

LIFE HISTORY AND HABITAT REQUIREMENTS OF  
BURROWING OWLS IN WESTERN OKLAHOMA

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## CHAPTER I

### INTRODUCTION

The western burrowing owl historically occupied nonforested areas generally west of a line extending from northwestern Louisiana northward through Minnesota and into Manitoba (Figure 1). The Bureau of Sport Fisheries and Wildlife included it on their first list of rare and endangered species (Committee On Rare And Endangered Wildlife Species 1966). A subsequent mail survey to zoologists living within the owl's range indicated greater populations than previously believed. Consequently, it was absent from the revised list of rare and endangered species in 1968 (Committee On Rare And Endangered Wildlife Species 1968).

However, the status of the western burrowing owl in much of the West, at least where owls live in association with prairie dogs, may be more precarious than cursory observations would indicate. In Oklahoma, burrowing owls are found in their greatest abundance in association with black-tailed prairie dog colonies, referred to as dog towns throughout this thesis.

Dog towns were extensive and numerous in western Oklahoma and the Texas Panhandle when white men first arrived (Merriam 1902, Thwaites 1905). In Texas a single dog town reportedly covered 16 million acres (Merriam 1902). Man, however, has waged an increasingly effective war against prairie dogs during the last few decades. From the millions of

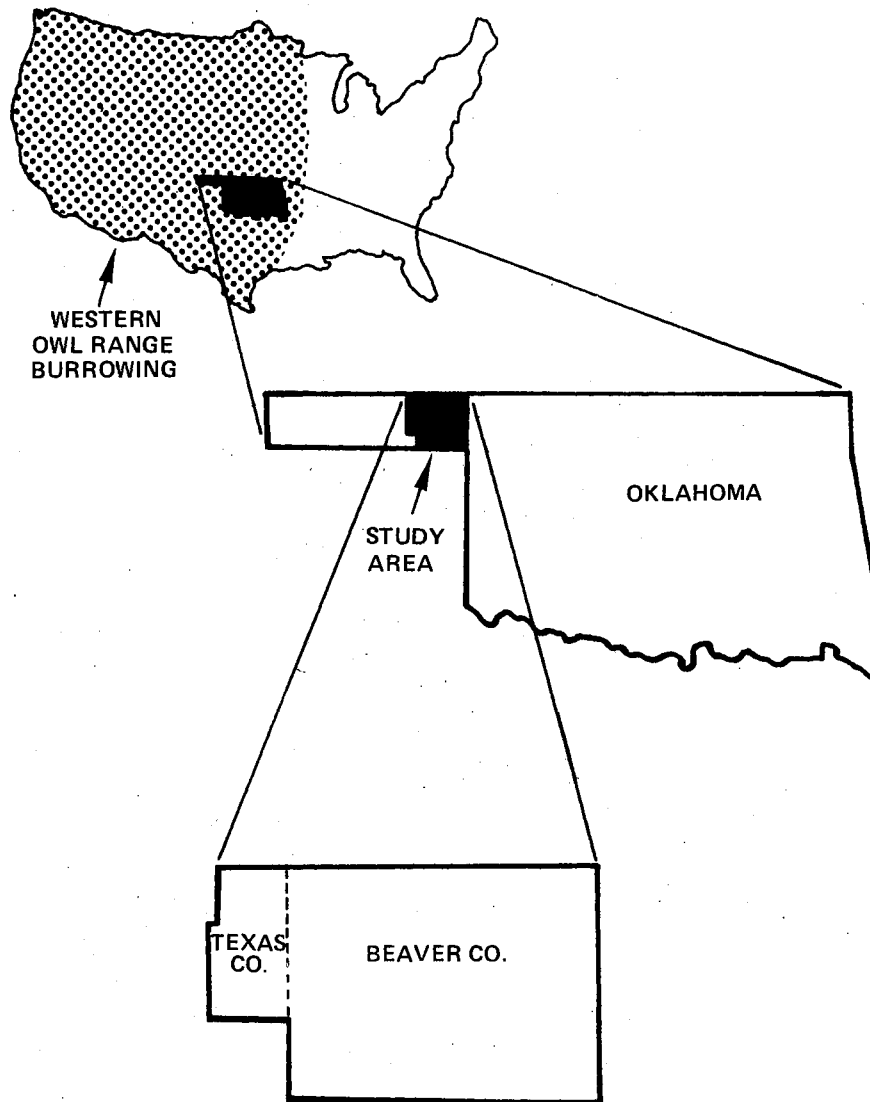


Figure 1. The Study Area in Relation to the Geographical Range of Western Burrowing Owls

acres of dog towns historically found in Oklahoma the acreage declined to 9,522 acres in 1968 (Tyler 1968). Poisoning techniques for prairie dogs have been improved, making elimination or severe reduction of large colonies relatively simple and economical. Research on the western burrowing owl is essential so this interesting and unique raptor can be managed and its welfare assured as a member of our western fauna. Many aspects of burrowing owl life history and habitat requirements are poorly understood. There has been no single comprehensive and quantitative study of the habitat requirements for the species.

Only recently, since initiating this project, have any thorough life history studies been published, and these were in an ecological setting quite different from western Oklahoma. Best (1969) studied burrowing owls in south-central New Mexico where they are associated with bannertail kangaroo rats. Coulombe (1971) and Thomsen (1971) studied burrowing owl populations associated with ground squirrels in the Imperial Valley of southern California and at Oakland Municipal Airport, respectively.

Bent (1938) summarized the information known at that time concerning the biology and life history of burrowing owls. Other literature contains only short observational notes or brief studies of facets of life history, such as food habits. There are conflicting reports concerning patterns of migration and overwintering, clutch size, and other factors important to management. As Erickson (1968:422) said, "Studies of the status and factors causing the decline of such raptors as the ... western burrowing owl are long overdue."

This study had the following three objectives: (1) to describe the life history of the species, (2) to determine whether local burrowing

owls migrated or overwintered in the study area, and (3) to determine the specific habitat preferences exhibited by this species including those for nesting, escape, feeding, and shelter.

## CHAPTER II

### DESCRIPTION OF THE STUDY AREA

Field studies were conducted in Beaver County, Oklahoma, and an area seven miles wide along the eastern border of Texas County, Oklahoma, between State Highway 3 and the Kansas border. This area encompassed 1,975 square miles, slightly more than the eastern one-third of the Oklahoma Panhandle (Figure 1). General life history studies were concentrated in 44 dog towns, 40 in Beaver County and four in Texas County (Figure 2). Fieldwork was accomplished between 1 June 1971, and early August, 1971.

The study area includes part of the High Plains, breaks in the Plains, erosional uplands, valleys, and sand dunes (USDA 1962). The surface was once a level plain, built up by outwash material from the Rocky Mountains, and was later dissected by the North Canadian (Beaver) and Cimarron Rivers and their tributaries (USDA 1962). These rivers have worn channels 200 feet below the level of the High Plains (USDA 1962). In some level areas the only drainage is into shallow playa lakes. The area slopes upward from east to west, elevations ranging from 2,170 feet to around 2,800 feet (USDA 1962).

Four game habitat types (Duck and Fletcher 1944) occur within the study area; they are short grass-high plains (80 percent), sand-sage grassland (15 percent), bottomland (4 percent), and mixed grass-eroded plains (1 percent). The short grass type consists mainly of buffalo

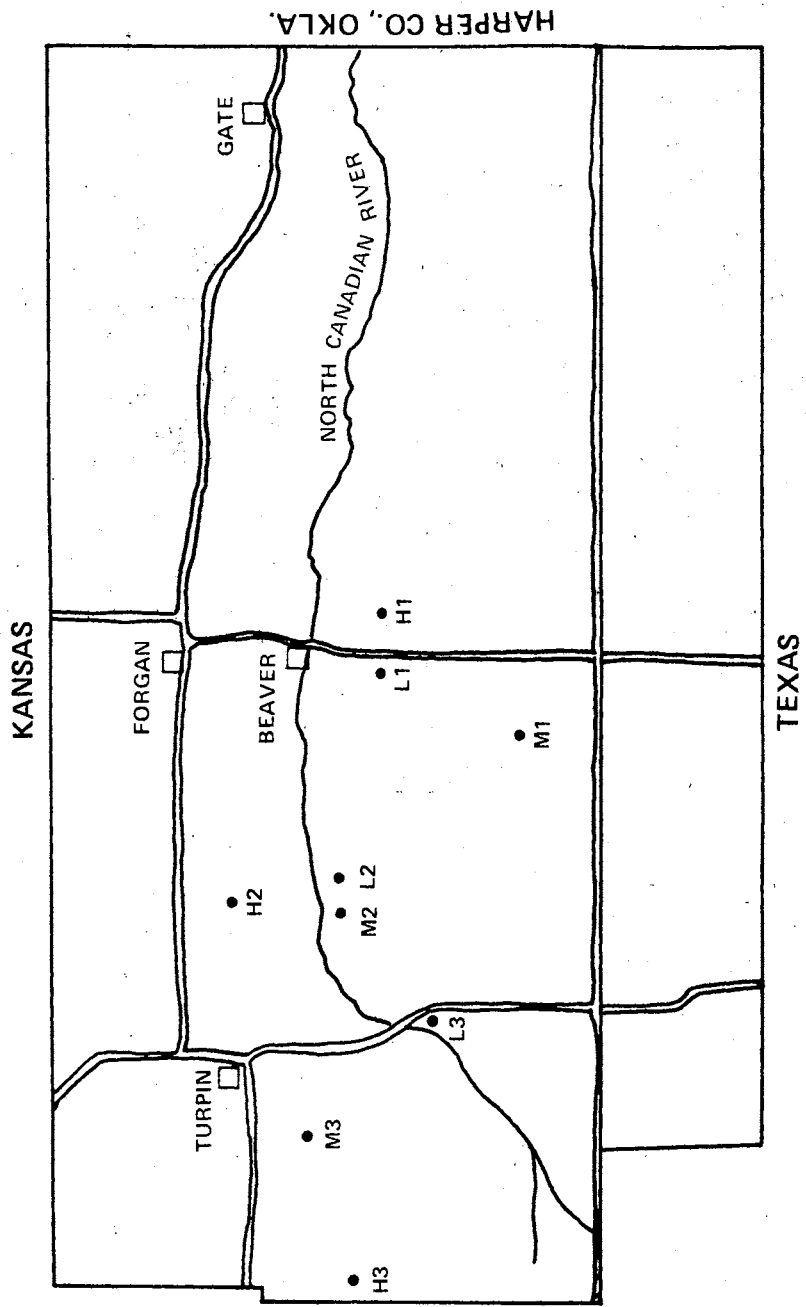


Figure 2. The Study Area, Showing Drainages, Locations of Intensively Studied Prairie Dog Towns, Main Roads, and Cities



grass, blue grama, and patches of wire grass and side oats grama.

Scientific names of all plants mentioned in this thesis are listed in Appendix A. Scattered legumes such as prairie clover and forbs such as bladder pod are also common. Prickly-pear cactus is often abundant in prairie dog towns due to disturbed and overgrazed conditions (Smith 1940). Topography varies from nearly level to strongly sloping uplands dissected by gully-like draws. Soils are ten inches or more deep and include sandy loams, clay loams and limy soils.

Sand-sage grassland includes sand sage and grasses such as little bluestem, sand bluestem, Indian grass, and switchgrass. Sand dropseed and sand reedgrass are common invaders on active sand dunes. Short grasses dominate the tighter soils. Woody species include patches of sand plum, skunkbrush, and hackberry. Topography is rolling to dune-like with sandy loam soils or loose "blow sand."

Bottomlands include stream courses and first terraces mainly along the North Canadian (Beaver) and Cimarron Rivers, and their tributaries. Dominant woody vegetation includes cottonwood, willow, and salt cedar. Herbaceous vegetation is typically annuals including sunflowers and ragweed. In other areas tall grasses or wetland species such as sedges and flatsedge are prolific. Topography is flat except for a few deep valleys. Alluvial soils range from coarse sand to fine clay.

The mixed grass-eroded plains game type is of very minor importance in the study area. It is similar to short grass-high plains but has rougher topography.

Most dog towns were in short grass; a few were in overgrazed areas of sand-sage grasslands. Only rarely did dog towns include any bottomlands.

The acreage of Beaver County is about equally divided between pasture and crop land (USDA 1962), and roughly two-thirds of Texas County is under cultivation (USDA, 1961). Wheat and sorghum are grown on over two-thirds of the cultivated land (USDA 1962). Other crops include corn, barley, oats, and alfalfa. At least 50 percent of the short grass game type is presently cultivated (USDA 1962) due to its high soil fertility and level topography. Lower percentages of the other game types are cultivated.

The beef cattle industry is also important. Much pasture land has been severely overgrazed, resulting in extensive stands of sand sage and soapweed on the sandier soils. On tighter soils overgrazing has favored the increase of prickly pear and soapweed. Overgrazing on all soils has resulted in increase of annuals such as thistle, milkweed, and bladder pod.

A large percentage of grazing land is located in linear strips along major drainages, and most prairie dog town are located within these strips. Absence of dog towns along the north side of the Beaver and Cimarron Rivers was likely due to the preponderance of sandy soils and sand-sage grasslands there.

The area is mesothermal and semiarid, generally with a deficiency of moisture at all seasons (Davy 1956). Average annual precipitation is 19.3 inches, of which 15 to 16 inches falls between 1 April and 1 November (U. S. Dept. of Commerce 1969). High summer temperatures, often in the 90's and occasionally exceeding 100 F, combine with strong winds to induce an evaporation rate near 70 inches annually (Davy 1956). Winter temperatures occasionally dip to 0 F and below, and the wind-chill index is sometimes -30 to -40 F. The mean annual snowfall is 17

inches, with occasional severe blizzards (U. S. Dept. of Commerce 1969).

## CHAPTER III

### METHODS AND MATERIALS

#### Census

Adult burrowing owls were censused in 1970 in all prairie dog towns known within the study area. Dog towns were located using information published in the dissertation by Tyler (1968), data provided by personnel of the Wildlife Services Division, Bureau of Sport Fisheries and Wildlife, and tips from local landowners. Most censusing was done during the first two weeks of June. Burrowing owls were inactive and often remained hidden from view during midday and during high temperatures or high wind velocities, so the census was conducted in late evening, early morning, or when the temperature was 70 to 85 F and the wind velocity less than 10 mph.

Owls were searched for in dog towns using a Zoom 15X-60X spotting scope and 7X35 binoculars. Dog towns were then examined thoroughly on foot or from a vehicle in an attempt to locate nest burrows by flushing females, noting other behaviors characteristic of paired owls, and by finding owl pellets, droppings, or cow manure, bones, feathers, and parts of insects spread in typical fashion about the entrance of nest burrows (Figure 3).

Sixteen of the prairie dog towns were not discovered (13 were less than 15 acres in size) until late in the summer of 1970. In those colonies the adult owl population was estimated by counting nest burrows

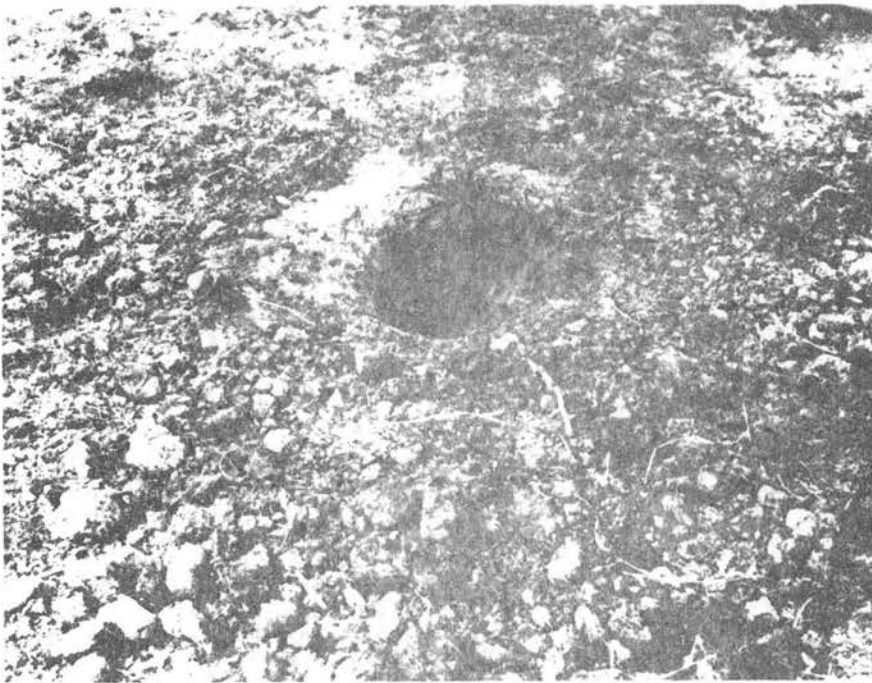


Figure 3. Typical Appearance of Entrance to  
Active Burrowing Owl Nest - Note  
Crumbled Horse Dung

or broods. The population may have been slightly underestimated due to nest burrows not found and small numbers of owls that were probably nonbreeders (Hennings 1970). However, counting extra nest burrows that resulted from renesting attempts should have compensated somewhat for such underestimation.

Burrowing owls were again censused in June, 1971, in 17 dog towns that contained over 70 percent of the breeding owl population in the study area in 1970. This census was designed to compare populations for the two years.

Burrowing owls living outside the influence of prairie dog towns were also censused in Beaver County in 1970. Sections at least one mile away from all dog towns were eligible for sampling. For the population sample 54 one-square-mile sections were selected at random, one from each township, using a table of random numbers. The sample represented 3.7 percent of the 1,468 square miles eligible for sampling. This census was conducted 1 to 14 August between sunup and 10:00 a.m. or from 5:30 p.m. to sunset because young owls were then visible and active outside burrows. The sections were thoroughly viewed with a Zoom spotting scope, and walked or driven over. Where census coverage was difficult, the person managing the land was asked if he had seen any burrowing owls in that section.

Burrowing owls wintering in the study area were censused 11 to 16 February, and 3 March 1971. All dog towns except four, which contained only 28 adult owls in June, 1970, were censused when temperatures were higher than 50 F and wind velocities less than 10 mph. Thus, the census was made when weather was moderate enough so that owls would probably be active outside their burrows. Wintering owls were also searched for in

the vicinities of five of the six nest burrows found outside dog towns in 1970.

Eleven dog towns were frequently checked during March, 1971 to monitor increases in populations of owls. Thus, approximate dates could be determined for when wintering owls returned for the nesting season.

#### Trapping and Marking

When the study was initiated, not much published information was available describing techniques for capturing burrowing owls. Patton (1926) trapped burrowing owls by placing a "gill net" over burrows. Brenckle (1936) reported the capture of 481 burrowing owls, but did not mention methods used. Coulombe (1968) "easily" captured burrowing owls by placing single-door Tomahawk live traps in the entrance of occupied burrows.

Three other publications became available after capture techniques were developed. Hennings (1970) used steel traps, modified so the jaws would not close completely, to capture 107 burrowing owls. Ross and Smith (1970) trapped 48 owls in Potter 3-cell traps unbaited or baited with a variety of small rodents, sparrows, and artificial arthropods. Martin (1971) captured adult females and young by inserting Hav-A-Hart box traps into owl burrows.

Trapping was initiated in early June, 1970, when nesting activity peaked, and continued sporadically through May, 1971. Capture techniques tested early in the season were mainly devices that blocked entrances of nest burrows, thereby favoring capture of females and owlets. These devices included a woodcock trap (Sheldon 1967), Tomahawk box trap

(Coulombe 1968), mist net, and the Anderson trap (Figure 4) developed by summer aide Leroy Anderson.

The Anderson trap (Figure 4) consists of mist netting stretched over two square wire frames that are hinged together on one side. The trap was set over a nest burrow entrance, with the netting of the lower frame covering the entrance. The upper frame extends at an 80-degree angle from the ground surface and falls over the owl when it trips a trigger wire while attempting to enter the burrow.

Pole traps were tested, including steel traps with padded jaws (wrapped with one-inch-thick foam rubber to protect the owls' legs from injury) and Verball traps (Austing and Holt 1966), for capturing sentinel adult male owls. Sentinel males are mated birds that remained near the nest on a "satellite" perch or in a nearby "satellite" burrow (James and Seabloom 1968), while their mates were in the nest burrow. Satellite perches and burrows are within 10 to 30 yards of a nest and are characterized by an abundance of droppings and pellets, testimony to their importance in terms of the time spent there. Steel traps were also set around burrows used by an owl or owl brood. Bal-chatri traps (Berger and Mueller 1959) baited with grasshoppers, frogs, or mice were used singly or encircled by size 0 steel traps with weakened springs.

A bright light was utilized at night to temporarily blind owls that were then captured in one-inch-mesh netting strung over a two-foot diameter hoop at the end of a 12-foot-long handle. Light was provided by combinations of truck headlights, a six-volt flashlight, and a 12-volt spotlight plugged into the cigarette lighter of the truck.



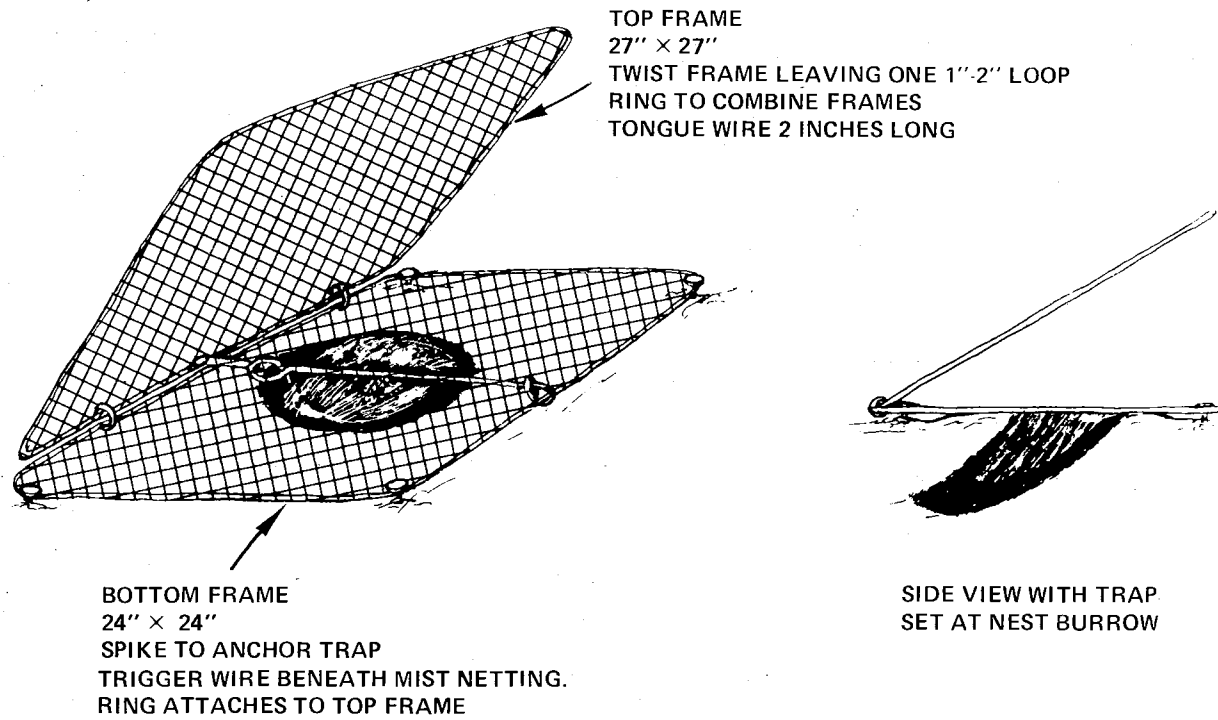


Figure 4. Anderson Trap for Capturing Burrowing Owls

Previous investigators used metal leg bands and colored plastic leg bands to mark burrowing owls (Coulombe 1968, Hennings 1970, Ross and Smith 1970). Hennings (1970) used combinations of three or four colored plastic leg bands to mark owls so each could be identified at a distance.

Size 3 aluminum leg bands from the U. S. Fish and Wildlife Service and combinations of colored plastic leg bands (red, white, blue, orange, and green) were placed on captured owls. Colored plastic poncho markers, modified from those used by Pyrah (1970) on grouse and partridge, were also used.

Attempts were made to capture and band owls that were winter residents of the study area. Information gained from these banded individuals hopefully would indicate whether wintering owls were permanent residents or migrants.

#### Observations of Behavior

Approximately nine months were spent in field work: 28 May through 23 August 1970; four days in September to October, 1970; 11 days in January to February, 1971, and 1 March to 8 August 1971. Field notes were recorded on behavior of owls. A Zoom spotting scope and 8 x 36 mm binoculars were used to observe behavior.

Roughly 75 percent of the observations of behavior were made from a vehicle, usually at a distance of at least 100 yards. Burrowing owls apparently became accustomed to the presence of a stationary vehicle in a relatively short time. Owls seemed less apprehensive of the vehicle in dog towns that were visited frequently, and in those located near well-traveled roads. Owls apparently were also more tolerant of human

disturbance during reduced light conditions at dusk and dawn, because a human could approach closer then.

Extensive observations on behavior of three nesting pairs and their broods were made from a blind, between 18 June and 10 July 1970. Occasionally owls were watched from behind vegetation on rims of shallow canyons bordering two dog towns. Observations of behavior were made at all hours of the day and night, but especially at one hour before and one hour after sunset.

An owlet captured at about three weeks of age, and kept under observation for six weeks, provided limited behavioral data on certain subjects such as feeding behavior. Limitations of behavioral data collected from captive animals were recognized and these data evaluated accordingly.

In 1970, nest burrows were marked in intensively-studied dog towns with numbered wooden stakes and orange flagging tape. Maps were prepared showing locations of nest burrows and density and spatial distribution of the nests determined. This data was then compared with field notes that described territorial behavior in relation to nest locations.

Home ranges of owls were determined by: (1) observing a marked owl at a measured distance from its nest burrow, (2) measuring the distance traveled by an owl foraging and returning to feed young, and (3) measuring the distance between an owl and the nearest dog town. Unfortunately, the last method was used more often than the first two. Distances were measured by pacing or by using a truck odometer.

### Burrow Ecology

Patterns of distribution of habitat, surrounding vegetation, soil type, and other ecological factors, were examined in relation to location of nest burrows, both within and outside dog towns. Thirteen nests, 11 within prairie dog towns and two outside dog towns, were excavated to study their biotic and abiotic environments. Three active nest burrows were excavated in dog towns, one on 17 May and two on 29 May. Five inactive nest burrows were excavated in dog towns on 12 September, and one on each of the following dates: 10 March, 7 August, and 8 August. Two inactive nest burrows were excavated outside dog towns on 12 March.

During February and early March, 19 burrows were excavated in six dog towns to search for inactive owls and collect data on burrows used by wintering owls. Owl feathers and droppings, indicating fairly recent owl use, were at the entrance of all 19 burrows. These burrows represented approximately 75 percent of those showing evidence of use by wintering owls.

### Production of Young

The three excavated active nests provided information on clutch size. Average brood size was calculated from a sample of 61 broods, 54 in 1970 and seven in 1971. Each brood was observed several times while it awaited feeding outside its burrow. Nesting success was calculated from data on 69 nesting attempts, 54 in 1970 and 15 in 1971. A nest was considered successful if at least one outlet was observed. Survival of young owls was calculated from fledgling stage through July from data on eight broods (39 owlets) that were observed regularly in 1970. Total

owl production was estimated for 1970 by utilizing data on the total number of nesting attempts, average nest success, average brood size, and survival rate.

#### Food Habits Studies

Owl food habits were determined by collecting and analyzing 790 pellets, examining remains of 137 identifiable prey found at burrows used by owls, and identifying 155 prey seen captured, carried, or eaten by owls.

Pellets (castings) were collected for one year, beginning on 28 May 1970. Most were collected from dog towns in the vicinity of nest burrows and satellite burrows. Pellets were collected during all phases of field research, but deliberate searches were made for pellets in the fall and early winter. Pellets were placed in plastic bags with labels showing date of collection, estimated date ( $\pm$  2 weeks) of deposition, number of pellets, location, and field observations such as nearby prey fragments that would facilitate identification of pellet contents.

Pellets were placed into one of four categories, depending on date of deposition. Analyses of each of these groups were tabulated separately. The four categories were: (a) summer, 16 June through 15 September; (b) fall, 16 September through 15 December; (c) winter, 16 December through 15 March; and (d) spring, 16 March through 15 June. Division at mid-month insured that most pellets deposited by overwintering owls would be included in the winter category. Also, very few pellets from owlets would be found before 16 June, so the summer category included their diet.

Pellets were softened in water in the laboratory and identifiable prey remains removed with forceps. A flexible lamp was used with a circular bulb enclosing a large magnifying glass to improve sorting and reduce eyestrain. A binocular dissecting microscope was utilized for identification of the items.

Pellet contents were quite fragmentary because burrowing owls eat by "picking" small bites (Thomsen 1971). Owls were frequently observed taking six bites to consume a one-inch grasshopper. Mandibles of orthopterans and complete heads of coleopterans and other insects were the only pellet contents suitable for enumeration and identification of insects. Marti (1969) also examined insect heads and mouth parts to identify and enumerate insects in burrowing owl pellets. Counting insect legs proved unsatisfactory because they were often fragmented and owls frequently tore off and flipped away insect legs without ingesting them. Skull parts, mainly mandibles and upper incisors, were examined to determine numbers and types of mammalian prey. Body parts, such as feet of birds and skin of reptiles and amphibians, were examined to enumerate and identify other prey items.

A sample of each kind of insect head and mandible was numbered and placed in a container for reference. Identification of insect fragments was facilitated by comparing them with whole specimens. Mammalian prey remains were identified using a key to mammal skulls (Glass 1951) and by comparing them with specimens in the Vertebrate Museum at Oklahoma State University. Nomenclature follows Burt and Grossenheider (1964) for mammals, Petersen (1963) for birds, Conant (1958) for reptiles and amphibians, and Borror and DeLong (1954) for insects.

Frequency of occurrence, the percent of total pellets containing a particular prey item, were calculated for species and broader groupings such as mammals. The percent volume was estimated for general prey categories, for vegetation (including seeds), and for dirt and gravel found in each pellet. Each prey item's percentage of the total number of prey items was calculated for vertebrate prey items, and for arthropod prey items.

Prey remains found at owl burrows were counted, including live prey that owls has disabled, such as numerous injured Jerusalem crickets. Owls were observed capturing, carrying or eating prey that could not be identified until prey remains had been examined at the owl burrow. These instances were included in the category "prey seen captured, carried, or eaten."

Attempts were made to distinguish between availability and preference for prey eaten by owls. The relative importance of a particular prey in the owls' diet was compared with the relative abundance of that prey in the study area. Relative dietary importance was determined primarily by analyzing results of pellet studies. Relative abundance of rodents was determined by analyzing results of extensive rodent trapping. Conclusions concerning availability of certain insect groups were based on results of short-term studies of arthropod populations, and on field observations made throughout the study.

#### Habitat Utilization

The use of abandoned dog towns by burrowing owls was investigated during the 1970 census, and during winter, spring, and summer of 1971. Throughout the research period burrowing owls were studied in active dog

towns. All dog towns were examined periodically for the presence of owls or owl sign.

Searches were made for burrowing owls nesting outside dog towns, especially in summer, 1970. Solitary nest burrows were found in three ways: (1) during the census of owls living outside dog towns, (2) through observations made while driving the thousands of miles logged throughout the research, many on section line roads and petroleum well access trails and (3) from reports of local landowners.

#### Intensive Habitat Analyses

In nine study blocks intensive habitat observations were made, in the spring and summer of 1971, to determine factors that might influence owl populations. Each study block was square, included nine square miles, and contained a dog town in the center section. Study blocks this size were chosen because the studies on home range had already indicated that most factors determining owl populations were probably contained within a 1.5 mile radius of dog towns. Those specific study blocks were chosen because of their accessibility, owl populations, landowner attitudes, and knowledge of characteristics and histories of dog towns.

Each study block was classified into a population category (High, Moderate, or Low) determined by the number of breeding owls present in 1970. Each category of population density was represented by three study blocks. Dog towns within the blocks placed in the category of high populations exhibited population densities of less than 1.7 acres per pair of nesting owls, those in the "Moderate" category 6.7 to 4.0 acres



per nesting pair, and those in "Low" category more than 20.0 acres per nesting pair.

Each study block was given a symbol designating its population category along with a number that identified it with one of three sets of simultaneous samples. For example, a study block in the category "Low" and the second set of food availability samples was designated L2.

Maps were prepared showing patterns of habitat types and agricultural crop lands for each study block. Aerial photographs and farm operation folders on file at county offices of the Agricultural Stabilization and Conservation Service (ASCS), U. S. Department of Agriculture, were used in conjunction with field reconnaissance to complete the mapping.

Four broad habitat types - grassland, cropland, wetland, and miscellaneous idle ground - were included on the base maps. Appendix D contains descriptions of subcategories of these habitat types. Acreages were determined using a compensating polar planimeter. Locations and descriptions of soil types were determined from publications (U. S. Department of Agriculture 1961, 1962).

Mean acreage figures for each habitat type were compared within each category of study blocks to identify habitat characteristics of each category of population density. Sample means ( $\bar{X}$ ) of acreage figures were calculated for each habitat type for all study blocks in each category. For example, significance tests were made comparing the mean acreage of short grass habitat in all three study blocks containing owl populations of high density to the mean acreage of short grass habitat in all three study blocks containing owl populations of low density.

The significance test utilized was a modified t-test for comparing the means of two independent samples (Snedecor and Cochran 1967:115). This modification of the ordinary t-test eliminated the need to assume equal population variances for the independent samples. Throughout this thesis differences were considered significant when  $P \leq 0.05$  for two-tailed tests.

### Food Availability Studies

Indices to small mammal and arthropod populations were obtained in habitat types within study blocks. These indices presumably indicated availability of food for burrowing owls. These results, and those of the habitat analyses, were examined for ecological factors that may have influenced population densities of burrowing owls.

Three 1,035 yard-long line transects were established in each study block and small mammal and insect populations were sampled along these transects. Habitat types were generally sampled in each study block in proportion to their presence. An exception was dog town habitat, purposely sampled with greater intensity because of the large amount of time most burrowing owls occupied this habitat.

Study blocks were separated into three groupings; each grouping contained a block with a low population density, one with a moderate population, and one with a high population. Rodent and arthropod populations were sampled simultaneously on the three study blocks within each grouping. Dog towns near one another were arbitrarily selected for each sample grouping in order to increase work efficiency and to minimize the influence of localized weather conditions on capture success.

Populations of small mammals were sampled from 23 April through 26 May 1971, using Museum Special traps baited with a peanut butter-oatmeal mixture (Smith 1966). Seventy traps were placed at 45-foot intervals along each transect line. Traps were set for 48 hours at each location, and checked and baited every 24 hours. The capture success and number of traps sprung was recorded for each habitat type. Mammals were identified using the text by Burt and Grossenheider (1964).

Populations of ground surface-dwelling arthropods were sampled 10 July through 24 July 1971 by using pit traps. Pitfall traps (Dr. William Drew, personal communication; Smith 1966) were constructed by cutting both ends from 12-ounce cans. Cans were pushed into the ground until the top edge was flush with the ground surface. Cutting both ends from the cans permitted this with a minimum of disturbance to the ground surface. A seven-ounce paper cup was then placed inside the can so the top of the cup was at least one and one-fourth inches below the top of the can. A weak formaldehyde solution was poured into the cup to a depth of about one inch. The cups served as handy temporary containers for the day's capture. Fourteen pitfall traps were placed at 225-foot intervals along each transect line, and left for 24 hours at each location.

Total catch was recorded for each trap and habitat type present. Arthropods were taken to the laboratory for identification unless field identification was definite. The text by Borror and DeLong (1954) was used as an identification key.

Foliage-dwelling arthropod populations were sampled from 26 July through 28 July 1971, using a sweep net 15 inches in diameter. A series of 10 sweeps, each 39 inches in length and 36 inches apart, were taken at 225-foot intervals along the line transects. Numbers and kinds of

arthropods, along with habitat information, were recorded for each series of sweeps. Identification procedures were identical to those described for the pitfall trap sample.

Arthropods smaller than 1/4 inch in length were not recorded. This size limit was chosen after observations of a captive burrowing owl and limited field observations indicated owls did not usually attempt to capture prey smaller than about 1/4 inch long.

Trap success was considered a measure of food availability for burrowing owls and compared with owl population densities. Catch per trap day (24 hours) was used as the index to populations of rodents and ground-dwelling arthropods. Catch per 10 sweeps was the comparable index to populations of foliage-dwelling arthropods. Data from the three transect lines were combined for each study block and sample means calculated.

Tests for significant differences between means were made among study blocks within a sample grouping. For example, tests compared the population means of H1 vs. L1, H1 vs. M1, and M1 vs. L1 for rodents, ground-dwelling arthropods, and foliage-dwelling arthropods. In addition, the data were combined from samples in all three study blocks of each category of owl population density. T-tests were made for significant differences between the means of H1+2+3 vs. L1+2+3.

Relative food availability in croplands was compared to that in grasslands. Mean capture success for traps, and for each series of 10 sweeps in grasslands and croplands, was calculated for each sample taken in each study block. Total sample means ( $\bar{X}$ ) were then calculated for trap and sweep net success in cropland and grassland. T-tests were made between means of trap and sweep net success for the two broad habitat

categories. Data on sampling success in wetland and miscellaneous idle ground were insufficient to allow a meaningful comparison.

#### Effects of Habitat Changes on Owl Populations

Attempts were made to measure changes in burrowing owl habitat, especially fluctuations in quantity and quality of dog towns, and how these changes affected associated populations of burrowing owls. Acreages for the active dog towns were determined by the odometer readings, measuring by pacing, information given by landowners, and rarely on "sight" estimates. Acreages for the abandoned dog towns were based largely on information provided by Tyler (1968).

Landowners were interviewed and personnel in the Division of Wildlife Services, Bureau of Sport Fisheries and Wildlife, contacted in an attempt to determine methods and approximate dates of recent campaigns to poison prairie dogs in the study area. Field notes were maintained on population trends of burrowing mammals, trends in habitat conversion from grassland to cropland, increases in irrigated acreage, and other factors affecting burrowing owl habitat in areas outside dog towns.

## CHAPTER IV

### RESULTS AND DISCUSSION

#### Description and Sexual Dimorphism

Bent (1938), Blair et al. (1957), and Peterson (1963) gave accurate morphological descriptions of the western burrowing owl. Its small body size, relatively long and bare legs, and unique nesting habitat and behaviors combine to make identification of this species relatively easy.

Sexual dimorphism was not apparent in the 15 museum specimens of western burrowing owls examined at the University of Oklahoma's Stoval Museum (13) and the Oklahoma State University Vertebrate Museum (2). The sexes of a pair of owls could be distinguished in spring and early summer by observing behavioral differences. In addition, females generally exhibit more barring on the breast and belly. Males were a lighter, more grayish color than the brownish females. However, the sex of a solitary owl could not always be determined easily.

Color differences were absent immediately after the postnuptial molt in August, and did not become apparent again until mid or late winter (February). Sexual dimorphism was not noted in young owls up through six months of age.

Others have distinguished the sex of adult burrowing owls by the same criteria (Bailey and Niedrach 1965, Coulombe 1971, Palmer 1896, Roberts 1936, Thomsen 1971). Thomsen (1971) attributed the lighter

color of males to greater wear and sun bleaching of their feathers, and to less extensive barring.

Thomsen (1971) also observed a sex-related difference in the posture of owls standing or perching. The females held their bodies in a more horizontal position. This difference, however, was not readily applicable to birds sleeping during the day or to disturbed birds (Thomsen 1971). This behavioral difference was not observed in Oklahoma.

#### Plumage and Molt

Only one owlet was seen that was less than one week old. It was completely covered with white down (Figure 5). Owlets still had a fuzzy appearance but had assumed a brownish coloration about 10 days after hatching. Owlets 2½ to 3 weeks old exhibited some pinfeathers and the beginnings of flight feathers (Figure 6). They had grown retrices and flight feathers at about 4½ to 5 weeks of age (Figure 7). The fuzzy, downy appearance of the head changed to a sleek, chocolate-brown with a prominent white area on the lower part of the face by the time the owlets were five weeks old (Figure 7). Also, five-week-old owlets exhibited a prominent wing stripe composed of light-colored middle secondary coverts.

The wing stripe was visible on owlets in flight and at rest, and even at night provided a means of distinguishing juveniles from adults. This coloration persisted at least one month. Brown coverts gradually replaced the wing stripe and adult feathers replaced the creamy juvenile feathers on the owl's belly and breast. By mid August, when owlets were about 10 weeks old, they were not easily distinguished from adults.

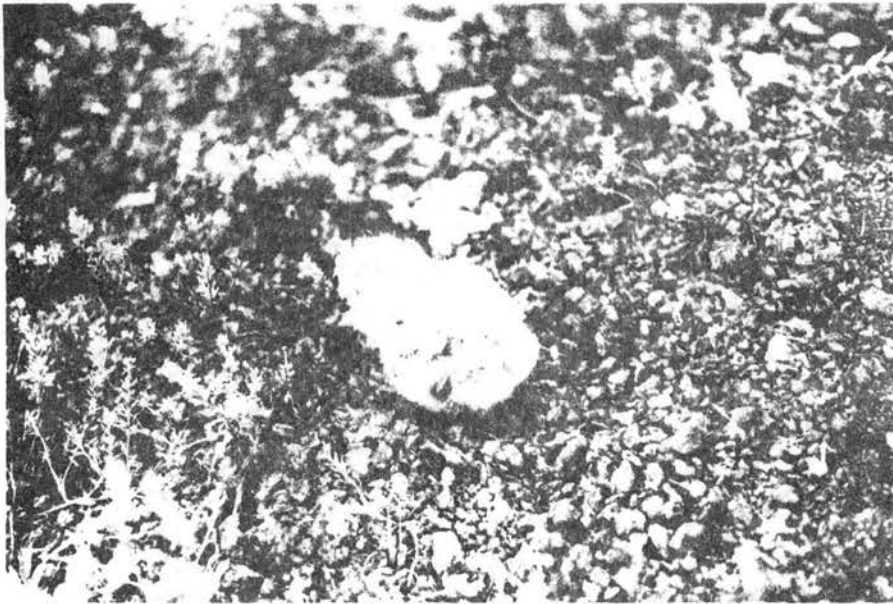


Figure 5. Burrowing Owllet Less Than One  
Week Old



Figure 6. Burrowing Owllet Approximately  
Three Weeks Old





Figure 7. Burrowing Owllet Approximately  
Five Weeks Old

At least a partial prenuptial molt occurred about mid March. The loss of some contour feathers during this molt may have been one way males became more lightly barred than females (Thomsen 1971).

A postnuptial molt was noticeable by early August when several feathers, especially contour feathers, were evident around burrows used by adult owls. Adults flushed in early August were ragged in appearance and sometimes had primaries and secondaries missing. Molting adults were usually quite inactive, apparently relying heavily on ground foraging near their burrows for acquiring food. They seemed reluctant to fly but were capable of flight. Some escaped disturbance by running into burrows rather than taking flight, a behavior not observed among adults at other times of year.

In California the postnuptial molt began and was completed earlier in nonbreeding adults, and female members of pairs apparently molted before their mates (Thomsen 1971). In New Mexico the postnuptial began in mid to late August, and was complete by late September (Best 1969). Owls were quite inactive during this molt, even though it was gradual and they were capable of flight (Best 1969).

#### Owl Populations

The breeding population of burrowing owls in 1970 was 543 (1,939 acres per owl); 359 resided in dog towns (4.8 acres of dog town per owl).

The 1971 census revealed no significant change in the breeding population (Table I). Distribution of the population, however, differed the second year; owl populations changed drastically in some dog towns

TABLE I

BREEDING POPULATIONS OF BURROWING OWLS IN  
 17 DOG TOWNS, OKLAHOMA PANHANDLE,  
 SUMMERS OF 1970, 1971

Owner or Other Name	Dog Town Legal Description (Township-Range- Section)	Breeding Populations		
		1970	1971	Percent Change, 1970-71
McGrew	4N-24E-31	12	16	+33
Ross	5N-21E-25	14	32	+129
Dondelinger	5N-27E-26	3	4	+33
Olenberger	1N-21E-26	10	8	-20
Delk	2N-21E-35	10	44	+340
Kirkhart	28N-26W-26	9	16	+178
Chance	4N-18E-24	85	52	-38
Anderson	4N-19E-24	24	16	-33
Randles	4N-20E-18	28	18	-36
Wilson	2N-20E-26	9	4	-56
Pierce	2N-23E-5	12	12	0
"Canyon"	4N-24E-32	14	4	-71
Pope	2N-20E-16	4	4	0
Dyer	4N-27E-26	4	4	0
"Rattlesnake"	3N-19E-12	6	12	+100
T-T Ranch	4N-21E-24	16	8	-50
Smith	4N-21E-5,8	8	6	-25
Totals		268	260	-3

(Table I). Available habitat data did not suggest any explanation for these changes.

Published literature does not list estimates of breeding owl population density in prairie dog towns that could be compared to the population data. Tyler (1968) counted 788 burrowing owls, one per 12.5 acres of dog town in western Oklahoma. However, he made this count during all seasons of the year incidental to surveys of prairie dogs rather than attempting to thoroughly census all burrowing owls, and thus included young owls and possibly migrants. Breeding densities of burrowing owls in California (none associated with dog towns) ranged from one per 6.25 acres on the Oakland Municipal Airport (Hennings 1970) to one per 50 acres along a census route in the Imperial Valley (Coulombe 1968).

Two owl nests were located during the inventory of owl populations residing outside the influence of prairie dog towns. A brood of young owls was also seen in the road separating a sample from a non-sample section, but a nest burrow was not found even though badger burrows were available along both road ditches. A landowner reported frequently seeing "a prairie dog owl or two" by his barn on the edge of a sample section. His observations seemed reliable but neither owls nor nest burrows were found within that section.

One of the two unverified pairs was arbitrarily included in the survey. Thus there were three pairs of owls or six adults on the 54 square-mile sample area. This population density was assumed typical for the 1,468 square miles located one mile or more from dog towns. The total calculated population of breeding owls living at least one mile from dog towns was 92 pairs (5,683 acres per owl).

## Trapping and Banding

Results of trapping and banding operations are summarized in Table II. Certain types of capture techniques tended to favor capture of specific age and sex groups. Nest-blocking devices, woodcock traps, Tomahawk traps, mist netting, and Anderson traps, selected nesting females. Padded steel traps set on the ground proved most effective for capturing adult males. Most young owls were captured using a hand net and light.

Eighteen owls were captured using nest-blocking devices. Of this group, the Anderson and Tomahawk traps proved best due to superior ease of transport and use, success per unit effort, and safety to owls. Mist netting placed over entrances to nest burrows produced many near-captures and failures, and often was difficult to operate because it snagged on vegetation. Woodcock traps received only limited testing, but the Anderson trap seemed simpler and more reliable.

Various pole traps and bal-chatri traps proved unsuccessful, apparently due to the cautious nature of burrowing owls. Pole traps, especially Varbail traps, could probably be used more successfully if placed on short stakes near owl nest burrows. Disturbance by cattle, horses, and people, prevented adequate testing during this study.

Size 0 steel traps set on the ground accounted for the second-highest number of total captures (21 owls) and were the most successful technique for capturing adults. These traps were particularly valuable during fall and winter because they provided a means of capturing adult owls when association with any particular burrow was weak. Traps that could not be concealed were usually unsuccessful during these seasons.

TABLE II

A COMPARISON OF CAPTURE TECHNIQUES FOR BURROWING  
OWLS, OKLAHOMA PANHANDLE, 1970, 1971

Capture Technique	Number of Owls Captured				Total
	Juveniles	Adult			
		Sex Unknown	Female	Male	
Woodcock traps	0	0	2	0	2
Verbail pole traps	0	0	0	0	0
Padded-jaw steel traps (pole sets)	0	0	0	0	0
Tomahawk box traps	1	0	4	0	5
Bal-chatri trap, with frogs and grasshoppers	0	0	0	0	0
Mist nets over burrows	3	0	1	0	4
Anderson traps	2	0	5	0	7
Hand net and light	31	1	0	0	32
Padded-jaw steel traps (ground sets)	7	1	5	8	21
Hand capture*	2	1	1	2	6
Total captured	46	3	18	10	77
Total color banded	15	3	8	9	35

\*Includes one captured in a rodent snap trap and three excavated from burrows.

The most successful method of capture (32 owls) was spotlighting. This method was useful almost exclusively for capturing young owls (the one adult captured was flightless, apparently due to injury), and the method was most effective when owlets had just begun to fly. This method proved much more successful in 1970 than in 1971 for reasons unknown. The effectiveness of the method in 1970 would likely have been further improved if: (a) an assistant had been available, (b) a dipnet with a 12 foot handle had been used throughout the capture attempts, and (c) the nights had been moonless.

In addition to aluminum leg bands placed on all captured owls, combinations of colored plastic leg bands were placed on 35 owls. Plastic poncho markers were tested on two adult owls; one removed her marker later the same day. The other owl was retrapped three days later and the marker was removed because she was continuously preoccupied with attempting to remove it.

Winter trapping efforts resulted in capture of three owls that were winter residents, and two others that probably overwintered. All five were banded with colored plastic leg bands.

## Foraging and Feeding Behavior

### Foraging Patterns

Four types of foraging behavior were observed and these were apparently similar to those noted by Thomsen (1971). Few observations of feeding were made from mid September through mid February. Thus, the various foraging patterns described in the following paragraphs may have differed from those characteristic of the late fall - early winter period. In the following paragraphs these four patterns are described

in decreasing order of importance, as determined by field observations.

Ground Foraging. Owls ran or hopped across the ground surface like a killdeer or robin, often with a short burst of speed, much headturning, stooping, looking, and ending with a cat-like pounce. They usually captured more mobile prey, such as grasshoppers or crickets, with their claws, but picked up, with their beaks, slower prey such as dung beetles. Sometimes a foraging owl interspersed its running with short, gliding flights at altitudes of one to three feet.

Ground foraging was observed during all seasons and at all times of day and night except predawn. It was definitely the dominant type of foraging in late morning and early evening. Ground foraging was also very important in the morning feeding periods in spring before initiation of egg laying.

Ground foraging was observed most often in short vegetation or on bare ground such as roads or dry playa lakes. It was the only method used to any appreciable extent in foraging within dog towns. Ground foraging was noted in taller vegetation. Late one evening several owls engaged in ground foraging in green wheat about six inches tall. On another evening a young owl foraged in wheat stuble about nine inches high.

Both sexes of adult owls engaged in ground foraging. This was apparently the primary foraging method utilized by adult females during the reproductive season; they sometimes ground foraged in the vicinity of the nest while their mates foraged outside the dog town. Owlets used this method almost exclusively when they first began capturing food.

All observed prey were insects, usually grasshoppers or beetles.



Hovering. The owl held its body nearly vertical, usually facing the wind and with rapid wingbeats remained at one spot in mid air. Owls often hovered at one altitude for several seconds, then dropped down 10 to 15 feet and flew horizontally 50 to 75 yards, and swooped back up to their former altitude before resuming hovering. This same pattern sometimes continued 10 to 15 times or until a capture was made--all hovers at the same altitude were preceded by a substantial drop, a horizontal move, and a seemingly effortless upward sweep to the hovering altitude. Perhaps a certain pattern of air currents determined the constant altitude.

Owls usually hovered over one spot for 7 to 10 seconds although hovers of 15 seconds were not uncommon and four of unusual duration were for 25 to 29 seconds each. Owls hovered at elevations of 10 to 75 feet. Observations suggested inconclusively that stronger winds or taller, denser ground cover may have induced a lowering of hovering altitude. High winds apparently discouraged hovering; hovering was observed only twice when wind velocity exceeded 12 miles per hour. Observations during periods of changing wind velocities showed that owls switched from hovering to foraging from observation perches when wind velocities increased to over 10 miles per hour.

Hovering was first noted in early April, and it continued at least through mid September. Most hovers occurred in the period between 30 minutes before, to 30 minutes after, sundown. Twice during early summer many owls began foraging by hovering, nearly simultaneously, when a heavy thundercloud covered the sun about two hours before sunset. Numerous hovers were also noted on cloudy mornings from 30 minutes after sunrise to as late as 9:00 a.m. Owls were commonly seen hovering at dusk when

only their silhouette could be seen against the sky. Hovering was observed twice on moonlight nights; nocturnal hovering may have been common.

Three-fourths of the hovers were over cultivated crops, mostly wheat more than four to five inches high. Most of the remaining 25 percent occurred over old fields seeded to mixed-grasses over four inches high. Hovers were rarely observed over short-grass pastures or plowed fields. Both row crops, and seeded grass fields dominated by bunch grasses, contained much bare ground. This vegetation to bare ground ratio presumably provided habitat for prey species, as well as open areas where owls could see and capture prey.

Males hovered in all but 4 of approximately 300 instances when sex could be determined. Most hovering was observed during the reproductive season when adult males provided food for their young and mates. Both members of mated pairs with fledglings were seen hovering on four occasions, each involving numerous hovers. Only two young owls were seen hovering; both were approximately two months old and hovered for only four to five seconds.

Prey captured by hovering owls were insects in 398 of 400 observations when insect prey could be distinguished from vertebrate prey. Jerusalem crickets were the most frequent prey (50 percent). In descending order of significance were various beetles (25 percent), field crickets (20 percent), and grasshoppers (5 percent); as based on 300 observations made when identity of insect prey was determined. Two owls seen hovering in late evening captured mice. Meadow voles were the primary prey of owls seen hovering in California (Thomsen 1971).

Foraging From an Observation Perch. Owls scanned the surrounding area from an elevated perch. When they detected prey they flew a short distance and pursued prey in the same manner as in ground foraging. The maximum distance owls were seen flying from perch to prey was about 100 yards. This foraging was recorded in spring and summer, it happened occasionally in the morning, but most often in the late evening. Observation foraging may have been common at night because at that time owls were seen perched on posts.

Owls commonly perched on fence posts, especially those bordering wheat fields. They occasionally perched on a power line or pole, a tall weed, or a yucca stalk. In the evening during the nesting season, male owls frequently flew from the vicinity of their nest burrow to a power line or pole adjacent to the dog town. They perched there for as long as 10 minutes, then flew to a distant fence post and began the typical foraging pattern. During the nesting season owls immediately carried prey back to their nests.

Both sexes foraged in this manner. However, 73 of 100 observations involved adult males foraging for nestlings. Young owls occasionally foraged by this method as early as mid August, or at 8 to 10 weeks of age.

Often prey captured during observation foraging could not be identified. Fourteen of 15 identifiable prey items were insects, mostly crickets and grasshoppers. The single exception was a fledgling meadow-lark captured by an adult owl.

Flycatching Behavior. Owls were observed capturing insects in their claws while flying. Abbot (1930) reported burrowing owls "hawking" moths around city street lights. Thomsen (1971) recorded infrequent

"flycatching" in the manner of Tyrannidae. Mid-air captures of four June beetles near a yard light one-half hour after sunset, and captures of grasshoppers put to flight by cattle or prairie dogs were observed. An owl also captured a moth flying towards the spotlight. Adults of both sexes were observed flycatching but this behavior was not observed among young owls.

### Prey Transfer and Ingestion

Males provided most food for their mates and owlets during the 8 to 10 week reproductive season beginning in early May soon after initiation of a clutch. Males generally hunted within one-fourth mile of the nest. Their role as food providers continued until offspring began foraging at about six weeks of age. Ninety percent of approximately 700 foraging trips observed occurred in the three and one-half hours preceding darkness or the first three and one-half hours after sunrise.

Three feeding patterns were observed during egg laying and incubation. The first, seen numerous times, was characterized by the following sequence of events: (a) the female waited above ground in the general vicinity of the nest while the male foraged, (b) she ran or flew 5 to 20 yards to meet him, (c) the male transferred the prey from his beak to hers, and (d) the female remained above ground to eat the prey.

In the second pattern the male brought the prey back to the mound of the nest burrow and paused for a few seconds. His mate then came up out of the nest, took prey from his beak as he leaned over into the burrow mouth, and then she moved back into the burrow. Presumably the male used a vocalization to inform his mate of his presence (Walker 1952).

This pattern of feeding was observed in both morning and evening, but somewhat less than the first pattern.

The male carried prey to the mound of his nest burrow in the third feeding pattern during the incubation period. He left the prey on the burrow mound, either dead or with a crippling injury. All prey observed were insects, often with a crushed thorax, broken antennae, crushed exoskeleton on the head, or other injuries resulting from capture and carrying. The female periodically came up from the nest and ate the food.

Two feeding methods were observed after young hatched but before they emerged from the burrow. One was the deposition of dead or incapacitated prey at the mouth of the nest burrow, as previously described. As many as nine Jerusalem crickets were found at nest burrows, and two or three Jerusalem or field crickets were at nearly all active nests in the late evening or morning during this period. Walker (1952) noted that males often brought live prey items to nestlings, and theorized that this may have helped train owlets to capture prey.

The most commonly observed pattern was for the female to wait above ground near the nest burrow, run or fly a short distance to meet the returning male, take the prey in her beak and run down the nest burrow. The male then resumed foraging.

The feeding pattern after owlets had emerged from the burrow was less ritualized than earlier. The female usually received the prey from her mate and fed it to the brood; the male gave prey to owlets on the infrequent occasions when his mate was absent.

As noted earlier, the male was responsible for most food gathering. Thomsen (1971) also noted this pattern, but Robertson (1929) said both

parents caught prey for owlets. Infrequently the female foraged for her owlets (usually near the nest); she watched for her mate and often flew to intercept him and distribute prey to the young.

The male was observed taking food items into the nest burrow in only two circumstances. The first occurred in late evening soon after initiation of egg-laying at a nest. The male carried a freshly killed, small snake back to the vicinity of his nest. Both he and his mate picked at the snake for a few minutes. They then entered the burrow carrying the snake with them. After two minutes they exited without the snake.

The other observations were made one morning at a nest containing owlets too young to come above ground. Both adults foraged for their young; the male often arrived with food when his mate was out foraging. He then took the prey into the burrow.

The process of eating was leisurely, except among fledglings, who gulped their food. Eating an inch-long grasshopper frequently required two minutes or longer and at least six bites. A ground foraging owl often pounced on an insect and then stood looking around for a minute or more before indicating it had made a capture.

Owls held most prey items in their claws, and either leaned over to tear off bites or lifted a claw to their beak. They swallowed whole only the smallest prey items, such as small beetles. Owls usually immediately decapitated larger prey. They often pulled off and flung aside certain body parts of insects, including tibia and intestines of grasshoppers.

## Activity Patterns

Owls in the study area were diurnal, crepuscular, and nocturnal. Notwithstanding previous reports (Dice 1945, Murphy and Amaden 1953), observations in Oklahoma and those of Coulombe (1971) and Thomsen (1971) indicated that burrowing owls can see well in dim light.

Coulombe (1971:164) stated: "...the conspicuous diurnal behavior centers around the burrow sites and patterns of activity are related to the season." He recognized four classes of daily patterns: winter, incubation, fledgling, and post-breeding. Data collected throughout this study generally supported his observations. A fifth class of daily activity pattern, spring prenesting, became apparent during the study.

### Winter

Limited observations in late fall and winter indicated that burrowing owls exhibited little, if any, diurnal activity above ground. Daylight visits to dog towns containing wintering owls usually revealed an owl sitting in a burrow mouth, shielded from the wind and with only its head visible, or more frequently, no owls at all. The owls were presumably below ground when they were not observed in these same dog towns on other days. This presumption was strengthened by excavation in winter of burrows containing owls and by flushing owls on two occasions when dog towns were traversed on foot or by vehicle.

### Spring Prenesting

Activity patterns changed drastically with the return, in the second or third week of March, of owls that migrated. Owls remained inactive in late morning and early afternoon, usually staying within the

burrow, in the burrow mouth, or on the down-wind side of a clump of vegetation such as soapweed. Late evenings were devoted mostly to pair formation, courtship, selection of nest sites, and associated reproductive behavior. Reproductive behavior was also observed in the morning periods, but it was usually less intense. Owls frequently foraged in the mornings until about two and one-half to three hours after daylight. Many foraged intermittently during the first three to four hours after dark.

### Incubation

Females were seldom active about ground during the period of egg laying and incubation. Females were seen occasionally in the evening and morning when their mates brought food but they remained in or near their burrows. Females remained near the nest after some eggs had hatched and until owlets emerged above ground.

Males were usually quite sedentary during midday and rested in the mouth of a satellite burrow or on a satellite perch. Palmer (1896) noted that males stood watch while their mates were in their burrow, and warned them with an alarm call when intruders appeared. This general pattern was observed in Oklahoma, especially during incubation and before owlets emerged from their nest. Males left their sentry positions and foraged in the late evening hours.

### Fledgling

Both adults became more active when their young emerged from the burrow. Diurnal activity increased, often including all but three to four hours at midday. Again males were more active than females,



however, females exhibited frequent flurries of activity, usually within 100 yards of the burrow. During midday, owlets were normally within their nest burrow, adult females were in the mouth of their nest burrow or an adjacent burrow, and males remained on a satellite perch or in the mouth of a satellite burrow near the nest. Coulombe (1971) noted the same general activity patterns for this period.

Owlets frequently came above ground in the morning and evening. Little activity other than what might be called play behavior was noted when owlets first came above ground. They became more active as they matured, often pouncing on sticks and other debris, and running in and out of their burrow but never straying far. Walker (1952) noted that owlets a few weeks old spent much time running around their nest chamber, often clutching an unhatched egg from various positions.

Owlets flew quite well at six weeks of age. They usually remained within 50 yards of their burrow, but occasionally flew 100 yards when disturbed. Owlets gained skill in foraging as they increased the scope and intensity of their activity.

Owlets were recorded outside their burrow 100 to 125 times during the first three hours of darkness, on moonlight and dark nights. Adults were also active at night during the fledgling period, foraging as late as 1:00 a.m. on both moonlight and dark nights.

#### Post-Nesting

A distinct change in activity patterns occurred as the owlets became fairly independent around 1 August. Adults were sedentary during daylight hours. Most spent the day in the mouth of a burrow or in the shade of a clump of vegetation, usually in the general vicinity of the

nest. Adults fed mainly after sundown. High temperatures in the study area, usually in the 90's and occasionally exceeding 100 F, may have induced owls to restrict their diurnal activities in August and early September as Coulombe (1971) noted in California.

Young owls exhibited more diurnal activity than adults and normally began actively foraging two to two and one-half hours before sundown. This crepuscular foraging by the young was so intense in late August and early September that, where several broods were foraging, accurate counts of owls were virtually impossible at sundown. Young owls continued to forage after dark as late as 11:00 p.m.

#### General Behavior

##### Response to Weather Conditions

Coulombe (1971) studied behavior of burrowing owls responding to high temperatures at Imperial Valley, California. He noted: (1) owls often sought perches above the ground surface, apparently escaping heat radiation from the ground, (2) they usually faced away from the sun and also utilized any other available shade for their relatively bare legs, (3) they held their wings away from their bodies, and (4) for periods of one hour or less they utilized evaporative cooling by means of gular fluttering. Coulombe (1971) also observed owls drinking water, and concluded that they may have resorted to evaporative cooling more frequently had free water been readily available.

The length of time individual owls resorted to gular fluttering was not recorded; however, on several occasions it was observed at 6:00 p.m. after noting it four to five hours earlier. Drinking water was

available within one-half mile in these situations. Owls were not seen drinking in Oklahoma except in captivity.

Burrowing owls also respond to low temperatures; they often fluff their feathers (Coulombe 1971, Thomsen 1971), and may face the sun (Coulombe 1971). On cool mornings owls were often observed with feathers fluffed.

Cold temperatures alone may not have seriously hampered owl activity. Tyler (personal communication) observed burrowing owls active above ground when ambient temperature was 18 F. An instance of above-ground activity by an owl was observed when ambient temperature ranged from 13 to 18 F. Excavation of owls from burrows when temperature was less than 35 F and wind velocity greater than 15 miles per hour, however, gave some reason to suspect that low temperatures, possibly in coordination with other factors, may have retarded activity of burrowing owls.

Ligon (1969) failed to induce torpor by a combination of fasting and low ambient temperature (minimum of 44 F) in any of three species of small owls: elf owl, whiskered owl, and screech owl. The response of all three species included an appreciable loss in body weight, maintenance of high metabolic rate, and absence of hypothermia.

The response of burrowing owls to high wind velocity is apparently not documented in the literature. As stated earlier, high winds altered foraging patterns. Owls usually squatted in burrow mouths, depressions, or on the lee side of vegetation when wind velocity exceeded about 15 miles per hour. At these times they were reluctant to flush, often squatting lower and lower as a vehicle or person approached to within 25 to 35 yards. A possible reason for their reluctance to fly in high

winds was noted when an adult male attempted to fly to a distant burrow mound. As he spread his wings to alight, a strong gust of wind, exceeding 30 miles per hour, flipped him into a head first crash landing.

Well-feathered burrowing owls did not ordinarily seek shelter from spring and summer rain showers. Bailey and Niedrach (1965:430) described the reaction of a family of "three-quarter grown" owls to afternoon showers as follows:

...with the first drops of moisture all wings were out-stretched, and as the rain intensified, the owls would begin to circle, flapping their wings -- young and adults -- and then, if downpours continued, they squatted and pumped wings violently up and down. When the showers were over, the birds gathered in little groups, stretched wings and legs, and preened themselves.

Varied reactions of owls to rain showers were observed. Flightless owlets retreated into nest burrows during showers, presumably because they lacked protective feathers. Adults squatted with feathers fluffed, occasionally slightly sheltered by vegetation such as thistles, but never retreating into burrows. Young owls capable of flight usually assumed the same posture as adults. However, on one occasion a young owl chased down a grasshopper during a light shower. During a hard shower another young owl ran down a burrow, remained for about two minutes, and then came back up and stood in front of the burrow for the remainder of the downpour, occasionally giving the rasp call described later.

#### Play Behavior

Several investigators (Bailey and Niedrach 1965, Hennings 1970, Walker 1952) described actions of young burrowing owls that might be

construed as play behavior, although no one called it that. Numerous activities of owlets were observed that could not be interpreted as anything except play behavior. Fledglings often sneaked up and pounced on nest mates, falling over, rolling around and sparring with outstretched claws as they rolled on the ground, biting and chasing each other. Some of these activities such as pouncing and chasing presumably had survival values to the owlets.

### Vocalizations

Burrowing owls are capable of producing a surprisingly wide variety of sounds. Thomsen (1971) thoroughly described these vocalizations and the conditions eliciting them. The following discussion of each type of vocalization adopts the terminology and often the descriptions first utilized by Thomsen (1971).

(1) Chuck--a sharp, single note given simultaneously with each bow after a flushed bird landed. This was apparently a mild note of excitement that probably drew attention away from the burrow. It was also a warning call; young owls retreated into burrows when the chuck was given. The chuck may have denoted alarm (Coulombe 1971).

(2) Chuck-chatter--several chucks (three to seven) followed immediately by a chatter of notes on the same pitch. This vocalization apparently functioned much as the chuck, but denoted a slightly higher level of excitement. Goss (1891) stated that burrowing owls often chuckled, chattered, and squalled, but he did not interpret functions of these sounds.

(3) Chatter--several rapid notes on the same pitch, but not preceded by any chucks. The pitch and volume were variable, becoming

louder and higher as the owl became more upset. Adults often gave this call when large predators, including humans, approached the nest. Coulombe (1971) said the chatter was alarm behavior. Bent (1938) noted that the alarm call of burrowing owls was a "cackly" sound, thus probably referring to the chatter or the chuck-chatter. This chatter and the scream were the only calls owls gave while flying. Adults, especially males, usually chattered as they flew over predators near the nest. Chattering was heard both at daylight and after dark.

(4) Primary song--a cooing somewhat similar to the mating call of a mourning dove. It sometimes sounded two-syllabled, with the second syllable of longer duration. Four or five notes with the last notes slurred together could sometimes be differentiated. Bent (1938) probably referred to a version of primary song when he described a "love call" of rapid cooing notes somewhat like a cuckoo. Apparently only the male gave this call, frequently heard from early March through May and occasionally in June. Dusk was the favored time for calling (primary song), although owls often called early in the morning and as late as 11:30 a.m. on cool and cloudy days. The primary songs were not heard later than one hour after sunset or earlier than one hour before sunup. Goss (1891) however, noted that burrowing owls gave a nocturnal cry resembling a cuckoo.

Primary song was a key feature of pair formation, courtship, and mating. Males usually called from burrow mounds, but occasionally from fence posts. The posture of calling males resembled the threat posture, described later. The body was held in a horizontal position, wings drooped, and two white throat patches and white areas around the eyebrows became very prominent. The calling owl often swiveled abruptly,

turning 90 degrees while retaining his horizontal posture and continuing to call.

(5) Rasp--a short "buzzt," lasting one or two seconds. Adults and owlets both rasped, usually at dusk or after dark. Limited field data suggested that owlets begged for food by rasping. Owls may have used the rasp also as a means to locate one another, and as an "all's clear" signal to encourage owlets to leave the burrow (Thomsen 1971).

(6) Scream--a loud, scratchy, hissing scream used only in times of extreme distress or when enraged (Bent 1938). Trapped owls occasionally screamed when approached. Owls screamed, some while on the ground and some while circling and diving about, when badgers and coyotes hunted in the vicinity of owl nests. Screaming was heard after dark on several occasions, presumably when a predator disturbed the owls.

(7) Rattlesnake--given by owlets as the precursor of the adult scream (Thomsen 1971). The sound is very similar to that of an agitated rattlesnake, especially if slightly muffled when an owlet was within a burrow. The resemblance was such that on several occasions it temporarily deceived me and a dog. Bailey and Niedrach (1965), Goss (1891), and Walker (1952) also described this sound. It may have functioned as a deterrent to potential predators, although it is apparently not unique to the burrowing owl (Thomsen 1971).

(8) Warble--a series of very soft, liquid notes, somewhat similar to those of the red-shafted flicker (Thomsen 1971). It was heard infrequently throughout late spring and into September, always at dusk or after dark. Its function was not apparent, but it may have been a greeting note (Thomsen 1971).

### Relationships With Other Vertebrates

Various species of songbirds were seen harassing burrowing owls on over 75 occasions. Usually harassment consisted of birds diving at a resting owl and the owl reacting by ducking and sometimes chattering. Occasionally it flew and then became the target for more harassment. Birds engaging in this activity included barn swallows, cliff swallows, western kingbirds, eastern kingbirds, mockingbirds, scissor-tailed flycatchers, red-winged blackbirds, western meadowlarks, lark buntings, horned larks, lark sparrows, common nighthawks, and a sparrow hawk.

A pet owl, perched on a clothesline pole, always attracted a number of scolding songbirds within one to two minutes after removal from its pen. Apparently these birds recognized burrowing owls as a potential enemy, although studies of owls' food habits indicated birds were a relatively minor dietary component. Both Thomsen (1971) and Tyler (1968) also noted songbirds harassing burrowing owls.

Burrowing owls at rest often turned their heads to scan the skies overhead, possibly to detect large raptors. Owls squatted in mouths of burrows or occasionally ran into the burrow when hawks, eagles, or turkey vultures approached. Owls did not retreat from crows and white-necked ravens. A marsh hawk was seen surprising a pair of owls as it glided low over a knoll. The female owl dived into a nearby burrow but the male had only enough time to squat in a slight depression in a sparse clump of thistles. When the hawk had passed on, the male ran to the mouth of a burrow about 10 feet away.

On another occasion a golden eagle swooped low over a dog town and four owls ran out of sight into burrows. One of the adult males became white and tall just before he retreated into the burrow, apparently



expressing intense excitement and fear of the approaching eagle. Large raptors were not seen attempting to capture burrowing owls, although a rancher in the area related he observed a "chicken hawk" capture a burrowing owl. In California large raptors elicited fear responses from burrowing owls; the owls squatted in a burrow mouth or ran inside (Thomsen 1971).

Burrowing owls ignored cattle and horses and allowed them to approach closely before flying away. During the nesting season and during late August, disturbance by dogs, coyotes, or badgers elicited chattering, screaming, and aerial attacks (but little actual attack) by owls. Disturbance by dogs in early spring, before owls nested, caused owls to chatter, but not to dive or scream. Owls never dived at humans and screamed at them only when restrained in a trap. Others have reported burrowing owls harassing potential mammalian predators including dogs, badgers, weasels, and skunks (Koford 1958, Robertson 1929, Thomsen 1971).

Trapped owls gave a typical strigiform bluff or threat response when approached by humans. This bluff posture included fluffing of feathers and the resultant appearance of increased body size, drooping the wings and rotating them forward, and often the crouched owl weaved back and forth. Sometimes, but not always, screaming and snapping of the bill accompanied the threat posture. Both Coulombe (1971) and Tyler (1969) described this posture.

Burrowing owls usually ignored jackrabbits, and vice versa. On two occasions a jackrabbit grazed to within about two yards of burrowing owls by their nest burrow. The adult male at one nest and the female at the other both responded by giving the threat posture, without the

scream. The jackrabbits responded by running away. Thomsen (1971) described similar contacts between jackrabbits and burrowing owls.

Little interaction was seen between burrowing owls and desert cottontails, although both occupied abandoned prairie dog burrows (apparently not at the same time). Owls displayed the threat posture to desert cottontails on several occasions. Most occasions involved an adult owl attempting to intimidate a rabbit that had grazed too close to the owl's nest; two were rabbits that attempted to "sniff" young owls and were promptly threatened. On four occasions cottontails attempted to enter burrows where owls perched and were forced to turn to other burrows because of the threatening owls. Owls never screamed at cottontails, but intimidated them in all instances except one. One owlet, still displaying the threat posture, even waddled after a retreating cottontail, who then broke into a full run.

The single exception to the owls' dominance occurred when an adult owl was flushed and it flew to a burrow mound. As it lit on the mound a desert cottontail hopped away from the burrow, apparently startled by the owl. After a minute or two the rabbit started back towards its burrow. When it was about two feet from the owl it stopped, then jumped toward the owl, who then flew away without a protest. The rabbit disappeared into the burrow. Thomsen (1971) and Tyler (1968) reported that burrowing owlets successfully bluffed rabbits with displays of the threat posture.

Surprisingly few behavioral interactions were observed between burrowing owls and prairie dogs. Owls responded to warning barks of prairie dogs, and very likely depended on them to help watch for the

appearance of large raptors. Prairie dogs, especially young animals, occasionally sat up and watched activities of nearby owls.

The infrequent direct confrontations observed between the two species always revealed that prairie dogs were submissive to the owls. Adult owls initiated most instances of direct contact by attacking a prairie dog in the vicinity of the owl's nest. Both male and female owls (never at the same time) made these attacks, generally consisting of an owl diving at a prairie dog. Occasionally owls lightly struck the backs of prairie dogs. Harassment sometimes continued until the prairie dog entered a burrow. Once an adult male owl dived and twice struck an adult prairie dog. On the third swoop the prairie dog sat up and tried to fight off the attacking owl, then turned and ran into a burrow.

Sometimes owls displayed the threat posture to prairie dogs before attacking them. At other times they apparently attacked without warning. Owls often permitted prairie dogs to approach within two to three feet of their active nest; however they occasionally attacked grazing prairie dogs 25 feet from any owl nest. One female owl displayed the threat posture to a young prairie dog that ventured near her nest burrow where two owlets sunned. When the prairie dog sat up to gaze at the threatening owl, she waddled toward it with wings drooped and chased it about 15 feet until it went into a burrow.

Behavioral relationships between burrowing owls and ground squirrels, as described by Thomsen (1971), closely paralleled this study's findings on owl-prairie dog relationships. Coulombe (1971) did not mention interactions between burrowing owls and round-tailed ground squirrels that lived in close association with owls in his study area in southern California.

Observations did not indicate whether burrowing owls appropriated active prairie dog burrows for their own use or if prairie dogs reclaimed burrows occupied by owls. Four active burrowing owl nests in the egg laying-incubation stage, had prairie dogs residing in them three to six days later. Broken shells of owl eggs and debris apparently cleaned from the burrows by prairie dogs were found in three of these situations.

Prairie dogs may have entered nests when adult owls were absent or death of the female owl or predation on the eggs by weasel, snake, or spotted skunk may have caused abandonment of the nest whereupon prairie dogs occupied the burrows. The apparent preference owls exhibited for dog towns as nesting habitat was evidence that prairie dogs were not important enemies.

#### Escape Behavior

Escape behavior and habitat preferred for escape from danger varied. Owls always attempted escape from large raptors by retreating into burrows. Owls usually escaped danger in fall and winter by flying away. They remained in the immediate vicinity, flying to a burrow or perch less than 100 yards away, if the disturbance was only mild or brief. Often they fled the area, taking cover in taller vegetation such as sage brush, if potential danger such as the presence of a vehicle, remained for prolonged periods of time. In New Mexico burrowing owls usually retreated from an open area to dense vegetation when alarmed or flushed (Best 1969).

Nesting adults tried to escape danger by flying from the area of the nest to a nearby perch or burrow mound, usually within 75 yards of

the nest. If pursued they continued to remain in the area, flying from one secondary perch to another and seemingly trying to draw attention away from the nest. Coulombe (1971) described a decoy behavior pattern in which the owl called attention to itself through a ritualized pattern, gave chucks and bobbed, and then retreated to a secondary perch.

Owlets younger than six weeks of age always attempted escape from danger by retreating into their burrow. Older owlets flew away from danger but still remained in areas of short vegetation, seldom straying farther than 200 yards from their burrow until they were eight to nine weeks old.

At all seasons adult owls occasionally attempted to hide when approached, and sometimes hid after being flushed. They usually squatted low in a slight depression or in a clump of taller vegetation such as thistles, as noted also by Coulombe (1971).

#### Territoriality

Published data on territoriality in burrowing owls are scarce. Best (1969) did not observe "competitive interactions" between members of burrowing owl colonies in New Mexico. In California burrowing owls established territories at the commencement of pair formation, and continued to defend these territories against other owls throughout the summer (Thomsen 1971). The three methods of territorial defense were calling, the resident male presenting himself to the intruder, and physical contact (Thomsen 1971). The latter method was the least important, and contact was unusual unless an intruder approached within 10 yards of the nest burrow (Thomsen 1971). Coulombe (1971) observed that burrowing owls defended territories consisting of the immediate

vicinity of their burrows, but he noticed a marked absence of interaction among owls foraging in the same areas.

Burrowing owls in the study area exhibited territorial behavior, at least during the reproductive season. The owl's burrow and a portion of the surrounding area constituted a territory. Owls only occasionally defended vertical space. Resident male owls usually paid no attention to other males flying low over their territories when the intruding male was bringing prey from a distant foraging area back to his own nest area.

Owls exhibited only intraspecific territoriality, except for defense of the nest. Territoriality was not apparent among adult owls foraging in close proximity to one another over fields. Young owls foraged on the ground without conflict in fields and roadsides even though as many as 20 were sometimes in close proximity.

The establishment of territories and pair formation occurred at roughly the same time. Occasionally, however, an unpaired male established a definite territory. Male members of pairs established and usually maintained territories, although females were noted defending territory on two occasions; the mate of one assisted her in the defense.

Calling (primary song) by the male was probably the most important means of establishing and maintaining territory. Calling often served a dual and simultaneous role in courtship and territorial behavior. The simple presence of a resident male owl, especially if he perched on a burrow mound or similar place where he was easily seen, was also important in establishment and especially in maintenance of territories.

Owls occasionally employed actual physical contact, usually in the form of chases and brief mid-air skirmishes, in territorial defense. This physical contact was ordinarily limited to a resident owl briefly striking an intruding owl in mid air, or diving and brushing an intruder that alighted before moving far enough away to satisfy the defender. Most instances of territorial defense occurred when owls were flushed and they strayed into another's territory.

Active defense of territory, when human disturbance was not a factor, usually occurred when an intruding owl failed to see one or both members of the resident pair, who were resting or otherwise partially hidden from obvious view. In one instance an unmated female flew to a mound where a mated male was calling, apparently failing to see his mate partially hidden in the mouth of the burrow. Both members of the mated pair immediately drove the intruder from the vicinity without resistance.

On another occasion a female loafed on a burrow; her mate squatted in a sparse clump of thistles about two feet away. An unpaired male, who had been calling, flew in and alighted beside the female, probably failing to see her mate. This was the only genuine fight observed; it lasted about 8 to 10 seconds and involved all three owls. The intruder finally flew, the defending male gave chase for a short distance and then returned to his mate and both preened.

Territorial defense by adults was not observed after the owlets became active above ground; however, owl families generally remained in the vicinity of their respective nest burrows throughout summer. No evidence of territorial behavior was seen during limited observations in

fall and early winter. During this period, the sparse wintering population presented little opportunity to exhibit territorial behavior.

On an admittedly shaky basis, Thomsen (1971) estimated sizes of six individual territories of owls, and found they averaged 1.98 acres, ranging from 0.1 to 4.0 acres. Twelve nests were found in an 8.8-acre dog town (one nest per 0.73 acre) in Oklahoma; 10 were within a 1.5-acre block (one nest per 0.15 acre). Eight of these 10 were 25 yards or less apart, and two were 13 yards apart. Therefore, territories of individual nesting pairs may have occasionally been less than 0.1 acre in size, assuming that territories were roughly circular with radii representing one-half the distance between adjacent nests as Thomsen (1971) assumed.

In two intensively studied areas in 1971, each 10 to 11 acres in size, approximately twice as many territorial conflicts were seen per hour in the area with one nest per 0.7 acre than in the area with one nest per 1.7 acres.

#### Home Range

Burrowing owls flew at least one mile to obtain crayfish in Colorado (Hamilton 1941), and owls apparently ranged at least 0.6 mile from their burrow to foraging grounds in California (Hennings 1970).

Difficulties were encountered determining home range of burrowing owls because only a small number of owls were color marked, and it was difficult to see markers on owls foraging at night. Data on home range were limited to spring and summer.

Radii of home ranges of adults in spring and summer were apparently less than 1.5 miles, and trips more than 0.7 mile from nests were



uncommon. Foraging trips of 100 to 350 yards, in early morning and late evening, were common when adult males were feeding young. Owls generally ranged the greatest distances between sundown and sunrise, even on moonless nights. Adult owls were seen on three occasions between 9:15 and 10:00 p.m., at distances of .05 to 0.6 mile from their burrows. Another adult was seen 0.7 mile from its nest at 10:00 p.m. and again at 11:30 p.m. on a moonless night in mid July. In early August an adult owl was found, that had been struck by a car, 1.5 miles from any known dog town or owl nest.

Young owls apparently had home ranges with radii up to 1.5 miles. Young owls were observed 1.0 to 1.5 miles from their nest six times in late July on moonless nights after 11:00 p.m. Young owls were also seen 0.5 to 0.8 mile from their dog towns on 13 occasions; nine were seen at night, and on seven occasions there was little or no moon.

### Reproductive Behavior

#### Pair Formation

The first indication of pair formation was 10 March when a pair of owls were observed together in a burrow mouth, and the male exhibited sexual excitement, as described later. Considerable courting activity, calling and displaying by males, was noted on 11 March in a dog town containing 15 to 20 owls. Pair bonds apparently were not yet solidified because individual males courted several females.

Some pairs were apparently formed by mid March. On 12 March one dog town contained five owls, including a pair having a well-established bond. This pair stayed to themselves and spent much time in mutual preening. By 17 March a second pair had formed. In California pair

formation begins in early December; most pairs are formed by late February, but some are not formed until mid May (Thomsen 1971).

Calling was an important component of pair formation. Its importance became quite evident when several unpaired males called extensively while courting a single female. Males attempted to lure females into their territory by calling. Imitation of the primary song nearly always evoked calling by unpaired males, but seldom drew a response from mated males. Thomsen (1971) also found primary song a principal component of pair formation.

Most pairs were quite stable and there were few interactions among different pairs by the last week of March. However, an apparent case of infidelity was noted on 28 May. While the male member of a late-nesting pair was away from their nest, a male from a pair that was maintaining a nest about 100 yards away flew to the late-nesting female and gave her a Jerusalem cricket. The original mate of the female then returned and drove the intruder away. A short while later both males brought food to their respective mates.

By late August and September pair bonds were apparently weak or absent. Pairs were not seen from October through February. In California some, but not all, owls maintained pair bonds for a year or more (Coulombe 1971, Thomsen 1971). Thomsen (1971) noted that family groups remained together until September, and then dispersed. Paired owls appeared on the plains of Colorado in early April (Bailey and Niedrach 1965), thereby implying that owls paired before arriving on the nesting grounds, or had permanent pair bonds.

### Courtship and Mating

The "white and tall" posture of owls (Thomsen 1971) denoted a state of sexual excitement, as well as occasionally denoting fear. Like calling, it was usually closely associated with courtship and mating. Owls stood erect with feathers on neck and back fluffed out, and with white throat patches and white areas around their eyes very prominent. Females seldom displayed this posture during courtship.

Preening was a component of courtship behavior. Self-preening was observed only slightly more during the courtship period than during summer and early fall. Differences between the amount of self-preening by males and females were not apparent. Courting birds frequently engaged in mutual preening, especially head scratching, before they had formed definite pair bonds, and mated pairs also preened. Head scratching involved one bird scratching the other's face and head feathers with its bill. Males scratched the females more. Females occasionally seemed to solicit scratching by walking up to the males, lowering their heads, and closing their eyes. Males usually obliged immediately. Preening was usually observed late in the morning and early in the evening, when vigorous courting activity was absent or diminished.

Numerous copulations were observed between 11 March and 22 June, with mating activity in 1971 peaking between 25 March and 10 April. Copulation was usually four to six seconds in duration, as also noted by Coulombe (1971). The usual pattern of courtship behavior leading to and immediately following copulation was as follows: (1) the male commenced calling, often from the mound of the nest burrow, (the female was sometimes present), (2) if present, the female soon ran or flew away,

leaving the calling male alone, (3) the male ceased calling and became white and tall as the female departed, (4) the female stayed away for a minute or more, while the male gradually relaxed his white and tall stance and often commenced calling again, (5) the female flew back to the male, who became white and tall as she approached, (6) copulation occurred soon after the female returned, (7) after copulation the male dived off and ran down the burrow, where he remained out of sight for about 15 seconds, (8) the male emerged from the burrow white and tall, but gradually relaxed, (9) one or both members of the pair flew or ran away to ground forage, or sometimes just loafed at the burrow, occasionally preening themselves or each other.

The preceding sequence of events was much more typical for paired owls than for courting owls before pair formation was complete. Copulations and attempted copulations before owls formed definite pair bonds tended to be much less ritualistic, often taking on the appearance of rape. For example, one male flew and alighted directly on the back of an uncooperative female and attempted copulation.

Many copulation attempts early in the season were apparently unsuccessful. Difficulties observed included male falling off female and female running out from under male. Early in the breeding season apparent mistakes in sex recognition were noted, always in the form of a male attempting to court another male. Females were quite unresponsive early in the season, becoming more easily stimulated and more cooperative a week or more after initial courtship activities. This may have indicated that males were sexually ready before the females.

Thomsen (1971) and Coulombe (1971) gave detailed descriptions of courtship and mating behavior of burrowing owls in California. Coulombe

(1971) described the males' courtship display of drooping their wings and crouching, while giving the primary song. He made no mention of the white and tall stance of a courting male, but clearly illustrated it in his photograph (Coulombe 1971:166) of courtship display by a male. Owl pairs with fledgling young in California sometimes continued to court and occasionally copulate (Coulombe 1971).

Thomsen (1971) noted several reproductive behaviors that were not seen in Oklahoma. These included a precopulatory circular flight performed most often by males and usually before sunrise, a simulated exchange of food accompanying copulation, the male bringing food gifts to the female before she began laying, and mock copulations performed by owlets.

#### Selection of Nest Site and Nest Construction

Owls usually undertook selection of a nest site after formation of pair bonds. Just after sunset on 29 March and one hour after sunrise on 2 April, owl pairs were seen flying to three and two burrows, respectively. The males went inside the burrows and remained for 45 to 120 seconds. All burrows inspected were unoccupied prairie dog burrows. The female members of the pairs remained outside and waited for their mates in all but one instance. In the exception the female flew to another burrow where the male soon joined her and inspected the burrow.

In California owls conducted burrow hunting at dusk and probably during the night. An owl pair sometimes visited more than one burrow each evening (Thomsen 1971).

Cleaning out the burrow was the first step in nest building. During the first hour of daylight on 30 March, three separate paired

females faced down burrows and gave vigorous backward kicks or scratches, sending dirt and debris flying. These bursts of activity lasted for two to three minutes.

At 8:00 a.m. on 2 April a pair that earlier in the morning had inspected two burrows began cleaning out the second burrow. The female initiated the work, scratching with such vigor in the mouth of the burrow that the male moved out of the resultant shower of debris and dirt. After one minute the female came out to stand near her mate, who then walked to the burrow mouth and commenced scratching out debris. He soon disappeared into the burrow, and the female stood in the burrow mouth. Immediately a cloud of dust fogged up in front of the female, coming from within the burrow. She responded by kicking debris out of the burrow, in what was apparently a relay of debris. This operation continued for 90 seconds, a series of seven kicks, and then the female ran out of the burrow mouth and shook herself. In one minute the male also came out and shook himself. The male members of two pairs were observed cleaning out burrows on the evening of 2 April.

Male and female owls participated in digging and burrow cleaning with the same frequency in California, but females tended to work longer (Thomsen 1971). Burrowing owls in Minnesota always cleaned debris from badger burrows that were converted to nest burrows (Roberts 1936). Owls scratched considerable material from their prospective nest burrows in Arizona by facing down the burrows and with each scratching effort throwing material closer to the surface (Brandt 1951).

Despite the renovating and burrow cleaning activities, evidence was not found that burrowing owls ever dug their own nest burrows. Judging from the size and shape of the burrows, badgers had originally dug those

used by owls outside dog towns. Goss (1891) stated that western burrowing owls in Kansas dug their own burrows, but did not elaborate on the basis of his contention. Palmer (1896), referring to Florida burrowing owls, maintained that owls dug their own burrows. In California burrowing owls rarely dug their own burrows (Thomsen 1971).

A few owls in the study may have used the same burrow for a nest two years in succession. A male banded as an adult at his nest in 1970, chose the same burrow for a nest site in 1971. A female banded as an adult in 1970, was flushed from the vicinity of her 1970 nest burrow late in March, 1971. However, she and all other owls disappeared from the dog town a little later. Several nest burrows marked in 1970 were utilized again in 1971. The owls nesting there may have been adults that nested there previously, young owls that hatched there in 1970, or other owls that utilized the burrows for the first time.

Some owls definitely did not nest in the same burrow where they hatched or nested the previous year. One female banded as a nesting adult in 1970, nested in the same dog town but in a different burrow in 1971; prairie dogs occupied her former nest burrow.

The number of nest burrows reused each year always exceeded the number of new nests in New Mexico (Best 1969). Best (1969) did not band any owls and thus presumably did not know if the same owls used these nests each year. This relatively high percentage of reused burrows may have reflected the lower availability of completely made-to-order nest burrows. Nesting owls modified kangaroo rat dens (Best 1969), and thus may have preferred a burrow already modified.

Owls often returned to nesting holes used the year before in Colorado (Bailey and Niedrach 1965). Brenckle (1936) reported

recapturing four nesting female owls in the same field in California where they were banded the previous year. He also found an owl dead in the same field in South Dakota where he had banded it the previous year, and captured another in North Dakota at the same den where he banded it the previous year.

Observations in Oklahoma indicated that males gathered materials and constructed the nests. As described later, owls constructed nests primarily of cow and horse dung. At dusk on 29 March, the male member of an owl pair twice pounced on boluses of cow and horse manure and carried them to a vacant prairie dog burrow. He carried the dried manure in his claws, alighted on the burrow mound, pecked a couple of times at the material, took it in his beak, and went into the burrow where he remained for 75 seconds with the first bolus and three and one-half minutes with the second. The female sat five feet to one side of the burrow but paid no attention to the activities of her mate. Other observations of nest construction were lacking.

Much nest construction probably occurred after dark. On three occasions, burrows checked early in the morning had parts of cow or horse dung in the tunnel or on the burrow mound where none were seen the previous evening. April was definitely the peak time of nest construction, but two to three weeks variation among nesting peaks in different dog towns was obvious. One nest, possibly a renesting attempt, was not built until the first week of June. James Lewis (personal communication) noted the apparent beginning of nest construction, a chow chip being crumbled to line a burrow, on 7 March 1971, in Jackson County, Oklahoma.



Males apparently attempted to maintain a supply of cow or horse dung around the mouth of nest burrows. They occasionally carried pieces of dried dung to their nest burrows and placed them on the burrow mounds as late as three to five weeks after nest construction was apparently complete. This accumulation of dry manure maintained at burrow entrances may have helped prevent some water runoff into nests (Bailey and Niedrach 1965).

Males in California also carried more nesting materials than the females (Thomsen 1971). Owls there first gathered material, mostly golf divots and grass, during the first two weeks of April (Thomsen 1971). This activity dwindled in May, and ceased two to three weeks before the owlets emerged from burrows (Thomsen 1971). In New Mexico two to seven days were required for nest preparation, and owls first piled cow chips outside their burrows before taking them inside (Best 1969).

The relationship between early nesting activities such as inspecting and cleaning out burrows, and actual construction of nests, was unclear. A pair of owls that had previously relayed debris from a burrow did not commence construction of a nest until nearly three weeks later. Then they built their nest in a burrow about 15 yards from the one where they were first observed.

Also of interest were the observations that several burrows where owls first accumulated nesting material were abandoned two to three weeks after gathering of material ceased. Possible explanations included eviction by prairie dogs, unsuccessful efforts of unpaired males to attract a mate, or construction of a nest before pair bonds were completely formed. Very limited field data, discussed earlier, supported eviction by prairie dogs. In California, owls occasionally moved and

established nests in different burrows than those they first brought nesting materials to, but reasons for this behavior were not clear (Thomsen 1971).

#### Incubation and Care of Young

Males were nearly always visible during the incubation period and apparently did not participate in incubation, at least during daylight hours. A nesting female captured on 25 May had a large incubation patch. Her mate, captured five days later, had no trace of a brood patch. Another female captured 17 May also exhibited a large brood patch. The patch in both females extended from the base of the throat to the vent, was about four inches long and two inches wide, completely bare of feathers, and appeared to be highly vascularized.

Although Bendire (1892) stated that male burrowing owls assist females with incubation, others did not find evidence that supported his contention (Howell 1964, Thomsen 1971, Walker 1952). Coulombe (1971) occasionally observed males entering nests during the day for short intervals during the breeding season, but he did not speculate whether or not they incubated during these periods.

Burrowing owls, like other owls (Lack 1968), commenced incubation soon after laying the first eggs. Two active nests excavated on 29 May 1970, and 17 May 1971, contained clutches of eight and nine eggs, respectively. The oldest egg of each clutch contained an embryo over half developed and the other eggs contained successively younger embryos down to one in each clutch that had apparently been incubated for only one to three days. In addition, the female captured at the second nest had a well-developed incubation patch even though the youngest egg was

quite fresh. The other female escaped capture. Bailey and Niedrach (1965) and Thomsen (1971) observed considerable variation in the size of owlets within broods, especially noticeable when they first emerged from their burrows, and attributed the variation to initiation of incubation before completion of the clutch.

Exact hatching dates could not be determined because the owlets did not come above ground for several days. This brooding period was apparently 10 days or more. One owlet, evidently four to six days old, was seen above ground on 2 June 1971. However, in all other cases owlets were at least 10 days old when first observed outside their burrows. In 1970, the first owlets were observed on 16 June. The 1971 hatching dates were 7 to 10 days earlier than the 1970 date.

Interesting observations were made of care of owlets at a nest where the female died in a trap on 17 June. Two days later the male was flushed from the burrow at 10:30 a.m. This indicated he was incubating eggs or brooding young, because males never stayed in the nest burrow under normal circumstances. On 25 June five owlets were seen above ground at this nest burrow. The youngest appeared to be about 10 days old. The adult male was frequently seen foraging for his brood, and at least four owlets survived through 1 August. This male thus brooded very young owlets, and provided and distributed food without help of a mate.

The age difference among brood mates may have precluded equal distribution of food among them. The older owlets of broods often ran or flew to meet an adult returning with food, while their younger brood mates waited on the burrow mound. However, the returning adult occasionally passed up the older offspring to feed younger, more sedentary.

owlets. Robertson (1929) did not note any difference in the number of prey items fed to older and to younger brood mates in his observations of parental feeding of an owl brood. Thomsen (1971) found that the heaviest siblings tended to be the survivors of a brood, although weight differences were sometimes only tenths of grams.

Owl families began utilizing other burrows, in addition to nest burrows, soon after owlets first appeared above ground. In several cases the oldest two to four owlets moved to a burrow 12 to 50 yards from the nest burrow where their younger brood mates remained. This arrangement may have allowed better distribution of food among young of unequal size. It may also have relieved crowded conditions within nest burrows. Either possibility could have increased survival rates for younger members of broods. Brood mates usually remained separated for less than one week; then the younger owlets joined their brood mates at a burrow in the vicinity of the nest.

Entire owl families continued to switch burrows, remaining at each for 5 to 15 days. The seldomed returned to the original nest burrow, but remained in the general vicinity. In one instance, however, an owl family moved from its hillside nest 175 yards to utilize burrows in a weedy draw near a wheat field where they obtained most of their food. This move occurred only nine days after the oldest owlets were first seen above ground at their nest. Prairie dogs occasionally utilized nest burrows, promptly cleaning out and renovating the burrows and mounds.

Reasons for the owls moving from one burrow to another were unknown. Perhaps they moved in response to a concentration of ectoparasites and ants at burrows. Numerous ants were observed at burrows used by owl.

families. The numerous prey remains and general filth probably attracted ants and ectoparasites. Other investigators have also noted that burrowing owl families used several burrows. Owl families utilized from 2 to 10 burrows in North Dakota (James and Seabloom 1968). A family of owlets barely capable of flight occupied two burrows in Colorado; four in the nest burrow and three in another burrow 50 yards away (Bailey and Niedrach 1965).

Young owls developed fairly rapidly and were capable of sustained flight at six weeks of age. At about seven weeks of age owlets began foraging at night in fields and roads as far away as 0.5 mile. Young owls gathered most or all of their own food by the time they were eight to nine weeks old.

Most owl families still remained together as a loosely knit group through August even though little interaction between parents and owlets was apparent. In California owlets began foraging independently at five to six weeks of age, and became completely independent of their parents in September, or at least at 12 weeks of age (Thomsen 1971).

### Nest Ecology

#### External Factors

The arrangement of nest burrows within dog towns varied. In certain dog towns most nests were located near the edges (Figure 8). Bendire (1892) also found most owl nests on the outskirts of dog towns. Advantages of this arrangement presumably included availability of fence posts for perching sites, nearby fields for foraging, and greater insect populations along the ecotone. Also, empty burrows were generally more numerous along the periphery of dog towns, especially in winter and

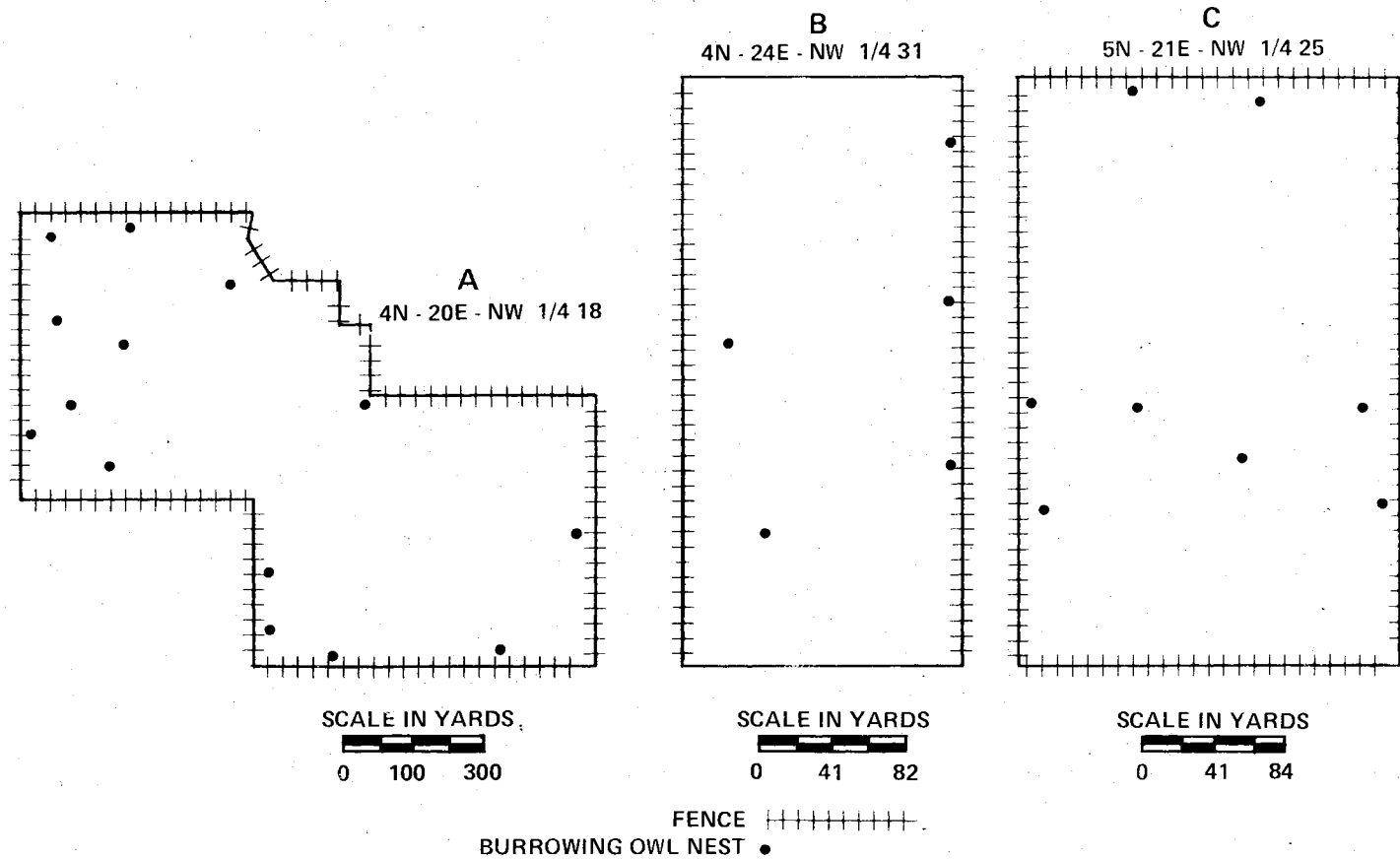


Figure 8. Preponderance of Burrowing Owl Nests Near Borders of Dog Towns, Oklahoma Panhandle, 1970

early spring (Koford 1958, Smith 1967). Edge (ecotone) may also have been important in nest burrows outside dog towns, because four of six solitary nests were within 75 yards of a fence and change in habitat.

In some dog towns nests appeared slightly clumped in distribution (A and C, Figure 8). Advantages of such a distribution were not apparent. Clumping may have reflected greater availability of vacant burrows in a particular area. Vacant burrows were often more prevalent in the area where a dog town first began (Koford 1958). Owl nests were randomly distributed in some dog towns, especially where nest density was high (Figure 9).

Topography around the nest burrow and orientation of the entrance were both highly varied. Nests were not found on steep slopes or vertical banks, but availability of burrow sites was limited in these areas. Nest burrows were oriented to virtually all points of the compass.

In southern California burrowing owls nested primarily along irrigation canal banks on moderate to steep slopes and oriented to various directions (Coulombe 1971). Owls on the Oakland Municipal Airport, California, nested on level terrain (Thomsen 1971). Burrows used by owls in southwestern North Dakota were on flat terrain or well-drained gentle slopes (James and Seabloom 1968).

Nest burrows were not found where vegetation height exceeded four inches. Only six of about 275 nests were outside grazed short grass or overgrazed mixed grasses. Five of the exceptions were in edges of fields, four in wheat and one in a fallow field, where prairie dogs kept the vegetation clipped short. One solitary nest was in a sand-sage pasture.

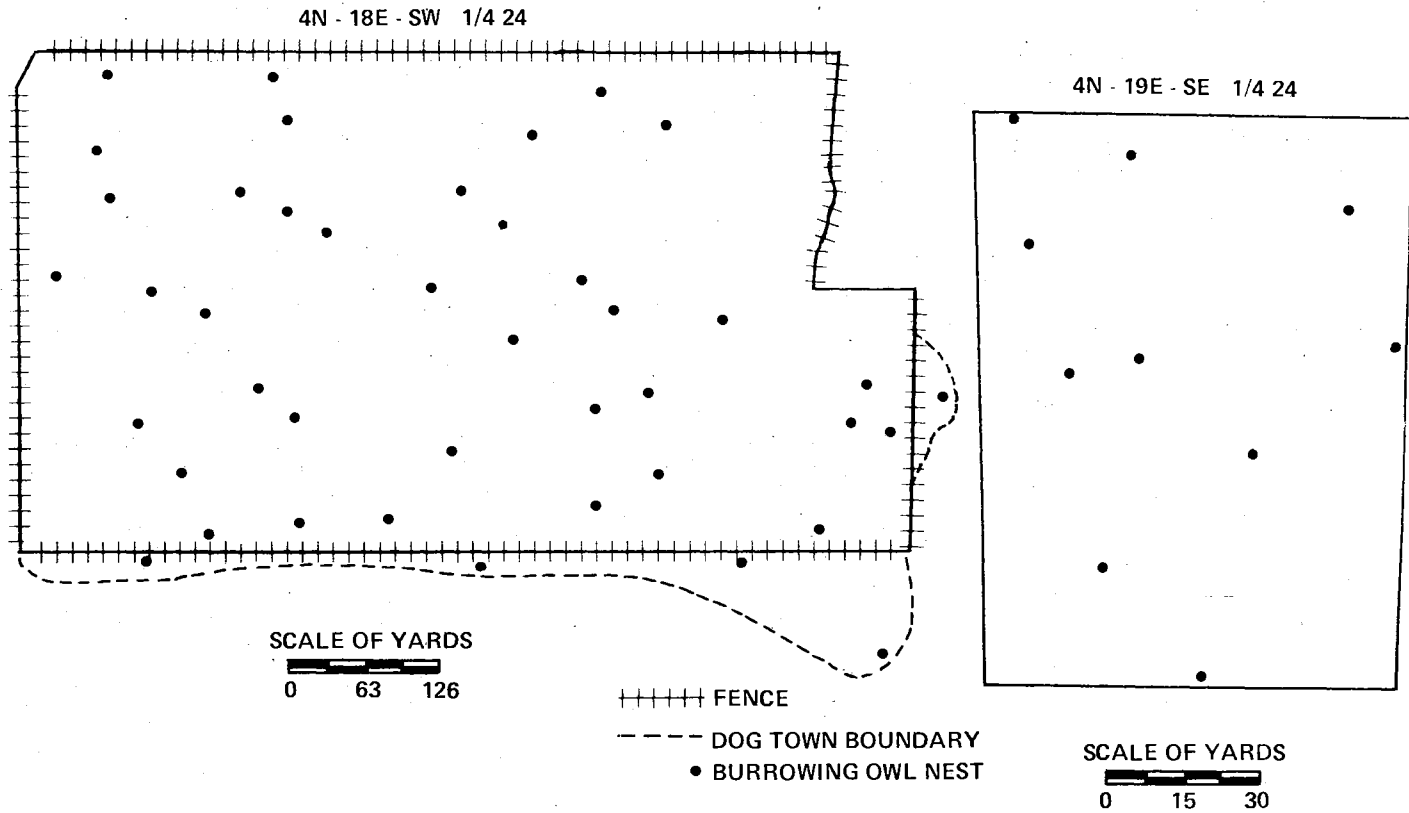


Figure 9. Random Distribution Pattern of Burrowing Owl Nests in Dog Towns, Oklahoma Panhandle, 1970



Other investigators have also reported an absence of burrowing owl nests in areas of dense and tall vegetation. The preferred nesting habitat in south-central New Mexico was short and sparse grassland with scattered soapweed plants used for perches (Best 1969). Vegetation in the vicinity of owl nests in southern California was sparse and dominated by forbs; telephone poles provided perches (Coulombe 1971). Owls on the Oakland Municipal Airport, California, nested in areas vegetated by annual grasses, mustard, and scattered coyote brush (Thomsen 1971). Owls in southwestern North Dakota utilized burrows in grazed mixed-grass pastures (James and Seabloom 1968).

Burrowing owls did not show a preference for any particular soil type when selecting prospective nest burrows. Nest burrows were found in hard clays, powdery-fine sand, gravelly soil, and various mixtures of these. Nest burrows at the Oakland Municipal Airport were in soil composed of former bay bottoms, sand, and mixed fill material (Thomsen 1971). Nest burrows in south-central New Mexico were generally in sandy soil (Best 1969).

#### Internal Characteristics of Nest Burrows

Examination of nest burrows in dog towns did not reveal any stereotyped preference for certain kinds of burrows except that nest burrows never had vertical entrances. This may have reflected availability rather than preference because Smith (1967) reported in Kansas that less than three percent of the prairie dog burrows had vertical entrances. Most of the excavated nest burrows contained tunnels with slopes of 15 to 25 degrees. One had a tunnel in which the slope occasionally became 40 to 50 degrees. Six burrows curved gently to the

right, one curved very slightly to the left, another turned to the right at a 115 to 120 degree angle, and one curved sharply to the right and downward in such a manner that the nest chamber was under, and less than one foot to the right of, the burrow mouth.

In all cases, tunnel size remained fairly constant, about five and one-half to six inches wide and four and one-half to five inches high, back to the nest chamber. Occasionally the mouth of the burrow was slightly larger than the tunnel. The nest chamber itself was roughly circular or oblong, about 10 inches wide and four to six inches high. The nest chambers could have been former "turn-around" places for retreating prairie dogs (Smith 1967). However, excavation of 19 burrows used by wintering owls revealed that only two contained enlarged chambers. Therefore, chambers may have been burrows modified by nesting owls. Owls definitely modified existing burrows of bannertail kangaroo rats to form large, circular domed nest chambers in New Mexico (Best 1969).

All but two burrows examined had a tunnel leading away from the nest chamber. Usually this tunnel was at least partially plugged, and in one burrow it was tightly plugged with dirt and nest lining. The floor of the nest chamber was always covered with soft, crumbled, cow or horse dung one to three inches deep (Figures 10 and 11). In most burrows a slight amount of dung was scattered along the tunnel, increasing in quantity about one foot from the chamber. The nest chambers averaged about 27 inches (15 to 42 inches) below the ground surface and 59 inches (42 to 84 inches) from the burrow entrance.

Two nest burrows located outside dog towns were excavated. Burrows were 65 to 85 inches in length, and tunnel dimensions were seven to

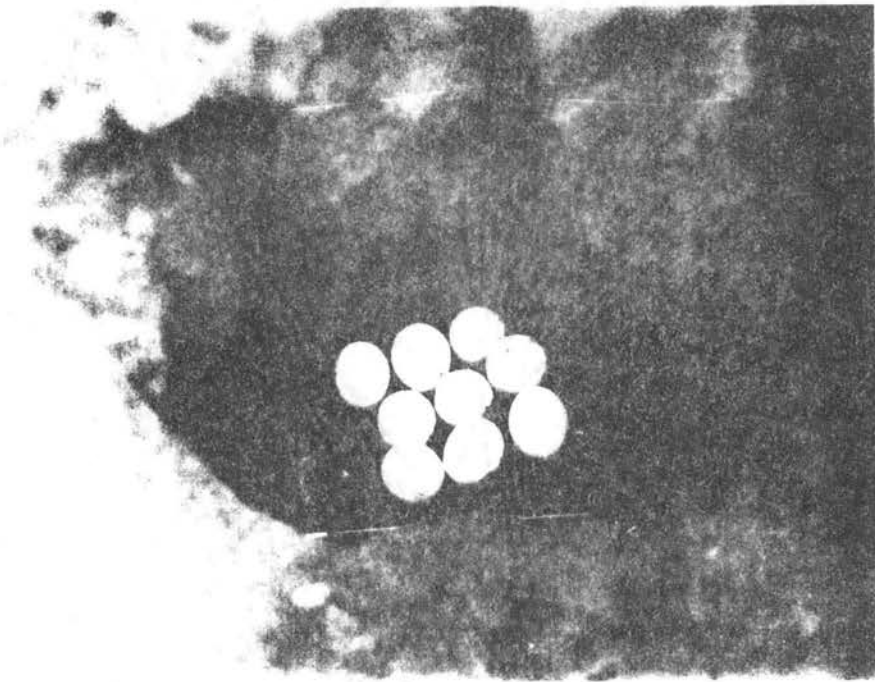


Figure 10. A Burrowing Owl Nest Excavated  
Showing the Nest Chamber, Eggs,  
and Nest Material, Oklahoma  
Panhandle, 1971

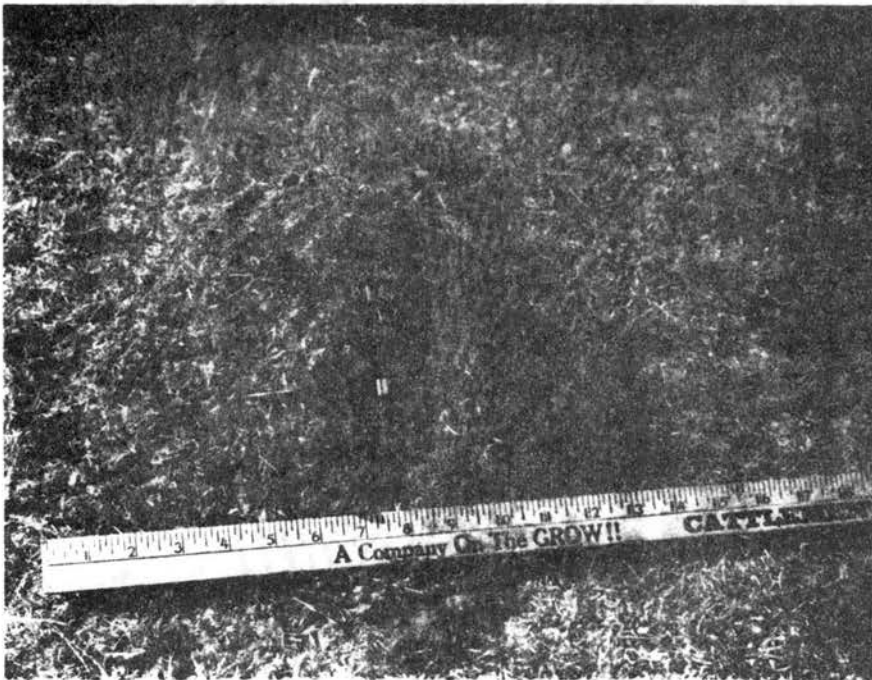


Figure 11. Nest Lining (Crumbled Cow and Horse Dung) From One Burrowing Owl Nest, Oklahoma Panhandle, 1971

eight and one-half inches wide and six to seven and one-half inches high. One burrow terminated in a circular nest chamber with dimensions similar to the chambers previously described. The other burrow was eight and one-half inches wide and seven and one-half inches tall at its terminus, but no chamber was evident. Both burrows curved slightly to the right, sloped very gently, and were 12 and 23 inches, respectively, from the ground surface at the end. Crumbled cow manure was near the ends of both burrows, but not in quantities as large as in nests excavated in dog towns.

The owl nest photographed by Walker (1952) was about 28 inches below ground and 47 inches from the burrow entrance. In describing his search for a nest burrow with a straight entrance, Walker (1952:79) said: "Most of the tunnels turned sideways. Some rose; a few dropped and doubled back in contortions that completely baffled my probing wire."

Bendire (1892), Bent (1938), and Canfield (1868) all gave descriptions of owl nest burrows and nesting materials very similar to those in Oklahoma. In southern California, owl burrows were variable, but most slanted downward at about a 15-degree angle and all had a turn within 39 inches of the mouth (Coulombe 1971).

Near Oakland, California, owls cleaned the nesting material from their burrow and its mouth shortly after the owlets hatched (Thomsen 1971). Nesting materials persisted on the outside and inside of nest burrows well into September at practically all nests that were not disturbed by prairie dogs. In March, 1971, one could still, by debris about the entrance, distinguish nests used in 1970.

### Production of Young

Among factors affecting total production of young burrowing owls were clutch size, brood size, nesting success, extent of re-nesting activity, and survival of fledglings. Clutch size was determined only twice because it required excavation of active nests. Clutches of eight and nine eggs were found. Clutch size has been given as 6 to 11 (Bailey 1961, Bent 1938), 8 to 10 (Brenckle 1936, Canfield 1868), 5 to 9 (Brandt 1951), and 7 to 11 (Roberts 1936).

The average brood size, counted immediately after initial emergence of owlets from nest burrows, gave a rough idea of fecundity. However, this did not take into account unhatched eggs and nestling mortality. Bendire (1892) indicated that brood size and clutch size were similar, because he rarely found an "addled" egg. Average brood size was 4.7 (two to nine) in this study's sample of 61 broods. In southern California the average brood size was three to six (Coulombe 1971).

Fifty-five of 69 nests (80 percent) in Oklahoma produced at least one fledgling. Some causes of nest failure were: (a) flash flooding--four nests, (b) shooting the adult female--two nests, (c) destruction of burrow by farming operations--two nests, and (d) fumigation and subsequent sealing of burrow--one nest. Other possible causes of nest failure were pesticide-induced reduction in nesting success and predation on nesting adults or eggs by snakes, badgers, skunks, or prairie dogs.

Nest success in California was 89 percent one year and 33 percent the following year (Hennings 1970). Nest success was higher for owl pairs older than one year and especially in pairs that had hatched young the previous year (Thomsen 1971). Pairs tended to be more unstable and

less productive when at least one member was a yearling (Thomsen 1971). Large snakes, striped skunks, feral house cats, and badgers were all probably predators of burrowing owl eggs and nestlings in California (Coulombe 1971).

Burrowing owls raise only one brood per season, but will renest, with a small clutch, if their first clutch is destroyed (Bendire 1892). Thomsen (1971) recorded two possible cases of owls renesting after loss of eggs or nestlings.

Four renesting attempts were observed in 1970. One was successful, and produced two young. The burrow of a banded pair of owls was excavated on 17 May 1971, and nine eggs found. Construction of a new nest 10 yards from the first commenced within 10 days. Three owlets were subsequently produced there. Renesting attempts may have occurred quite late in the season, because copulation occurred on 22 June 1970. One nest was not constructed until the first week of June, 1971, one month later than most nests.

Thirty-five of 39 (89 percent) owlets observed survived from fledgling stage through six to eight weeks of age. Survival of owlets in California from fledgling stage through about 12 weeks of age (August) was 88 percent one year and 96 percent the following year (Hennings 1970).

The number of young owlets surviving through July (six to eight weeks of age), in the 1970 nesting season, were calculated. Eight percent of the adult owls may have been nonbreeders. Thus the breeding population contained approximately 250 pairs in 1970. Calculations were made as follows: (a) 250 nesting attempts x 79 percent success = 198 successful nests, (b) 198 successful nests x 4.7 owlets per brood = 931

owlets fledged, and (c) 931 fledglings x 89 percent survival = 829 owlets produced, or 3.3 owlets per breeding pair of owlets.

The above approximations were subject to error, the most serious limitation being the small sample used to estimate survival rate. Nevertheless, burrowing owls in the study area were obviously quite productive.

Calculations from data given by Hennings (1970) indicated that 3.2 owlets per breeding pair survived through August in 1965, and 1.5 per breeding pair in 1966. Her data were based on only 9 and 15 pairs, respectively.

#### Mortality and Survival

Exact annual survival data were extremely difficult to obtain, due to the scarcity of 1970-marked owls observed in 1971. The June, 1971, census of 17 dog towns that contained over 70 percent of the adult owl population in June, 1970, revealed only a 3 percent decrease from 1970 (Table I). A census was not conducted to determine the owl population living at least one mile from dog towns in 1971.

Annual mortality was calculated from the data, making the following assumptions: (a) all adults censused in June, 1970, survived through July, 1970, thus making 1,372 the total owl population on 1 August 1970, (b) the owl population outside dog towns in June, 1971, decreased 3 percent from the 1970 level as it did in dog towns, thus making 527 the total adult owl population in June, 1970, and (c) differences between owl populations of 1 August 1970, and June, 1971, (845 less) were due entirely to mortality. Total mortality from 1 August 1970, to June, 1971, was 62 percent ( $845/1,372$ ) if these assumptions were valid.



The breeding owl population of one area in southern California remained the same for two years (Coulombe 1971). In another study in California survival from September, 1965, to April, 1966, was 30 percent for juvenile owls; 81 percent for adults; and 65 percent for the total population (Thomsen 1971). Data indicated an annual mortality rate of about 20 percent for owls over one year old (Thomsen 1971).

#### Mortality Factors

Death of one fledgling was noted 24 June 1971, about 90 miles west of the study area. As a nest burrow was approached, one of two fledgling owls seen in the burrow entrance ran down the burrow. The other remained standing in the same position, with eyes closed, giving no sign that it was aware of the intrusion. Closer examination revealed that a third owlet was lying dead, about 18 inches from the burrow mouth.

The owlet had been dead only a few hours, and most of the skin and muscle had been picked from the back of its head and neck. No internal abnormalities were evident except a BB-size hole and associated tissue discoloration in the pelvic region. It had probably been shot with an air (BB) gun, a possibility strengthened by fresh tracks of boy-size tennis shoes near the nest burrow.

The lethargic owlet had owl feathers on its beak, indicating it had engaged in cannibalism, probably along with its nest mate(s). Cannibalistic nest mates may have killed the owlet after it was wounded by the air rifle.

The lethargic owlet was kept under observation. Even after being fed, it remained weak and uncoordinated. Twelve hours later its

condition improved, and it was fed about 10 small June beetles. Twenty-four hours after capture the owlet's condition deteriorated, and it was unable to stand, snapped at any sudden movement, and drooped its head. It was again fed about 10 live June beetles. Sometime during the next six hours it died. An autopsy revealed no clues to the cause of death.

Other likely causes of fledgling mortality included: (a) predation by mammals, large raptors, and snakes, (b) starvation, due to loss of parent(s), or to inability of parents to supply food for a large brood, (c) cannibalism among nest mates, and (d) diseases, poisoning, and heavy parasite loads. Results of a small-scale supplemental feeding experiment in California suggested that food may have been a limiting factor to fledgling survival (Thomsen 1971). Coulombe (1971) saw a badger in the process of digging out a burrow containing six fledglings, and he considered large snakes to be potential predators of owlets in southern California (Coulombe 1971).

Two types of mortality were observed after owls were about seven weeks old. The cause of death was ascertained in 15 cases, shooting accounted for 10. Adults were the most frequent victims; the sex of most victims was unknown. The other mortality factor was roadway fatalities. One was an adult female, and the others were young owls of unknown sex killed in August when roads were popular foraging areas.

The importance of other mortality factors was largely conjectural. Starvation of owls in winter was rare, judging from external examination of sterna and from weights of three owls captured in winter. There was no evidence that parasites or disease were serious mortality factors.

Burrowing owls may have died from secondary (indirect) and direct poisoning when poison grain was distributed to kill prairie dogs. Owls could have directly ingested poison grain while ground foraging for insects in areas where the grain littered the ground surface. Possibly the grain stuck to the owl's feet and was inadvertently ingested along with insects captured by the owls. Several owl pellets having a few seeds or grain also contained insect remains. Owls could also have captured and eaten heteromyid rodents whose cheek pouches were stuffed with poison grain. Two pellets containing numerous weed seeds also contained skull parts of pocket mice.

Mortality was not observed that could definitely be attributed to poison grain. However, the Canyon dog town (Table I) that had an abundance of 1080 (sodium fluoroacetate) grain on the ground surface when owls returned in March, 1971, exhibited a 71 percent greater reduction in the breeding population in 1971 than in 1970. The owl population in 1971 gradually declined from 11 owls in early April to two pairs that apparently constructed nests in early May. In late May both nests were vacant and all owls gone from the dog town, and owls were not seen there for the remainder of the summer. No evidence was found of predation on owls or their nests.

Other than presence of poison grain, no explanation could be offered for this decline in the owl population of the Canyon dog town. Prairie dog towns did not disappear from the dog town, but were somewhat reduced in number. Numbers of small mammals were not particularly low, as shown by results of rodent trapping in late April. This dog town was the only one studied where associated owl populations decreased from April through June, 1971.

Koford (1958) stated that eradication of dog towns by poisoning may directly reduce owl populations by killing the owls, but he did not elaborate on how this occurs. Another recent study (Cain 1972) described deleterious effects on raptors caused by various rodenticides commonly used to treat prairie dog towns.

### Wintering Status

#### Winter Population Size

The owl population wintering in dog towns of the study area in 1970-71 apparently consisted of six owls. This was only 0.44 percent of the owl population living in the same dog towns in late July, 1970. Some difficulty was encountered conducting a census of owls because they exhibited little diurnal activity in winter. Nevertheless, results of the winter census were fairly accurate because: (1) weather conditions were favorable during most of the census, (2) hundreds of hours of observations were made, especially at dog towns showing sign of wintering owls, and (3) approximately 75 percent of the burrows exhibiting signs of use by owls were excavated. Owls or owl sign were not found in the vicinity of six nest burrows located outside dog towns in 1970.

A few owls wintering in the study area may have been paired. In California one member of a pair was usually below ground during the day in winter, while the other remained near the burrow entrance (Coulombe 1971). An owl was seen in the Dondelinger dog town 5 February. A burrow was excavated there 5 March and a female owl captured. The mouth of a burrow about 75 yards from the one excavated also contained fresh owl sign on 5 March but it was not excavated because only one owl was seen on each of two previous visits to the dog town. In this dog town on

10 March another burrow was excavated in order to capture a pair that had retreated into the burrow after they were sighted together in the burrow mouth. The female was the owl banded and released on 5 March. The male was banded and both owls released. They remained together and raised a brood the following summer.

In most dog towns all burrows exhibiting recent owl sign were excavated in quick succession. Consequently, uncounted members of owl pairs did not appear to be present.

#### Characteristics of Winter Burrows

In winter, owls utilized burrows that were variable in structure (Table III). The ends of burrows were from 9 to 52 inches below the ground surface, 14 of 19 were three feet or less in depth. Ten of the burrow tunnels were less than seven feet in length, but the longest continued an unknown distance past 15 feet. Only two had enlarged chambers at the end. Only four tunnels contained turns sharper than 90 degrees. One of these curved down and to the left so sharply that it passed directly beneath the entrance. One tunnel terminated by branching into two one-foot tunnels. One of the burrows, Dondelinger (a), contained a nest in 1970 (Table III).

Active prairie dog burrows were not excavated to determine if burrows used by owls, either for nesting or winter shelter, were typical prairie dog burrows. Most burrows excavated were shallower and less extensive than those usually credited to prairie dogs (Henderson et al. 1969, Sheets and Linder 1969, Wilcomb 1954). Smith (1967), however, indicated that prairie dog burrows varied widely, depending on soil types, moisture, and other factors.

TABLE III

MEASUREMENTS (INCHES) AND OTHER FEATURES OF BURROWS USED BY WINTERING BURROWING OWLS, OKLAHOMA PANHANDLE, FEBRUARY AND MARCH, 1971

Deg Town		Tunnel Dimensions						
		Length	Maximum Depth	At Mouth		At X Inches From Mouth		
Owner	Burrow			Width	Height	X	Width	Height
Ross	(a)	180+	43	5.0	4.5	48	4.5	4.5
Ross	(b)	130	52	5.0	5.5	124	4.5	4.5
Pope	(a)	33	16	7.0	8.0	33	7.0	9.0
Pope	(b)	55	16	6.0	5.5	24	6.5	5.0
Pope	(c)	49	10	6.0	4.0	27	7.5	9.0
Olenberger	(a)	38	12	5.5	4.5	30	6.0	5.0
Olenberger	(b)	45	9	5.0	4.5	45	8.0	7.0
Olenberger	(c)	66	23	5.0	4.0	66	6.0	7.5
Olenberger	(d)	32	14	5.0	5.0	32	4.0	6.5
McGrew	(a)	60	31	5.0	4.5	42	4.5	4.5
McGrew	(b)	60+	32	5.0	4.5	60	5.0	4.0
McGrew	(c)	90	23	4.5	5.0	84	4.0	5.0
McGrew	(d)	96	40	5.0	5.0	80	4.0	5.0

TABLE III (Continued)

Dog Town		Tunnel Dimensions						
		Length	Maximum Depth	At Mouth		At X Inches From Mouth		
Owner	Burrow			Width	Height	X	Width	Height
McGrew	(e)	60	28	4.5	4.5	48	4.5	4.5
McGrew	(f)	90	50	5.5	6.0	85	4.5	4.0
Dondelinger	(a)	80	39	5.5	4.5	60	4.5	3.5
Dondelinger	(b)	108	36	5.0	5.0	54	5.0	6.0
Kirkhart	(a)	96	29	5.5	5.0	84	5.0	5.5
Kirkhart	(b)	120+	36	5.5	5.0	72	5.0	5.0

Signs of occupancy by owls (pellets, droppings, prey remains) were found in 17 of the 19 excavated burrows. This material was in the first four feet of the tunnels, with most concentrated in the first 30 inches.

In Oklahoma, where the frost line rarely extends very deep, temperatures in prairie dog burrows at least five feet from the burrow mouth and under the frost line probably seldom go below 40 F. Wilcomb (1954) recorded the following temperatures in an Oklahoma dog town in January and February: six feet above ground--15 to 55 F; soil surface--24 to 66 F; and in burrows at depths of 42 to 66 inches--40 to 51 F. Temperatures were measured in seven owl burrows during March, when air temperatures four feet above ground were in the mid 40's (F), and an increase of two to four degrees existed at 55 inches or more inside the burrows.

#### Food Storage and Consumption Within Burrows

Agersberg (1885) found large caches, one consisting of 43 dead mice and several "shore" larks, in burrows occupied by burrowing owls in winter in southeastern South Dakota. Ligon (1961) also stated that burrowing owls cache food in winter, but did not clarify whether he based his conclusion on original data or on Agersberg's (1885) report.

No evidence was found that owls hoarded large amounts of food in caches in Oklahoma during winter. In three instances, however, dead rodents were found in the first 18 to 24 inches of burrows used by wintering owls. A plains harvest mouse was found at 9:30 a.m. on 20 February in a burrow from which an owl flushed. The owl had apparently killed the mouse during the previous night. Another plains harvest mouse was found on 4 March, when an owl was flushed from a burrow at



6:00 p.m. This mouse was cold but undeteriorated. The owl had apparently just begun eating it and only the posterior one-half remained. These two burrows were excavated, one the same day and the other four days later. Neither contained other food items. A large hispid cotton rat was found at 4:30 p.m. on 19 March, in a burrow from which an owl was flushed. The rat was cold, undeteriorated, and its head had recently been eaten.

Rodent remains found in burrows represented food items captured recently by owls and apparently were not part of a larger cache. The presence of bird remains, blood, and insect fragments in winter burrows was additional evidence that owls sometimes consumed prey in the shelter of a burrow.

#### Hibernation, Torpor, or Simple Fasting

It was not determined conclusively whether burrowing owls overwintering in the study area hibernated or entered a torpid state during adverse weather or periods of food shortage. An owl excavated from a burrow on 20 February 1971, was apparently inactive. Its posterior one-half was uncovered first, 50 inches back in the burrow. The owl showed no apparent reaction to the sudden influx of light, the cold wind (28 F, wind 15 miles per hour), or initial attempts to remove it from the burrow. In addition, the blunt probing wire accidentally jabbed it before excavation began. The owl did not move until more of the burrow was uncovered, and further attempts made to remove it. It then tried to move beyond reach in the tunnel. This apparent inactive state was especially interesting because a blizzard struck the area that evening, and deposited snow drifts 10 to 20 feet high.

An owl found on 5 March was apparently more active. Excavation of the burrow began at 9:00 a.m., when two fresh (still soft) owl droppings were found on the mound. The owl was unintentionally poked with a blunt probing wire as well as with a yardstick in an attempt to determine how much further the burrow extended. It had considerable opportunity to arouse from any inactive state because excavating was interrupted for 45 minutes while only 20 inches of the tunnel remained covered. However, the fresh droppings on the burrow mound indicated that the owl had been active earlier in the morning.

An owl found at the end of a burrow in the Oklahoma Panhandle on 11 January 1972, was definitely not inactive, and was recovered in two to three minutes of digging (James C. Lewis, personal communication). The maximum temperature that afternoon was 51 F.

Wintering owls may have been capable of fasting for several days. Heavy snow and ice cover during a blizzard in February, 1971, made it unlikely that owls could have escaped their burrows for at least three days. Yet, the owl burrow excavated only hours before onset of the blizzard did not contain any food cache.

Literature sources do not describe any state of torpor or hibernation for burrowing owls, although both Agersborg (1885) and Ligon (1961) indicated that owls remained underground for several days during winter. Ligon (1969) failed to induce torpor in whiskered, elf, or screech owls when he deprived them of food for three to four days with ambient temperatures of 44 to 59 F. The owls did not exhibit physiological manifestations of torpor, but remained healthy in spite of 16 to 24 percent losses in body weight (Ligon 1969).

## Migration

Field observations indicated that most burrowing owls in the study area were migratory. The owl population increased from six on 3 March, to an estimated 527 during early June, 1971. Changes in owl populations of 11 dog towns between 8 March and 29 March are shown in Table IV.

This tremendous increase in numbers of owls seen locally, during March and early April, probably indicated the return of owls that wintered elsewhere, presumably in more southern areas. The sporadic nature of increases in owl numbers in various dog towns, some still without owls on 26 March, also probably indicated migratory movements. If all owls present in spring had overwintered, they presumably would have become active at approximately the same time and many would have been seen during winter.

Excavation of approximately 75 percent of the burrows showing evidence of use by wintering owls yielded only three owls. Mild weather conditions during much of the winter census, as discussed previously, increased the likelihood that other owls would have been seen if they had overwintered. Both Ligon (1961) and Ross and Smith (1970) found more owls above ground as the temperature increased.

The most tangible proof of migration came after the study had terminated. A female owl, banded as a nesting adult on 26 June 1970, was shot by a hunter near Zapotlanejo, Jalisco, Mexico, 1 November 1971.

Results of the winter banding indicated the small population of owls were permanent residents and not migrants from more northern areas. All three banded owls that definitely overwintered also remained to breed and nest in the same dog town where they were banded. Two other

TABLE IV

APPARENT CHANGES IN BURROWING OWL NUMBERS IN 11 DOG TOWNS,  
OKLAHOMA PANHANDLE, MARCH, 1971

Dog Town	Wintering Owls	Number of Owls Seen on Dates in March											
		8	9	10	11	12	15	16	23	24	25	26	29
McGrew	1		0		2		3	5		4		7	12
Ross	1	1	1		4	5	5		8				15
Dondelinger	1			2			2			2			
Olenberger	1		0		5			5					
Delk	1		1	2	6			10					
Kirkhart	1						8			5			
Chance	0	0				0					20+		
Anderson	0	0				1			5			6	
Randles	0	1				0			5				
Wilson	0				0							0	
"Canyon"	0				1			0					3
Totals	6	2	2	4	18	6	18	20	18	11	20+	13	30

owls captured on 10 March 1971, that may have overwintered in the study area, also remained to nest near the site of their capture.

Probably only a few burrowing owls are permanent residents in Oklahoma; most migrate (Tyler 1968). Limited field observations in Jackson County, southwestern Oklahoma, indicated a severe reduction of owl numbers during winter and a population increase during March (James C. Lewis, personal communication). One or possibly two owls stayed on the Washita National Wildlife Refuge in western Oklahoma during the first two to three weeks of March. These were apparently migrating because owls did not winter in the area and were not seen after late March (Robert Stratton, personal communication).

Drs. G. M. Sutton (personal communication) and J. D. Tyler (personal communication) reported occasional winter sightings of burrowing owls in Oklahoma. Most sightings were of only one or two owls including several records in mid-December but none in January or February in the Panhandle. Wildlife biologist Joe Ellis (personal communication), while trapping skunks and rabbits, occasionally found owls inside prairie dog burrows during winter in the 1940's in north-central Oklahoma.

Data from an area in the Texas Panhandle 150 to 175 miles south of the study area, indicated that part of the breeding population of burrowing owls overwintered and some migrated (Ross and Smith 1970). In February, Ross and Smith (1970) recaptured an owl banded at the same site the previous August. However, recapture of another owl near El Paso (over 300 miles to the southwest) 363 days after its banding in March in the Texas Panhandle apparently indicated migration (Ross and Smith 1970). Presumably this owl was recaptured on its wintering ground.

shortly before it migrated northward, or was enroute to the Texas Panhandle after wintering in another area.

Burrowing owls were probably permanent residents in northeastern New Mexico, remaining in burrows during adverse winter weather (Ligon 1961). On 30 January at a dog town about 200 miles southwest of the Oklahoma study area, Ligon (1961) did not see any owls, but excavated a burrow and found an owl there. He saw about 40 owls "a little later" in that dog town when weather was milder (Ligon 1961). Owls were present in south-central New Mexico throughout the winter (Best 1969). However, they moved around and Best was unable to determine if migration actually occurred.

Burrowing owls were summer residents of Colorado, migrating in mid October and returning in April (Bailey and Niedrach 1965). However, a few owls occasionally lingered through the winter (Bailey and Niedrach 1965).

Burrowing owls nesting in the Dakotas may have included both permanent residents and owls that migrated. Eleven owls banded in the Dakotas in June or July, 1931 through 1936, were recovered in central Texas and adjacent parts of Oklahoma and Arkansas between 15 October and 3 April (Brenckle 1936, Cooke 1941). Three owls banded in the summer in Manitoba and the Dakotas were recovered in Nebraska and Kansas in late September and early October, presumably enroute to wintering grounds further south (Brenckle 1936, Cooke 1941). Agersborg (1885), however, found as many as 20 owls in one burrow during winter in southeastern South Dakota. He believed these owls were permanent residents, foraging when weather conditions were favorable and retreating into burrows stocked with food during severe weather (Agersborg 1885).

The migratory status of burrowing owls in California was not clear. Owls in the Oakland area did not migrate (Brenckle 1936). In the same area Thomsen (1971) noted in winter that some birds disappeared from view for a few days to a few weeks, but she did not determine if they migrated, withdrew into burrows, became strictly nocturnal, or moved to nearby areas. In the Imperial Valley, 75 to 80 percent of the breeding population migrated in winter (Coulombe 1971). A part of the wintering population there consisted of immigrants, because only one of seven owls banded during winter remained to nest the following season (Coulombe 1971).

Miscellaneous literature sources concerning migration of burrowing owls included Stefferud's (1966) account of an owl moving from Utah to Baja California. He did not give details such as circumstances or dates of movement.

#### Food Habits

Arthropod remains occurred in 90 percent of the owl pellets in spring and, on the average, constituted nearly 60 percent of each pellet (Table V). Ground beetles and June beetles were definitely the most important groups. Field crickets were also a staple dietary item. Owls ate Jerusalem crickets, dung beetles, and grasshoppers regularly but in relatively small quantities.

Mammals were the primary vertebrate prey of owls during spring (Table V). Their remains occurred in over one-half of the pellets and constituted 38 percent of an average pellet. Harvest mice were the most numerous, followed by deermice and unidentified cricetid rodents.

TABLE V

FOOD HABITS OF BURROWING OWLS IN SPRING, BASED ON ANALYSIS OF 452 PELLETS,  
OKLAHOMA PANHANDLE, MARCH 16 - JUNE 15, 1970, 1971

Food Items	Percent of				Volume <sup>1</sup>
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	
<u>Mammals:</u> <sup>2</sup>	4.8		100.0	57.3	38.4
Harvest mice (plains and western)	1.3		26.7	7.9	
Deer mice	0.9		18.6	5.9	
Unidentified cricetids	0.9		19.3	5.9	
Pocket mice (plains and silky)	0.5		11.0	3.5	
Kangaroo rat	0.4		8.2	2.4	
Hispid cotton rat	0.3		6.8	2.2	
Ground squirrel	0.1		2.1	0.6	
Mexican pocket gopher	tr. <sup>3</sup>		0.6	0.2	
Least shrew	tr.		0.6	0.2	
<u>Birds:</u> <sup>2</sup>				1.5	0.7
<u>Reptiles and amphibians:</u> <sup>2</sup>				0.6	0.2
<u>Total Vertebrates:</u> <sup>2</sup>	4.8		100.0	59.5	39.3



TABLE V (Continued)

Food Items	Percent of			
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence
<u>Arthropods:</u> <sup>2</sup>	95.1	100.0		90.0
Miscellaneous ground beetles	26.8	28.2		40.0
June beetles	21.3	22.3		39.1
Field crickets	14.5	15.2		18.1
Jerusalem crickets	9.4	9.8		22.7
Dung beetles	5.3	5.6		18.1
Grasshoppers	3.2	3.4		13.7
Caterpillar hunters	3.4	3.6		9.0
Darkling beetles	0.9	0.9		5.0
Unidentified beetles	0.7	0.7		4.2
Snout beetles	2.5	2.6		2.6
Ants	6.4	6.7		1.7
Crayfish	0.2	0.2		1.1
Leaf beetles	0.1	0.1		0.6

TABLE V (Continued)

Food Items	Percent of				
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	Volume <sup>1</sup>
Cicadas	0.1	0.1		0.4	
<u>Vegetation</u>				11.0	0.4
<u>Dirt and Gravel</u>				8.6	0.7

<sup>1</sup>Average percent per pellet.

<sup>2</sup>Includes material not identified to genus or family.

<sup>3</sup>"tr." denotes trace (less than 0.1 percent).

Remains of birds, reptiles, and amphibians were comparatively rare in owl pellets deposited during spring (Table V).

All owl pellets deposited in summer contained remains of arthropods. On the average 96 percent of each pellet consisted of arthropod materials (Table VI). Grasshoppers were overwhelmingly the leading prey item, followed by field crickets and miscellaneous ground beetles. Remains of June beetles, Jerusalem crickets, and dung beetles occurred regularly in pellets in summer, but generally in small numbers.

Mammals were the only vertebrates represented in owl pellets during summer. Mammalian remains occurred in less than 10 percent of the pellets and constituted less than four percent of an average pellet (Table VI). Remains of harvest mice, hispid pocket mice, and unidentified cricetid rodents occurred with equal frequency and in equal numbers followed by equal numbers and frequency of deermice, plains and silky pocket mice, and kangaroo rats.

Arthropod remains occurred in over 85 percent of owl pellets deposited in fall, and constituted 66 percent of an average pellet (Table VII). Grasshoppers predominated and miscellaneous ground beetles were second in abundance. Remains of field crickets appeared regularly in small amounts.

Mammals were the only vertebrates found in pellets deposited during fall. Their remains were in 44 percent and comprised 33 percent of an average pellet (Table VII). Harvest mice were predominant, followed by equal numbers and frequency of deermice, kangaroo rats, hispid pocket mice, and unidentified cricetid rodents.

Arthropods constituted 15 percent of the average pellet during winter and occurred in less than 36 percent of these pellets

TABLE VI

FOOD HABITS OF BURROWING OWLS IN SUMMER, BASED ON ANALYSIS OF 134 PELLETS,  
OKLAHOMA PANHANDLE, JUNE 16 - SEPTEMBER 15, 1970

Food Items	Percent of				
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	Volume <sup>1</sup>
<u>Mammals:</u> <sup>2</sup>	0.6		100.0	9.7	3.7
Harvest mice (plains and western)	0.1		18.2	1.5	
Hispid cotton rat	0.1		18.2	1.5	
Hispid pocket mouse	0.1		18.2	1.5	
Unidentified cricetids	0.1		18.2	1.5	
Deer mice	tr. <sup>3</sup>		9.0	0.7	
Pocket mice (plains and silky)	tr.		9.0	0.7	
Kangaroo rat	tr.		9.0	0.7	
<u>Total vertebrates:</u> <sup>2</sup>	0.6		100.0	9.7	3.7
<u>Arthropods:</u> <sup>2</sup>	99.4	100.0		100.0	96.3
Grasshoppers	47.8	48.1		81.3	
Miscellaneous ground beetles	18.7	18.8		55.2	
Field crickets	17.6	17.7		42.5	

TABLE VI (Continued)

Food Items	Percent of				Volume <sup>1</sup>
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	
Jerusalem crickets	4.5	4.5		26.1	
June beetles	3.6	3.6		22.3	
Dung beetles	4.0	4.0		19.4	
Caterpillar hunters	1.0	1.0		10.4	
Unidentified beetles	0.3	0.3		2.9	
Crayfish	0.3	0.3		2.9	
Ants	1.3	1.3		0.7	

<sup>1</sup>Average percent per pellet.

<sup>2</sup>Includes material not identified to genus or family.

<sup>3</sup>"tr." denotes trace (less than 0.1 percent).

TABLE VII

FOOD HABITS OF BURROWING OWLS IN FALL, BASED ON ANALYSIS OF 55 PELLETS,  
OKLAHOMA PANHANDLE, SEPTEMBER 16 - DECEMBER 15, 1970

Food Items	Percent of				
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	Volume <sup>1</sup>
<u>Mammals:</u> <sup>2</sup>	3.8		100.0	43.6	33.4
Harvest mice (plains and western)	1.8		47.3	10.9	
Deer mice	0.4		10.5	3.6	
Unidentified cricetids	0.4		10.5	3.6	
Hispid pocket mouse	0.4		10.5	3.6	
Kangaroo rat	0.4		10.5	3.6	
Hispid cotton rat	0.3		5.2	1.8	
<u>Total vertebrates:</u> <sup>2</sup>	3.8		100.0	43.6	33.4
<u>Arthropods:</u> <sup>2</sup>	96.2	100.0		85.4	65.9
Grasshoppers	68.3	71.0		76.3	
Miscellaneous ground beetles	19.1	19.9		40.0	
Field crickets	4.2	4.4		18.1	
Unidentified beetles	1.2	1.2		10.9	

TABLE VII (Continued)

Food Items	Percent of				
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	Volume <sup>1</sup>
Jerusalem crickets	2.4	2.5		5.4	
June beetles	0.8	0.8		3.6	
<u>Vegetation:</u>				12.7	0.6
<u>Dirt and gravel:</u>				3.6	0.1

<sup>1</sup>Average percent per pellet.

<sup>2</sup>Includes material not identified to genus or family.

(Table VIII). Miscellaneous ground beetles were preponderant, followed by grasshoppers.

Mammalian remains composed over 77 percent of the average pellet deposited by owls during winter, and were in about 86 percent of these pellets (Table VIII). Harvest mice were most abundant, followed closely by deermice and more distantly by unidentified cricetid rodents.

Avian remains occurred in eight percent of owl pellets deposited during winter, constituting six percent of an average pellet (Table VIII). Most of the avian material could not be identified, but horned larks and sparrows were present.

Remains of reptiles and amphibians occurred in 0.7 percent of the owl pellets deposited during winter, and composed only 0.2 percent of an average pellet (Table VIII). It was not possible to identify any of these remains.

Tabulation of items found at owl burrows (Table IX) revealed few differences from results of the pellet studies. Sun spiders and caterpillars were prey items absent from pellets but occasionally present at owl burrows. Remains of reptiles and amphibians were relatively more common at burrows than in pellets. Turtles found at owl burrows were quite young, all less than one and one-half inches in diameter.

Owls occasionally ate carrion. Vehicles had obviously smashed several items found at burrows, including prairie dogs, rabbits, and a rattlesnake. One of the prairie dogs had been shot. I could not definitely determine the amount of pellet material derived from carrion. However, numerous pellets consisting largely of unidentified vertebrate remains also contained many heads of small ants. Owls presumably



TABLE VIII

FOOD HABITS OF BURROWING OWLS IN WINTER, BASED ON ANALYSIS OF 149 PELLETS,  
OKLAHOMA PANHANDLE, DECEMBER 16 - MARCH 15, 1970, 1971

Food Items	Percent of				
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	Volume <sup>1</sup>
<u>Mammals:</u> <sup>2</sup>	21.8		97.5	85.9	77.5
Harvest mice (plains and western)	7.1		31.9	20.1	
Deer mice	5.8		26.2	18.8	
Unidentified cricetids	3.8		17.2	13.4	
Pocket mice (plains and silky)	1.4		6.5	5.4	
Kangaroo rat	1.4		6.5	4.7	
Hispid cotton rat	0.7		3.2	2.7	
Hispid pocket mouse	0.5		2.4	2.0	
Least shrew	0.3		1.6	1.3	
Grasshopper mouse	0.2		0.8	0.7	
House mouse	0.2		0.8	0.7	
<u>Birds:</u> <sup>2</sup>	0.5		2.5	8.1	6.6
Unidentified sparrows	0.3		1.6	1.3	

TABLE VIII (Continued)

Food Items	Percent of				Volume <sup>1</sup>
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	
Horned lark	0.2		0.8	0.7	
<u>Reptiles and amphibians:</u> <sup>2</sup>				0.7	0.2
<u>Total vertebrates:</u> <sup>2</sup>	22.3		100.0	94.6	84.2
<u>Arthropods:</u> <sup>2</sup>	77.7	100.0		35.6	14.8
Miscellaneous ground beetles	43.6	56.1		16.1	
Grasshoppers	26.0	33.5		10.7	
Field crickets	2.0	2.6		3.4	
Jerusalem crickets	1.8	2.4		3.4	
Snout beetles	2.6	3.3		2.0	
Unidentified beetles	0.5	2.4		2.0	
Darkling beetles	0.5	2.4		1.3	
Caterpillar hunters	0.2	0.2		0.7	
Dung beetles	0.2	0.2		0.7	
Unidentified spiders	0.2	0.2		0.7	

TABLE VIII (Continued)

Food Items	Percent of				
	Total Number	Number of Arthropods	Number of Vertebrates	Frequency of Occurrence	Volume <sup>1</sup>
<u>Vegetation:</u>				10.1	0.8
<u>Dirt and gravel:</u>				4.0	0.1

<sup>1</sup> Average percent per pellet.

<sup>2</sup> Includes material not identified to genus or family.

TABLE IX

PREY ITEMS FOUND AT BURROWS USED BY BURROWING OWLS,  
OKLAHOMA PANHANDLE, 1970, 1971

Food Item	Spring (84 items at 55 burrows)		Summer (55 items at 49 burrows)		Fall (2 items at 2 burrows)		Winter (7 items at 7 burrows)	
	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence
Kangaroo rat	2.4	3.6	10.2	12.5	50.0	50.0		
Deer mice	2.4	3.6					28.6	28.6
Harvest mice			2.0	2.5			28.6	28.6
Cotton rat	1.2	1.8					14.3	14.3
Grasshopper mouse	1.2	1.8						
Jackrabbit	2.4	3.6						
Cottontail rabbit	2.4	3.6						
Mexican pocket gopher	2.4	3.6						
Prairie dog	1.2	1.8	4.1	5.0				
Painted turtle			4.1	5.0				
Horned lizard			2.0	2.5				
Prairie rattlesnake	1.2	1.8						

TABLE IX (Continued)

Food Item	Spring (84 items at 55 burrows)		Summer (55 items at 49 burrows)		Fall (2 items at 2 burrows)		Winter (7 items at 7 burrows)	
	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence
Tiger salamander			6.1	7.5				
Unidentified toad			2.0	2.5				
Spadefoot toad	4.8	7.3	6.1	7.5				
Leopard frog	2.4	3.6	6.1	7.5				
Meadow lark	1.2	1.8						
Horned lark	2.4	3.6	2.0	2.5				
Unidentified sparrow	2.4	3.6	2.0	2.5	50.0	50.0		
Killdeer			2.0	2.5				
Spotted sandpiper	1.2	1.8						
Jerusalem cricket	47.6	25.5	12.2	7.5				
Field cricket	8.3	7.3	8.2	7.5				
Grasshopper			20.4	12.5				
Ground beetles	2.4	3.6	4.1	5.0				

TABLE IX (Continued)

Food Item	Spring (84 items at 55 burrows)		Summer (55 items at 49 burrows)		Fall (2 items at 2 burrows)		Winter (7 items at 7 burrows)	
	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence	Percent by Number	Percent by Occurrence
Dung beetles	2.4	3.6	2.0	2.5				
Darkling beetles	4.8	7.3	4.1	5.0				
Caterpillar	1.2	1.8						
Sun spider	2.4	3.6						

ingested the ants while feeding on carrion such as rabbits, because there was no evidence of anting behavior in owls.

Burrowing owls are occasionally cannibalistic (Robinson 1954). Remains of owls were found in or near nest burrows in eight instances. These had apparently not been fed upon except for the nestling previously mentioned in "Mortality Factors."

Owls were observed capturing, carrying, or eating prey (Table X) primarily when adults were providing food for their young. These observations confirmed that owls ate sun spiders and caterpillars. A snake carried by an owl to its burrow (Table X) was definitely not carrion.

The maximum size of prey killed by owls was not determined but prey included 13-lined ground squirrels (Table V) and a snake two to three feet long (Table X). This observer did not see owls kill prairie dogs, although Robert McVickers (personal communication), employee of the Bureau of Sport Fisheries and Wildlife, saw an owl carrying a freshly-killed, young prairie dog in the study area. Although owls occasionally ingested ants (Tables V and VI), the smallest prey they intentionally ate probably was larger.

Vegetation composed 30 percent of pellets deposited by burrowing owls in all seasons in California (Thomsen 1971). Somewhat over one-half of this material was presumably food of the consumed prey animal, and the rest was consumed directly by owls (Thomsen 1971). Small amounts of vegetation were found in approximately 10 percent of owl pellets in all seasons except summer (Tables V, VII and VIII). Owls apparently directly consumed most of this, because it was not chewed up or partially digested as it would have been from stomachs of prey animals.

TABLE X

PREY ITEMS SEEN CAPTURED, CARRIED, OR EATEN BY BURROWING OWLS,  
OKLAHOMA PANHANDLE, 1970, 1971

Prey Item	Spring		Summer		Fall		Winter	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Small rodents			2	2.5			3	100.0
Unidentified snake	1	1.4						
Spadefoot toad			1	1.2				
Meadowlark (fledgling)	1	1.4						
Jerusalem and field crickets	52	74.3	40	49.4	1	100.0		
Unidentified beetles	15	21.4	11	13.4				
Grasshoppers			25	30.9				
Cicada			1	1.2				
Sun spider	1	1.4						
Caterpillar			1	1.2				
Totals	70	99.9	81	99.8	1	100.0	3	100.0



Owls occasionally ate unusual materials including a bologna peel from one pellet collected near a house. Two pellets collected in May contained finely crushed eggshell, constituting about 25 percent of one pellet. Bird remains were not found in these pellets, so the owls may have intentionally ingested eggs. Pea-size chunks of gravel and pieces of glass, the largest  $3/8 \times 5/8$  inch, were found in several pellets. The gravel and glass were inside the pellets, not stuck to the outside. Part of the small amount of dirt occasionally found in pellets (Tables V, VII and VIII) likely adhered to the pellets when they were moist.

The relative importance of arthropods and vertebrates in the diet of owls fluctuated seasonally, as indicated by changes in frequency of occurrence (Figure 12) and percent of volume (Figure 13). In Iowa a progressive increase in the frequency of insects in the diet of burrowing owls, between June and August, may have indicated the young owls' inability to seek and capture the more elusive vertebrates, or may have only reflected the increased availability of insects in mid and late summer (Errington and Bennet 1933).

Insect numbers, especially grasshoppers, obviously increased from late spring through August. This increase was probably a primary factor in the increased consumption of insects during summer. Conversely, increased consumption of rodents during winter was probably due largely to decreased availability of insects. Decreased vegetative cover during winter also made rodents more vulnerable prey. The greater importance of birds in the winter diet may have resulted from decreased availability of insects and increased vulnerability of birds due to adverse weather, starvation, and lack of cover.

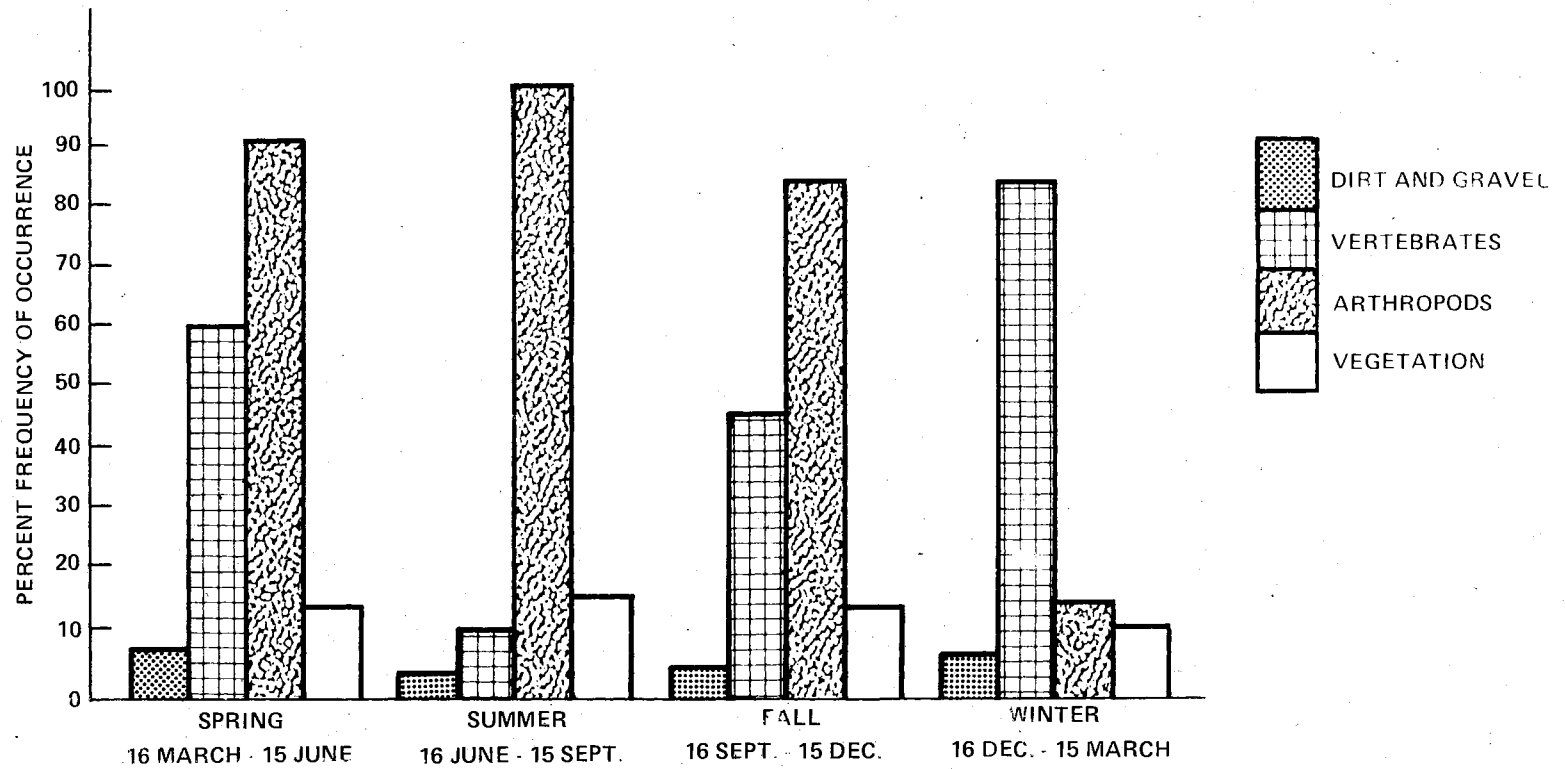


Figure 12. Seasonal Variations in Frequency of Occurrence of Materials in Burrowing Owl Pellets, Oklahoma Panhandle, 1970-1971

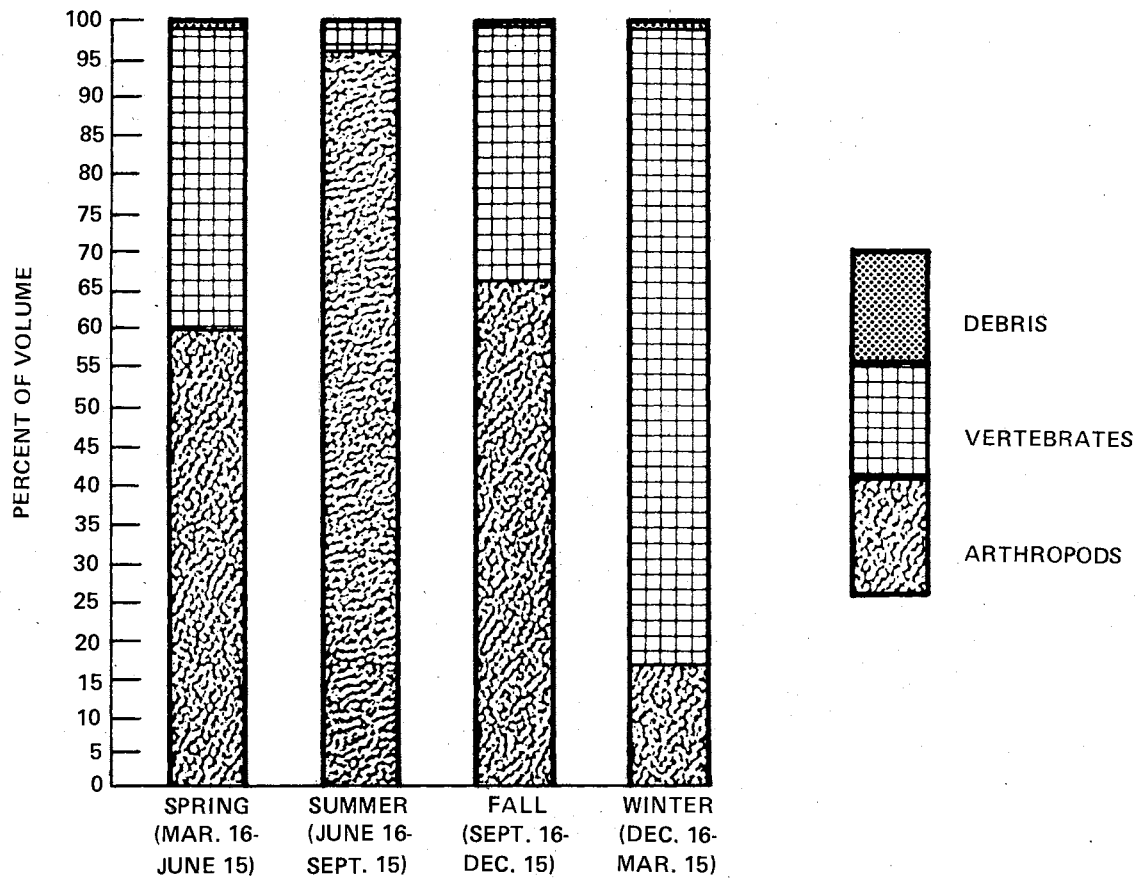


Figure 13. Seasonal Variations in Volume of Materials in Burrowing Owl Pellets, Oklahoma Panhandle, 1970-1971

Owls apparently did not eat most rodent species in the same proportions as they existed in the total rodent population. Harvest mice composed 27 percent of all identifiable vertebrates in owl pellets deposited in spring (Table V), but were only 6 percent of the rodent population sample in spring (Table XI). Deer mice composed over 58 percent of the rodent population sample; however, only 19 percent of all identifiable vertebrates in owl pellets deposited in spring were deer mice (Table V). Grasshopper mice made up only 3 percent of the identifiable vertebrates in owl pellets deposited during spring (Table V), although they composed 27 percent of the rodent population sample (Table XI). About 11 percent of the vertebrates identified in owl pellets deposited in spring were plains or silky harvest mice (Table V), but these small mice constituted less than 1 percent of the rodent population sample (Table XI). Thus, owls may have selected for harvest mice and for the smaller species of pocket mice, but grasshopper mice were a surprisingly insignificant dietary component.

Explanations for the apparent prey selections by owls were difficult. Harvest mice and pocket mice could have been slightly under represented in the population sample, because their small size and the large traps used may have lowered capture success for these species. Differences between activity patterns of owls and certain species of rodents may have been important. Other behaviors inherent in the biology of predator and prey, such as foraging patterns in relation to cover types and moon phase, may also have affected predation on certain rodent species.

Distinguishing between availability and preference for arthropods eaten by burrowing owls was even more difficult than for vertebrate

TABLE XI

RELATIVE NUMBERS OF RODENTS IN VARIOUS HABITAT TYPES,  
OKLAHOMA PANHANDLE, SPRING, 1971

Species	Number of Rodents Captured in Each Habitat Type								
	Short Grass and Dog Towns	Mixed Grass and Sage Land	Tall Grass	Total Grasslands	Wheat Field	Fall Crop and Fallow Fields	Total Croplands	Total Capture	Percent of Total Capture
Deer mice	32	27	8	67	124	16	140	207	58.6
Grasshopper mice	27	11	0	38	54	5	59	97	27.5
Harvest mice (western and plains)	1	3	1	5	10	7	17	22	6.2
Hispid pocket mice	2	2	3	7	2	0	2	9	2.6
Kangaroo rats	2	5	0	7	1	1	2	9	2.6
Pocket mice (silky and plains)	1	0	0	1	2	0	2	3	0.8
House mice	0	0	0	0	2	1	3	3	0.8
Thirteen-lined ground squirrel	3	0	0	3	0	0	0	3	0.8
Total capture	68	48	12	128	195	30	225	353	99.9
Percent of total	19.3	13.6	3.4	36.3	55.2	8.5	63.7	100.0	

prey. Data from arthropod availability studies were of limited value when discussing a long time period, because populations of insect species fluctuated tremendously in a short time interval.

Darkling beetles were the only insect species that owls ate much less frequently than expected. These beetles constituted over half of the ground-dwelling arthropod sample, and they were commonly observed throughout the study area. One type, about one inch long (apparently Eleodes sp.), was seen frequently in short grass areas, in dog towns, on country roads, and even within prairie dog burrows. Another darkling beetle about 3/8 inch long, was sometimes very abundant (over 50 per trap on four occasions) in wheat-stubble fields where owls frequently foraged. However, darkling beetles made up only 0.9 percent and 2.4 percent of identifiable arthropod remains in owl pellets deposited during spring and winter, respectively (Tables V and VIII), and none in summer and fall. One possible reason for this apparent discrepancy could be that some darkling beetles have an offensive taste. Certain species of darkling beetles defend themselves by discharging a pungent oily fluid (Comstock 1930). Other factors such as periods of peak activity may have been important.

Miscellaneous ground beetles were consistently an important dietary item for owls. They constituted from 19 (summer) to 56 percent (winter) of arthropod remains in owl pellets, and their remains occurred in over 40 percent of pellets deposited in all seasons except winter, when they occurred in 16 percent of the pellets (Tables V through VIII). Ground beetles were apparently not abundant in any single locale. They were present in small numbers in virtually all habitats including prairie dog burrows, at all times of the day and night, and in all seasons.

Thus, these beetles were a year-round, staple dietary item for owls, apparently due to availability and possibly to other factors such as taste.

June beetles were seasonally important in owls' diets. Their remains were present in 39 and 22 percent of owl pellets deposited in spring and summer respectively, and composed 22 percent of all identifiable arthropod remains in pellets from spring (Tables V and VI). Peak occurrence of June beetles in owl pellets in late May and early June corresponded with the apparent peak populations. Therefore, June beetles were probably important in owls' diets primarily because of their seasonal abundance.

Dung beetles occurred in 18 to 19 percent of owl pellets deposited in spring and summer, although they made up only 4 to 6 percent of the identifiable arthropods in pellets at these seasons (Tables V and VI). The manure and midden around owl nests probably attracted dung beetles; they exhibited considerable diurnal activity, and they were often conspicuous because of their brilliant colors. These characteristics probably increased their vulnerability to predation by owls that remained in dog towns between periods of intense foraging activity, and also to owlets just learning to forage.

Grasshoppers were the most important arthropod prey of owls in summer and fall, when they occurred in over 75 percent of the owl pellets and constituted 48 and 71 percent, respectively, of the identifiable arthropods (Tables VI and VII). Grasshoppers were extremely numerous from mid June through September. Their abundance, large size, and visibility due to frequent activity, undoubtedly accounted for heavy predation by owls.

Owls may have preyed upon crickets more than other arthropods with similar population levels. Jerusalem and field crickets occurred in 23 and 18 percent, respectively, of owl pellets deposited in spring, and in 26 and 42 percent, respectively, of pellets deposited in summer (Tables V and VI). They collectively made up 22 to 25 percent of the identifiable arthropods in owl pellets during spring and summer. The sample of ground-dwelling arthropods did not reveal a high population of crickets. However, they were frequently observed in wheat fields where owls foraged; their relatively large size made them more visible to owls, and their crepuscular and nocturnal activity made them vulnerable to predation by owls. Thus, owls may have selected for crickets.

Study of raptor food habits through pellet analysis is justifiable when no other source of data is available, or when the species involved is too rare to permit collection of stomachs (Hartley 1948). Results of the present food habits study seemed fairly accurate, but probably had more qualitative than quantitative value.

Some of the following factors may have limited the accuracy of the food habits study: (1) vertebrate prey in summer pellets could have been under represented because young raptors often digest bones of prey (Errington 1932), (2) pellets composed entirely of insect fragments disintegrated much more rapidly than those containing vertebrate remains, thus, the importance of insects may have been slightly greater than the study revealed, (3) sample size of the pellets deposited in fall may have been inadequate to present an accurate picture of food habits, and (4) owls definitely ate soft-bodied prey in greater quantities than indicated by pellet analyses. For example, spiders and caterpillars were absent from pellets but were eaten by owls (Tables IX and X). Owls



also apparently ate reptiles and amphibians in greater quantities than revealed by pellet analyses (Tables V-VIII), probably because the owls ingested little skeletal material from this type of prey (Thomsen 1971).

Results from other studies of food habits exhibited a wide variation among the principal prey items (Table XII). Many of these studies involved analyses of pellets collected in spring and summer (Glover 1953, Hamilton 1941, James and Seabloom 1968, Longhurst 1941, Marti 1969). Sample size in some studies were quite small, and may have depended on numerous pellets collected from only a few individuals (James and Seabloom 1968, Neff 1941, Scott 1938). Nevertheless, the variety of dominant prey items found in these studies suggested that availability of prey species was of paramount importance in determining food habits of burrowing owls in a particular area. Obviously, the insect orders Coleoptera (beetles) and Orthoptera (grasshoppers and crickets), and the rodent families Cricetidae (New World mice and voles) and Heteromyidae (pocket mice and kangaroo rats), generally were vital food items of western burrowing owls. This is not surprising because these probably dominate the rodent and large insect populations throughout the geographic range of the western burrowing owl.

### Habitat Utilization

#### Utilization of Habitat Outside Dog Towns

Owls seldom utilized areas not containing prairie dogs. The 1970 census indicated 5,683 acres per adult owl in that portion of the study area at least one mile from any dog town. In comparison, population density was 4.8 acres per adult owl in dog towns. At least three, and

TABLE XII

## FOOD HABITS OF BURROWING OWLS REPORTED IN OTHER STUDIES

Authority	Locality	Major Food Items
Best (1969)	New Mexico	insects, sun spiders, pocket mice
Bond (1942)	Nevada	spadefoot toads, beetles
Coulombe (1971)	Southern California	earwigs, crickets, darkling beetles
Errington and Bennett (1933)	Iowa	beetles, meadow mice, deer mice
Glover (1953)	Arizona	scorpions, beetles, cicadas, pocket mice and kangaroo rats
Hamilton (1941)	Colorado	crayfish, crickets
James and Seabloom (1968)	North Dakota	grasshoppers, carrion beetles, dung beetles
Longhurst (1942)	Colorado	cicadas, deer mice, flower beetles, kangaroo rats
Marti (1969)	Colorado	ground beetles, deer mice, wasps
McBee (1927)	South Dakota	horned larks
Neff (1941)	California	black terns, red-winged blackbirds, beetles
Patton (1926)	South Dakota	horned larks, "field" mice
Ross and Smith (1970)	Texas (winter)	house mice, deer mice
Ross and Smith (1970)	Texas (summer)	beetles, grasshoppers and crickets, rodents

TABLE XII (Continued)

Authority	Locality	Major Food Items
Scott (1938)	Iowa	scarabid beetles, ground beetles, grasshoppers, deer mice
Sperry (1941)	Montana, Colorado, Washington, Kansas	beetles, crickets, grasshoppers, spadefoot toads
Thomsen (1971)	Oakland, California	meadow voles, beetles, vegetation, Jerusalem crickets
Tyler (1968)	Oklahoma	grasshoppers, dung beetles, ground beetles

possibly five, pairs of owls resided in solitary situations outside, but within one mile of, dog towns. These owls shared some feeding areas with owls in the nearby dog towns, but they nested in habitat unmodified by prairie dogs.

All solitary nest burrows were apparently slightly modified badger burrows. Badger burrows may have been preferred because of their large size and other internal characteristics that made major modifications by owls unnecessary. Burrows of ground squirrels or Ord kangaroo rats existed in moderate abundance in the immediate vicinity of most solitary nest burrows, but were not utilized by owls. Two owls, apparently migratory individuals, used depressions about six inches deep that they had presumably scooped out in sandy mounds pushed up by pocket gophers, while they remained at Washita National Wildlife Refuge in western Oklahoma for a few weeks during March (Robert Stratton, personal communication).

Numerous authors have noted burrowing owls living in habitat other than prairie dog towns. These included owls living in modified kangaroo rat dens (Best 1969), modified ground squirrel dens (Coulombe 1971, Thomsen 1971), swift fox dens (Cutter 1958, Kilgore 1969), burrows dug by coyotes (Allen 1914), abandoned badger burrows (Scott 1938), a ground hog burrow (DuMont 1932), and culvert drains (Abbot 1930). In Cimarron County, Oklahoma, two owls lived in a sage-dotted pasture three miles from the nearest dog town; however, the original designer of their burrows was unknown (Sutton 1967). The primary habitat characteristics common to these diverse situations were openness (few trees and shrubs) and short vegetation.

### Utilization of Abandoned Dog Towns

Owl utilization of abandoned dog towns was minimal, as indicated by results of the census in 10 dog towns (302 acres) poisoned between 1967 and 1970. In three dog towns cultivation had drastically altered the habitat and owls were not present. In 1970 two active nests were found in a 35-acre dog town poisoned in 1968, but owls were not present in 1971. One pair of owls nested in 1971 in an abandoned six-acre dog town poisoned in 1968. This nest was in a pipeline right-of-way, the only area where vegetation (sand sage and mid grasses) was not fairly tall and dense. A pair of owls were also seen there in 1970, but their nest was not found.

Small populations of prairie dogs often persisted, perhaps migrating from neighboring colonies (Smith 1967), when drastic habitat changes did not follow poisoning. Eight owl nests were located in 1970 in five dog towns totaling 95 to 100 acres, including abandoned segments. All nests were in the active parts of dog towns that made up less than 10 percent of the former acreages. The drastic decline in owl numbers in the Canyon dog town after it was poisoned, but not completely eradicated, in early March was discussed earlier.

One landowner felt "dog owls" increased in number after he had killed the prairie dogs on his land. No evidence to support this contention was found on the study area. Coues (1874), however, reportedly found owls in their greatest numbers in deserted dog towns from which prairie dogs had "migrated". Others reported decreases in owl numbers in areas where prairie dogs were eliminated or reduced (Bailey and Niedrach 1965, Koford 1958, Ligon 1961, Tate 1923).

### Utilization of Active Dog Towns

Active prairie dog towns were undoubtedly the primary habitat for burrowing owls in the study area. Sixty-six percent of the adult owls lived in dog towns although this habitat constituted only 0.16 percent of the total area. Utilization of active dog towns by owls was extremely variable, as evidenced by the broad range of breeding population densities of owls in dog towns of different sizes (Table XIII).

Active prairie dog towns have long been a favorite habitat of burrowing owls (Bendire 1892, Bent 1938, Smith 1967, Tate 1923, Thwaites 1905). Wes Webb (personal communication), Game Ranger, estimated that 90 to 95 percent of the burrowing owls in Jackson County, southwestern Oklahoma, resided in dog towns.

The owls' obvious preference for nesting in prairie dog burrows, rather than modifying and utilizing burrows of small mammals such as kangaroo rats and ground squirrels, could not be fully accounted for. Availability of suitable burrows was only part of the answer. Owls were often absent from areas having an abundance of rat and ground squirrel burrows.

Habitat selection in birds may involve imprinting (Smith 1966). Dog towns have been ancestral breeding grounds for burrowing owls where their range overlaps with that of prairie dogs. Owls may exhibit an innate preference for this ancestral habitat, recognizing it by characteristics not necessarily vital to their welfare. This same reasoning may explain why populations of burrowing owls exist, and have apparently always existed, in areas outside the geographical range of prairie dogs.

TABLE XIII

POPULATION DENSITY OF ADULT BURROWING OWLS IN PRAIRIE DOG TOWNS OF  
VARIOUS SIZE GROUPINGS, OKLAHOMA PANHANDLE, SUMMER 1970

Size of Dog Towns (Acreage)	Populations of Adult Owls Per Acre							Total Number of Towns
	0	0-0.1	0.1-.29	0.3-.49	0.5-.99	1-1.9	>2	
0.1-10	2		1	1	4	8	5	21
11-20	1				4	1		6
21-40			1	1				2
41-100		2	1	2	1	1		7
>100	2	2						4
Totals	5	4	3	4	9	10	5	40

## Intensive Habitat Analyses

### Ecological Characteristics of the Nine

#### Intensively-Studied Dog Towns

Ecological factors intrinsic to the nine intensively-studied dog towns were determined (Table XIV). Characteristics for H2 and H3 were remarkably similar; soils of both were Richfield deep loam, both were nearly level with drainage into playa lakes, and natural vegetation was dense, short-grass sod. Soils of H1 were Mansic, deep loam with generally sloping topography and drainage into a permanent stream. The natural vegetation of H1 was predominantly short grass forming moderately dense sod, interspersed with eroded areas and clumps of soapweed.

Ecological characteristics of the dog towns with owl populations of low density differed markedly from those with owl populations of high density. Soils were coarse-textured, gravelly, clayey in spots, and eroded in both L1 and L2, and in 40 percent of L3. All three had sloping topography and drained into draws or ephemeral creeks. Natural vegetation varied but included short grass in densities ranging from broken patches to continuous dense sod, mid grasses, and areas of sand sage or soapweed-dotted grasslands.

Soils, topography, and natural vegetation varied in the three dog towns with moderately dense populations of owls, representing a combination of virtually all characteristics described in low and high population categories. The only exception was a paucity of soapweed in their vegetation.

Extrinsic environmental factors were delineated, including hunting pressure, approximate year of last poisoning, density of prairie dog



TABLE XIV

INTRINSIC ECOLOGICAL CHARACTERISTICS OF NINE INTENSIVELY STUDIED DOG TOWNS,  
OKLAHOMA PANHANDLE, 1971 (USDA 1962)

Dog Town		Ecological Characteristics		
Study Block	Legal Description (Township-Range-Section)	Ecological Characteristics		
		Soil	Topography	Natural Vegetation
H1	4N-24E-32	Mansic-Woodward complex, deep, dark, loamy soil. Much clay in spots. Generally eroded.	about 50 percent with slopes 3-5 percent; drainage into permanent creek	short grass; wheatgrass in flood plain
H2	5N-21E-25	100 percent Richfield loam. Deep and friable soil.	nearly level; drains into playa lakes	short grass; dense sod
H3	4N-18E-24	100 percent Richfield clay loam. Deep, dark, clayey soil.	nearly level, drains into playa lakes	short grass; dense sod
M1	2N-23E-5	100 percent Mansic clay loam, eroded to the extent that caliche often appears on hills.	slopes (3-5 percent), drains into dry ravine	short grass
M2	4N-21E-24	Pratt fine sandy loam over entire dog town.	undulating, slight drainage into sandy draws	sand sage, mixed grasses
M3	4N-20E-18	About 10 percent Dalhart fine sandy loam on ridges and knobs; Richfield clay and Richfield loam on remainder.	occasional 1-3 percent slope; drains into playa lakes	short grass

TABLE XIV (Continued)

Dog Town		Ecological Characteristics		
Study Block	Legal Description (Township-Range-Section)	Ecological Characteristics		
		Soil	Topography	Natural Vegetation
L1	4N-23E-35	100 percent Woodward Mansic association, coarse-textured, gravelly soil, eroded.	gentle slopes (1-3 percent) into grassy draw	short grass
L2	4N-22E-19,20	100 percent Woodward Mansic complex; coarse-textured, gravelly soils, much reddish soil; eroded.	sloping (5-10 percent) toward ephemeral creek	short grass; scattered sage and yucca
L3	3N-21E-18	60 percent Otero-Pratt, fine sandy loam in draws; 40 percent Mansic-Woodward complex on knobs, some gravel and clay; eroded.	slopes (5-12 percent) into broad, dry draws	short grass in upland; mid-grass in draws

populations, and distance to the nearest dog town, for each of the nine intensively-studied dog towns (Table XV). Differences, if existent, were subtle. Only H2 and H3 received relatively heavy hunting pressure, and they were also the only two comparatively isolated from other dog towns. Prairie dog population densities in dog towns with dense populations of owls varied from low to high, while those in dog towns with sparse populations of owls were all moderate. A relationship was not apparent between approximate year of last poisoning and population density of owls.

#### Patterns of Distribution and Comparative

#### Quantitative Analyses of Habitat Types

#### in the Nine Study Blocks

Cover maps showing distribution patterns of various habitat types within each of the nine study blocks are given in Appendix D. Wheat fields bordered at least one side of all three dog towns with owl populations of high density; only one dog town with a sparse population of owls had a wheat field bordering a side. Conversely, all dog towns with sparse populations of owls were bordered by grassland on at least 75 percent of their perimeters, while 25 percent of the perimeter was the maximum amount of grassland bordering dog towns with dense populations of owls.

Permanent water areas, including windmills with associated stock tanks and ponds, were within one-half mile of each of the nine intensively studied dog towns. In addition, several of these dog towns contained seasonal water sources in playa lakes or intermittent streams.

TABLE XV

EXTRINSIC ECOLOGICAL FACTORS OF THE NINE INTENSIVELY STUDIED DOG TOWNS,  
OKLAHOMA PANHANDLE, 1971

Study Block	Estimates of Hunting Pressure	Approximate Year of Last Poisoning	Estimates of Relative Density of Prairie Dogs	Nearest Known Dog Town
H1	Moderate	1967	Low	<1 mi.
H2	High	1969	Moderate	>5 mi.
H3	High	Before 1963	High	>5 mi.
M1	Moderate	1967	Moderate	2 mi.
M2	Low	1967	Moderate	<1 mi.
M3	Low	Before 1963	High	<1 mi.
L1	Low	1967 (edges of dog town)	Moderate	1-1/4 mi.
L2	Moderate	1967	Moderate	<1 mi.
L3	Moderate	1969	Moderate	<1 mi.

Comparisons of the average acreages of habitat types and road mileages revealed striking differences in composition of the nine study blocks (Tables XVI and XVII). Fields of cereal grains comprised 45 to 46 percent of study blocks with owl populations of high density, but only 3 to 17 percent of those with populations of low density (Table XVI). Grasslands constituted 61 to 80 percent of study blocks with owl populations of low density, but only 4½ to 34 percent of those with populations of high density (Table XVI). Statistical analyses indicated that study blocks with owl populations of high density contained significantly more cropland, less grassland, and more miles of road than did those with populations of low density (Table XVII). Study blocks with owl populations of moderate density exhibited habitat characteristics not significantly different from those in the other two population categories (Table XVII).

#### Food Availability in the Nine Study Blocks

Tests were made for statistical significance of differences in food availability (prey populations) among the nine study blocks (Table XVIII). When trapping results were pooled from all three study blocks in each population category, and the three treated as one sample, rodent populations were significantly greater in study blocks containing owl populations of high density (Table XVIII). No significant differences were found in rodent populations, between study blocks with owl populations of moderate and low density.

Populations of ground-dwelling arthropods were also significantly greater in study blocks with owl populations of high density than in those with low density (Table XVIII). No significant differences were

TABLE XVI

PERCENTAGE OF EACH STUDY BLOCK OCCUPIED BY VARIOUS HABITAT TYPES AND MILES  
OF ROAD IN EACH, INCLUDING PERIMETER, OKLAHOMA PANHANDLE, 1971

Habitat Types	Study Blocks								
	H1	H2	H3	M1	M2	M3	L1	L2	L3
Short Grass	11.5	4.0	2.2	20.2	16.6	2.3	47.6	19.1	4.6
Tall Grass	6.8	1.9	0.7	23.4	10.4	0.7	4.9	22.2	12.1
Mixed Grass	15.4	2.3	Tr.	14.7	32.2	0	7.9	35.3	53.6
Dog Town	0.4	0.4	1.6	0.8	2.5	1.4	0.4	3.0	1.1
Wetland Tall Vegetation	0.4	Tr. <sup>1</sup>	Tr.	0.2	15.2	Tr.	Tr.	8.6	3.9
Grassland Totals	34.1	8.6	4.5	59.1	61.7	4.4	60.8	79.6	71.4
Cereal Grains	45.6	46.0	45.2	25.8	9.3	53.6	17.0	2.8	13.7
Fall Crops (including hay)	1.1	9.7	24.0	2.0	5.9	12.2	2.3	1.2	3.3
Fallow Cropland	17.5	34.6	25.3	12.5	1.8	29.2	18.8	2.4	3.9
Cropland Totals	64.2	90.3	94.5	38.3	17.0	95.0	38.1	6.4	20.9
Woody Vegetation	0.2	Tr.	Tr.	0.1	1.9	Tr.	0.2	2.0	3.1
Water Areas	0.2	0.2	Tr.	Tr.	1.9	0.1	0.2	2.0	0.5

TABLE XVI (Continued)

Habitat Types	Study Blocks								
	H1	H2	H3	M1	M2	M3	L1	L2	L3
Buildings, Idle Land	0.9	0.9	0.2	0.3	0.2	0.5	0.7	0.2	0.2
Sand Dunes	0	0	0	0	2.1	0	0	1.3	Tr.
Total Miles of Roads	20	22	24	20	5.0	22	13	8	9

<sup>1</sup>Tr. = less than 3 acres (0.05 percent).

TABLE XVII

SIGNIFICANCE TESTS (MODIFIED  $t$ -TEST) OF DIFFERENCES IN  
HABITAT TYPE ACREAGES IN STUDY BLOCKS STRATIFIED  
ACCORDING TO OWL POPULATION DENSITIES, OKLAHOMA  
PANHANDLE, 1971, WITH SIGNIFICANT  
RESULTS UNDERScoreD

Habitat Types	Statistical Comparisons		
	High versus Low	Moderate versus High	Low versus Moderate
Short Grass	T = -1.384 P = 0.32	T = 1.135 P = 0.38	T = 0.790 P = >0.5
Tall Grass	T = -1.843 P = 0.21	T = 1.247 P = 0.35	T = 0.189 P = >0.5
Mixed Grass (including sage and yucca pastures)	T = -1.892 P = 0.20	T = 0.922 P = 0.46	T = 1.024 P = 0.41
Grassland Totals (including dog towns)	T = -4.492 P = <u>0.047</u>	T = 1.296 P = 0.34	T = 1.176 P = 0.37
Cereal Grains (early summer harvest)	T = 8.017 P = < <u>0.025</u>	T = -1.271 P = 0.37	T = -1.373 P = 0.32
Fall Crops (including sorghums, tame hay, etc.)	T = 4.294 P = <u>0.050</u>	T = -0.672 P = >0.5	T = -1.470 P = 0.30
Fallow Cropland	T = 2.429 P = 0.15	T = -1.228 P = 0.36	T = -0.633 P = >0.5
Cropland Totals	T = 4.854 P = <u>0.043</u>	T = -1.329 P = 0.33	T = -1.174 P = 0.37
Buildings and Associated Idle Land	T = 1.090 P = 0.37	T = -1.500 P = 0.28	T = 0.400 P = >0.5
Woody Vegetation (not including sand sage)	T = -2.022 P = 0.19	T = 0.944 P = 0.45	T = 1.017 P = 0.42
Water Areas (including ephemeral streams and playa lakes)	T = -1.344 P = 0.33	T = 0.882 P = 0.47	T = 0.283 P = >0.5
Wetland Tall Vegetation	T = -1.584 P = 0.27	T = 0.989 P = 0.43	T = -0.177 P = >0.5
Miles of Road (including perimeter)	T = 6.316 P = < <u>0.025</u>	T = -1.160 P = 0.38	T = -1.141 P = 0.38



TABLE XVIII

SIGNIFICANCE TESTS (MODIFIED t-TEST) OF DIFFERENCES IN FOOD AVAILABILITY IN STUDY BLOCKS  
STRATIFIED ACCORDING TO OWL POPULATION DENSITIES, OKLAHOMA PANHANDLE, 1971,  
WITH SIGNIFICANT RESULTS UNDERScoreD

Study Blocks Compared	Statistical Comparisons of Capture Per Trap Day and Capture Per 10 Sweeps		
	Rodent Sample	Ground (Arthropod Sample)	Sweep Net (Arthropod) Sample
H1 vs L1	$\bar{X}H=0.1380$ , $\bar{X}L=0.1285$ (P > 0.50)	$\bar{X}H=0.881$ , $\bar{X}L=1.690^1$ mH > mL (P < 0.01)	$\bar{X}H=2.214$ , $\bar{X}L=1.071$ mH > mL (P < 0.01)
H2 vs L2	$\bar{X}H=0.1452$ , $\bar{X}L=0.0500$ mH > mL (P < 0.01)	$\bar{X}H=0.881$ , $\bar{X}L=1.690$ mH < mL (P = 0.02)	$\bar{X}H=1.048$ , $\bar{X}L=2.048$ mH < mL (P < 0.01)
H3 vs L3	$\bar{X}H=0.0905$ , $\bar{X}L=0.0643$ (P > 0.10)	$\bar{X}H=2.119$ , $\bar{X}L=0.714$ mH > mL (P < 0.01)	$\bar{X}H=1.310$ , $\bar{X}L=1.619$ (P > 0.40)
H(1+2+3) vs L(1+2+3)	$\bar{X}H=0.1246$ , $\bar{X}L=0.0809$ mH > mL (P < 0.01)	$\bar{X}H=4.294$ , $\bar{X}L=1.365$ mH > mL (P < 0.01)	$\bar{X}H=1.524$ , $\bar{X}L=1.579$ (P > 0.50)
H1 vs M1	$\bar{X}H=0.1380$ , $\bar{X}M=0.1429$ (P > 0.50)	$\bar{X}H=9.881$ , $\bar{X}M=5.167$ (P = 0.14)	$\bar{X}H=2.214$ , $\bar{X}M=1.762$ (P = 0.31)
H2 vs M2	$\bar{X}H=0.1452$ , $\bar{X}M=0.0333$ mH > mM (P < 0.01)	$\bar{X}H=0.881$ , $\bar{X}M=1.667$ (P = 0.12)	$\bar{X}H=1.048$ , $\bar{X}M=1.905$ mH < mM (P < 0.01)
H3 vs M3	$\bar{X}H=0.0905$ , $\bar{X}M=0.0476$ mH > mM (P = 0.01)	$\bar{X}H=2.119$ , $\bar{X}M=0.714$ mH > mM (P = 0.02)	$\bar{X}H=1.310$ , $\bar{X}M=1.095$ (P > 0.50)
H(1+2+3) vs M(1+2+3)	$\bar{X}H=0.1246$ , $\bar{X}M=0.0746$ mH > mM (P < 0.01)	$\bar{X}H=4.294$ , $\bar{X}M=2.516$ (P = 0.11)	$\bar{X}H=1.524$ , $\bar{X}M=1.587$ (P > 0.50)
M1 vs L1	$\bar{X}M=0.1429$ , $\bar{X}L=0.1285$ (P > 0.50)	$\bar{X}M=5.167$ , $\bar{X}L=1.590$ M > mL (P = 0.04)	$\bar{X}M=1.762$ , $\bar{X}L=1.071$ mM > mL (P = 0.02)

TABLE XVIII (Continued)

Study Blocks Compared	Statistical Comparisons of Capture Per Trap Day and Capture Per 10 Sweeps		
	Rodent Sample	Ground (Arthropod) Sample	Sweep Net (Arthropod) Sample
M2 vs L2	$\bar{X}M=0.0330$ , $\bar{X}L=0.0550$ ( $P=0.23$ )	$\bar{X}M=1.667$ , $\bar{X}L=1.595$ ( $P>0.50$ )	$\bar{X}M=1.905$ , $\bar{X}L=2.048$ ( $P>0.50$ )
M3 vs L3	$\bar{X}M=0.0476$ , $\bar{X}L=0.0643$ ( $P=0.31$ )	$\bar{X}M=0.714$ , $\bar{X}L=0.809$ $mM<mL$ ( $P<0.01$ )	$\bar{X}M=1.095$ , $\bar{X}L=1.619$ ( $P=0.20$ )
M(1+2+3) vs L(1+2+3)	$\bar{X}M=0.0746$ , $\bar{X}L=0.0809$ ( $P>0.50$ )	$\bar{X}M=2.516$ , $\bar{X}L=1.365$ ( $P=0.10$ )	$\bar{X}M=1.587$ , $\bar{X}L=1.579$ ( $P>0.50$ )

$\bar{l}_m$  = Theoretical population mean -  $\mu$  (Snedecor and Cochran 1967).

found between availability of ground-dwelling arthropods in study blocks containing owl populations of high density and those with moderate density, nor between those with moderate and low population densities.

No significant differences in foliage-dwelling populations were found among the three categories of owl population density.

Relationships Among Habitat Characteristics and  
Dispersion, Food Availability, and Owl  
Populations in Dog Town Areas

It was difficult to assess the importance of surrounding habitat to burrowing owls residing in dog towns. Dog towns provided most habitat for nesting, loafing, and shelter. Areas outside dog towns occasionally provided escape cover, but availability and quality of this escape cover did not have any apparent regulatory effect on densities of owl populations. Owls in the study area depended heavily on areas around dog towns for food. Field observations indicated that owls residing in dog towns derived over 50 percent of their diet from habitat surrounding dog towns. Habitat surrounding dog towns thus influenced burrowing owl populations primarily through its food production.

Data were analyzed to determine if the somewhat direct relationship that apparently existed between population densities of burrowing owls in dog towns and the surrounding cropland-to-grassland ratio, resulted from differences in food availability in the two habitats (Table XIX). Rodent numbers were significantly higher in croplands than in grasslands (Tables XI and XIV). Kangaroo rats, hispid pocket mice, and ground squirrels were the only rodents captured more frequently in grasslands than croplands (Table XI), even though grasslands had 640 more trap days

than did croplands. None of these species were vital dietary components, although owls occasionally ate kangaroo rats and hispid pocket mice (Tables V-VIII).

TABLE XIX

SIGNIFICANCE TESTS (MODIFIED  $t$ -TEST) OF DIFFERENCES BETWEEN FOOD AVAILABILITY IN CROPLAND AND GRASSLAND, OKLAHOMA PANHANDLE, 1971 WITH SIGNIFICANT RESULTS UNDERSCORED

Prey and Sampling Intensity	Mean Capture Success (Captures Per Trap Day or Per 10 Sweeps) and Significance
Rodent (1,562 traps in cropland; 2,202 in grassland)	$\bar{X}$ cropland = 0.1668; $\bar{X}$ grassland = 0.0550 <u>P = &lt;0.0025</u>
Ground-Dwelling Arthropods (154 traps in cropland, 221 traps in grassland)	$\bar{X}$ cropland = 6.718; $\bar{X}$ grassland = 1.459 P = 0.13 (2-tailed test)
Flying and Foliage-Dwelling Arthropods (153 sweep series in cropland; 222 series in grassland)	$\bar{X}$ cropland = 0.539; $\bar{X}$ grassland = 2.141 <u>P = &lt;0.0005</u>

Differences between numbers of arthropods in croplands and grasslands were unclear. Flying and foliage-dwelling arthropods were significantly more numerous in grasslands (Table XIX). Ground-dwelling arthropods were apparently more abundant in croplands, but the difference was not statistically significant (Table XIX) due to wide

variability of trap results (0 to 76 arthropods per trap).

The significantly greater mileage of roads in study blocks with owl populations of high density than in those with populations of low density could have been a factor that helped regulate owl populations. Increased road acreage may have aided populations by providing favored feeding habitat. Owls often utilized road surfaces and edges for foraging. However, the increased road mileage in the study blocks with owl populations of high density may have simply reflected the required roadways in areas where most land was cultivated (Appendix D).

In conclusion, one possible explanation for the higher population density of owls in certain dog towns was greater availability of prey in habitat surrounding these dog towns. Prey populations fluctuated seasonally, and some were apparently a function of the higher percentage of cropland associated with dog towns containing denser populations of owls. This larger acreage of cropland was likely a function of more fertile and productive soil types than found in many uncultivated areas. Owls may have been dependent on rodent populations for food during early spring before insects became numerous. Wheat fields usually had more cover in early spring than did many other habitat types, and supported substantial rodent populations. Owls foraged extensively in wheat fields in spring. Therefore, the large acreage of wheat and other cereal grain fields associated with dog towns having owl populations of high density could have been partially responsible for the higher population density of owls in these areas.

Habitat Changes and the Resultant  
Effect on Owl Populations

Extent of Habitat Changes

Prairie dog towns were the primary habitat for burrowing owls in the study area. Substantial reduction in their acreage undoubtedly had a detrimental impact on owl populations. Changes in the status of active prairie dog towns from 1967 through 1970 are recorded in Table XX. The figures for estimated total dog towns include three (less than 40 acres) for which date of establishment was unknown.

Destruction of 10 dog towns (Table XX) resulted in severe degradation of habitat for nesting owls. These 10 dog towns do not include three (37 acres) listed by Tyler (1968) but not located in 1970. Three (207 acres) were under cultivation in 1970, including 180 acres of irrigated cropland. Less than six prairie dogs remained in each of four destroyed dog towns, thus making available a few burrows for use by owls.

Active prairie dog towns decreased nearly 7 percent in acreage and 12 percent in number in the study area from 1967 through 1970 (Table XX). Formation of four new dog towns and a 9.5 percent (acreage) expansion of existing dog towns between 1967 and 1970 prevented the net loss of preferred owl habitat from being much greater. It was assumed that the rate of gain for the 17 dog towns overlooked by Tyler (1968) was the same as for those he recorded.

The extent of changes in habitat outside prairie dog towns was not documented to the same extent as changes in the status of dog town habitat. A trend in the study area, supported by personal communication

TABLE XX

CHANGES IN NUMBERS AND ACREAGE OF DOG TOWNS, BEAVER COUNTY  
AND EASTERN TEXAS COUNTY, OKLAHOMA 1967-1970

Category	Number of Dog Towns	Percentage of Dog Towns in 1967	Acreage	Percent of Acreage in 1967
Estimated total dog towns (Tyler 1968, and dog towns overlooked by Tyler)	50	100.0	1,830	100.0
Dog towns known destroyed, 1967-1970	10	20.0	302	16.6
Dog towns formed, 1967-1970	4	8.0	20	1.1
Estimated acreage gain in dog towns (1967-June 1970)	40	80.00	175	9.5
Net losses, 1967-1970	6	12.0	127	6.9
Net dog town status, August 1970	44	88.0	1,703	93.1

with local USDA officials, was an increase in cultivated areas, especially irrigated cropland. A second agricultural trend was a sharp decrease in the acreage of ungrazed, seeded grasslands. These areas were mostly mixed or tall grasses planted in fields retired from crop production under various USDA programs. Drouth in both 1970 and 1971 resulted in a provision by the USDA to allow livestock grazing on such set aside areas.

No changes were detected in the availability of mammal burrows, other than those dug by prairie dogs, during the study. Population levels of large mammals, including coyotes, swift foxes, and badgers, may have decreased due to distribution of poisoned horse meat, organized coyote hunts, and a general local public attitude that all such vermin should be killed on sight.

#### Effect of Habitat Changes on Owl Populations

Changes in non-dog town habitat presumably had a small effect on the total population of burrowing owls in the study area. Converting grassland to cropland and especially to irrigated cropland caused a decrease in the availability and persistence of suitable nest burrows that could have adversely affected owl populations. Agricultural operations in southern California apparently caused burrowing owls to abandon the immediate locale (Coulombe 1971). Conversely, certain important prey items were present in greater numbers in cultivated fields, and fields were favorite foraging areas for burrowing owls. The increase in grazing (often overgrazing), areas formerly vegetated with relatively tall grasses probably favored owl populations by creating habitat suitable for use by prairie dogs, ground squirrels, and nesting owls.



Changes in population levels of the large burrow-digging mammals may have slightly affected owl populations through changes in availability of suitable nesting sites outside dog towns.

Few owls in the study area utilized abandoned and partially-abandoned dog towns treated with poison. Owl populations have decreased or disappeared in other areas where prairie dogs were reduced or eliminated (Bailey and Niedrach 1965, Ligon 1961, Tate 1923, Wes Webb, personal communication). Eradication of dog towns may have directly reduced owl populations through killing owls (Cain 1972, Koford 1958). Deterioration of habitat probably reduced populations of owls more than did direct poisoning of owls.

A very damaging result of eradicating prairie dogs was the relatively rapid decline in numbers of burrows available for owl nest sites. Availability of suitable burrow sites in southern California was the major factor controlling abundance of burrowing owls (Coulombe 1971). Burrows of abandoned dog towns soon filled in with dirt and debris in the study area, or were closed by a plug of sod-forming grass. Nearly all burrows lost their identity within three years after disappearance of the prairie dog towns. In southwestern Oklahoma burrows in abandoned dog towns began caving in soon after the first hard rains, and were often virtually worthless to owls within one year (James C. Lewis and Wes Webb, personal communication).

Vegetation in abandoned dog towns of the study area sometimes became fairly tall in areas receiving low to moderate grazing pressure, especially where natural vegetation was mid grasses and sand sage. These areas apparently lost most of their attractiveness to owls, except occasionally as feeding and escape habitat.

The 12 percent reduction in the number of active dog towns in the study area from 1967 to 1970 may have been more detrimental to owl populations than the 7 percent decrease in acreage (Table XX). Eradication of a dog town tended to eliminate, or reduce to a few scattered individuals, a distinct colony or segment of the total owl population. The ultimate result was a reduction of owl numbers and a loss of distribution and ability to disperse, all detrimental to survival of the species.

A much larger proportion of the study area probably contained dog towns and associated owl colonies in times past. This assumption was strongly supported by historical records in other similar areas, and by statements of several long-time residents of the area. The burrowing owl population in the Oklahoma Panhandle will be even more drastically reduced if poisoning of prairie dogs continues at the same rate experienced during the study.

## CHAPTER V

### SUMMARY

Research was conducted in the eastern one-third of the Oklahoma Panhandle from May, 1970, through July, 1971, with the following three objectives: (1) to describe the life history of western burrowing owls, (2) to determine whether local burrowing owls migrated or overwintered in the study area, and (3) to determine specific habitat preferences exhibited by this species.

Adult male owls were lighter and more grayish (less brown) than were adult females after the owls' prenuptial molt in mid March and before their complete postnuptial molt in late July through mid August. Certain behavioral differences also made possible sexual identity of most adult owls in spring and early summer.

The total breeding population of owls in the study area in 1970 was 543, including 359 in the 44 prairie dog towns (4.8 acres of dog town per owl) and 184 outside dog towns (5,683 acres per owl).

Ten trapping techniques were tested and 75 owls captured. A hand net and light at night proved most successful for capturing young owls. Various nest entrance-blocking devices captured nesting females. Padded and weakened steel jaw traps, placed as ground sets, captured owls of all ages and both sexes, but proved especially valuable for capturing owls during winter and early spring when other techniques

failed. Each owl captured was banded with an aluminum leg band, and 35 were also marked with various combinations of colored plastic leg bands.

Owls obtained food by: (1) ground foraging, (2) hovering, (3) foraging from an observation perch, and (4) flycatching behavior. Males provided food for their mates soon after initiation of clutches, and also provided a large share of the food for young owls up to about six weeks of age. Females usually distributed food among brood mates.

Activity patterns were described for winter, spring prenesting, incubation, fledgling, and postnesting periods. Owls were diurnal, crepuscular, and nocturnal.

General behaviors of burrowing owls were delineated including: (1) response to weather conditions, (2) play behavior, (3) vocalizations, (4) relationships with other vertebrates, and (5) escape behavior. Surprisingly few behavioral interactions were noted between burrowing owls and prairie dogs despite their usual close association.

Owls exhibited intraspecific territoriality from mid March through July. Territories centered around nests, and the most important means of establishing and maintaining territories was apparently calling by males.

Young owls had home ranges with radii up to one and one-half miles. The home range of adults in late spring and early summer may have been slightly smaller. Owls ranged their greatest distances at night, even on moonless nights.

Pair formation became apparent by mid March and was usually completed by early April. Mating activity occurred primarily between mid March and early May, and peaked in the first week of April. Calling by males, along with their various postures and displays, was closely

associated with courtship, mating, and pair formation. Certain typical behaviors were usually associated with copulation.

Males selected nest sites, gathered nesting materials, and constructed nests. Nest materials were typically cow or horse dung and April was the peak time of nest construction. All nests were located in short vegetation in abandoned prairie dog or badger burrows, 12 to 42 inches below the ground surface and 42 to 84 inches from the burrow mouth.

Males apparently did not participate in incubation. Females commenced incubation soon after laying the first eggs, resulting in brood mates of uneven sizes. Owlets were brooded for approximately 10 days before they emerged from nest burrows. The peak of the hatch occurred in mid June.

Average brood size was 4.7 in a sample of 61 broods. At least one fledgling was produced in 80 percent of 69 nests. Five renesting attempts were noted. Survival rate of 39 owlets from fledgling stage through July (six to eight weeks of age) was 89 percent.

The estimated number of young owls surviving through July, 1970, were 829 or 3.3 per breeding pair. Known causes of nest failure were: (1) flash flooding, (2) shooting the adult female, (3) burrow destruction by farming operations, and (4) fumigation and sealing of a burrow. Several probable causes of fledgling mortality were discussed.

Annual mortality was apparently high, possibly approaching 60 percent, because breeding populations were very similar in 1970 and 1971 despite the 829 owlets surviving through July, 1970. The two observed causes of adult owl mortality were shooting and roadway fatality.

Apparently only six owls wintered in dog towns of the study area in 1970-71, or less than 0.5 percent of the population there in late July, 1970. Owl populations increased very sharply but sporadically during March. Evidence of extensive winter food caches was not found. There was little evidence that wintering owls entered a state of hibernation or torpor; however, they may have fasted for at least three days during blizzard conditions.

Most of the burrowing owls breeding in the study area migrated; at least one went as far as west-central Mexico. Results of the limited winter banding studies, however, indicated that the small population of wintering owls were permanent residents rather than migrants from more northern areas.

Food habits of owls exhibited considerable seasonal variability. Small mammals were an important winter food (77.5 percent of volume), but were of only minor importance (3.7 percent of volume) in summer. Arthropod remains composed 96.3 percent of the volume of owl pellets during summer, but only 14.8 percent during winter. Remains of reptiles, amphibians, or birds did not usually occur in significant quantities in pellets; however, avian remains constituted 6.6 percent of the volume of pellets in winter.

Dietary importance of rodents in winter was probably due to decreased arthropod numbers and increased vulnerability of rodents. Harvest mice and deer mice were the most frequent mammalian prey in all seasons.

Importance of arthropods in summer was apparently due largely to their increased availability. Remains of miscellaneous ground beetles occurred in at least 40 percent of owl pellets in all seasons except

winter, when they were still the most frequent arthropod species taken by owls (16 percent). Remains of June beetles were found in 39 percent of pellets deposited in spring, and grasshoppers dominated prey frequency of arthropods in summer (81.3 percent) and fall (76.3 percent). Other arthropod groups of seasonal importance included Jerusalem crickets, field crickets, and dung beetles.

Food availability studies indicated that owls may have taken harvest mice more frequently than expected, while grasshopper mice were a surprisingly insignificant food item. This selectivity by owls involved more than simply differences in prey populations.

Darkling beetles were the only insect group that owls obviously ate less frequently than expected when availability was considered. Both field and Jerusalem crickets were apparently preferred dietary components of owls.

The food habits studies had more qualitative than quantitative value because of various factors that may have affected accuracy and reliability.

Prairie dog towns were definitely the preferred nesting habitat for owls, because 66 percent of the adult owls occupied dog towns in 1970 although this habitat comprised only 0.16 percent of the total study area. Possible reasons for this habitat preference were discussed.

Nine dog towns, and the nine square miles surrounding each, constituted study blocks chosen for intensive habitat analyses and food availability studies in the attempt to determine why owl populations were not distributed more evenly throughout the dog towns. Three categories of study blocks were established on the basis of owl populations resident in the central dog town of each in 1970. In the three dog

towns with owl populations of high density, soils were generally more loamy and fertile, topography more level, and vegetative cover consistently shorter than in the three dog towns with owl populations of low density. Study blocks with owl populations of high density had significantly more cropland, less grassland, and more miles of road than those with populations of low density.

The nine study blocks were divided into three sample sets, each set containing one study block of each density category, and small mammal and arthropod populations were sampled in order to compare food availability. Populations of both rodents and ground-dwelling arthropods were significantly higher in study blocks with owl populations of high density than in those exhibiting owl populations of low density.

A possible explanation for the higher population density of owls in certain dog towns was higher availability of prey in habitat surrounding these dog towns. Prey populations may have limited owl populations in the early spring before arthropod numbers increased, and when owls depended heavily on vertebrates for food. Greater acreages of wheat and other cultivated crops were at least partially responsible for higher prey populations and resultant higher numbers of owls.

Control of prairie dogs, using poison, adversely affected owl populations primarily by destroying nesting habitat. Drastic habitat changes, such as cultivation, sometimes followed eradication of prairie dogs and resulted in elimination of owl populations. Most burrows in dog towns were unsuitable for owl use within one to three years after elimination of prairie dogs, even without cultivation. When poisoning efforts did not result in complete eradication of prairie dogs, owls apparently nested only in the active segments of the dog towns.



The number of active dog towns in the study area decreased 12 percent, and acreage of dog towns decreased 7 percent from 1967 to 1970. Reduction in the number of active dog towns may have been more critical than the decrease in acreage. Complete eradication of a dog town tended to eliminate, or reduce to a few scattered individuals, a distinct colony or segment of the total burrowing owl population. The ultimate result was a reduction of owl numbers and a loss of distribution and ability to disperse, all being detrimental to survival of the species.

Insights gained through this research facilitated delineation of six recommendations, presented in Appendix E, for preservation and management of western burrowing owls. The research also revealed aspects of burrowing owl ecology which need further investigation. Consequently, 13 questions indicating research needs are listed in Appendix E.

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APPENDIX A

COMMON AND SCIENTIFIC NAMES OF PLANTS

<u>Common Name</u>	<u>Scientific Name</u>
alfalfa	<u>Medicago sativa</u>
barley	<u>Hordium vulgare</u>
bladder pod	<u>Lesquerella</u> sp.
blue grama	<u>Bouteloua gracilis</u>
buffalo grass	<u>Buchloe dactyloides</u>
cattail	<u>Typha</u> sp.
corn	<u>Zea maize</u>
cottonwood	<u>Populus deltoides</u>
coyote brush	<u>Baccharis</u> sp.
dock	<u>Rumex</u> sp.
flatsedges	<u>Cyperus</u> spp.
hackberry	<u>Celtis</u> sp.
Indian grass	<u>Sorghastrum nutans</u>
little bluestem	<u>Andropogon scoparius</u>
milkweed	<u>Asclepias latifolia</u>
mustards	<u>Brassica</u> spp.
oats	<u>Avena sativa</u>
prairie clover	<u>Psoralea tenuiflora</u>
prickly pear	<u>Opuntia</u> sp.
ragweeds	<u>Ambrosia</u> spp.



<u>Common Name</u>	<u>Scientific Name</u>
sand bluestem	<u>Andropogon halii</u>
sand dropseed	<u>Sporobolus cryptandrus</u>
sand plum	<u>Prunus angustifolia</u>
sand reedgrass	<u>Calamovilfa gigantea</u>
sand sagebrush	<u>Artemesia filifolia</u>
sedges	<u>Carex</u> spp.
side-oats grama	<u>Bouteloua curtipendula</u>
skunkbrush	<u>Rhus trilobata</u>
smartweed	<u>Polygonum</u> sp.
soapweed	<u>Yucca</u> sp.
sorghum	<u>Sorghum vulgare</u>
sunflowers	<u>Helianthus</u> spp.
switchgrass	<u>Panicum virgatum</u>
salt cedar	<u>Tamarix gallica</u>
thistle	<u>Cirsium</u> sp.
wheat	<u>Triticum aestivum</u>
willow	<u>Salix</u> sp.
wire grasses	<u>Aristida</u> spp.

APPENDIX B

COMMON AND SCIENTIFIC NAMES OF VERTEBRATES

<u>Common Name</u>	<u>Scientific Name</u>
<u>Birds:</u>	
barn swallow	<u>Hirundo rustica</u>
cliff swallow	<u>Petrochelidon pyrrhonota</u>
common crow	<u>Corvus brachyrhynchos</u>
common nighthawk	<u>Chordeiles minor</u>
eastern kingbird	<u>Tyrannus tyrannus</u>
elf owl	<u>Micrathene whitneyi</u>
Florida burrowing owl	<u>Speotyto cunicularia floridana</u>
golden eagle	<u>Aquila chrysaetos</u>
horned lark	<u>Eremophila alpestris</u>
killdeer	<u>Charadrius vociferus</u>
lark bunting	<u>Calamospiza melanocorys</u>
lark sparrow	<u>Chondestes grammacus</u>
marsh hawk	<u>Circus cyaneus</u>
meadowlark	<u>Sturnella sp.</u>
mockingbird	<u>Mimus polyglottos</u>
red-winged blackbird	<u>Agelaius phoeniceus</u>
robin	<u>Turdus migratorius</u>
scissor-tailed flycatcher	<u>Muscivora forficata</u>
screech owl	<u>Otus asio</u>

Common Name

sparrow hawk

turkey vulture

western burrowing owl

western kingbird

whiskered owl

white-necked raven

Mammals:

badger

bannertail kangaroo rat

Beechey ground squirrel

black-tailed jackrabbit

black-tailed prairie dog

coyote

deer mice

desert cottontail

domestic dog

ground hog

hispid cotton rat

hispid pocket mouse

house cat

long-tailed weasel

meadow vole

Mexican pocket gopher

Ord kangaroo rat

plains harvest mouse

plains pocket gopher

Scientific NameFalco sparveriusCathartes auraSpeotyto cunicularia hypugaeaTyrannus verticalisOtus trichopsisCorvus cryptoleucusTaxidea taxusDipodomys spectabilisCitellus beecheyiLepus californicusCynomys ludovicianusCanis latransPeromyscus spp.Sylvilagus auduboniCanis familiarisMarmota monaxSigmodon hispidusPerognathus hispidusFelis domesticusMustela frenataMicrotus sp.Cratogeomys castaneusDipodomys ordiReithrodontomys montanusGeomys bursarius

Common NameScientific Name

plains pocket mouse

Perognathus flavescens

round-tailed ground squirrel

Citellus tereticaudus

silky pocket mouse

Perognathus flavus

spotted skunk

Spilogale putorius

striped skunk

Mephitis mephitis

swift fox

Vulpes velox

thirteen-lined ground squirrel

Citellus tridecemlineatus

western harvest mouse

Reithrodontomys megalotisReptiles:

horned lizard

Phrynosoma cornutum

painted turtle

Chrysemys picta

prairie rattlesnake

Crotalus viridisAmphibians:

leopard frog

Rana pipiens

spadefoot toad

Scaphiopus sp.

tiger salamander

Ambystoma tigrinum

toad

Bufo sp.

APPENDIX C

COMMON NAMES AND TAXONOMIC

GROUPING OF ARTHROPODS

<u>Common Name</u>	<u>Order</u>	<u>Family</u>
ants	Hymenoptera	Formicidae
carrion beetle	Coleoptera	Silphidae
caterpillar	Lepidoptera	unknown* <sup>1</sup>
caterpillar hunter	Coleoptera	Carabidae
cicada	Homoptera	Cicadidae
crayfish	Crustacea	unknown*
darkling beetle	Coleoptera	Tenebrionidae
dung beetle	Coleoptera	Scarabidae
earwig	Dermoptera	unknown*
field cricket	Orthoptera	Gryllidae
flower beetle	Coleoptera	unknown*
grasshopper	Orthoptera	Acrididae
ground beetle	Coleoptera	Carabidae
Jerusalem cricket	Orthoptera	Gryllacrididae
June beetle	Coleoptera	Scarabidae
leaf beetle	Coleoptera	Chrysomelidae
scorpion	Scorpionida	unknown*













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<sup>1</sup>Family not specified in literature source that gave only common name or order as a food item of owls.

<u>Common Name</u>	<u>Order</u>	<u>Family</u>
snout beetle	Coleoptera	Curculionidae
sun spider	Araneida	Solpugidae
wasp	Hymenoptera	unknown*

APPENDIX D

HABITAT DISTRIBUTION IN THE NINE STUDY BLOCKS

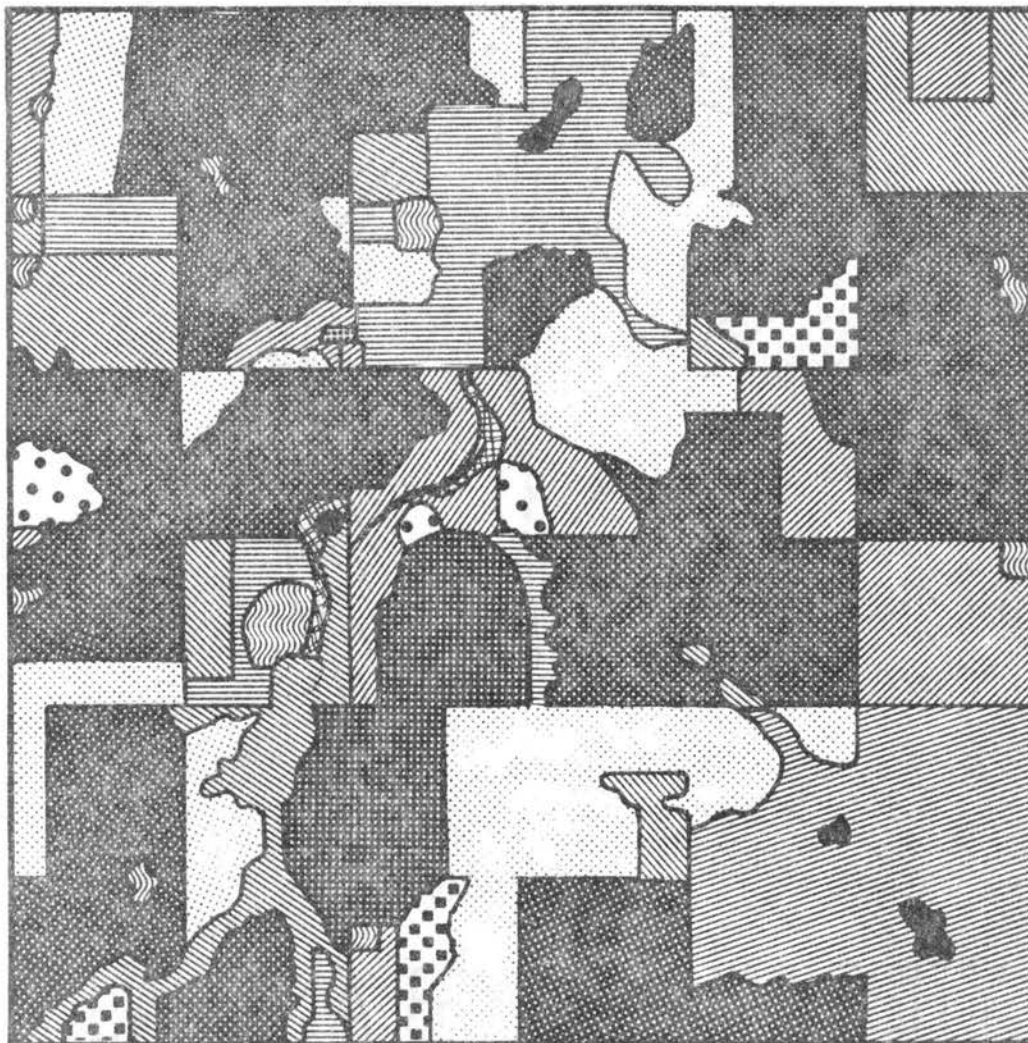
	Dog town
<b>GRASSLAND</b>	
	Short grass
	Tall grass
	Mixed grass
<b>CROPLAND</b>	
	Cereal grain
	Fall crops
	Fallow fields
<b>WETLANDS</b>	
	Wetland herbaceous vegetation
	Woody vegetation (excluding sand sage)
	Water areas (including playa lakes)
<b>MISCELLANEOUS</b>	
	Buildings and associated idle ground
	Active sand dunes

Key to Appendix D

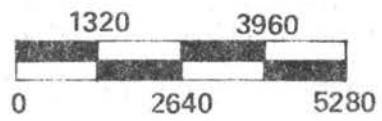
## Characteristics of Habitat Types in Appendix D

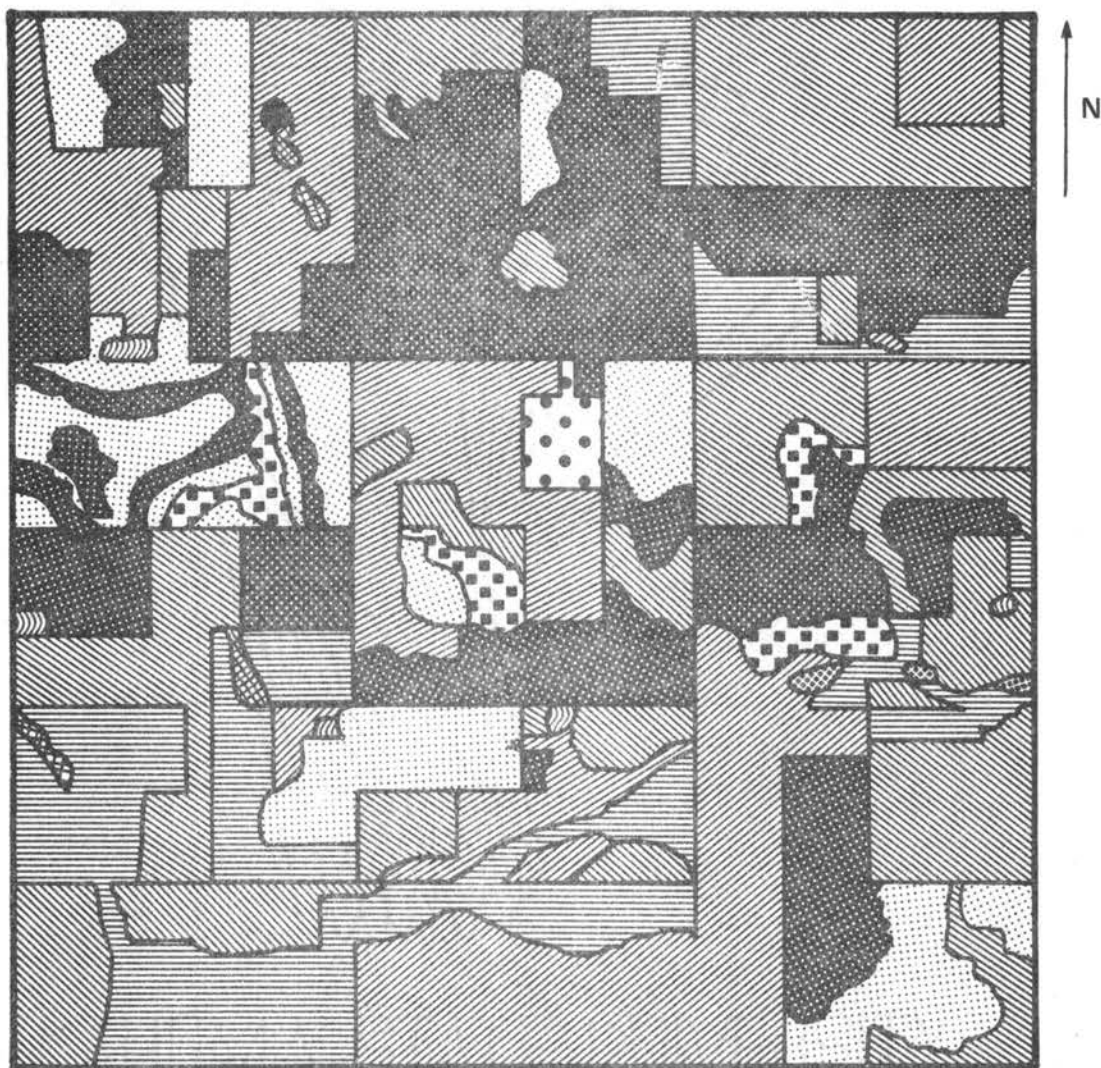
<u>Type</u>	<u>Vegetation Height</u>	<u>Dominant Species</u>
Short Grass	<4 in.	buffalo grass, blue gramma
Tall Grass	>4 in.	switchgrass, little bluestem, Indian grass, sideoats grama
Mixed Grass	variable	mixture of short and tall grasses, sand bluestem, sand sage, and soapweed
Dog Town	<4 in.	short grass species plus numerous forbs including milkweed, thistle, and prickly pear
Cereal Grain	variable	wheat, barley, oats
Fall Crops	variable	grain sorghums, hay, corn
Fallow Fields	usually <4 in.	forbs, old crop stubble and trash
Wetland Vegetation	>4 in.	sedges, flat sedges, forbs (e.g. sunflower)
Woody Vegetation (excluding sand sage)	>6 in.	tamarisk, willow, cottonwood
Water Areas (including playa lakes)		dock, smartweeds, cattail often on borders of playa lakes
Buildings		
Sand Dunes (active)		scattered sand reedgrass, sand dropseed



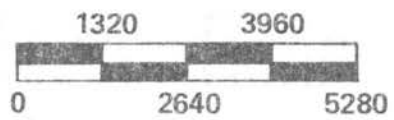


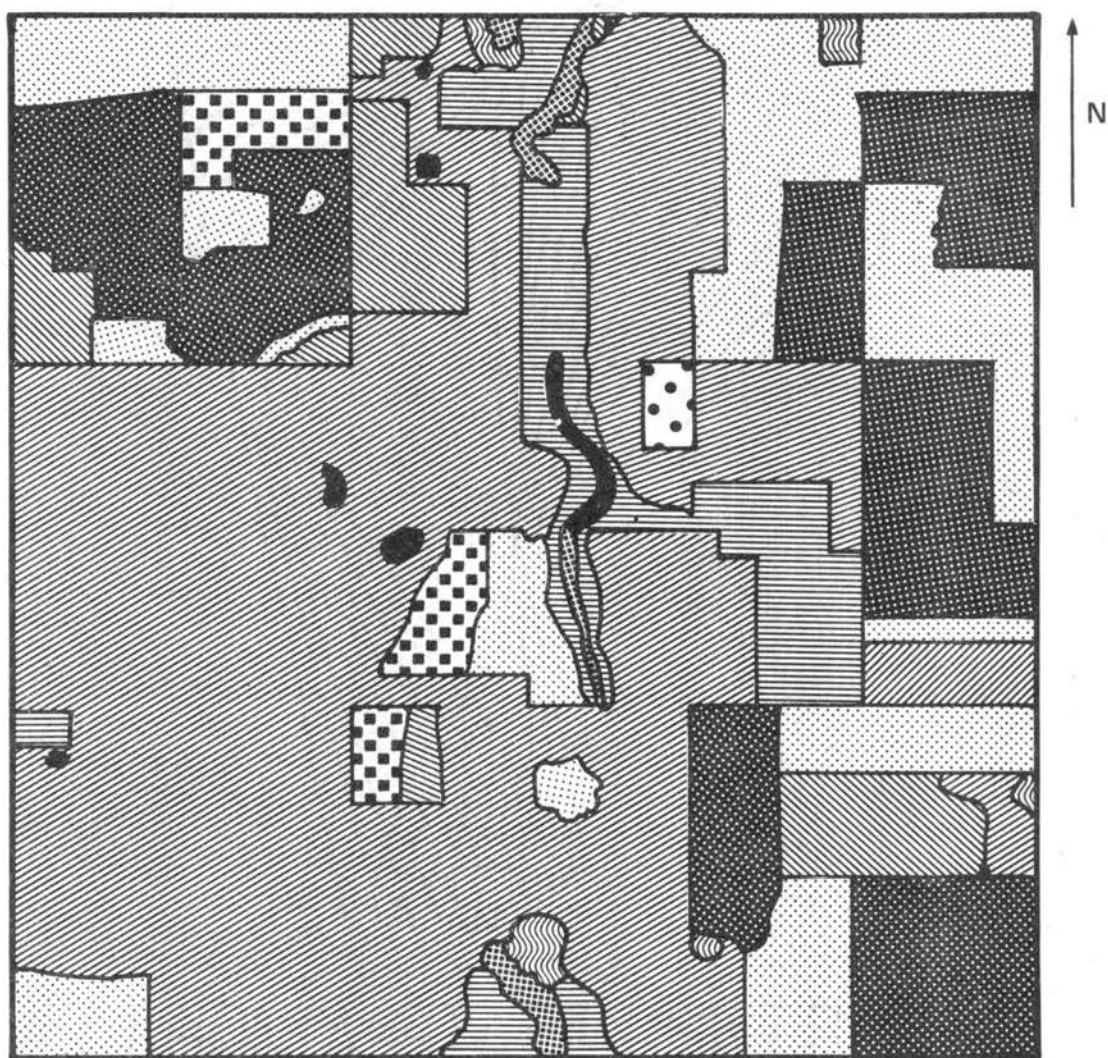
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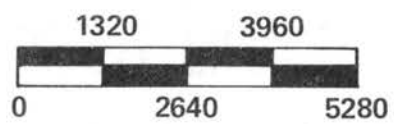


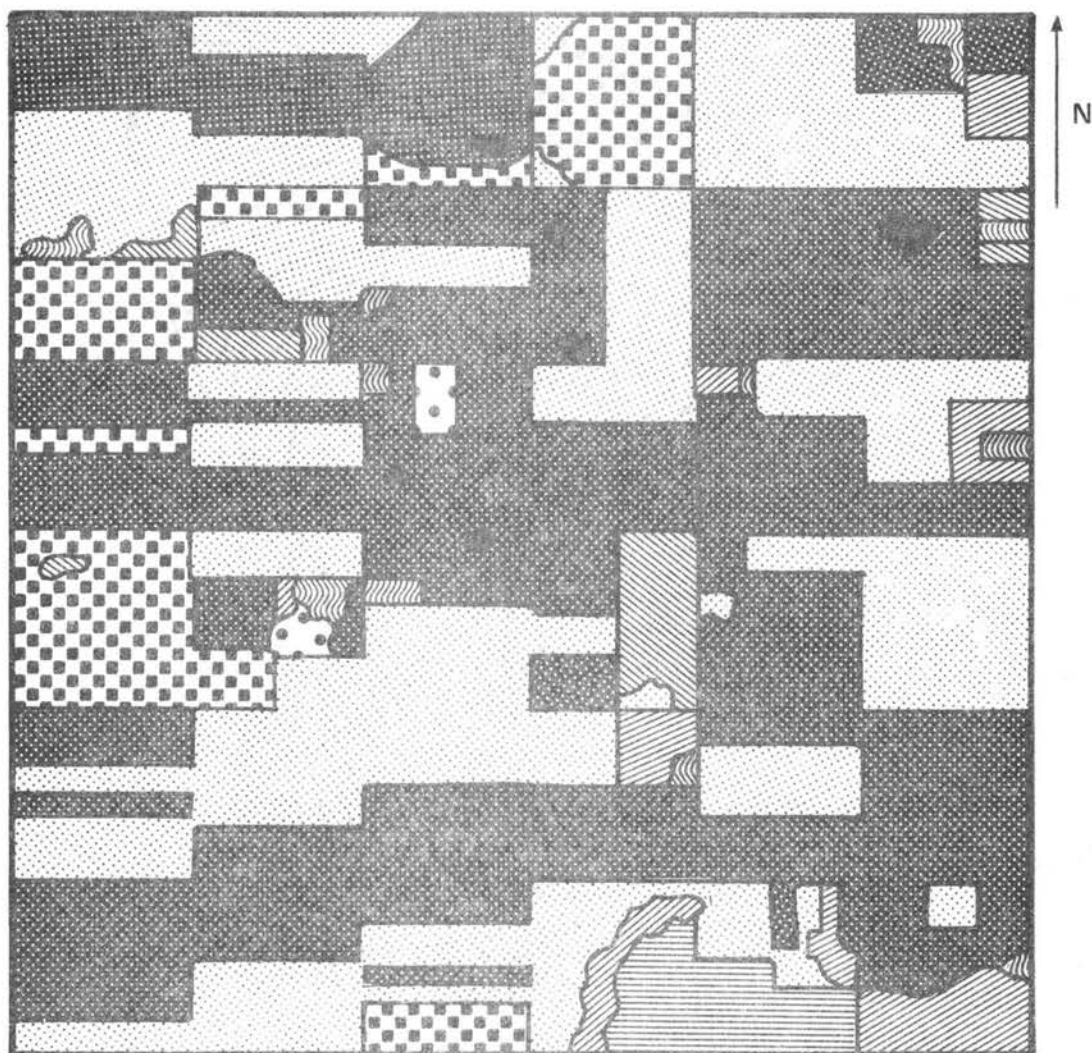
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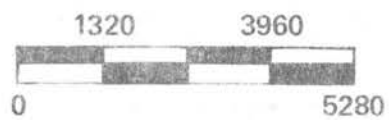


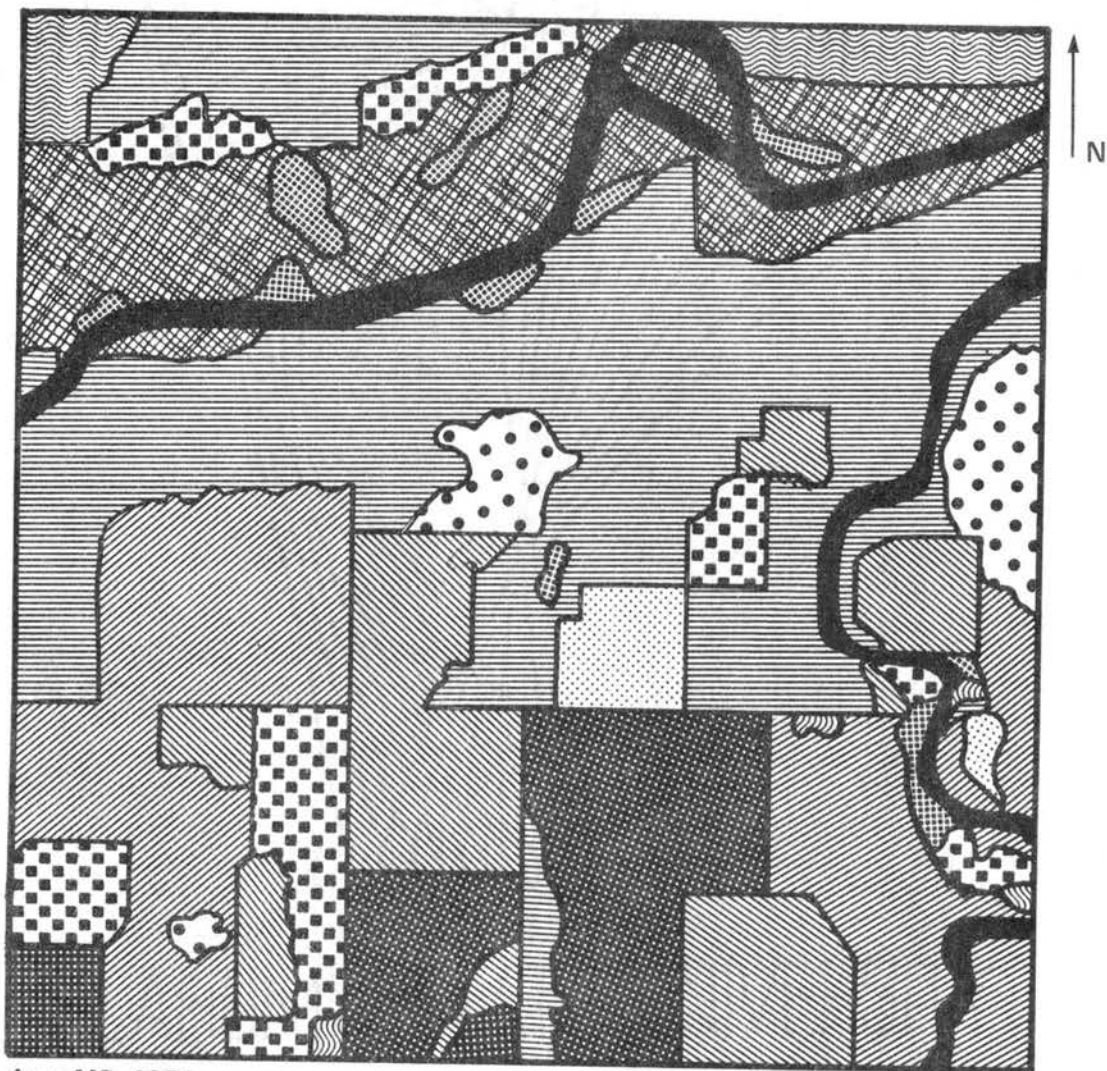
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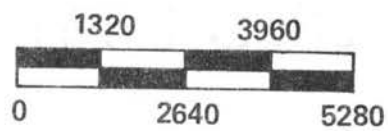


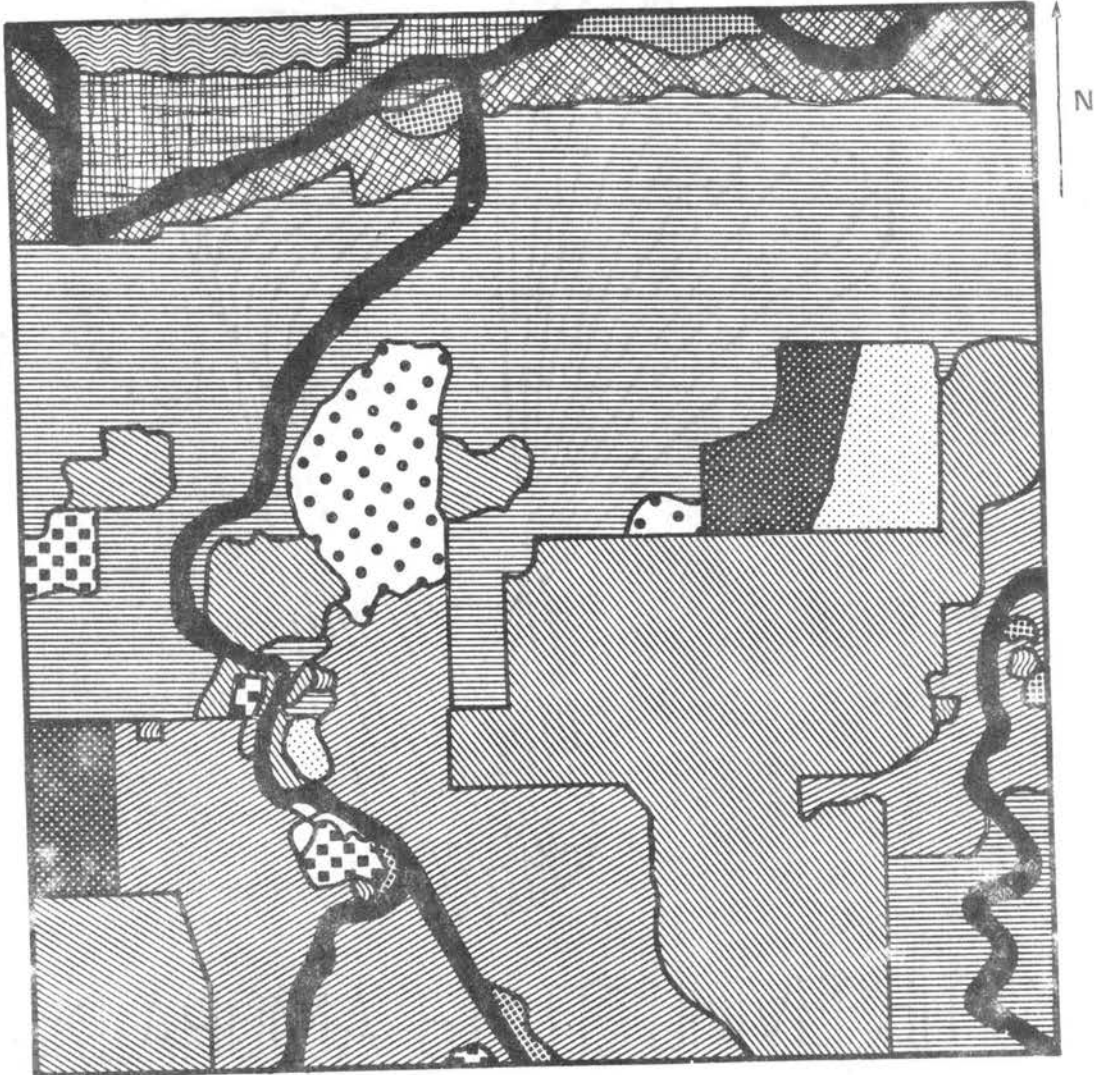
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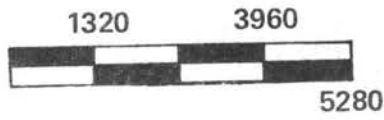


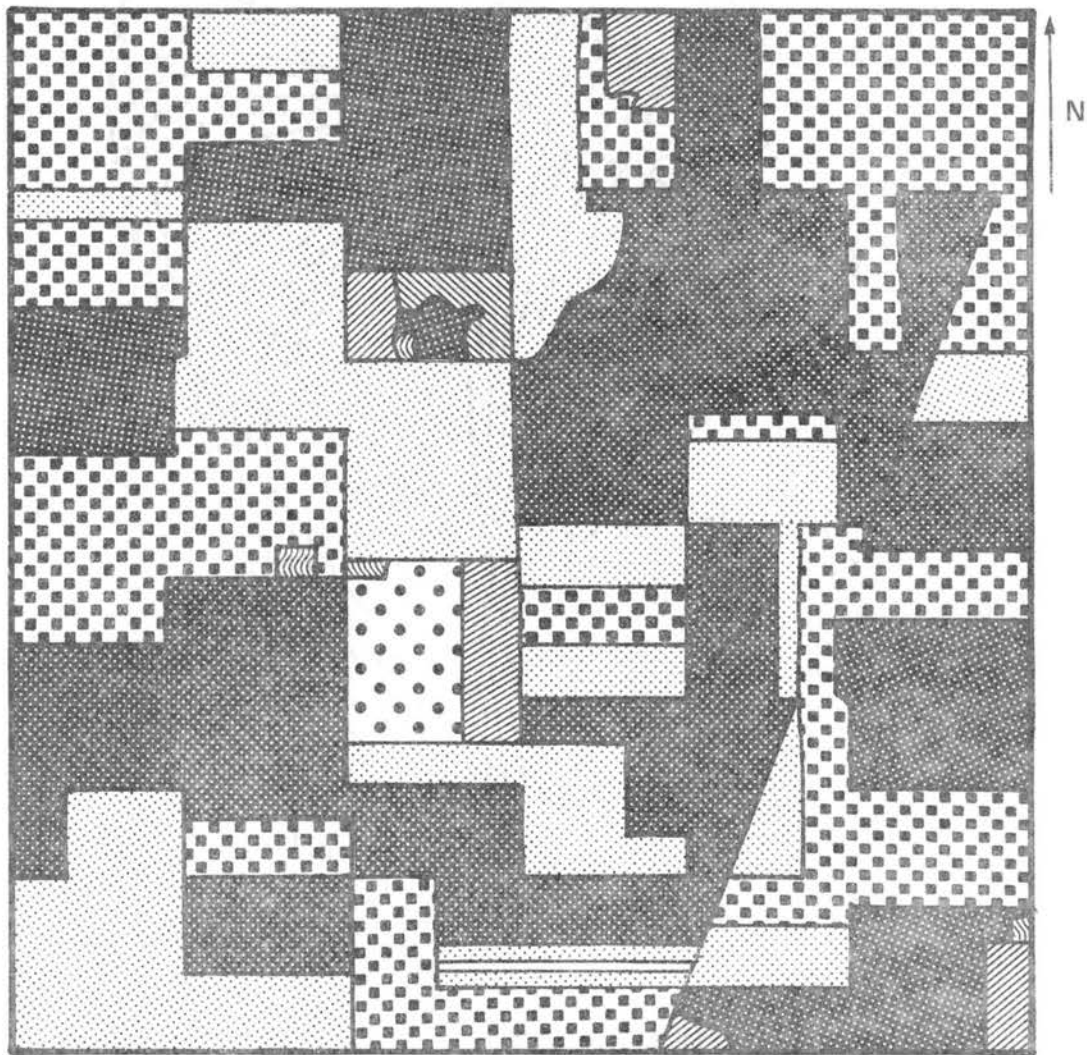
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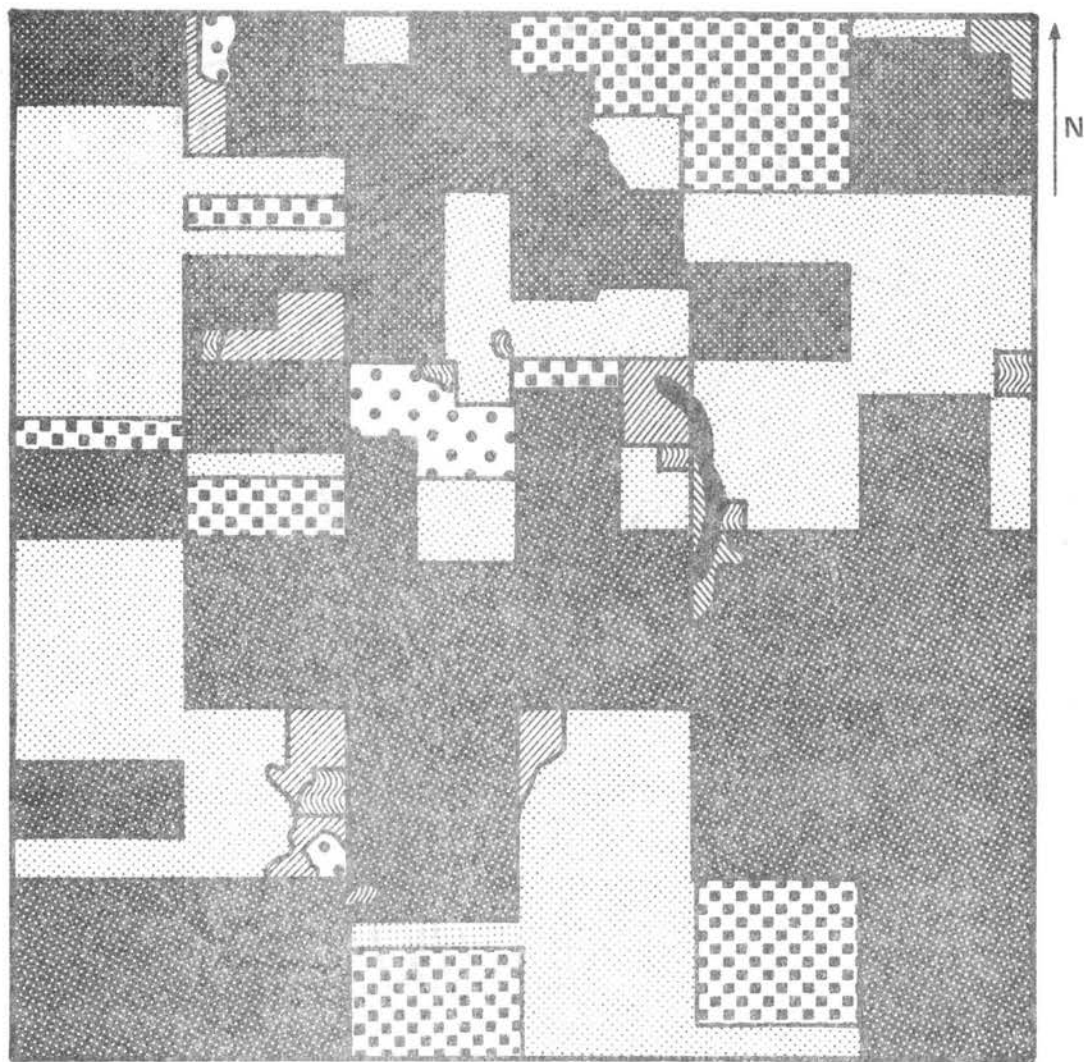
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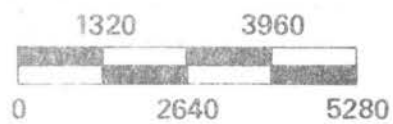


Area H3 1971

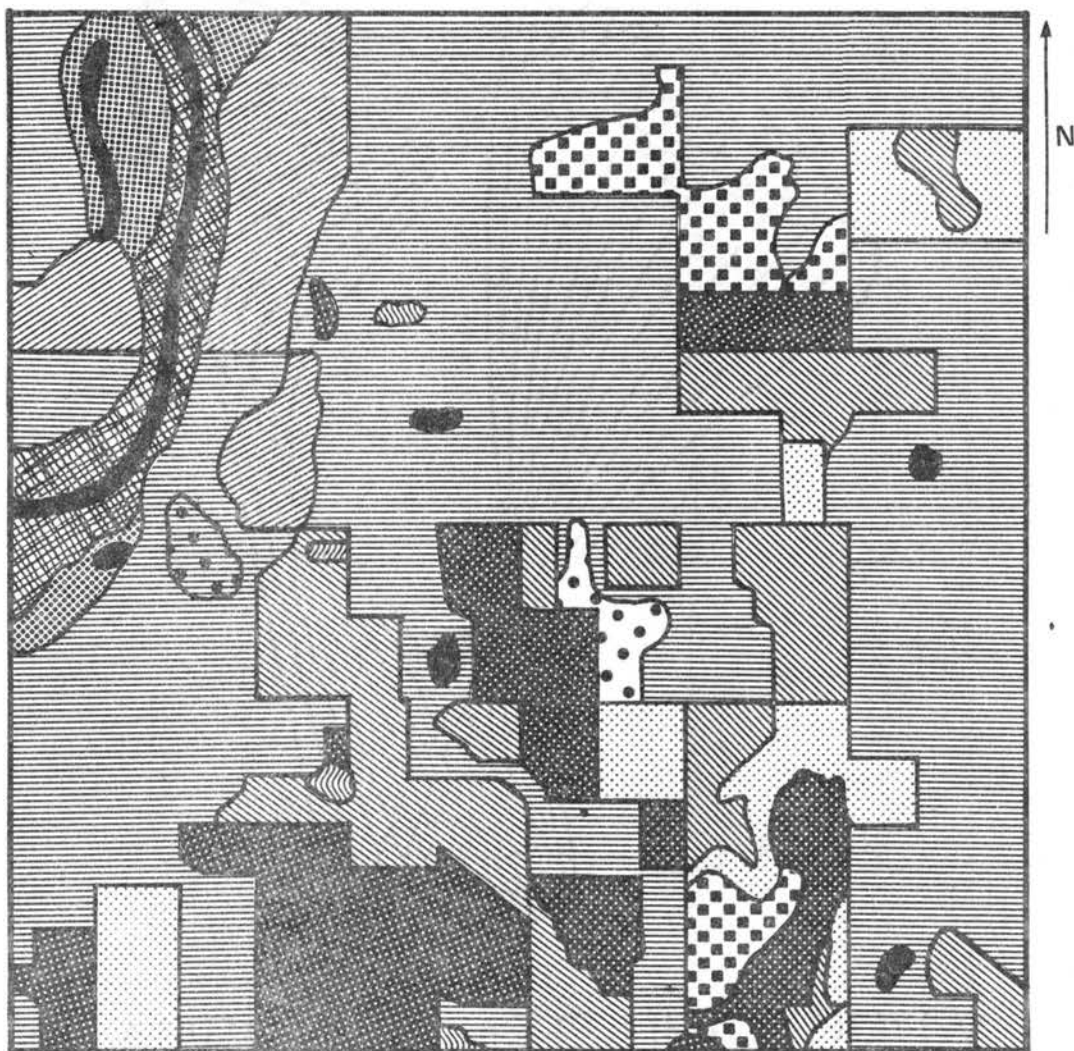




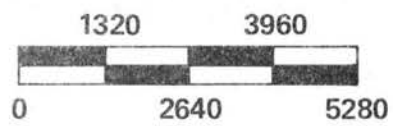
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Area L3 1971



## APPENDIX E

### RECOMMENDATIONS FOR PRESERVATION AND MANAGEMENT OF BURROWING OWLS

1. Intensive efforts should be made to preserve dog towns containing high concentrations of burrowing owls. Means of preservation might include the following: (a) purchase of dog town or at least an easement by an appropriate governmental agency (state or federal) or by private conservation groups; (b) periodic payments to the landowner as compensation for damages or loss of agricultural profits inflicted by prairie dogs. Both measures should probably include an agreement to restrict the dog town to a designated size. This could be accomplished by periodic population control at peripheral burrows, taking care that owl burrows are not destroyed.
2. Dog towns where poisoning campaigns are planned, should be thoroughly surveyed during the owl nesting season to identify those containing owl populations of high density. A count of nest burrows would give a more accurate idea of the breeding density of owls, especially if surveys are conducted at midday, during periods of high temperatures or when wind velocity exceeds 10 miles per hour. Surveys conducted for owls in dog towns in Oklahoma would have very little value from October through March.
3. Refuge dog towns should be established at regular intervals throughout an area. Preferably, these might be the dog towns mentioned

previously that contain owl populations of high density. If poisoning is unavoidable, efforts should be made to trap and transplant to refuge dog towns at least a part of the associated owl populations. Techniques such as transplanting entire broods to encourage the owls to remain in transplant areas, would need to be adequately tested. At the very least, dog towns should be established on all national wildlife refuges, national grasslands, and other public lands, possibly including school lands, in areas throughout the range of western burrowing owls. These dog towns on existing public lands could then act as the "refuge" dog towns for burrowing owl populations.

4. Poisoning of dog towns with treated grain should be restricted to January and February, in order to minimize deleterious effects on burrowing owls. Distributors of poison and poison grain should be required by law to obtain at least one year's notice before dispensing their products to those intending to poison dog towns. This stipulation would allow adequate time for: (a) surveys of owl populations during the nesting season, as outlined in Recommendation 2, in order to identify dog towns where preservation efforts might be initiated, as described in Recommendation 1; and (b) trapping and transplanting owls, as mentioned in Recommendation 3; if preservation of the dog town is not assured and if owl populations warrant these efforts.
5. Poisoning of dog towns during late spring and summer, if allowed at all, should be restricted to fumigation of burrows unoccupied by burrowing owls. Nest burrows are easily identified, and scolding adult owls, owl droppings, tracks, etc. reveal the presence of

owlets that take shelter in burrows other than nest burrows.

Poisoning by fumigation should reduce chances of secondary poisoning of non target species.

6. Preservation of burrowing owls should be encouraged by educating the public about values of burrowing owls including: (a) high aesthetic value--nature study, photography, etc.; (b) beneficial food habits--insect and rodent control; (c) historic significance of the species so intimately associated with western prairies and so unique in its underground nesting habits; and (d) general ecological value as an indicator of environmental health and as an integral component of the prairie ecosystem.

## APPENDIX F

### RECOMMENDATIONS FOR FUTURE STUDIES OF BURROWING OWLS, ESPECIALLY THOSE ASSOCIATED WITH PRAIRIE DOGS.

Results of this research obviously did not provide complete information on every aspect of burrowing owl ecology. For brevity, the following is a listing of questions that should give an idea of needs for future studies.

#### Relationships Between Owl Physiology and Environmental Conditions in Winter

1. Do owls stockpile food in burrows, or eat more prior to onset of adverse weather such as blizzards?
2. What physiological or environmental conditions trigger owls to retreat into burrows for a few days (at least 72 hours)--physical entrapment in burrows (blockage by snow), or a physiological response to environmental conditions (temperature, wind, moisture, barometric pressure, etc.)?
3. What are environmental conditions in burrows containing wintering owls, as compared to conditions outside the burrows?
4. Do owls ever manifest physiological alterations, such as a mild torpid state, during winter? This question, as well as number 2, might be best answered through studies under laboratory conditions.

### How Poisoning Prairie Dogs Affects Owls

1. How substantial is owl mortality due to poisoning of prairie dogs?
2. What are mechanisms by which owls are poisoned--direct ingestion of treated grain that adheres to their feet, or ingestion of grain from stomachs or cheek pouches of rodents they capture.
3. What are physiological and behavioral manifestations in owls receiving lethal and sublethal dosages of poisoning? Studies performed under laboratory conditions might prove useful in answering numbers 2 and 3.

### Establishment of "Refuge" Dog Towns for Owls

1. What are practical techniques for transplanting and establishing owls in "refuge" dog towns?
2. What is the maximum density that owl populations in dog towns will successfully maintain?

### Miscellaneous Information on Life History Obtainable Through Intensive Study of a Distinct Owl Population (e.g. in One Dog Town)

1. What are precise dates and patterns of migration and dispersal movements?
2. What percentage of the population overwinters, and what are activity patterns of wintering owls in relation to environmental conditions?
3. What is the survival rate, and what are important mortality factors?
4. Do prairie dogs ever commandeered active owl burrows or prey on owl nests?

VITA 2

Kenneth Olin Butts

Candidate for the Degree of

Master of Science

**Thesis:** LIFE HISTORY AND HABITAT REQUIREMENTS OF BURROWING OWLS IN WESTERN OKLAHOMA

**Major Field:** Wildlife Ecology

**Biographical:**

**Personal Data:** Born in Higgins, Texas, January 22, 1948, the son of Ted K. and Vivian Butts.

**Education:** Graduated from Higgins High School, Higgins, Texas, in May, 1965; received the Bachelor of Science degree (Magna Cum Laude) from Bethany Nazarene College, Bethany, Oklahoma, in May, 1969, with a major in Biology; completed requirements for the Master of Science degree at Oklahoma State University in December, 1973.

**Professional Experience:** Student Biological Aide, U. S. Fish and Wildlife Service, Division of Fishery Services, Valentine, Nebraska, Summer, 1968; Senior Laboratory Assistant in Biology Bethany Nazarene College, Bethany, Oklahoma, 1968-69; Biological Technician, U. S. Fish and Wildlife Service, Clark Salyer National Wildlife Refuge, Upham, North Dakota, Summer, 1969; Graduate Teaching Assistant in Zoology, Oklahoma State University, Stillwater, Oklahoma, 1969-70; Graduate Research Assistant, Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University, 1970-71; Wildlife Biologist, U. S. Fish and Wildlife Service, Division of River Basin Studies, Decatur, Alabama, 1971-73; Fish and Wildlife Biologist, U. S. Fish and Wildlife Service, Division of River Basin Studies, Atlanta, Georgia, 1973.

**Honorary and Professional Societies:** Associate Member of the National Nazarene Honor Society; The Wildlife Society; and the Georgia Chapter of The Wildlife Society.