineral extraction at present involves quarrying of limestone, clay, and calcite; this activity is widespread but pursued only intermittently throughout the study area.

The principal use of the area at the present time is for livestock grazing, notably as winter sheep range. According to Bureau of Land Management personnel, upwards of 40,000 sheep winter in the general study area each year. Such intensive use has had detrimental effects upon forage conditions, and much of the range has been overgrazed. Most of the desirable forage species such as winterfat, bud sage, four-wing saltbush, big sage, and Indian rice grass are reduced both in number and vigor. Less desirable invading species such as halogoton, Russian thistle, matchweed, and cheat grass are now common. Range revitalization programs are presently in effect in parts of the area, utilizing desirable native and introduced species of grasses.

Agricultural practice is limited to the valleys, especially Cedar Valley. Dry-farm wheat raising is the principal activity; the recent introduction of portable overhead sprinkling systems will no doubt extend the acreage involved in wheat production.

A sizable portion of Rush Valley (about 30 square miles) serves as a military reservation for ordnance storage, the Deseret Depot Activity of the Tooele Army Depot.

An additional human activity of increasing importance in recent years is the utilization of the area for sport shooting of rabbits in the winter. Cedar and Rush Valleys usually support dense jack rabbit populations, and owing to their proximity to the urban centers of northern Utah, receive surprisingly heavy hunter visitation, especially on weekends. This activity is evidently not without consequence for the raptors which present a large and tempting target for the undisciplined gunner. In fact, our observations indicate that shooting is probably a primary cause of post-fledgling raptor mortality in the study area (see Ellis et al, 1969).

ADVANTAGES OF THE STUDY AREA

The area offers a number of substantial advantages to the raptor populations as well as to students of raptor ecology. These may be summarized as follows:

1. Human population density is minimal, and the effects of human manipulation or utilization of the habitat have had no obvious adverse effects on the raptors except for the shooting noted previously.

2. Prey populations appear to be sufficiently large and diverse to support the concentration of different raptors present at optimum densities in all seasons. Although we as yet have no reliable data on cycles or other population dynamics in the prey species, indications are that the raptors readily resort to alternate prey when a prime prey species is temporarily at low levels. The diversity in size and behavior of potential prey species permits allocation of the various raptors to specific trophic niches; this will be elaborated upon more fully in the individual studies.

3. While the nearly treeless, shrub-covered valleys provide adequate hunting territories, the adjacent hills and mountains provide nesting and roosting sites in close proximity to the areas of greatest prey density. Geologically, the sequence of strata in the hills is conducive to providing excellent nesting situations for ledge and hole nesting species. Resistant layers of limestone, alternating with softer beds and generally inclined at an angle, provide the most favorable sites. Tree-nesting species such as the Ferruginous Hawk, Great Horned Owl, and the accipiters frequently utilize the junipers which form an open stand in a characteristic belt throughout the lower elevations of the mountains.

4. Since raptors in the area are in contact with livestock for much of the year, an excellent opportunity is provided for assessment of alleged or actual predation on sheep and other domestic stock. The Golden Eagle, which is the species most often indicted by stockmen, is present year-round in the area; we have been, therefore, paying particular attention to the food habits and economic relations of this species.
THE INDIVIDUAL STUDIES

The individual reports are primarily based upon research conducted by each of the junior authors in the process of obtaining a graduate degree in zoology, under the supervision of the senior author. The papers by Camenzind and Smith deal with species whose biology, although extensively studied in other habitats, is poorly known for desert regions. Weston’s study of the Ferruginous Hawk is evidently the first detailed treatment of the nesting ecology of this species; it adds a great deal of new information to existing published accounts of this interesting raptor in such general works as Bent (1937), and Brown and Amadon (1968).

One of the more significant conclusions that may be drawn from a comparison of the three papers relates to trophic niche allocation. Although there is considerable overlap in the kinds of prey items taken, it should be noted that the three species tend to hunt during different parts of the diel cycle. Thus the Golden Eagle is primarily diurnal in hunting activity, the Great Horned Owl is nocturnal, and the Ferruginous Hawk is to a large extent crepuscular, as indicated by the fact that Kangaroo Rats accounted for nearly 45 percent of the prey taken by this species. This utilization of separate hunting periods may be an important factor in permitting populations of several large raptors to coexist within the same area, utilize a common pool of prey species, and yet avoid direct confrontation or competition.

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The junior authors wish to express appreciation to Drs. C. Lynn Hayward, Herbert H. Frost, and J. R. Murdock who served as members of advisory committees and assisted with preparation and editing of the individual theses. They are also especially grateful to their wives, JoAnn Camenzind, Beth Anne Smith, and Linda Weston, who provided moral support, encouragement, and assistance with field work and preparation of manuscripts.

NESTING ECOLOGY AND BEHAVIOR OF THE GOLDEN EAGLE.
AQUILA CHRYSAEA TOS L.

by
Franz J. Camenzind

INTRODUCTION

The Golden Eagle, Aquila chrysaetos canadenis Linn., is facing extinction in much of its range. In the Western Hemisphere its distribution is restricted primarily to the mountainous regions west of the 99th meridian, from extreme northern Alaska to northern Mexico (Hobbie and Cade, 1962) and from timberline in Colorado to below sea level in Death Valley, California (Summer, 1929a).

Although a Federal Law was enacted in 1962 protecting this species, it continues to suffer losses through illegal killing and the enactment of temporary moratoriums on the hunting restrictions wherever it is alleged to interfere with livestock operations. In order to better manage this species, its life history and local behavior patterns must be thoroughly understood. Although numerous reports have been published from various geographic areas concerning the Golden Eagle’s productivity, nesting ecology, and behavior, little is known of its biology in Utah.

It was the principal objective of this study to determine the productivity, nesting ecology, and behavior of the Golden Eagle in west central Utah.
LITERATURE REVIEW

Gordon (1927) wrote one of the first thorough reviews of the nesting behavior of a pair of Golden Eagles in Scotland. Since that time much has been done to qualify and expand his findings. Watson (1957), Sandeman (1957), Lockie (1964), and Lockie and Ratcliffe (1964) have all added knowledge to the breeding activities of this species in various areas of Scotland.

Similarly, countless notes and articles have been published in the United States concerning various aspects of the Golden Eagle's ecology. Finley (1906) published one of the first of a long series of reports concerning the activities of this species in California. Slevin (1929) published an account concerning seven pairs of Golden Eagles over a six-year period in Santa Clara and San Benito Counties, California. Dixon's account (1937) attempt to map the territories of various pairs of eagles has provided a record that has been substantiated by numerous accounts from several localities in North America.

With the exception of Cameron's work (1905, 1906) concerning some Golden Eagles in Montana, little information was published for the Rocky Mountain Region until the late 1940's. It was then realized that this region had one of the largest concentrations of Golden Eagles remaining in the continental United States. Many of the later reports (Wood, 1946; Williams and Matteson, 1947; Brown and Calley, 1950; Carne, 1954; Fevold and Craighead, 1958; Strandmann, 1962) were concerned with eye-witness accounts of various behavioral patterns or reports on the food habits of different populations of Golden Eagles. The latest effort to report life history data as well as detailed food habit information is that of McGahan (1967, 1968) concerning a population of eagles in southwestern Montana.

Unfortunately, only scattered reports (Towey, 1942; Hardy, 1945; Hayward, 1967) on the status of the Golden Eagle in Utah have been published; it is anticipated that this study will begin to fill the void that exists in our knowledge.

LOCATION AND DESCRIPTION OF THE STUDY AREAS

The nest sites were grouped into two study areas which will be referred to as Area A and Area B. The principal study area (Area A) is located west of Utah Lake in Utah and Tooele Counties, Utah and contains approximately 540 square miles. It is bordered on the east by Utah Lake, on the north by a line running from Utah Lake to its intersection with State Highway 36 on the west, south by a line running from Vernon to the extreme north front of the East Tintic Mountains, and east to Utah Lake. As indicated in Fig 2, there are three broad land areas between the two parallel mountain ranges. These include (1) the lowland between Utah Lake and the Lake Mountains; (2) Cedar Valley west of the Lake Mountains; and (3) parts of Rush Valley west of the Oquirrh Mountains, Thorpe Hills, and East Tintic Mountains.

Area B includes several nest locations throughout west central Utah. Included are nests on the west front of the Wasatch Mountains near Provo in Utah County, Utah, as well as in several adjacent canyons. Other nests under observation are located in and around Yuba State Park, Juab County, Utah.

METHODS AND PROCEDURES

The study was conducted from January 1967 until July 1968 with the majority of the field work occurring during the nesting seasons (late February to early June) of both years. Field observations were made with the aid of a 20-power spotting telescope and a pair of 7x35mm field glasses; notes were taken on a portable tape recorder. Approximately 600 hours were spent in the field, which includes 150 nest visits.

Locating nest sites proved to be a demanding physical task which included observing the activities of adult Golden Eagles, thoroughly searching suspected nesting areas on foot, and taking two survey flights over the area. Additional information was obtained by consulting U. S Fish and Wildlife Service personnel, through personal communication with John Hutchings of Lehi, Utah, and by reading the personal field notes of the late B. G. Bee of Provo, Utah; these two individuals are veteran field naturalists who compiled long-term records dealing with central Utah ornithology.

In order to obtain an accurate timetable of events, eyries were kept under observation during the stages of nest construction, incubation, and brooding. Burlap hides were placed near three eyries at the time of hatching to facilitate more detailed observations of the behavior associated with brooding and fledging. A photographic record of activity was taken with the aid of a 35mm single-lens reflex camera equipped with telephoto lenses.

Home range was determined by recording the direction of flight activity in relation to individual nests. The directions were then plotted on circle graphs as percentages, and these were placed around a map of the study area.
Fig. 2. Study Areas A and B.
Unsuccessful attempts were made throughout the winter of 1967-68 to live trap and mark Golden Eagles with the use of a Bal-chatri trap with both mammalian and avian bait. Victor No. 1½ and No. 2 spring jump traps with padded jaws were also placed on favored roosting posts in Cedar Valley. This resulted in the capture of two Great Horned Owls (*Bubo virginianus*), one Short-Eared Owl (*Asio flammeus*) and one Long-Eared Owl (*Asio otus*), but no eagles were obtained.

**RESULTS**

_Nest locations._ A total of 31 active nests were observed during the two-year period. Of these, 11 were recorded in 1967 and 20 in 1968. The increase in 1968 was owing to the addition of the Yuba State Park area nests, as well as the discovery of additional nests in Areas A and B.

Eighty-seven percent of all nesting activity occurred on cliffs (27 activities), 6.5 percent (2 activities) on the ground and 6.5 percent (2 activities) on an artificial structure. The latter structure, located on the U. S. Army Deseret Depot Activity (Nest A-14), is an abandoned gunnery tower extending 11 meters above the ground. The nest is situated at the top and surrounded by a 1 meter high metal railing and a 2 meter high wooden frame (Fig. 3).

The ground nest (A-5) is located atop a rock ledge three meters high. The ledge remains level for about 1.5 meters, and then rises at an angle of approximately 13 degrees to the top of the hill.

All except five nests were reached without the aid of ropes. The nests ranged from two meters (A-4) to 13 meters (A-8) above the base of the cliffs. Most of these cliffs are limestone, with the exception of one (B-3) which is sandstone, and three others (B-4, B-5a and b, and B-6) which are shale.

_Altitudinal distribution._ Of all active nests in the study area, 61.3 percent were at altitudes between 5,000 and 6,000 feet, 9.7 percent below 5,000 feet, and 29.0 percent above 6,000 feet (Table 1). The altitudinal extremes are nests A-5 and A-13 at approximately 4,750 feet and 6,800 feet respectively, with the average altitude for all active nests being 5,750 feet.

_Nest aspect._ For both years, 55.5 percent of all active cliff nests faced west, 22.2 percent north, 18.6 percent south and 3.7 percent East (Table 2). There is no apparent difference either in the number of available cliffs facing various directions or in the distribution between the two years. This is in addition to the tower and the ground nests that were active both years and were completely exposed to all directions.

_Nest size._ The largest nest (A-3b) measured 1.0 meter wide, one meter from front to back,
and 1.6 meters high, and had a large amount of
nesting materials on the ground immediately
below. This was the only nest with an easterly
exposure and was located on a small ledge half-
way up on a 9 meter cliff. The smallest nest
was believed to be A-1, but unfortunately, it
was destroyed before accurate measurements
could be taken. With the aid of photographs
and measuring the debris, it was estimated to
be one meter long, 0.7 meter from front to back,
and 0.5 meter high. This nest was located on
loose rock in a limestone quarry and collapsed,
presumably under its own weight, when the
Eaglets were ten days old.

Nest materials. Nest materials usually re-
lected the surrounding vegetation in both com-
position and abundance. Those nests with jun-
iper or piñon pine nearby had an abundance of
shredded bark as lining, leafed branches as de-
coration, and larger branches in the main
structure. Nest A-2a had as its lining both
shredded juniper bark and juniper leaves in
almost equal proportions. This is in contrast
to A-6 which had predominantly piñon
branches, leafed and about 0.3 meter long, not
shredded into a fine mulch but packed with use.

Only nest A-3 had foreign material incor-
porated into the nest. It contained a piece of
wire about two meters long placed vertically on
the outside of the nest and extending slightly
above the top edge.

Nest Density and Home Range

Pair density. Pair density and all home range
data were taken only from Area A which con-
tained approximately 540 square miles of land
area including villages and cultivated fields. In
1967, nine nesting pairs were recorded in the
area, for an average density of one pair per
60 square miles. This is in contrast to 14 nesting
pairs in 1968 averaging 38 square miles per pair.
These figures express the maximum area per
pair, for rarely during the nesting season were
adult birds seen in the townships east of Faust
in Rush Valley or east of Fairfield in Cedar Val-
ley, and unknown nesting pairs may also have
been present

The two active nests with the greatest un-
occupied distance between them were A-15 and
A-14, 16.1 miles apart. This area was occupied
predominantly by sheep and cattle operations
and provided virtually no nesting habitat for
eagles. The closest active nests, 0.7 miles apart,
were found in 1968 when A-3b and A-4 were
both active. The divide between the two nests
was 125 feet higher than A-3b and 225 feet high-
er than A-4. A third nest active in 1968 (A-5)
completed a triangle whose sides measured:
A-3b to A-4, 0.7 miles; A-4 to A-5, 1.5 miles;
and A-5 to A-3b, 1.5 miles. The area of this
triangle was 0.5 square miles.

Home range. Only in area A was an attempt
made to measure home range. The direction of
all eagles going to or from their nests was re-
corded and only those nests with four or more
sightings appear in Fig. 4. Recordings for both
years were included when the same nest or
known alternate nests were involved.

The birds of nest A-15a and b and A-8a and
b had their activity rather evenly distributed
in four directions. Those of nest A-15a and b had
33.3 percent of their activity to both the north
and south and 16.6 percent to both the east and
the west; while A-8a and b had 18.2 percent to
the east and the west, 36 percent to the south,
and 27 percent to the north.

Pairs A-5, A-4, A-3, and A-2a and b had their
activity somewhat restricted to various direc-
tions. The birds of nest A-2 had no sightings
to the north while 37.5 percent were to both
south and east, with 25 percent to the west. Pairs
A-3, A-4, and A-5 had their activity pri-
marily in opposite directions. Fifty-four percent
of the activity of A-3a and b was to the north,
while 45.5 percent and 31.8 percent of the ac-
tivity of A-5 was to the east and south respec-
tively. All of the activity of pair A-4 was evenly
divided between both the south and west.
Similarly, pairs A-9, A-10, and A-11 had the
greater part of their activity in directions op-
posite to each other. Sixty-one percent of the
activity of pair A-10 was to the south, while pair
A-11 had 50 percent to the north and 33.3 per-
cent to the east. Pair A-9 had 66.6 percent to
the south and 33.3 percent to the east and no
reported activity to the north and west.

Alternate nests. Many of the pairs of eagles
had one or more alternate nests. Eleven of the
21 pairs considered had known alternate nests.
Of these, 8 pairs had three nests and 3 pairs had
two. Three of the 11 pairs with alternates are
known to have used different nests the same
year. The distance from active to alternate nests
ranged from slightly less than 25 meters at A-4
to 1.3 miles at A-8.

Nesting Activity

Nest preparation. Preparation of the nests
varied greatly, with several being almost
doubled in size prior to nesting, while others
remained virtually unchanged. Nest A-10 was
increased in height nearly 0.4 meter for the
Fig. 4. Home range based on directional activity.
1968 season; in contrast, nest A-5 was enlarged very little during the same period. Of all the nests studied for the two years, 54.5 percent had an increase in height of 0.1 meter or more, while the remaining 45.5 percent had less than 0.1 meter of new material added.

**Egg laying.** Egg laying dates varied from year to year as well as within a given year. The first egg was noted in nest A-3b on February 25, in A-10 on February 26, and in A-14 on March 1, 1968. Two eggs were seen in nests B-5 and B-6 on the second of March, 1968, and in nest A-15 on the fourth of March, 1968. This is in contrast to 1967 when, based on a 42-day incubation period, the first eggs were laid on March 6 at nest A-10 and March 9 at Nest A-14. Two eggs were found in nest A-3a on March 11, 1967, but unfortunately no laying date could be determined, as the nest was destroyed before hatching.

The last two eggs laid in 1968 were found on April 11 at nest B-5b, and were abandoned about May 16, with evidence that incubation had lasted nearly 35 days. This is believed to be the second nesting effort for this pair, their first having ended with two abandoned eggs about March 17, 1968 at nest B-5a. Another late nesting date occurred at nest A-7 where one young hatched about May 5. Based on a 42-day incubation period, the egg would have been laid about March 24.

Temperature data from the two years indicate no appreciable differences and provide no obvious correlation between the laying dates for both years.

**Incubation periods.** Fairly accurate incubation periods were obtained from three nests, Nest A-15b had an egg present on March 4 and the young eaglet was estimated to have hatched between April 12 and 14. This would indicate a minimum of 39 to 41 days of incubation. However, it is believed that this egg was laid March 2 when the bird was observed for 35 minutes to be sitting on the nest. This would increase the incubation period to a probable 41 to 43 days. Similarly, nests A-14 and B-6 held two eggs each on March 1 and 3, respectively. The estimated dates of hatching are April 13 to 15 for the eggs of nest A-14 and April 14 to 16 for the eggs of nest B-6. This results in a minimum 41- to 43-day incubation period for both clutches.

**Fledging.** The length of time required for the young to fledge varied from 8.5 weeks to 10 weeks. Pair A-8b hatched two birds about April 7, shortly after which one died. Fifty-nine days later, on June 5, the nest was empty, and what is believed to be the remaining bird was seen 1.5 miles east of the nest resting on a low ledge. It allowed our vehicle to approach within 100 meters, and then flew poorly for about 0.25 mile, and landed roughly on a hillside.

One young at nest A-15b fledged in approximately ten weeks in 1968, and two young fledged in 9 weeks in 1967. Three other pairs (A-5, A-12, and A-14) each fledged one bird in nine weeks in 1968, and pair A-4 fledged two birds in this same period in 1968.

**Productivity**

In 1967 and 1968, 23 nesting pairs of Golden Eagles produced eggs for an average of 1.91 eggs per nest. Three pairs produced one egg each, 19 produced two eggs each, and the remaining pair produced three eggs (Table 3). A total of 31 active pairs in 1967 and 1968 hatched 35 birds for an average of 1.13 young per pair. Twenty-six or 74 percent of these subsequently fledged for an average of 0.84 fledglings per pair for both years (Table 4).

**Unsuccessful nests** Six of the 13 nesting attempts that failed are believed to have been interfered with by humans. Nest A-3a and b were destroyed during incubation in both years of study. In 1967 the female was shot off the nest by a small caliber bullet and both eggs destroyed, and in 1968 all three eggs were found broken in the same area below and to the side of the nest. Nests A-6, A-10, and A-11 had the eggs removed, and no remains could be found in or around the sites. Four people with a rope were seen near nest A-11 on the last day the eggs were reported present.

Human interference is also blamed for the abandonment of nest A-8a in 1967 before eggs were laid. It is known that at least one man attempted to approach this nest with a rope on the last day it was reported active.

One nest (A-2) was abandoned in 1967 after a fire of unknown origin destroyed a wood rat den 12 meters to the side of the nest. Although the nest and egg were undamaged they were

<table>
<thead>
<tr>
<th>TABLE 3</th>
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<tbody>
<tr>
<td>Clutch size for various Golden Eagle nests for Areas A and B</td>
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</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>1967</th>
<th>1968</th>
<th>Total</th>
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</thead>
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<tr>
<td>1</td>
<td>1</td>
<td>14.2</td>
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<tr>
<td>2</td>
<td>6</td>
<td>85.8</td>
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<tr>
<td>3</td>
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<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>100.0</td>
<td>16</td>
</tr>
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</table>
TABLE 4
Productivity records, 1967-1968, Areas A and B

<table>
<thead>
<tr>
<th></th>
<th>Area A</th>
<th>Area B</th>
<th>Area A and B</th>
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<tr>
<td>Number of nesting efforts 1967</td>
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<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Number of nesting efforts 1968</td>
<td>14</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Number of nesting efforts with eggs 1967</td>
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<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Number of nesting efforts with eggs 1968</td>
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<tr>
<td>Number hatched 1967</td>
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<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Number hatched 1968</td>
<td>17</td>
<td>6</td>
<td>23</td>
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<td>Average number hatched per nest 1967</td>
<td>1.11</td>
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</tr>
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<td>Average number hatched per nest 1967-68</td>
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<td>1.00</td>
<td>1.13</td>
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<tr>
<td>Number fledged 1967</td>
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<td>9</td>
</tr>
<tr>
<td>Number fledged 1968</td>
<td>12</td>
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<td>17</td>
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<tr>
<td>Average number fledged per nest 1967</td>
<td>0.78</td>
<td>1.00</td>
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<td>Average number fledged per nest 1968</td>
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<tr>
<td>Average number fledged per nest 1967-68</td>
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<td>0.88</td>
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<tr>
<td>Percent of hatched that fledged 1967</td>
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<td>75.0</td>
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<tr>
<td>Percent of hatched that fledged 1968</td>
<td>70.5</td>
<td>83.3</td>
<td>73.9</td>
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<tr>
<td>Percent of hatched that fledged 1967-68</td>
<td>70.3</td>
<td>87.7</td>
<td>74.3</td>
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</table>

abandoned, even though the eagles remained in the area. The cause for abandonment of this nest in 1968 was never determined.

As mentioned previously, nest A-12 collapsed in 1967 causing the death of both young.

Nest B-5a was abandoned with two eggs at least 14 days after incubation started. Possible explanations include the placement of a hide near by, or the constant activity of approximately 12 starlings in and around the structure of the eagle nest. Approximately 25 days after the initial abandonment, two eggs were noted in nest B-5b, 0.7 mile south of the first nest. This clutch was abandoned nearly five weeks later for no apparent reason.

Only the pairs at nests A-5 and B-2 in 1967 failed to produce eggs, although they remained in the area for most of the season.

Behavior

Incubation. Most of the incubation was done by the female. The only observed exceptions to this occurred on three occasions at two different nests when the male was seen to alight on the nest in mid-afternoon and to relieve his mate. This appeared to last less than two hours, at which time the male left the nest before his mate returned.

Nest sanitation. The nests were kept free of food remains during the incubation period by the adults who carried the debris away. However, this was not the case once the young hatched. Food remains built up to a point where at nest A-8b parts of 12 jackrabbits were on the nest proper. Nest A-14 had much the same situation from the time the young was four weeks old until it fledged.

Alternate roosts. The male spent very little time at the nest. Of all the nest visits, there were only two occasions when it was certain that the male and not the female was on the nest. In several cases there were roosting sites near the nest where the male spent much of his time. Site A-3b had such a roost 15 meters above and to the south of the nest. Birds of nest A-4 used the large hill directly south of the nest, and an alternate nest 30 meters to the east. Nest A-5a had two roosting locations, one 110 meters to the northwest on a higher ledge, and another approximately 0.25 miles west of the nest. Other obvious roosts occurred at nests B-4 and B-6, immediately above and to the east of the nest and to the south of the nest respectively.

Nest aspect. Nest A-5 was exposed in all directions to the sun, and the young appeared to suffer from the heat. The female of this nest was often seen shading the young with her wings. On four occasions the male brought large tumbleweeds to the nest; three times he placed them to the west side of the nest where they provided some shade for the young. The young spent much time in gular panting, with its legs and wings outstretched on the nest.

On two occasions at nest A-4, the young were seen to seek the small available areas of shade to the extent that they crowded each other and
forced the smaller bird to occupy an exposed position.

Nest Defense. Only three of the nesting pairs showed any indication of defensive behavior. Most of the birds would fly out of sight as soon as they were aware of my approach. One exception was the pair at nest A-5. From incubation to fledging, these adults would stay in the area when disturbed and at time call in a rather shrill "chepop" sound. Particularly during incubation the female would remain within 45 meters and circle and call while the male, if present, would be higher and usually silent. This type of behavior continued through the fledging period with only the call being omitted. At this nest the young began leaving the nest and walking about on the hillside when 6.5 weeks old, and on at least one occasion before the young fledged, the female came to within 50 meters of me, circling and calling. Although this bird made no aggressive moves when disturbed, she did remain nearby and defensive. All defensive activity decreased sharply if two or more persons visited the nest at the same time.

The female at nest B-5 would not leave the nest until observers were almost within touching distance; when she occupied nest B-5a, I could approach to within 10 meters of her, and later when at nest B-5b, this same female would not leave until someone was looking over the edge of the nest. Upon leaving she usually circled two or three times in the immediate vicinity before disappearing.

The third eagle to show any indication of defensive behavior was at nest A-12 during the 1967 nesting season. On one occasion, I was able to approach to within 25 meters in a vehicle and then subsequently climb to the nest while in full view of the bird and touch her wing. She left, however, when the nest was approached to within two meters from above. At this time there were two one-week old eaglets in the nest.

Fledging behavior. Prior to leaving the nest, the eaglets appeared to perform wing exercises. This was noted on several occasions at nests A-5, A-15, and B-3. The eaglets started stretching their wings over their backs when five weeks old and progressed to wing flapping until their first flight. The eaglet of nest A-5 left the nest when 6.5 weeks old and two weeks later was seen walking on the hillside with a combination of wing flaps and jumps. When approached, this bird attempted to fly down the hill but was unable to get off the ground for more than short wing jumps. The following day under similar conditions, this bird did manage to fly about 200 meters down the hill with a combination of glides and stilted wing flaps. Once on the level valley floor it was unable to regain flight and was then captured and carried to the top of the hill and released.

The first flight of the eaglet in nest A-11 was one of little hesitation. When approached from above, it walked to the nest edge and immediately jumped off and with a series of very stilted wing and tail flaps it glided 250 meters to the valley floor. Once there it also could not regain flight and was captured after attempting to defend itself by lying on its back and extending its open talons. This bird was also returned to the hilltop and released.

The eaglets of nest A-15 in 1967 and A-4 in 1968 had very similar initial flights. Only the last eaglet to leave nest A-15 was observed as it jumped off the nest after making two approaches to the edge. It glided at least 350 meters with no real wing flapping and only the most abrupt turning. When about halfway into its flight, it produced two very plaintive "chepops" and continued to its destination, a juniper tree.

Both young in nest A-4 left the nest at about 7.5 weeks and were found on another ledge 20 meters above and to the northwest of their nest. These birds apparently walked slowly to this point, possibly taking several days, as droppings could be seen leading from their nest to this final roosting area. These birds both jumped off this ledge and glided, one to the west 300 meters and the other southeast 500 meters, before landing in low sagebrush.

The first flights of all these young, with the exception of those of nest A-11, were witnessed by at least one of the adult birds. Only nest A-8b contained large amounts of food after the young had left. At none of the other nest sites was there any food found, although all had remained scattered about. No adults were seen near the young before their flight, and adults made no attempts to come to their aid during the flight.

Renesting attempts. There were two cases of renesting attempts after the failure of the first nest. In 1967 nest A-2 was abandoned after a fire destroyed a nearby wood rat den. Three weeks later both eagles were seen carrying sticks to an alternate nest site 150 meters southwest of the original nest. Examination of this site indicated that material had been added to a height of 0.8 meter above the existing structure in the form of a pyramid. Later examina-
tion indicated that nest construction had ended at this stage.

Nest B-5a was abandoned with two eggs about March 17, 1968, and six days later on March 23, new decorations were evident on an alternate nest 0.7 miles south of the first. On April 11 two eggs were reported in this new nest, only to be abandoned between May 12 and 16. Examination of these last two eggs revealed feathered embryos with well-developed claws and bills. This would indicate that incubation had lasted at least 30 to 35 days, and that the eggs were laid about April 10 or 11. This allowed a period of 24 days from the time of the first nest abandonment to the time the second set of eggs were laid.

DISCUSSION

NEST LOCATIONS

The distinctive topographic features of Area A are the parallel mountain ranges with broad open valleys on either side. These mountain ranges provide an abundance of cliffs for potential nest sites, while the valleys with their rodent and lagomorph populations furnish excellent hunting areas. This undoubtedly accounted for the fact that of the 31 nesting activities reported in the two years, 87 percent occurred on cliffs, 6.5 percent on the ground, and 6.5 percent on an artificial structure. There were few trees large enough for nest sites in area A or around nests of Area B.

The utilization of the gunnery tower at site A-14 had enabled this pair of eagles to use this otherwise unsuitable portion of Rush Valley as their hunting range. The closest natural nest site would be in the Oquirrh Mountains five miles to the east or on the ground on several low hills. This location in the U. S. Army Desert Depot Activity offered protection from human hunting pressures and an abundant jackrabbit population.

The ground nest at A-5 is believed to be an abandoned Ferruginous Hawk (Buteo regalis) nest. Both McGahan (1968) and Wellein and Bay (1964) have reported unoccupied eagle nests on the ground.

McGahan (1968) reported that about 71 percent of the active nests in his study in southwestern Montana were on cliffs, with the remainder in trees. Wellein and Bay (1964) reported that of the 79 occupied and unoccupied nests found in Texas and New Mexico, 87 percent were on cliffs, 11 percent in trees, and one nest was on the ground. Only Murie (1944) had no tree nests to report when he observed 23 nests, all on cliffs, in Alaska. Bee (unpublished field notes) reported an active eagle nest in a fir tree on the eastern slope of the Lake Mountains of Area A in 1936. This nest could not be located in the present study.

The altitude of the active nests reflected the surrounding topography. The average altitude for all active nests in the study was 5,750 feet, with no nesting activity seen above 6,800 feet. Sixty-one percent of all active nests were located between 5,000 and 6,000 feet with 9.7 percent below 5,000 feet and 29 percent above 6,000 feet. A probable explanation is that only limited hunting is possible in areas at altitudes above 6,500 feet. McGahan (1968) has suggested that nest site preference is influenced by the direction of the sun’s rays; he reported that 49 percent of the nests in his study faced south, 14 percent west, and 23 percent east. Twenty-two percent of the active nests in my study faced north, 56 percent faced west, and 19 percent south. These figures fail to provide any evidence for or against the effect of the sun as a determining factor in nest selection.

NEST DENSITY AND HOME RANGE

Pair density and home range were determined for Area A only. The nine nesting activities reported in 1967 averaged 60 square miles per pair. With the addition of five more nests in 1968, the average dropped to 38 square miles per pair. This figure indicates a maximum area per pair, because few adult eagles were reported in areas near Faust in Rush Valley and Fairfield in Cedar Valley.

This density seems to coincide with reports from other areas. Dixon (1937) found that the 27 pairs observed in Southern California averaged 36 square miles per pair. Arnold (1954) in his study in Colorado found six pairs occupying six adjacent townships, and Lockie (1964) reported that his Scottish eagles averaged 27.1 square miles per pair. Another Scottish eagle study (Watson, 1957) indicated that five pairs of eagles averaged nine square miles of territory. McGahan (1968) found the birds in his study to average one pair per 66.3 square miles.

The shortest distance between active nests was 0.7 miles. A nearby nest provided the third point in a triangle the area of which was 0.5 square miles. McGahan (1968) reported two active nests being 1.0 mile apart but left it unclear as to the topography and home range allotment between the nests. Dixon (1937) stated that nesting pairs are sometimes within two square miles.
On a basis of the information concerning direction of activity of the various eagle pairs, their home ranges generally appeared to be opposite each other. Pair A-3a had 54.5 percent of their activity to the north and 27.3 percent and 18.2 percent to the east and south, respectively. By way of contrast, the activity of pair A-4 was evenly distributed between west and south. Pair A-5 had 45.5 percent and 31.8 percent to the east and south respectively, with only 18.2 percent to the west. This activity to the west was centered toward the roost located 0.25 mile in that direction, and at no time was there an indication of any bird of nest A-5 going far beyond this point. These birds were often seen hunting the area between their nest and the lake. It appears that these three nests are at the apex of their home ranges and that these ranges radiate away from each other. This corresponds to Dixon’s (1937) statement that eagles have their nests on the margin of their hunting range, and their activity radiates away from each other.

A similar situation appears to exist with nests A-9, A-10, A-11, and A-14. The direction of their activities indicates that their proximity to each other is only on the basis of nest site, and does not indicate an overlapping of ranges. Considering the lack of adequate nest sites in the valleys, this is the most effective way to utilize the available hunting area.

The birds of nest A-14 had most of their activity directed toward the north away from the Deseret Depot Activity. Those of nests A-5a and b and A-15 had their activity distributed in all directions, with slightly more to the north and south. This corresponds to the isolation of the respective hills and the somewhat north-south oriented highlands around their nests. Particularly at nest A-14, the adults were never seen low over the valley floor but always along the open ridge tops extending both north and south. It appears, therefore, that these nests are located near the center of the eagles’ ranges.

**NESTING ACTIVITY**

Earliest egg laying dates for both years differed by at least 10 days, from 24 February in 1968 to 6 March in 1967. There appears to be no correlation between this difference and the temperature variation between those two years. The average high temperature for January of both years was essentially the same, while the average low temperature for January 1967 was 5.2 degrees F. higher than for the same period in 1968. The high temperatures for February 1968 averaged 3.2 degrees F. higher than for the same period in 1967, and the low temperature for February 1968 averaged 4.4 degrees F. higher than for the same period in 1967. It is doubtful that these temperature differences account for the difference in egg-laying dates.

The incubation rate for the eagles in this study was determined to be 42 days. This corresponds closely to the 45 days determined by Hobbie and Cade (1962) in their work on some Alaskan eagles but is somewhat above the 33 to 35 days listed by Carnie (1954) for his study in Santa Clara County, California. Walker and Walker (1939) reported that a single nest in Southern California had a 43-day incubation period. Bent (1938) lists 28 to 35 days as the incubation time but adds that 35 seems more correct.

The male was seen to assist during incubation by relieving his mate in the afternoons. Walker and Walker (1939) also found this to be the case with one pair of eagles in Southern California. They stated that the male incubated from noon until 4 p.m., while the female rested. The male spent much of his time hunting or sitting on nearby roosts.

Summer (1929b) and Carnie (1954) both stated that the young remain in the nest from 65 to 70 days. Seventy-five days is the length of time Hobbie and Cade (1962) reported as required for fledging. In the present study, fledging periods varied from 59 to 70 days. The nest with a 59-day fledging period had only one young for the last seven weeks, and this bird was always supplied with more food than was eaten. This would indicate that the young are not starved from their nests but leave for other reasons as yet unknown.

The combined data for 1967 and 1968 resulted in 23 nesting pairs producing 44 eggs for an average of 1.91 eggs. This is only slightly lower than the 2.1 eggs per nesting pair reported by McGahan (1968). However, 1.13 eggs per pair hatched over the same period as compared to 1.8 and 1.59 respectively reported by McGahan (1968) and Wellein et al. (1964).

A total of 26 eagles fledged for an average of 0.84 fledglings per nesting pair. This is considerably less than the 1.37 and 1.32 fledglings per pair stated by McGahan (1968) and Wellein et al. (1964) but is similar to that described by Watson (1957) who found 0.8 fledglings per pair in Scotland.

The two reported renesting efforts (A-2, 1967; B-5a and b) seem to coincide with reports by Hanna (1930) and Dixon (1937) who es-
established 30 days and 28 days respectively between sets of eggs. Twenty-one days after nest A-2 was abandoned, the adults were seen carrying nesting materials to the new site. Although no eggs were laid in this second nest, the time interval would appear to coincide with a 28-day schedule.

Nest B-5a was abandoned on April 11, and 25 days later 2 eggs were seen in nest B-5b. It is believed that this was the same female. Her mottled color and willingness to stay on the nest when approached were the principle evidences for this belief.

**SUMMARY**

This study consisted of two years of observation on a population of Golden Eagles (*Aquila chrysaetos canadensis*) in and around Utah and Tooele Counties, Utah. The area can be classified as part of the sagebrush-shadscale biome with some juniper and pinyon pine growing on the higher ground. The topography of the major study area consisted of two parallel mountain ranges separated by broad open valleys.

Thirty-one nesting activities were observed over the two-year period. Of these, 57 percent were on cliffs, 6.5 percent on the ground, and 6.5 percent on an abandoned gunnery tower at the Deseret Army Depot in Tooele County, Utah.

The average elevation for the cliff nests was set at 5,750 feet with no nesting activities seen above 6,800 feet. Fifty-five percent of all active cliff nests faced west, 22 percent north, 19 percent south, and 4 percent east.

The size of the nests varied from the largest measuring 1.1 meters wide, 1 meter from front to back, and 1.6 meters high to the smallest measuring 1 meter wide, 0.7 meter from front to back, and 0.5 meter high. The materials used in nest construction reflected the surrounding vegetation in both composition and abundance.

Pair density and home range were determined for the 15 nesting activities in the major study area only. The greatest unoccupied distance between active nests was 16.1 miles, and the shortest distance between active nests was 0.68 miles. Pair density was set at one pair per 60 square miles in 1967, and one pair per 38 square miles in 1968. Three active nests were noted that formed a triangle whose area was 0.48 square miles.

Home range was based on the direction of activity of the adult birds from their nests. Eight nesting pairs were determined to have their nests on the perimeter of their ranges, while two other pairs located their nests near the center of their activity.

The first eggs reported for both years were laid on or about March 6, 1967, and February 24, 1968. The incubation period was determined to be 42 days, with the male assisting for only a limited amount of time during the afternoons. Fledging periods ranged from 28 to 70 days.

Productivity was broken down in the following manner: 11 nesting efforts in 1967 yielded 12 hatched young, and 9 of these fledged for an average of 0.82 fledglings per nesting effort, as compared to 20 efforts in 1968 with 23 young hatching and 17 eventually fledging, for an average of 0.85 fledglings per nesting effort. Seventy-five percent of the hatched birds fledged in 1967 as compared to 74 percent in 1968.

Adult defensive behavior was noted at three nests although no aggressiveness was apparent. It was noted in two cases that both young of a nest sparred for occupation of the shaded areas, with the smaller bird in both cases apparently forced to stay in the hot sun. This was in contrast to the situation at the one ground nest which was exposed to the sun at all times. Here the female was observed on several occasions partially spreading her wings and allowing the young to rest in her shade. On three occasions her mate brought tumbleweeds to the nest in an apparent attempt to shade the young eaglet.

Two renesting attempts were observed during the study. In 1967 a nest with one egg was abandoned, and the adults were seen adding materials to an alternate nest although they failed to lay eggs. In 1968, however, a nest was abandoned with two eggs, and the adults moved 0.7 mile and laid two eggs in a new nest. These, too, were abandoned before hatching.
NESTING ECOLOGY OF THE GREAT HORNED OWL

*BUBO VIRGINIANUS*

by

Dwight C. Smith

INTRODUCTION

The Great Horned Owl, *Bubo virginianus*, is a common nocturnal raptor of North and South America, occurring in most habitat types. Although it presumably exerts considerable predatory influence on certain mammalian and avian populations, relatively little is known of its natural history and ecology owing to its secretive habits and the inaccessibility of its nesting sites. Further interest is warranted in this raptor because of its decreasing numbers caused by a combination of factors, including habitat disruption owing to encroaching civilization, road kills, and indiscriminate shooting by hunters.

This study deals with the nesting ecology of the Great Horned Owl in the Great Basin deserts of central western Utah. Major aspects include nesting population and distribution, territoriality, and predation.

There are few comprehensive studies on the ecology of this species, and there appear to be no previous detailed investigations made in arid or semiarid habitats. Included among the more noteworthy studies are Baumgartner's (1938) work on its distribution and territoriality in New York forests, Errington's (1932) behavioral and predation studies in the cottonwoods of Wisconsin and the midwest, Orlan's and Kuhlman's (1956) population and distribution study, also in the Wisconsin area, and Fitch's (1940, 1947) population and predation studies in the California chaparral. Utah literature on this species is limited but includes notes on its nest site selection (Sugden, 1928), breeding records (Bee and Hutchings, 1942), some life history and ecology data (Bee, unpublished data), a trapping note reported by Stanford (1931), and numerous local distributional records as exemplified by Hayward's (1967) *Birds of the Upper Colorado River Basin*.

METHODS AND PROCEDURES

Study Area

The study locale of the first (1967) nesting season was the Thorpe Hills of central western Utah, an area of approximately 12 square miles of elevated topography located in Tooele and Utah counties (see Fig. 5). In the second study season (1968), the area was enlarged to include the adjacent Topliff Hills which increased the study area to approximately 25 square miles. These hills are low-lying extensions of the Tintic Range, with their highest elevations rising to about 1000 feet above the surrounding valley floors of Cedar and Rush Valleys.

FIELD STUDIES

The field work for this study was conducted for a period of two nesting seasons, the spring of 1967 and the spring of 1968. Field observations were aided by the use of 7 by 50 power binoculars and a 20 power spotting telescope.

Nests on the study area were located by a systematic search of all potential sites, that is, all cliff lines, rock outcroppings, abandoned quarries, and wooded areas. Those nests found were then plotted on a master map to determine the relative nesting population and distribution of the owls. Gaps in the suspected distribution were then rechecked several times during the nesting season for signs of roosting birds or nests previously missed. It was believed that all nests active during a given season were discovered and that an accurate picture of the nesting population and distribution of the Great Horned Owl was established during the two nesting seasons of the study.

Territorial studies were conducted at three nests, each representative of a different topographic site. These included a west-facing quarry nest and two cliff nests, one of which was located in an east-opening canyon and the other situated on a plateau with a western exposure. Territorial behavior was determined by visual observations during the hours from sunset until dark and was conducted from constructed blinds. Additional information on bird movements was gained from the plotting of sighting occurrences during the night. Owl movements were plotted, then territory size determined by planimeter measurements of the polygon formed by connection of points denoting the extreme distances from the nest site, following the method discussed by Odum and Kuenzler (1955).

Owl predation was determined by (1) weekly nest visitations to record prey types and frequency, and (2) pellet analysis.
Fig. 5. Study area location and vegetation
On discovery of a nest site, egg productivity was checked and the nest placed under weekly observation to note adult habits and egg-pipping time. After the young hatched the nest was inspected more frequently to ascertain food procurement items and adult territorial behavior. At nest abandonment with the development of flight by the young, nest measurements were taken and the remaining food items recorded and pellets removed for analysis. Data taken included nest size and material composition, its height relative to cliff size, and its elevation.

Additional data gathered included information on interspecific relations as determined by a search and location of active predatory bird nests in the vicinity of the owl nest sites.

RESULTS

Nesting Population And Distribution

Fourteen nests were found on the study area during the 2 breeding seasons, including 4 during the 1967 season and 10 the following year on the enlarged study area (Fig. 6). Homed Owl population density on the study averaged .35 nesting pairs per square mile during the 2 study years. During this period 5 additional nests were found outside the study area but in similar habitat type; unless otherwise noted, all observations and tabular information pertain to the study area nests.

Nests And Nest Site

Nest site and nest dimension data are presented in Tables 5 and 6. All four of the 1967 season nest sites were used the following year, thus 10 different sites were located during the two-year study. Birds on the study area utilized cliffs, abandoned quarries, caves and junipers for nest sites. Favorable sites were large sandstone or limestone cliff faces or rock outcroppings. Three sites were deep in canyons, one on a plateau, and the remainder in the hills and foothills. Six of the nests were on western exposures, three faced south, and one had an eastern exposure. Site elevations ranged from 5300 to 5750 feet and averaged 585 feet above the valley floors. None of the nests were actually built by the owls, but eggs were deposited in old Raven, Redtailed Hawk, and Ferruginous Hawk nests appropriated

<table>
<thead>
<tr>
<th>Nest number</th>
<th>Location</th>
<th>Site</th>
<th>Elevation</th>
<th>Valley floor elevation</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Foothill</td>
<td>Old Ferruginous Hawk nest in 13' juniper</td>
<td>5550</td>
<td>5350</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>Quarry</td>
<td>Niche in 34' sandstone face</td>
<td>5750</td>
<td>5350</td>
<td>400</td>
</tr>
<tr>
<td>3</td>
<td>Quarry</td>
<td>Ledge in 18' limestone block</td>
<td>5650</td>
<td>5250</td>
<td>400</td>
</tr>
<tr>
<td>4</td>
<td>Quarry</td>
<td>Niche in 36' sandstone face</td>
<td>5300</td>
<td>5150</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>Quarry</td>
<td>Old Red-tailed Hawk nest in 67' shale face</td>
<td>5400</td>
<td>5400</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Canyon</td>
<td>Old Raven nest in 29' limestone cliff niche</td>
<td>5650</td>
<td>5350</td>
<td>300</td>
</tr>
<tr>
<td>7</td>
<td>Canyon</td>
<td>Old Raven nest in 22' limestone cliff ledge</td>
<td>5450</td>
<td>5000</td>
<td>450</td>
</tr>
<tr>
<td>8</td>
<td>Canyon</td>
<td>Cave ledge in 38' limestone cliff</td>
<td>5750</td>
<td>5500</td>
<td>250</td>
</tr>
<tr>
<td>9</td>
<td>Plateau</td>
<td>Old Raven nest in 27' limestone cliff niche</td>
<td>5650</td>
<td>5300</td>
<td>350</td>
</tr>
<tr>
<td>10</td>
<td>Hills</td>
<td>Niche in 28' limestone cliff</td>
<td>5800</td>
<td>5450</td>
<td>350</td>
</tr>
</tbody>
</table>

Means: 5595  5310  285

Table 5

Nest site selection of the Great Horned Owl

<table>
<thead>
<tr>
<th>Nest number</th>
<th>Height above ground</th>
<th>Crevice size*</th>
<th>Nest size*</th>
<th>Nest composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>length</td>
<td>height</td>
<td>depth</td>
<td>length</td>
</tr>
<tr>
<td>1</td>
<td>14&quot;</td>
<td>22&quot;</td>
<td>40&quot;</td>
<td>33&quot;</td>
</tr>
<tr>
<td>2</td>
<td>15&quot;</td>
<td>30&quot;</td>
<td>33&quot;</td>
<td>30&quot;</td>
</tr>
<tr>
<td>3</td>
<td>16&quot;</td>
<td>25&quot;</td>
<td>23&quot;</td>
<td>22&quot;</td>
</tr>
<tr>
<td>4</td>
<td>17&quot;</td>
<td>204&quot;</td>
<td>66&quot;</td>
<td>27&quot;</td>
</tr>
<tr>
<td>5</td>
<td>12&quot;</td>
<td>28&quot;</td>
<td>33&quot;</td>
<td>28&quot;</td>
</tr>
<tr>
<td>6</td>
<td>24&quot;</td>
<td>41&quot;</td>
<td>17&quot;</td>
<td>25&quot;</td>
</tr>
</tbody>
</table>

*where applicable

Table 6

Nest dimensions of the Great Horned Owl
Fig. 6. Nest locations of the Great Horned Owl
by the early nesting owls, or were laid directly on unmodified rock or ground. Of the 10 nests, 4 were old Raven nests located in cliff crevices, one a Redtailed Hawk nest in a quarry crevice, one Ferruginous Hawk nest in a juniper tree, and the remaining 4 were on quarry and cave ledges. The nests outside the study area conformed to this pattern with the exception that one was located in a large Red-tailed Hawk nest high in a cottonwood tree.

The height of nests ranged from 11 to 55 feet above ground level. Nest size varied in proportion to crevice size, and as most nests were in poor repair, their external structure spilt throughout the crevice, conforming to the size and shape of the crevice. The larger nests actually formed the floors of huge cracks in the vertical stone faces of quarries, while the smallest nests were one ledge sites. Nests were composed of juniper and sagebrush twigs of varying sizes. All nests had extensive litter accumulation in the form of fecal material and prey and pellet remains. Toward the end of the nesting season this accumulation often spilled over the nests' edge forming large white streaks on the cliff face. Actual nest structure depended on 3 factors: age, exposure, and the original avian builder. The partially protected Raven nests tended to hold up best; they may thus provide several years of service.

Nest Distribution

Nests were evenly distributed in the study area, with sites averaging one mile apart. Maximum and minimum distances between nearest neighbors for both nesting seasons were three miles and three-quarters of a mile. The closest sites were on opposite sides of the same mountain range, hence the nesting birds hunted in separate valleys. The extreme distance between successive sites occurred in an area of fewer potential nest sites, and supported lesser numbers of predatory birds for any species. All nests were located in the periphery of the hills on sites overlooking the deserts. No nests were found in the study area interior (see Fig. 6) although potential sites were available.

Productivity And Nesting Success

A mid-September visit to the nests of the previous year (1967 season) disclosed no adult birds in the vicinity, but on December 2, (1967) I found a male occupying its nest site, presumably of the previous year. Owl pairs were initially observed together on January 5, and again on January 16, of the second study year. Egg-laying dates were between March 20 and April 10, in 1967, and between January 20 and February 10 in 1968.

In 1967 the 4 nests contained 8 eggs for an average clutch of 2.0 eggs per nest. In 1968 8 nests contained 24 eggs for an average clutch size of 3.0 eggs per nest. Maximum clutch size for the two-year study was 4 eggs while the minimum clutch size was one egg. In every case, repeat nests of the 1968 season contained one more egg than was contained in the 1967 season (see Table 7).

The fourteen nests of the 2-year study period hatched 29 young (2.1 per nest) and of these 23 (1.7 per nest) fledged, but yearly success varied. In the 1967 season, all nesting efforts were successful, but 5 of the 1968 study nests failed. Reasons for failure were ascribed to several causes based on circumstantial evidence. In at least 2 cases nest failure was attributed to human interference. Both nests failed after the young had hatched and survived for a period of 2 weeks. A third failure was attributed to interspecific action between close nesting Horned Owls and Red-tailed Hawks. In this case both species abandoned their nests after eggs had been deposited and were under incubation. Causes of the other 2 nest failures are unknown.

Adult Nesting Behavior

The 2 sexes differed in nest habits. During the daylight hours males generally roosted in favorite secretive spots such as trees, unoccupied nests or nesting crevices, and ledges at distances from 5 to 250 yards from the nest site.

Females roosted in the nest during the day, taking flight only when alarmed. Typical female diurnal activity after the young hatched

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of nests</th>
<th>Failures</th>
<th>Young per nest</th>
<th>Average clutch</th>
<th>Young hatched</th>
<th>Percent hatched</th>
<th>Young fledged</th>
<th>Percent fledged</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td>4</td>
<td>0</td>
<td>1 2 1 0</td>
<td>2.0</td>
<td>8</td>
<td>100</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>1968</td>
<td>10</td>
<td>5</td>
<td>0 1 6 1*</td>
<td>3.0</td>
<td>21</td>
<td>88</td>
<td>15</td>
<td>63</td>
</tr>
</tbody>
</table>

*Two histories unknown because of early nest failures.
consisted of positioning herself between the young and the edge of the nest. In this stance she would doze, occasionally awakening to visually sweep the nest site environs. The female would usually leave the nest approximately 45 minutes after sunset regardless of weather conditions, and join her mate at the roost, after which the pair would begin their nocturnal activities.

Nest Defense

Nest defense behavior differed with respect to sexes. Males took flight readily, but females remained on the nest until I flushed them. Six nesting pairs simply disappeared after being alarmed, but females of three nests would hoist protests from concealment. The female at nest ten repeatedly carried out determined attacks against me when I was near the nest.

Territoriality

Territories of 3 nesting pairs were determined during the growth of the young and are presented in Figure 7. Both hunting activity and sighting locations were plotted, thus maximum territory was established (Odum and Kuenzler, 1955). Results indicate territorial sizes of 172, 237 and 376 acres for the nests, or an average territory coverage of 261.6 acres. Territory size varied with topography. The largest territory (Fig. 7; nest 9) had the nest site on a plateau, and the nesting birds hunted in both surrounding valleys. The smallest determined territory (Fig. 7; nest 6) had its site in a narrow canyon with owls extending their hunting activity along a narrow strip into the desert. All determined territories extended only slightly into mountains but ranged far into the desert valleys. In no case did the size of the feeding territory have a radius exceeding one-fourth mile from the nest site into the hills, but the radius extending into the deserts ranged from one mile to one and one sixth miles, and spot observations on a fourth nest indicate a possible territorial range of two miles into the valleys.

Intra And Interspecific Relations

No interactions were observed between nesting pairs of Horned Owls, and no other large owls occurred in the study area. The medium sized Long-eared Owl (Asio otus) and Short-eared Owl (Asio flammeus) occur in the surrounding valleys, but neither species was found to be nesting in the study area. Several large avian raptors do nest in the study area, however, including the Golden Eagle, Red-tailed Hawk, Ferruginous Hawk, Swainson’s Hawk, Cooper’s Hawk and Prairie Falcon. These birds often nest close to the Horned Owl nests. Examples of nesting proximity include a Red-tailed Hawk nest situated on a ledge 25 yards from a Horned Owl cave nest, a Ferruginous Hawk juniper nest approximately 100 yards below a Horned Owl cliff nest, and a Horned Owl sharing quarry nesting sites with Golden Eagles and Prairie Falcons.

Interaction was observed in only one instance, wherein a Red-tailed Hawk attacked a flushed Horned Owl. There was no apparent injury to either bird, although both nests were later abandoned by the 2 nesting pairs.

Predation

Hunting activity of Horned Owls was often observed normally in late evening after sunset. Although there was some hunting in the hills and canyons, the principal prey procurement activity occurred in the deserts. Owls were observed to hunt either alone or in pairs, employing one of two hunting techniques. One method consisted of flying slowly, harrier fashion, over the ground, diving suddenly on prey spotted; the other method consisted of perching on suitable elevated objects such as telephone poles, rock outcroppings, and road banks to facilitate sighting of prey which would then be attacked by a direct flight to it.

Food items recorded were either prey remains found in the nest or items identified from pellets removed from the nest sites for analysis. A total of 173 food items was recorded; this included 101 prey remains and 72 items based on pellet analysis. Mammals recorded from pellets were counted only on the basis of skulls present, thus avoiding possible duplication of individuals. Table 8 lists the prey items found, along with percentage calculations based on numbers of individuals of each species relative to the total number of prey items, without regard to volumetric considerations.

Mammals comprised 156 items, or 90.2 percent of the total food intake. The Black-tailed jackrabbit (Lepus californicus) and desert cottontail (Sylvilagus auduboni) accounted for 67 items or 38.7 percent of the total of all items. This was equalled by the kangaroo rat (Dipodomys ordii), which totaled 68 items or 39.3 percent of the total food items. Other mammals less frequently recorded included the white-footed deer mouse (Peromyscus maniculatus), meadow mouse (Microtus sp.), ground squirrel (Citellus townsendii), and wood rat (Neotoma sp.).
Key

roads

sighting points

territory boundary

nest site

scale:

63mm. equals 1mi.

Fig. 7. Territories of three pairs of Great Horned Owls
**TABLE 8**

Food of horned owls in the study area

<table>
<thead>
<tr>
<th>Prey species</th>
<th>Scientific name</th>
<th>Number of items</th>
<th>Percent of total items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kangaroo Rat</td>
<td>Dipodomys ordii</td>
<td>68</td>
<td>39.3</td>
</tr>
<tr>
<td>Black-tailed Jackrabbit</td>
<td>Lepus californicus</td>
<td>41</td>
<td>23.7</td>
</tr>
<tr>
<td>Desert Cottontail</td>
<td>Sylvilagus auduboni</td>
<td>26</td>
<td>15.0</td>
</tr>
<tr>
<td>White-footed Mouse</td>
<td>Peromyscus maniculatus</td>
<td>13</td>
<td>7.5</td>
</tr>
<tr>
<td>Ground Squirrel</td>
<td>Citellus townsendii</td>
<td>4</td>
<td>2.3</td>
</tr>
<tr>
<td>Meadow Mouse</td>
<td>Microtus sp.</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>Wood Rat</td>
<td>Neotoma sp.</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Total mammals</strong></td>
<td></td>
<td>156</td>
<td>90.2</td>
</tr>
<tr>
<td><strong>Birds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mourning Dove</td>
<td>Zenaidura macroura</td>
<td>3</td>
<td>1.7</td>
</tr>
<tr>
<td>Pinyon Jay</td>
<td>Gymnorhinus cyanocephala</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Total birds</strong></td>
<td></td>
<td>5</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Invertebrates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scorpions</td>
<td>(unidentified)</td>
<td>12</td>
<td>6.9</td>
</tr>
<tr>
<td><strong>Total invertebrates</strong></td>
<td></td>
<td>12*</td>
<td>6.9</td>
</tr>
</tbody>
</table>

*present in 12 pellets

Only 2 species of birds were recorded, contributing 5 items or 2.9 percent of the total food items. Neither occurred in appreciable numbers, the Mourning Dove being represented by 3 specimens and the Pinyon Jay by only 2 specimens.

The only invertebrate representatives found belonged to a species of scorpion. Remains of these were found in 12 separate pellets, constituting 6.9 percent of the total prey items.

Volumetrically, the greatest single contributor of bulk food would be the black-tailed jackrabbit, followed by the desert cottontail. The kangaroo rat, although occurring in more numbers than both of the lagomorphs, would only constitute the third largest bulk contributor, owing to its smaller size, while the other mammals, birds, and invertebrates would contribute much less food.

**DISCUSSION AND CONCLUSION**

Nesting population densities for the 1967 and 1968 season were .36 pairs per square mile of study area and .40 pairs per square mile, respectively. Orians and Kuhlman (1956) found nesting densities of .22, 20, and .12 pairs per square mile in the cottonwoods of the Wisconsin plains. Errington, Hamerstrom, and Hamerstrom (1940) found .50 pairs per square mile in the same habitat type near Prairie du Sac, Wisconsin. Baumgartner (1939) estimated his study population in the cottonwood creek bottoms near Lawrence, Kansas, at 2.0 pairs per square mile. Fitch (1947) estimated a population in the California chaparral at 3.0 to 4.0 pairs per square mile. However, both of these latter investigations were based on the counting of hooting birds, and neither was substantiated by an intensive search for nests.

The observations cited above indicate that the availability of nesting sites may play a key role in determining the possible Horned Owl nesting density. Smaller densities were found in areas of widely scattered potential nesting sites, while larger densities occurred in those areas offering the greatest number of possible sites. My findings seem to substantiate this, as I found the greatest concentrations of Horned Owl nests in the numerous cliffs lining the periphery of the hills, whereas the interior of the hills and the deserts provided fewer nesting sites, and thus supported fewer owls. However, nesting density may also be modified by food availability, a subject which was not investigated in this study.

Owls of the study area commonly used cliffs, quarries, caves and ledges for nesting sites. Similar site usage has previously been observed by Bent (1937), Bee and Hutchings (1942), and Dixon (1914), but utilization of abandoned quarries has not been previously reported, although Sugden (1928) did observe owls nesting in abandoned Indian cliff dwellings in southern Utah.

Baumgartner (1938), and Orians and Kuhlman (1956) feel that hawks play an important role in Horned Owl productivity by providing nests for their breeding. Although owls on the study area commonly used old Raven, Red-tailed Hawk, and Ferruginous Hawk nests, I feel that their use of cliff sites precludes the necessity of hawks building nests for them, as four of the study nests were on unimproved rock and most of the remainder of the nests being used were in such poor condition that they pro-
vided no actual benefits to the owl occupants. This conclusion is reinforced by my observations that these desert Horned Owls may use the same nest for several years in succession, whereas Orians and Kuhlman (1956) found that the owls of their study were unable to use old nests for more than one season, as the nests would become too dilapidated unless repaired by hawks.

**Breeding**

Bent (1937) notes the average horned owl clutch size to be from two to three eggs, with one or four occurring uncommonly. In their later study, Orians and Kuhlman (1956) found a clutch size of two eggs to be the most common, with one-egg clutches appearing less frequently, and three-egg clutches rarely occurring. Bee (unpublished data) records Utah clutch sizes ranging from one to four eggs, with two appearing most commonly.

Bent (1937) further noted that egg-laying dates were between January and May, depending on the locality. My observations seem to indicate that both clutch size and egg-deposition date vary with yearly differences in winter temperature and severity, as there was a significant difference in egg-deposition dates (eggs were laid one full month earlier in the second study year) and clutch size (from an average of 2 eggs to an average of 3 eggs per clutch) in the two years of study. However, further observations would be necessary to substantiate this hypothesis.

**Territory**

My discovery of a male occupying his territory in December agrees with the findings of a number of observers, including Ridgway, Baird, and Brewster (1874), Errington (1932), Baumgartner (1938), and Orians and Kuhlman (1956), all of whom observed male Horned Owls occupying their territories in the late fall and winter.

The actual territory of these desert-dwelling owls seems to be larger than those found in previous studies. Ridgway, et. al. (1874) noted that horned owls rarely go more than a mile from their nest sites. Miller’s (1930) observations indicated that horned owls patrol an irregularly shaped territory with the largest diameter of no more than one half mile. Baumgartner (1938) obtained similar results, noting that his study birds also held territories of not more than a quarter mile radius in any direction from the nest site. I found that while the desert horned owls generally do not exceed a half mile radius into or along the periphery of the hill sites, they do range widely into the deserts, with activity radii often exceeding one mile.

Both Baumgartner (1938) and Bent (1937) state that horned owls will not tolerate other avian predators nesting in proximity, but I found several instances of other raptors nesting within a hundred yards of horned owl nests. This included one example of a Red-tailed Hawk nesting only 25 yards from an active horned owl nest. However, in agreement with Baumgartner (1938) I found no other species of large owls nesting in the proximity of the horned owl nests, although both the Long-eared Owl and Short-eared Owl occur in the adjacent valleys.

**Predation**

The results of my predation studies agree with those of Errington, Hamerstrom and Hamerstrom (1940), Alcorn (1942), Fitch (1947), and Orians and Kuhlman (1956), who found that lagomorphs constitute the principle volumetric items in the horned owl diet. Bond’s (1940) Nevada desert study demonstrated a similar utilization of several small species, including kangaroo rats, white-footed deer mice, meadow mice, and wood rats, but failed to show comparable use of rabbits and cottontails. I found that owls on the study area utilized fewer different species, but relied heavily on three species: the black-tailed jackrabbit, the desert cottontail, and the kangaroo rat.

**Summary**

This study describes the nesting ecology of the Great Horned Owl, *Bubo virginianus* in the desert regions of western central Utah. Study aspects included population and distribution as determined by the location of all active nests in a unit area; territoriality as determined by observations from constructed blinds and sighting information; and predation as demonstrated by a tabulation of prey remains found in nests and analysis of pellets removed from the nest site. Data were gathered for a period of two nesting seasons, the spring of 1967 and the spring of 1968, in the Thorpe and Topliff Hills of Utah and Tooele Counties, Utah.

Owl nesting densities were found to be .36 nests per square mile in 1967 and .40 nests per square mile in 1968. Nest sites included cliff lines, abandoned quarries, and junipers. Cliff nests occurred most often, with the eggs deposited either on bare rock or in old Raven, Red-tailed Hawk, or Ferruginous Hawk nests.
Both egg-deposition dates and clutch size differed between the two years of the study period, with an average clutch of 2 eggs being laid in late March or early April in the 1967 season, and an increased average clutch of 3 eggs being laid in late January or early February in the 1968 season. In 1967 four nests produced eight young, all of which were successfully fledged. In 1968 ten nests produced 21 young, of which 15 fledged. Nesting failures were frequent in the second-study season, occurring in five of the ten study-area nests. Reasons for failure were attributed to human interference and avian interspecific competition.

The nesting pairs maintained large territories, often ranging over one mile from the nest site into the surrounding valleys. These owls apparently tolerate the close nesting of diurnal avian predators, but not other owls.

The black-tailed jackrabbit and desert cottontail contribute the bulk of the horned owl food, followed by the kangaroo rat. Other mammals, birds, and invertebrates are utilized to a lesser extent.

Economically these owls are of little importance to agriculture or game management in this area, but may contribute to range management through their predation on the lagomorph and rodent populations.

NESTING ECOLOGY OF THE FERRUGINOUS HAWK

**BUTEO REGALIS**

by

John Bradford Weston

**INTRODUCTION**

The Ferruginous Hawk (*Buteo regalis*) is the largest and most powerful of the North American buteos. It is a bird of the western plains and arid regions, breeding from southwestern Canada to southern Arizona, New Mexico, and Kansas. It winters from California and Montana to Lower California and northern Mexico, seldom occurring east of the Mississippi River.

The Ferruginous Hawk may live on grassy prairies where it nests in the timber belts along the streams, or in the barren, treeless plains or badlands where it usually builds its nest on some convenient cliff, butte, or cutbank. Its chief habitat requirement seems to be a good supply of small rodents on which it characteristically feeds (Bent, 1937).

Fuertes (1920), May (1935), Bent (1937), Sprunt (1955), and Grossman (1964) have each described some phases of the natural history of this species. Bowles (1931) described ground and tree nesting of the Ferruginous Hawk in Washington. Cameron (1914) described nest sites and food preferences of this species in Montana. Salt (1939) listed migration routes of hawks banded in Alberta, Canada. To date, however, I have found no work that adequately covers the nesting ecology of the Ferruginous Hawk.

The purpose of this study is to furnish more information on the nesting ecology of the Ferruginous Hawk in Utah, with particular attention being paid to distribution, density, and nest sites. Observations on territorial behavior, feeding mechanics, nest behavior, hunting techniques, and mortality were also included.

**THE STUDY AREA**

The study area embraces some three towns- ships and three ranges of desert and semidesert land immediately south and west of Fairfield, Utah County, west central Utah (Fig. 8). The major portion of the area is formed by Cedar Valley and several ranges of low hills immediately adjacent to the valley. Topography is generally flat, broken only by the low hills. Elevation of the desert floor is about 4,900 feet above sea level. Within the eastern edge of the study area lie the Lake Mountains, and along the area's western edge the Toplift and Thorpe Hills are prominent. These mountains vary in altitude from 5,900 feet to 7,690 feet above sea level. To the north the Oquirrh Mountains rise well above 10,500 feet. The southern boundary
of the study area is an arbitrary line drawn through the southern portion of Cedar Valley and the adjoining hills. Agriculturally developed areas form portions of the northern and eastern boundaries.

METHODS AND PROCEDURES

Field work was conducted during the spring seasons of 1967 and 1968. During the spring of 1967, I spent nearly every weekend from February 20 through June 30 in the study area collecting data. In the spring of 1968, field work was again conducted from late February through June 30. In the course of this two-year project, no fewer than 450 man-hours were devoted to the field studies.

Owing to the large size of the study area, a small portion was chosen in which a more detailed, intensive study could be conducted (Fig. 9). The area chosen for intensive study represents a typical portion of the larger, more general study area. It was chosen because it was...
Fig. 9. Intensive study area nest site locations
easily accessible and contained a high density of nesting Ferruginous Hawks.

During the spring of 1967, a systematic search was conducted throughout the study area for Ferruginous Hawk nests. Behavior associated with hunting, courtship, and territorial defense of the hawks was often utilized in locating nests and delineating hunting ranges. Aerial surveys were also utilized to locate possible nest sites. Such surveys were valuable only to the extent of locating suitable nesting terrain.

After Ferruginous Hawk nests were located, those thought to be "active" or in use that year were kept under observation throughout the study. The remains of prey were observed and pellets were gathered from all nests in which they occurred. Pellets were also collected from roosting sites of the male hawks. Such sites were usually located near the nest.

Permanent blinds composed of a wire mesh frame with a burlap covering were placed upon hillsides above several nests. From these blinds observations were recorded on a portable tape recorder, and nesting activities were photographed with a 35mm, single-lens reflex camera equipped with several telephoto lenses ranging up to 600mm in length.

Known breeding pairs of hawks were assigned numbers, and each nest of that pair was assigned the corresponding number and an alphabetical designation. Therefore, nest 1a, 1b, ... 1d all belonged to pair number 1.

Analysis of prey remains and pellets was made by the writer. Bones were identified by comparison with those of known specimens. Pellets were analyzed on the basis of bones contained therein and the presence of general types of hair found. Where possible, all prey items were identified to species.

RESULTS

Population and Distribution

During 1967-1968 the general study area supported 21 known pairs of Ferruginous Hawks for an average density of one pair per 15.4 square miles. These figures express the maximum area per pair, for areas inhabited by humans are included, and unknown nesting pairs may also have been present. The majority of the hawks nested in the foothills surrounding Cedar Valley. The valley floor, which comprises a major portion of the study area, is essentially void of suitable nest sites.

The smaller intensive study area supported 11 known pairs of hawks for an average density of one pair per 7 square miles. Again, Cedar Valley comprised a large portion of the study area, with the hawks nesting in the foothills on its perimeter.

Seasonal displacement

The Ferruginous Hawk population in the study area was present at a high density only during the nesting season, which lasted from early March to late July. By September 1 no Ferruginous Hawks were observed in the study area. Several intensive searches conducted during the winter of 1967-68 revealed the presence of only one Ferruginous Hawk in the west desert area of central Utah. This bird was located some 25 miles west of the study area.

By mid-November a large population of raptors presumed to nest in more northerly areas had moved into the study area and surrounding terrain. The Rough-legged Hawk (Buteo lagopus) and the Bald Eagle (Haliaeetus leucocephalus) were present in particularly large numbers. These raptors remained in the area until late February and early March, when they departed and were replaced in part by Ferruginous Hawks which had presumably wintered farther south. Also occupying the study area only during the spring and summer months were the Red-tailed Hawk (Buteo jamaicensis), Swainson's Hawk (Buteo swainsoni), and Sparrow Hawks (Falco sparverius). The Golden Eagle (Aquila chrysaetos) and Great Horned Owl (Bubo virginianus) were permanent residents of the area throughout the study.

Fish and Wildlife Service locktite bands were placed on nesting hawks during the 1968 season. No recoveries which might indicate direction of seasonal movements had been made by the end of this study.

Nest Locations

Nest distribution

Ferruginous Hawk nests, often very old and in poor condition, were located on most low hills and many in scattered trees throughout the study area. However, occupied nests occurred in groups. That is, one portion of a large habitat area contained a series of active nests, while another nearly identical portion of the same habitat contained only old inactive nests. Active nests occurred in the same areas during both years of study. The Tenmile Pass and Blowhole Hill-Long Point areas exhibited a high concentration of active nesting pairs during the present study.

Proximity of Nests

The maximum and minimum distances between nearest neighbors for 13 occupied nests
in 1967 were 2.3 miles and 1.1 miles, respectively. In 1968 the maximum distance was 2.4 miles, and the minimum distance of 0.4 mile separated two nests on the same long hill, one facing south and the other north (Fig. 9, Nests 4b and 7b).

Supernumerary (alternate) nests were found for 25 nesting pairs, or 93 percent of 27 occupied nests visited during 1967 and 1968. The hawks often constructed entirely new nests each year. In 1967, 58 percent of the occupied nests had been entirely constructed during the spring of that year. In 1968 43 percent of the occupied nests were new, even though older nests were repaired and attended regularly until eggs were laid. Pairs with more than one nest had an average of 2.6 supernumerary nests. One pair attended five nests, no two of them farther apart than 0.1 mile; 4 pairs had one supernumerary nest each; the remaining 22 pairs had two or three additional nests.

Nest Sites, Composition, and Size

Of the 27 occupied nests found, 52 percent were located on the ground (Table 9). As a general rule, these nests were easily accessible from nearly every direction. The next most common nest site (11 active nests) was the Utah juniper, a tree characterized by large limbs that provide ideal support for the heavy, bulky nests. Juniper nests were usually located from six to ten feet above the ground. Unoccupied nests were classified as Ferruginous Hawk nests if they were constructed in the habitat preferred by this species or if they contained Ferruginous Hawk feathers.

In 1967 6 of 11 active nests were on eastern exposures, 2 faced west, 2 faced south; and although several hills with northern exposures were available, only one nest was found on them (Table 10). Differences observed in 1968 were negligible.

The typical nest is usually composed of sticks varying in size from that of a twig to those an inch or more in diameter (Fig. 10).

**TABLE 9**

<table>
<thead>
<tr>
<th>Nest sites</th>
<th>1967 Unoccupied</th>
<th>1967 Occupied</th>
<th>1968 Unoccupied</th>
<th>1968 Occupied</th>
<th>All nests*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>18 (58)</td>
<td>8 (62)</td>
<td>24 (69)</td>
<td>6 (43)</td>
<td>42 (64)</td>
</tr>
<tr>
<td>Juniper</td>
<td>11 (35)</td>
<td>4 (31)</td>
<td>9 (26)</td>
<td>7 (50)</td>
<td>20 (30)</td>
</tr>
<tr>
<td>Cliff</td>
<td>1 (3)</td>
<td>1 (7)</td>
<td>2 (5)</td>
<td>0 (0)</td>
<td>3 (5)</td>
</tr>
<tr>
<td>Cliffrose</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (7)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Totals</td>
<td>31 (100)</td>
<td>13 (100)</td>
<td>55 (100)</td>
<td>14 (100)</td>
<td>66 (100)</td>
</tr>
</tbody>
</table>

*This information was recorded for all nests, regardless of the years of construction, occupation, or abandonment.

**TABLE 10**

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>North (Percent)</th>
<th>East (Percent)</th>
<th>West (Percent)</th>
<th>South (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td>1</td>
<td>6 (55)</td>
<td>2 (18)</td>
<td>2 (18)</td>
<td></td>
</tr>
<tr>
<td>1968</td>
<td>1</td>
<td>6 (55)</td>
<td>1 (9)</td>
<td>3 (27)</td>
<td></td>
</tr>
</tbody>
</table>

*Applies only to tree and ground nests located on hillsides.

The lining is generally of juniper bark or bunch grass. One nest was lined with sheep's wool. Sixty-five percent of the active nests observed during the study had incorporated at least one piece of paper into the nest pocket. Most nests also contained pieces of dried manure. Juniper, shadscale, and big sagebrush, the most common plants in the area, provide most of the materials used in nest building.

After nesting activities had terminated in early summer, the dimensions of 24 active nests were measured and recorded. No trend in size variation could be distinguished between ground and tree nests. The average nest had a diameter of 39 inches, a thickness of 17 inches, a pocket diameter of 14 inches, and a pocket depth of 3 inches. The largest nest measured, a tree nest, had a diameter of 48 inches, a thickness of 43
inches, a pocket diameter of 17 inches, and a pocket depth of 4 inches. The smallest nest measured, a ground nest, had a diameter of 29 inches, a thickness of 8 inches, a pocket diameter of 11 inches, and a pocket depth of 2 inches.

**Initial Nesting Activity**

The earliest date in 1967 that hawks were observed near their nest sites was March 6. The first nesting pair observed in 1968 was seen February 25. In both 1967 and 1968 March was the month in which nearly all nests were constructed, with most of them being essentially completed by March 25.

Three different pairs of hawks were observed building their nests. In each instance both members of each pair were active in nest construction. Sticks of various sizes, which made up the bulk of every nest, were always carried to the nest site in the hawks' feet. On one occasion a strip of bark was seen to be carried to the nest in a hawk's bill. The female, distinguished by her larger size, did the actual arranging of materials in the nest. Once nest building had begun, each pair spent several hours every day carrying material to the nest until it was finished.

**Productivity**

*Clutch size*

In 1967 thirteen nests produced 20 eggs for an average of 1.5 eggs per nest. One nest produced 4 eggs, two nests produced 3 eggs, five nests produced 2 eggs, and the remaining five nests were abandoned before any eggs were laid.

In 1968 fourteen nests produced 50 eggs, an average of 3.57 eggs per nest. Eleven nests contained 4 eggs, two nests contained three eggs, and the remaining nest was abandoned before any eggs were laid (Table 11).

*Hatching, fledging success, and description of young*

In 1967 a total of thirteen nesting efforts produced 8 young, an average of .67 young per nest. Of those hatched 8 (100 percent) fledged.

In 1968 fourteen nesting efforts hatched 33 young for an average of 2.36 per nest. Of those hatched 28 (85 percent) fledged, an average of 2 fledged per nest (Table 11).

Within hours after hatching, the young hawks exhibited a dense covering of white down. Their gapes were noticeably broader than those of other species of hawks of similar size. Their ceces were greenish-yellow and their irises were dark gray. Pin feathers began to appear between the eighth and twelfth days and full juvenile plumage had developed by the seventh week.

**Observed dates of reproductive activity**

During both 1967 and 1968 every pair of hawks had selected its nest site by March 10. In 1968 the average laying date was April 8, the average hatching date was May 10, the average brood departure date was June 25, and the resulting average number of days in the nest was 45. Those differences observed in 1967 were probably not significant (Table 12).

**Behavior**

*Territorial behavior*

The observations on territorial behavior seemed to be rather inconclusive. At times each pair was seen to vigorously defend its territory against any intruding raptor. On other occasions predatory birds flew directly over active nests without eliciting any response whatsoever from the occupant pair. On one occasion two Swainson’s Hawks were seen to attack a soaring male Ferruginous Hawk whose mate was sitting with her three young on a nest directly below him. The intruding Swainson’s Hawk flew high

| TABLE 11 |
|---|---|---|---|
| Eggs laid, young hatched, and young fledged, 1967-1968 |
| | 1967 | 1968 |
| Number of nesting efforts | 13.00 | 14.00 |
| Number of eggs laid | 20.00 | 50.00 |
| Average number of eggs per nest | 1.50 | 3.57 |
| Number hatched | 8.00 | 33.00 |
| Average number hatched per nest | 0.67 | 2.36 |
| Number fledged | 8.00 | 28.00 |
| Average number fledged per nest | 0.67 | 2.00 |
| Percent of hatched that fledged | 100.00 | 85.00 |

| TABLE 12 |
|---|---|---|
| Observed dates of reproductive activity of the Ferruginous Hawk on the Utah study area |
| | 1967 | 1968 |
| First selection of nesting territory | III/6 | II/25 |
| Earliest laying date | IV/3 | IV/4 |
| Latest laying date | IV/15 | IV/19 |
| Average laying date | IV/10 | IV/8 |
| Earliest hatching date | V/9 | V/6 |
| Latest hatching date | V/17 | V/22 |
| Average hatching date | V/12 | V/10 |
| Earliest brood departure date | VI/18 | VI/12 |
| Latest brood departure date | VI/27 | VII/5 |
| Average brood departure date | VI/23 | VI/25 |
| Average number of days in nest | 43 | 45 |
| Breeding season span (days) | 115 | 132 |
above the resident Ferruginous Hawk, then swooped on him at steep angles, barely missing him several times. Finally, one of the Swainson's Hawks came too close and was grasped in the talons of the larger Ferruginous Hawk, who immediately released him. Upon being released, the Swainson's Hawk tumbled several feet, regained his balance and quickly flew away, followed closely by his partner. The Ferruginous Hawk returned to his leisurely soaring flight above the nest.

On five occasions as I visited five separate active nests, three adult Ferruginous Hawks soared above me, screaming, diving, and protesting my presence. At no time was hostility exhibited by the nesting pair toward the third hawk that had joined them in their attack on me. These were the only instances in which more than two Ferruginous Hawks were observed above any one nest site.

Several times during the study Ravens (Corvus corax) were attacked by nesting hawks, although no actual contact was ever observed. On one occasion a Golden Eagle was chased from a Ferruginous Hawk's nest site, although eagles were generally tolerated wherever they roamed.

Nest behavior

Only female hawks were observed incubating eggs, although the males may have participated in incubation during periods of my absence. Both members of each pair hunted prey for their young, but the male always left his catch on the edge of the nest and departed. By contrast, when the female carried prey to the nest, she remained to feed the young.

Throughout incubation and while the young were covered with down, the female remained at the nest almost constantly. However, as the young grew older and more self-sufficient both parents spent increasing amounts of time soaring and roosting together in areas near the nest. As the young reached their sixth week after hatching, the female was present at the nest only during the night time and on subsequent short visits to bring food to the nest during the day.

Food Habits

Remains of prey were counted, recorded, removed from the nest, and identified. When possible, food was squeezed from the crop of nestlings (Errington, 1932). Pellets regurgitated by both adults and young were counted, collected, and stored. However, pellet analysis is a poor method of determining quantitatively the food of nestling hawks, for such pellets contain very little osseous material. Prey species can be identified readily from most pellets, but it is frequently impossible to determine the number of individuals concerned. In all, 219 samples were taken from 26 eyries, which included 53 pellets and numerous parts and pieces of rabbits and other prey. From these, 283 prey specimens, or 1.3 per sampling, were identified, indicating the minimum number of individuals that the various identified items could represent.

Identified prey

Of the 283 prey specimens identified, 92 percent were mammals (Table 13). Kangaroo rats comprised 48 percent of the mammals and 44 percent of all prey items. Black-tail jackrabbits were the next most plentiful, representing 33 percent of the mammals and 30 percent of the total. It is likely, however, that jackrabbits represent the greatest amount of food material in the diet of these hawks. Birds composed 5 percent of the total number of prey items, with Horned Larks the most prevalent, representing 86 percent of the birds. The only reptiles tallied were 3 snakes and 6 horned lizards, representing only 3 percent of the total number of prey individuals.

Hunting techniques

The most common hunting technique exhibited by this species was to fly low over open country, never rising more than a few feet above the ground, with rapid wingbeats propelling it swiftly forward. Capture was attempted of any small animal encountered in the flight path. I often saw Ferruginous Hawks soaring in true Buteo style. On one occasion a soaring hawk swooped on a black-tail jackrabbit, which it missed. Twice during my study, hunting hawks were observed to hover in one place by rapid vibration of their wings, then fly on a few feet and repeat the procedure until prey was found and captured.

Observation of several nests from concealed blinds revealed that intensive hunting was usually initiated at first light of dawn, often being completed by sunrise. Evening hunting usually started at sundown. Food demands by nestling hawks necessitated extended hunts as the nesting season progressed.

Mortality

During this study several dead raptors were found. A fellow student conducted a mortality census of raptors along a utility pole line located in the center of my study area (Ellis et al., 1969). In 1967-1968 he counted 28 dead raptors (primarily eagles) along the nine-mile stretch
of poles, which was paralleled by a gravel road. The only Ferruginous Hawk mortality recorded during this project was an adult female shot at nest #3. As indicated by data previously cited in Table 11, nestling mortality did not appear to be excessive.

**DISCUSSION AND CONCLUSIONS**

The present study revealed a sizable population of Ferruginous Hawks in the west desert study area during the years of 1967 and 1968. Twenty-one pairs of hawks, or one pair per 15.4 square miles, were located. It should be noted that Cedar Valley, which embraces a large part of the study area and is essentially devoid of nests, was included when area-per-pair calculations were computed; this leads to indications of a larger area per nest pair than was actually utilized. Although present literature gives no indication of population densities in other areas, I assume that this population is representative of areas exhibiting similar habitat conditions.

An annual seasonal displacement was exhibited. Raptors from more northerly nesting grounds migrated into the study area during the winter months. They replaced the nesting population of Ferruginous Hawks, which had essentially departed from the nesting area by early September. Spring migrations brought the Ferruginous Hawks back to their nesting grounds by early March.

Salt (1939) banded 114 juvenile Ferruginous Hawks in Alberta, Canada. Band returns indicated that the wintering range of these birds included New Mexico, Colorado, Kansas, Texas, and Oklahoma. A single bird was recovered in the southwest corner of California. One bird, almost three years of age, was subsequently recovered within a dozen miles of its birthplace. He was unable to secure the body of the bird for dissection and examination which might have proved whether or not it was a breeding bird.

By the end of this study, no bands had been recovered from juvenile hawks banded in the west-central Utah study area. However, I assume that the hawks of this area pursued a southerly migration route similar to that of their Canadian counterparts.

Deserted nests indicate that Ferruginous Hawks have at some time, past or present, nested in essentially all suitable areas surrounding Cedar Valley. Current active nest locations, however, imply a preference to inhabit particular areas instead of dispersing in a random distribution pattern. Food availability and potential nest site locations seem to be uniformly distributed throughout the area, thus discounting these as major determining factors in site locality preferences.

The characteristic nest location of this species in the study area is upon the ground on the sides

### TABLE 13

Food of nesting Ferruginous Hawks in the west-central Utah study area*

<table>
<thead>
<tr>
<th>Prey species</th>
<th>1967</th>
<th>1968</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ord Kangaroo Rat (Dipodomys ordii)</td>
<td>31</td>
<td>40</td>
<td>93</td>
</tr>
<tr>
<td>Black-tail Jackrabbit (Lepus californicus)</td>
<td>23</td>
<td>30</td>
<td>62</td>
</tr>
<tr>
<td>Antelope Squirrel (Citellus leucurus)</td>
<td>5</td>
<td>6.5</td>
<td>10</td>
</tr>
<tr>
<td>Deer Mouse (Peromyscus maniculatus)</td>
<td>4</td>
<td>5.2</td>
<td>11</td>
</tr>
<tr>
<td>Desert Cottontail (Sylvilagus audubonii)</td>
<td>2</td>
<td>2.6</td>
<td>5</td>
</tr>
<tr>
<td>Pocket Mouse (Perognathus parvus)</td>
<td>1</td>
<td>1.3</td>
<td>6</td>
</tr>
<tr>
<td>Rock Squirrel (Citellus variegatus)</td>
<td>2</td>
<td>2.6</td>
<td>3</td>
</tr>
<tr>
<td>Harvest Mouse (Reithrodontomys megalotis)</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Long-tail Weasel (Mustela frenata)</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>68</td>
<td>88.2</td>
<td>192</td>
</tr>
<tr>
<td><strong>Birds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horned Lark (Eremophila alpestris)</td>
<td>3</td>
<td>3.9</td>
<td>9</td>
</tr>
<tr>
<td>Green-tailed Towhee (Oberholseria chlorura)</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Say's Phoebe (Sayornis saya)</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>3</td>
<td>3.9</td>
<td>11</td>
</tr>
<tr>
<td><strong>Reptiles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horned Lizard (Phrynosoma platyrhinos)</td>
<td>6</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td>Gopher Snake (Pituophis melanoleucus)</td>
<td>0</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>Western Whipsnake (Masticophis taenacus)</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>6</td>
<td>7.8</td>
<td>3</td>
</tr>
</tbody>
</table>

*Based on 219 samplings taken from 26 nests.
or summits of low hills. If constructed on the summit of a hill, it is usually situated atop a rock, and if on the side of a hill, a jutting ledge of rocks forming a natural shelf is selected to hold the bulky, loosely-constructed nest in place (Fig. 11). Behle, Woodbury, and Cottam (1943) describe ground nests located along the 1846 route of the Donner Party on the Great Salt Lake Desert north of Knolls, Utah. These nests varied in size up to 6 feet in height and 9 feet in diameter at the base and were composed of *Aulonofleja* roots and stems. The second most common type, the juniper nest, closely resembles the ground nest. It is usually constructed five to eight feet above the ground (Fig. 12). Nests similar to those found in the present study area are described by Cameron (1914) in Montana and Bowles (1931) in Washington. Bent (1937) describes nests in North Dakota which were situated 40 feet above the ground in tall swamp oaks. Nests I observed were composed of heavy sticks, manure, and other rubbish, and lined with grass, strips of bark, and paper, Williams and Matteson (1947b) recorded a nest lined with paper in Wyoming. They also reported that nests located by Wyoming biologists in the year 1880 were composed almost entirely of dried buffalo bones.

During the present study, 17 of 22 active nests were on southern or eastern exposures. These data suggest that nest site preference is influenced by the direction of the sun’s rays. Exposure should be important during the early spring months. Even in the warmer months of June and July, nests facing south and east might be preferable. Those with easterly exposures would receive the warm morning sun and be shaded in the hot afternoons. McGahan (1968) found that most of the Golden Eagle nests in his study area faced either south or east.

Direction of nest exposure seems to be a major factor in determining proximity of nests of neighboring pairs. Nests exposed to the same hunting areas were constructed no closer than 1.3 miles, whereas nests facing different hunting areas were constructed as close as 0.4 mile apart.

Weather, prey densities, and human interference may each be partially responsible for the dramatic variation in productivity experienced between 1967 and 1968. It may well be that inclement weather factors such as low temperature, high humidity, or a violent storm may occur at a critical period in the hawk's reproductive cycle, thereby affecting its reproductive capability. Bee (1935) noted that at times hawks of this species would abandon their nests during inclement weather. Weather data obtained from the Brigham Young University Physics Department revealed little variation in monthly temperature and precipitation averages during this study. However, day-to-day variations obviously occurred and may have had marked influence on hawk productivity.

Another influencing factor may have been variable densities in prey populations present
during each of the two years, but no data on prey densities was gathered during this study.

Human interference may also have been a factor in productivity variations. In 1967 three nests containing eggs and four nests ready for eggs were abandoned early in the nesting season after one visit to each nest by the author. Although identical nest observation procedures were conducted again in 1968, no nests were abandoned. This leads me to believe that the human interference factor was negligible both years.

Ferruginous Hawk pair #3 nested in the center of Cedar Valley atop the two foot high roadbank of a well-traveled, improved gravel road. Two days after the initial discovery of the nest the female was found shot and killed at the nest site. Both of her legs and five rectrices had been removed (Weston and Ellis, 1968). This is the only known instance of direct human interference with nesting hawks during the study.

Both members of each pair participated in most nesting activities, exceptions being that only female hawks were observed incubating eggs and feeding the young.

Reproductive activity began with territory selection in early March and ended when the young were fledged in late June. The average incubation period was 32 days, which is 5 days longer than the 27-day average recorded by Cameron (1914).

In 1968 nest #13, which contained a single fifteen-day-old hawk, became too bulky for the juniper in which it was located and fell from the tree. The adult hawks quickly remedied the situation by constructing a crude ground nest directly under the original tree. The young hawk remained in this nest until it successfully fledged on June 24. Also of special interest in 1968 was nest #11, constructed in a juniper by a melanistic male and a light-colored female. Four young were fledged from the nest, three exhibiting total melanistic plumage and one possessing characteristic light-colored plumage (see Frontispiece). This is especially intriguing in view of the fact that this was the only nesting melanistic adult in my study area and that the pair produced the only melanistic young observed during the study. Bent (1937) found that 50 percent of the hawks of this species observed in North Dakota were melanistic.

Territorial behavior appears to depend upon the mood of the hawks. Various raptors were often allowed to fly over the nest site throughout the nesting season, and during my visits other Ferruginous Hawks were allowed to come into the nesting territory to join the resident pair in attacking me. On other occasions, however, any bird that ventured near the nesting area was immediately attacked.

Ferruginous Hawk food-habit data indicate that mammals make up the bulk of the hawks' diet, with kangaroo rats and black-tailed jackrabbits comprising 74 percent of the total prey consumed. These findings seem to agree with other researchers, for May (1935) found this species to eat primarily mammals, but observed that in one area it was a conspicuous enemy of the California Clapper Rail (Rallus longirostris). Bent (1937) indicates that its food consists almost exclusively of mammals, ranging in size from jackrabbits to meadow mice. Cameron (1914) reported that in eastern Montana this hawk feeds chiefly upon prairie dogs and meadow mice. He saw Ferruginous Hawks kill a jackrabbit which they could not carry away. However, during the present study several adult jackrabbits were observed in different nests.

Hunting is usually conducted in this area before sunrise and after sunset of each day, indicating that the Ferruginous Hawk is primarily crepuscular in its hunting activities. This explains why a nocturnal animal such as the kangaroo rat is so often captured as prey.


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