# Distribution, Habitat, and Reproductive Success of Burrowing Owls on Holloman Air Force Base

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## Introduction

The Western Burrowing Owl (BUOW, *Athene cunicularia hypugaea*) is classified by the US Fish and Wildlife Service as a Species of Concern (formerly Federal Candidate 2 species) and as an informal Species of Concern by the state of New Mexico. Burrowing Owls are common in New Mexico (Draft: Partners in Flight State Conservation Plan 1997), and New Mexico is the second most important wintering area, behind California (James and Ethier 1989). With BUOW populations declining in other states, it is important that New Mexico populations be conserved. This study of Western Burrowing Owls was conducted at Holloman Air Force Base (HAFB), NM, between April, 1996, and July, 1997.

Burrowing Owls inhabit flat, open areas surrounded by short grass or bare ground and frequently nest near areas of human activity, such as golf courses and airports. They typically use burrows constructed by other animals, historically prairie dogs. With the decline of prairie dogs in the west, Burrowing Owls have adopted burrows abandoned by other species, including kit fox, coyote, and bannertail kangaroo rats. At HAFB they typically use badger, fox, and ground squirrel burrows. BUOWs are thought to be limited by the availability of burrows (Draft: HAFB Sensitive Species Management Plan), although this has yet to be established for HAFB. Availability of elevated perches nearby may also influence burrow selection (Green 1983). Threats to BUOWs include conversion of habitat to agriculture or pavement, pesticide use, control of burrowing mammals, and human disturbance of burrows and breeding areas (Draft: HAFB Sensitive Species Management Plan).

The threats to Burrowing Owls at HAFB vary according to burrow location. The majority of owls at HAFB nest in areas of heavy human activity, such as near the high speed test track or on the airfield. Owls appear to be attracted to these areas for a variety of reasons, including soil disturbance and insect-attracting lighting. Pairs in these areas are potentially impacted by construction, vehicle traffic, and other military activities. There is concern that owl burrows on the airfield have potential to flood and short out the runway lighting; therefore, HAFB plans to relocate owls nesting within approximately 7 m of runways and taxiways. In the dunes and arroyos, owl nesting efforts may be impacted by military activities such as training (Draft: HAFB Sensitive Species Management Plan). Burrowing Owls at HAFB thus have a complex relationship with humans, such that certain types of human activities enhance Burrowing Owl success, while others have negative impacts.

The aim of this study was to begin to identify the Burrowing Owl conservation issues on HAFB. We surveyed the developed areas of the base, where human disturbance of the natural landscape is highest, contrasted with surveys of more natural areas such as dunes and arroyos, to determine whether the owls were concentrated in either type of habitat. We also attempted to compare nesting success of nests in the two areas, an effort that met with limited success, due to the small number of nests located in natural areas. We measured habitat characteristics and monitored fledging success at active nests. These data provide the foundation for a description of Burrowing Owl habitat use on Holloman. Combined with information on human impacts on base, our data allow us to begin to identify conservation issues and make management recommendations. These subjects will be addressed in detail in the Sensitive Species Management Plan and the Integrated Natural Resource Management Plan, both currently in preparation by the New Mexico Natural Heritage Program.

## Methods

### 1996 Breeding Surveys

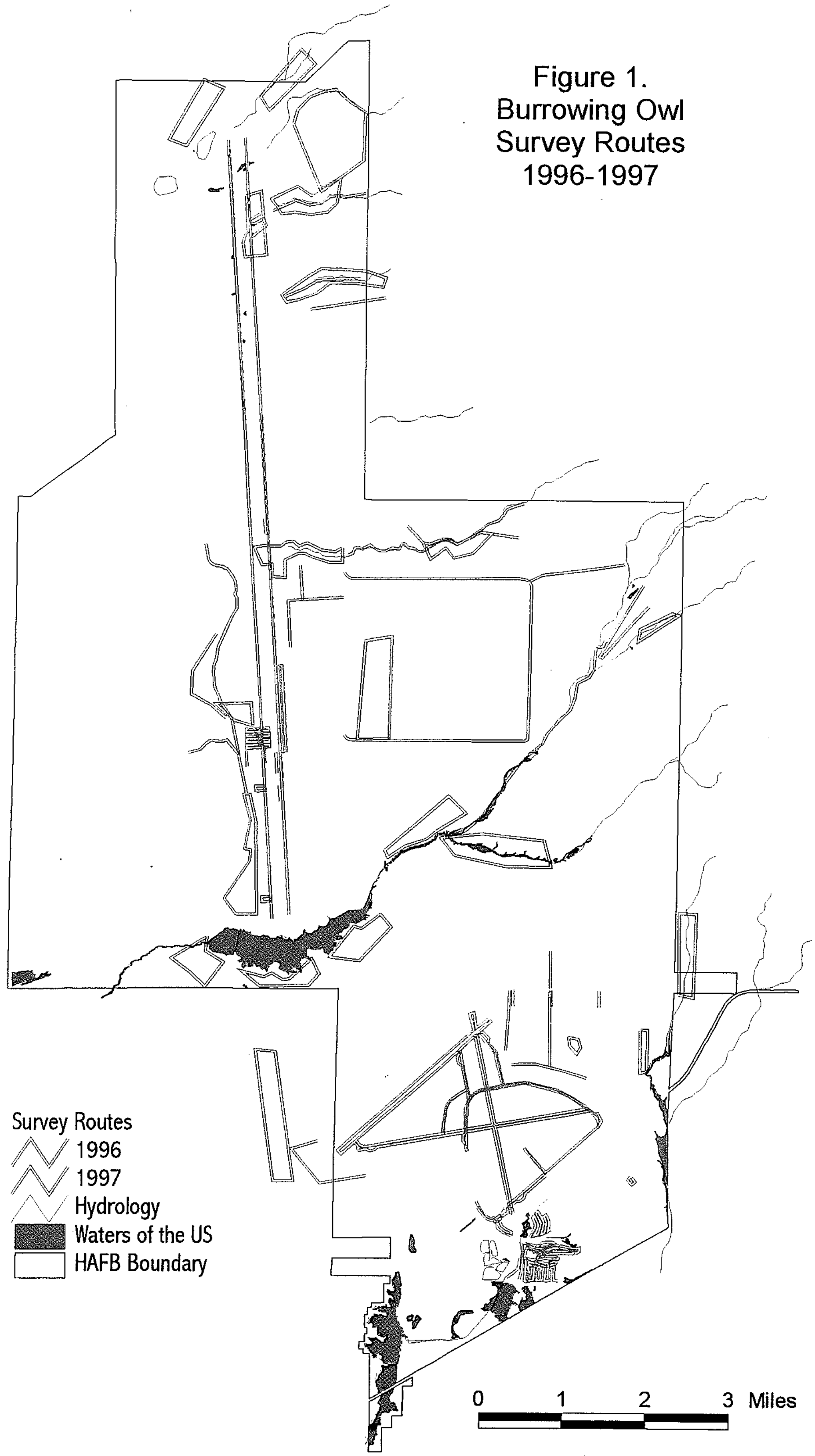
Surveys were conducted between mid-April and late May, 1996. Auditory surveys began four hours before sunset on non-windy days. We walked line transects down the center of each draw (Figure 1). We surveyed transects within three management areas on base: test track (4), cantonment (17), and north (4).

Depending on the topography of the draw, from 150 to 300 m was traveled between survey points; the tape broadcast could be heard up to 300 m if wind conditions permitted. We also played the tape in branches off the main draws. At each point along the roadside or draw transects, we employed a 15-minute survey procedure. The initial five minutes involved scanning the terrain for owl activity with 10 X 50 binoculars. Owls could be visually detected from up to 150 m with the aid of binoculars. While turning in all directions, we played a one-minute broadcast of the male's territorial call, *coo cooo*, through small Radio Shack external speakers. The broadcast was repeated again after five minutes. During and after each broadcast, we scanned the observation site for four minutes in search of owl response and activity. We also conducted several road-side surveys during which we stopped every 4/10 of a mile (approximately 600 m), or when we encountered owls or suitable owl habitat, to broadcast calls and scan for owls.

### 1997 Breeding Surveys

Surveys were conducted from March 20 to 27 and April 5 to 11, 1997. These months should have included early courtship and incubation behavior of Burrowing Owls, when they would be most responsive to territorial calls. The survey protocol was modified slightly in 1997 to cover the survey areas more efficiently. In 1997 we surveyed transects within four management areas: test track (10), cantonment (3), north, (18), and dunes (6).Surveys began four hours after sunrise and four hours before sunset. In 1997, transects were walked along both edges of each draw and playback points were situated at 300 m intervals. We also played the tape in branches off the main draws. At each stationary point, we broadcast a recording of Burrowing Owl territorial calls after an initial two-minute visual scan of the area. We played the recording for one minute while turning in all directions and followed up with another two-minute scan. We then repeated another broadcast and visual scan to conclude the eight-minute procedure. The amplifying speakers on our compact cassette player could broadcast sound 300 m, such that broadcast ranges of adjacent points overlapped.

Figure 1.
Burrowing Owl
Survey Routes
1996-1997



Our walking transects typically covered less than a mile, approximately 1500 to 1800 m, and consisted of five to six broadcast points. Owls typically flushed at 30 to 40 m. We also conducted several road-side surveys during which we stopped every 4/10 of a mile (approximately 600 m), or when we encountered owls or suitable owl habitat, to broadcast calls and scan for owls.

**Nest Monitoring**

To determine nest status/stage, the observer watched the burrow from at least 50 m away for about ten minutes. When monitoring earlier in the season, the tape broadcast was played to elicit a response. Later in the season, when response rate to tapes appeared lower, the observer relied solely on visual monitoring. If owls were detected at their burrows, the number of adults and fledglings was noted, and they were not disturbed. If no owls were seen within ten minutes, the observer walked to the burrow and checked for any obvious disturbance (e.g. predation, human tampering, collapse due to rain, etc.).

**Winter Surveys**

During December, 1996, and January, 1997, we checked all burrows that had been active during 1996 breeding surveys, to determine whether owls were overwintering in breeding season burrows. Winter surveys were conducted using procedures similar to those used in nest monitoring (above).

**Burrow Attributes**

All burrows currently or previously occupied by owls were classified as follows. Historical burrows were burrows known to have been occupied in the past or in a previous survey, but not in the current year. Nesting burrows were classed as either successful burrows, which fledged young in 1996 or 1997; failed burrows, which were 1996 or 1997 nesting burrows known to have failed due to unknown causes; destroyed burrows, known to have been destroyed by human activity or natural occurrence, or success unknown burrows, which were used for nesting in 1996 or 1997, with the outcome of the nesting effort unknown; i.e., signs of nesting were observed but fledglings were never seen. Auxiliary burrows were associated with nesting burrows, but were not used as natal burrows. Auxiliary burrows are frequently used by fledglings or adults for shelter from predators and inclement weather.

At each nest burrow, a series of habitat variables within a 15 m radius of the burrow was measured: the percent of area covered by four-wing saltbush (*Atriplex canescens*), ephedra (*Ephedra spp.*), mesquite (*Prosopis glandulosa*), alkali sacaton (*Sporobolus airoides*), gypgrass (*S. nealleyi*), forbs, soil with cryptogams, gravel, sandy soil, litter, manmade debris, and pavement.

We took GPS coordinates at each historical, auxiliary, and nest burrow. From each nest burrow, the height and distance to the two nearest shrubs was measured in the four cardinal directions. We estimated the distance from the active burrow to the nearest high perch, roadway, shrub, and auxiliary burrow. To obtain an estimate of burrow density we recorded the number of available, open burrows and burrows with owl sign within a radius of 40 m around each nest. We recorded orientation and dimensions of the burrow entrance. We later posted warning signs 10 m away from each nest and auxiliary burrow to limit disturbance and deter foot-traffic.

Using Mann-Whitney U tests, we compared attributes of nest burrows in areas of high and low disturbance. High disturbance nests were subjectively defined as those adjacent to frequently used roads and other high activity areas, while low disturbance nests were defined as those located along infrequently used roads or areas.

Assuming that more densely-spaced burrows are in preferred habitat, we compared attributes of isolated versus closely-packed nest burrows, also using Mann-Whitney U tests. Because high-density nests tended to be found in high-disturbance areas, only variables that differed between high and low disturbance nests were tested (distance to high perch, nearest shrub, and road; % shrub cover). Owls interacted socially with owls from burrows that were less than, but not greater than 600m away. We therefore defined closely-packed burrows as being less than 600m from the nearest burrow, and isolated burrows as more than 600m from the nearest burrow.

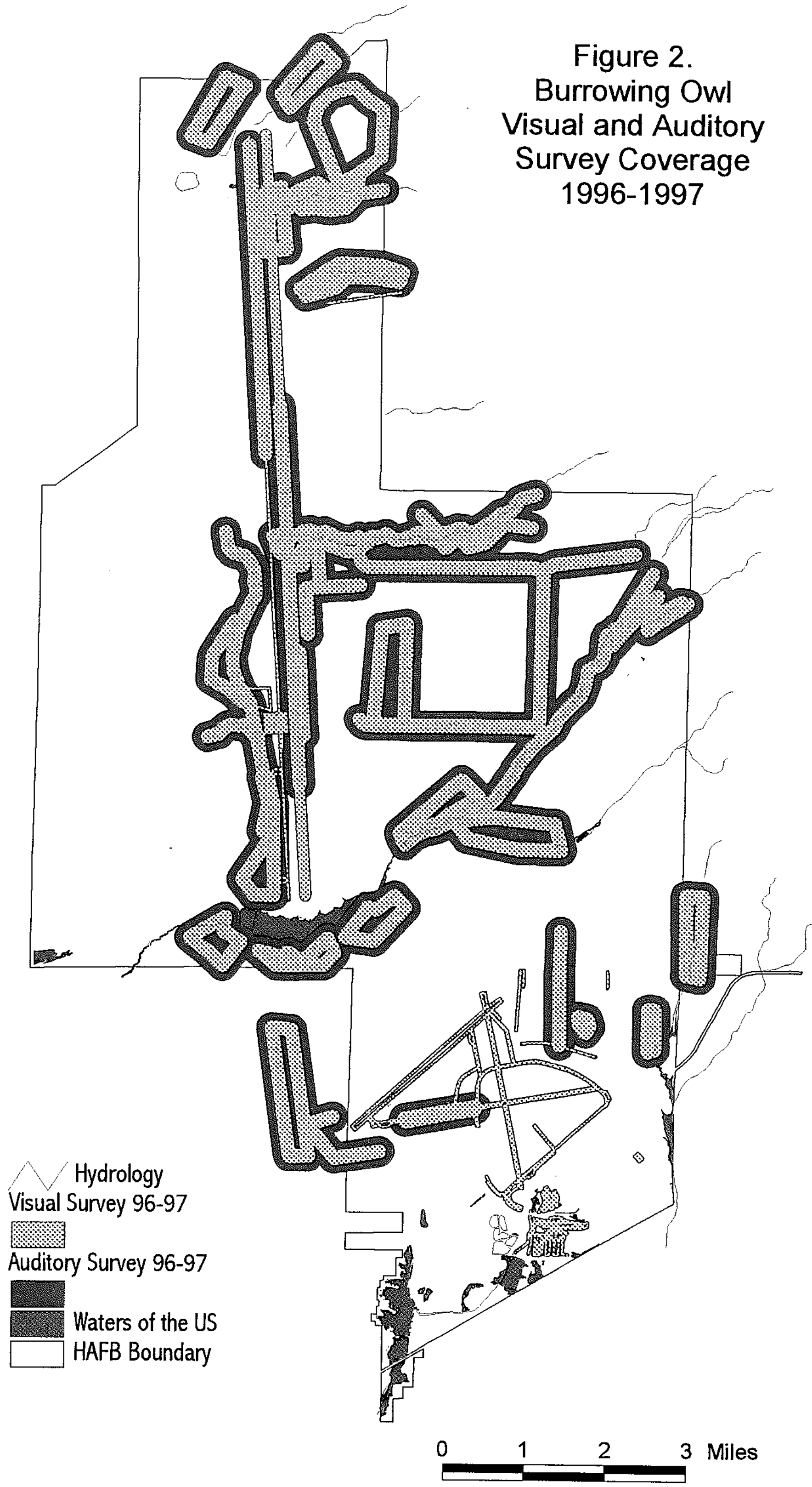
**Burrow Availability on Transects**

Burrow availability assessments were made to enable us to compare burrow availability in areas with and without burrows. For most draws or other natural areas surveyed in 1997, and for a sample of areas with large numbers of occupied burrows, we conducted from one to eight (mean=3.61) walking burrow-availability assessments. While walking along 300 m sections of a transect, the surveyor counted the number of unoccupied burrows with an owl-sized entrance within a 5 m visual radius. The counts were conducted on alternating 300 m sections of transects. Thus, different draws yielded differing numbers of burrow availability counts, depending on the lengths of the transects in those areas. Burrow densities were calculated for each draw or other area by dividing the number of available, unused burrows counted by the number of 300 m segments sampled to get a mean number of available burrows per area.

**GIS Mapping**

GPS coordinates were taken at each historical, auxiliary, or nesting burrow, and at the end points of each survey transect. GPS data were differentially corrected to account for selective availability and used to develop ArcInfo GIS coverages. Field notes were added to coverages as attributes. Additional buffer coverages were generated to represent the auditory and visual limits of the surveys (Figure **2**). The total length of transects surveyed, as well as the area covered visually and auditorially was computed using ArcInfo.

Figure 2.
Burrowing Owl
Visual and Auditory
Survey Coverage
1996-1997



## Results

**Surveys**
In 1996, surveys focused on areas of the base more disturbed by human activity, where owl activity is concentrated. In 1997, we covered primarily the more natural draws and dune areas not covered in 1996 (Figure **1**). A total of 247,058 m of linear transects was surveyed in the two years (Figure **1**). Assuming that surveyors are able to detect owls up to 150 m away using binoculars, and 300 m away by ear, the visual surveys covered 42,727,273 $m^2$ (4,272 ha), and the auditory surveys covered 65,923,831 $m^2$ (6,592 ha, Figure **2**).

**Table 1**. Transects surveyed for Burrowing Owls,1996-97, by HAFB management area.

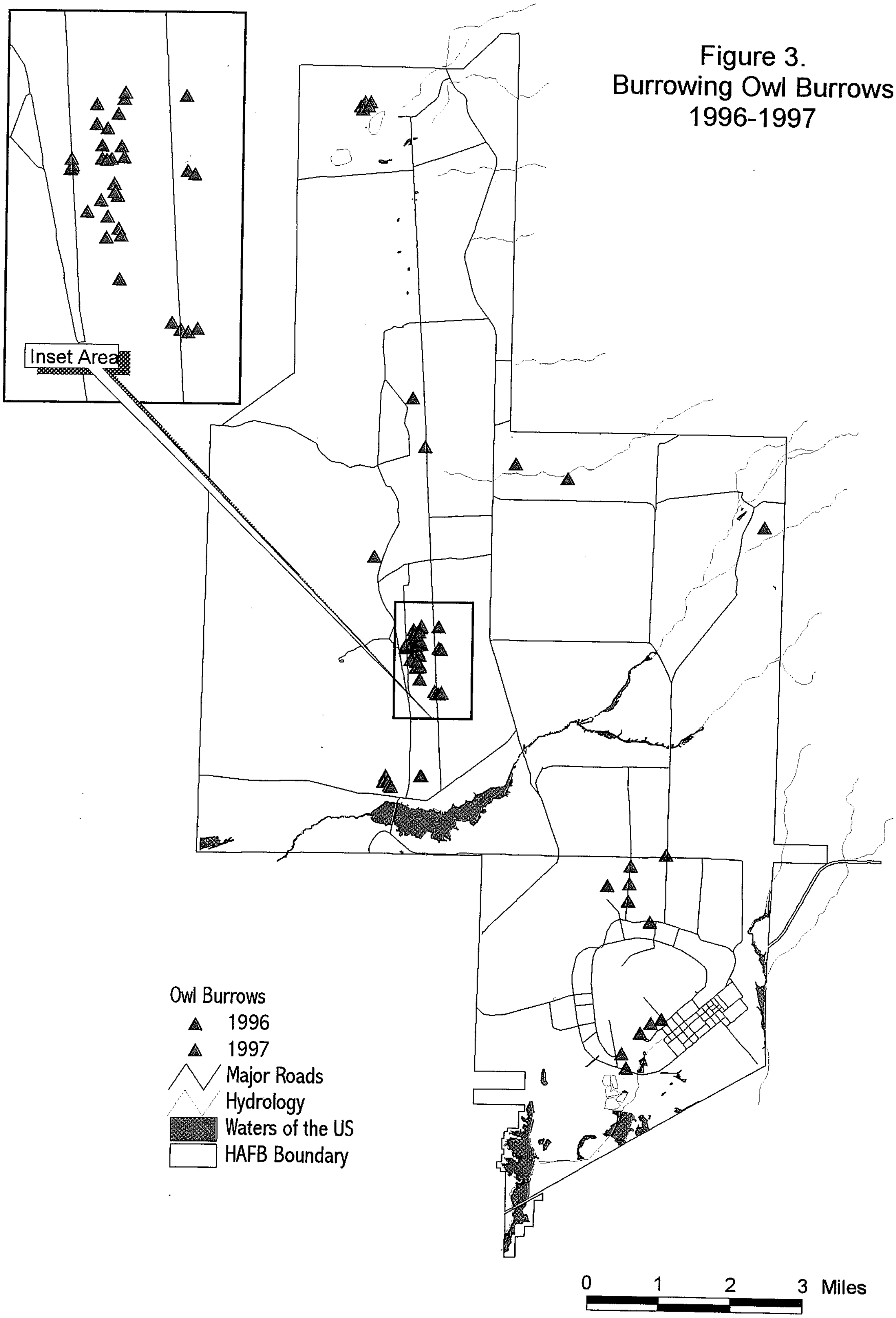
| (Site #) Transect # | Transect location | Management area | Date | Owls |
|---|---|---|---|---|
| 36 | Borrow pit | Cantonment | 5/8/96 | N |
| 37 | Golf course-all | Cantonment | 4/17/96 | N |
| 38 | Soccer field | Cantonment | 4/17/96 | N |
| 39 | Air/taxiway a-loop | Cantonment | 5/10/96 | Y |
| 40 | Air/runway 7(f-l) | Cantonment | 5/25/96 | N |
| 41 | Air/taxiway e | Cantonment | 5/11/96 | N |
| 42 | Air/runway 4-22 | Cantonment | 5/11/96 | Y |
| 43 | Air/runway 7-golf-4 | Cantonment | 5/11/96 | N |
| 44 | Air/above Base Ops | Cantonment | 5/10/96 | N |
| 45 | Air/runway 34/16x7/25 | Cantonment | 5/10/96 | N |
| 46 | Air/taxiway d-delta | Cantonment | 5/11/96 | N |
| 47 | Air/taxiway-echo-f | Cantonment | 5/11/96 | N |
| 54 | Dezonia dirt | Cantonment | 5/11/96 | N |
| 55 | Douglas/Vandergrift | Cantonment | 5/9/96 | Y |
| 56 | Dezonia pave | Cantonment | 5/11/96 | Y |
| 57 | Dezonia pipe | Cantonment | 7/15/96 | Y |
| 58 | Softball/49er | Cantonment | 5/10/96 | Y |
| 8 | Lost River | Cantonment | 4/9/97 | N |
| 10 | Henniger grassland | Cantonment | 4/9/97 | N |
| 28 | Kelly Rd, radio tw | Cantonment | 3/21/97 | N |
| 12 | WSMR 10 corner | Dunes | 4/10/97 | Y |
| 13 | W track rd | Dunes | 4/11/97 | N |
| 14 | NW track | Dunes | 4/11/97 | N |
| 20 | Test track end | Dunes | 3/22/97 | Y |
| 20 | Test track end* | Dunes | 3/23/97 | Y |
| 31 | West of track29500 | Dunes | 4/5/97 | N |
| 2 | Allen Draw | North | 3/23/97 | N |
| 5 | Carter Draw | North | 3/20/97 | N |

| | | | | |
|---|---|---|---|---|
| 6 | Top Carter Draw | North | 3/27/97 | N |
| 7 | Dillard Draw | North | 4/8/97 | N |
| 9 | SE Lost River Draw (n half) | North | 4/8/97 | N |
| 11 | SE Lost River Draw (s half) | North | 3/27/97 | N |
| 15 | Tech data cntr rd | North | 4/6/97 | N |
| 16 | WSMR 9 grass | North | 4/7/97 | N |
| 17 | WSMR 9 (mid gravel rd) | North | 4/11/97 | N |
| 17 | WSMR 9 (n gravel rd) | North | 4/6/97 | N |
| 18 | NE lost river draw | North | 3/26/97 | N |
| 19 | W. Ritas | North | 4/8/97 | N |
| 21 | Tularosa Peak | North | 3/26/97 | N |
| 22 | W. Guilez | North | 4/6/97 | N |
| 23 | Sheepcamp Draw | North | 4/5/97 | N |
| 23 | Sheepcamp Draw* | North | 4/6/97 | N |
| 24 | Sheepcamp Draw2 | North | 4/6/97 | N |
| 26 | Hay Draw | North | 3/24/97 | N |
| 27 | W. Hay | North | 4/7/97 | N |
| 29 | Dillard Dump | North | 4/9/97 | N |
| 32 | Sheepcamp East Draw | North | 4/16/96 | N |
| 32 | Sheepcamp West Draw | North | 4/16/96 | N |
| 33 | Malone Draw lower | North | 4/15/96 | N |
| 33 | Malone Draw upper | North | 4/15/96 | N |
| 34 | Hay Draw | North | 4/14/96 | Y |
| 35 | Guilez Draw | North | 4/16/96 | N |
| 1 | Track 11200+ | Test track | 6/15/97 | N |
| 3 | Camera Pad (car) | Test track | 4/11/97 | N |
| 4 | Camera Pad Rd, channel | Test track | 3/22/97 | N |
| 25 | N Camera Pad | Test track | 4/10/97 | N |
| 30 | Test track97 | Test track | 4/11/97 | N |
| 49 | Track 10780+ | Test track | 7/10/97 | Y |
| 50 | Camera Pad954+ | Test track | 7/10/97 | Y |
| 51 | Camera Pad916+ | Test track | 7/10/97 | N |
| 52 | Camera Pad926+ | Test track | 7/10/97 | N |
| 53 | Track 8700+ | Test track | 7/10/97 | N |
| 59 | Test track car | Test track | 6/22/96 | Y |
| 60 | Test track walk | Test track | 6/23,7/17,-7/28-8/1/96 | Y |
| 61 | Camera Pad Road | Test track | 7/28/96, 7/30/96 | Y |
| 62 | Camera Pad arroyo | Test track | 4/18/96 | N |

**Table 2.** HAFB Burrowing Owl nests, 1996-97.

| Nest Id | Year | Max no. Adults | Date 1st Detected | Max no. Young | 1st date Young | Young? | Sign? | # Aux |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **Test track** | | | | | | | | |
| 1580 (mi.03w) | 1996 | 2 | 6/23/96 | 0 | | No | Yes | 1 |
| 8700 (mi.17w) | 1996 | 2 | 6/23/96 | 2 | 7/31/96 | | Yes | 0 |
| | 1997 | 1 | 3/22/97 | 1 | 5/12/97 | | Yes | 0 |
| 9700 | 1997 | 2 | 6/15/97 | 4 | 7/10/97 | | Yes | 4 |
| 10458 | 1997 | 1 | 6/12/97 | 2 | 6/12/97 | | Yes | 3 |
| 10780-c | 1997 | 2 | 6/12/97 | 3 | 7/10/97 | | Yes | 6 |
| 11205 (pole 69w) | 1996 | 2 | 6/22/96 | ? | | Yes | Yes | 2 |
| 11265 (pole 69e) | 1996 | 1 | 6/22/96 | 2 | 7/31/96 | | Yes | 1 |
| | 1997 | 2 | 3/22/97 | 5 | 5/12/97 | | Yes | 5 |
| 11537 (pole 71w) | 1996 | 1 | 6/22/96 | ? | | Yes | Yes | 0 |
| | 1997 | 1 | 3/22/97 | ? | | Yes | Yes | 1 |
| 11880 (pole 74w) | 1996 | 1 | 6/22/96 | 2 | 8/1/96 | | Yes | 1 |
| 12400 (pole 77w) | 1996 | 2 | 7/28/96 | 1 | 7/30/96 | | Yes | 1 |
| 12487 (pole 77e) | 1996 | 1 | 6/22/96 | ? | | Yes | Yes | 0 |
| | 1997 | 2 | 3/22/97 | 5 | 5/12/97 | | Yes | 2 |
| 12487-n | 1997 | 1 | 6/15/97 | ? | | Yes | Yes | 0 |
| 29500 (pole 181e) | 1996 | 2 | 8/21/96 | ? | | Yes | Yes | 1 |
| | 1997 | 2 | 4/5/97 | ? | | Yes | Yes | 2 |
| F916 | 1997 | 2 | 3/23/97 | 0 | | No | Yes | 2 |
| F916-c | 1997 | 2 | 5/27/97 | 2 | 7/10/97 | | Yes | 3 |
| F923 | 1996 | 1 | 7/17/96 | ? | | Yes | Yes | 2 |
| F926 | 1996 | 1 | 7/30/96 | ? | | Yes | Yes | 0 |
| F954 | 1997 | 2 | 5/27/97 | ? | | Yes | Yes | 2 |
| **Dune edge** | | | | | | | | |
| T12 | 1997 | 2 | 3/23/97 | 1 | 6/12/97 | | Yes | 2 |
| T01 | 1997 | 1 | 6/12/97 | ? | | Yes | Yes | 4 |
| Ws-c | 1997 | 2 | 4/10/97 | 0 | | No | Yes | 5 |
| **Cantonment** | | | | | | | | |
| 16x22rwy | 1996 | 2 | 5/11/96 | ? | | Yes | Yes | Na |
| 48 rescue | 1996 | 2 | 5/10/96 | 2 | 6/22/96 | | Yes | NA |
| 48th (26) | 1997 | 2 | 3/23/97 | 0 | | No | Yes | 1 |
| Txy1 | 1996 | 2 | 5/10/96 | 4 | 6/22/96 | | Yes | NA |
| Bong | 1997 | 2 | 3/23/97 | 1 | 7/10/97 | | Yes | 1 |
| 49er | 1996 | 2 | 5/10/96 | 2 | 6/21/96 | | Yes | NA |
| Dezonia s | 1996 | 2 | 5/11/96 | ? | | Yes | Yes | NA |
| Dezonia poles | 1997 | 2 | 3/27/97 | ? | | Yes | Yes | 2 |
| Dezonia flyway | 1997 | 2 | 5/27/97 | 3 | 6/12/97 | | Yes | 3 |
| **North** | | | | | | | | |
| Hay1(old) | 1996 | 2 | 4/14/96 | 0 | | No | Yes | 3 |
| Hay2(new) | 1996 | 2 | 7/29/96 | ? | | Yes | Yes | 3 |

Figure 3.
Burrowing Owl Burrows
1996-1997



The distribution of transects was based on a combination of factors: known presence of owls, available owl habitat, and historical reports of owls, such that transects were not evenly distributed among management areas (Table **1**).

**Nests and Burrows**

We found 18 nest burrows in 1996 and 19 in 1997 (Table **2,** Figure **3**), for a total of 37. In 1996 there were 15 auxiliary and 2 historical burrows, and in 1997 we found 48 auxiliary and 10 historical burrows (Figure **4**). Five 1996 burrows were re-used in 1997, but all others were newly occupied in 1997 (Table **2**).

In both years the management area with the largest number of occupied burrows (nest plus auxiliary) was the test track, with a total of 20 in 1996 and 42 in 1997. The number of nest burrows was also highest at the test track, with 11 in 1996 and 12 in 1997. The cantonment area had the second highest number of nest burrows in both years, but a large number of auxiliary burrows in the north area in 1996 resulted in the total number of burrows being higher in the north area than in the cantonment area in 1996. Similarly, in 1997 there was a large number of auxiliary burrows in the dunes, making the total number of burrows in the dunes higher than in the north or cantonment for that year. (Figure **4**).

There were 21 nests in areas of high disturbance, defined as located adjacent to frequently-used roads and other high-activity areas; and 11 in areas of low disturbance, defined as located along infrequently used roads or natural areas such as draws. Five nests were not included in the disturbance count because they were renestings at the same burrow in both years.

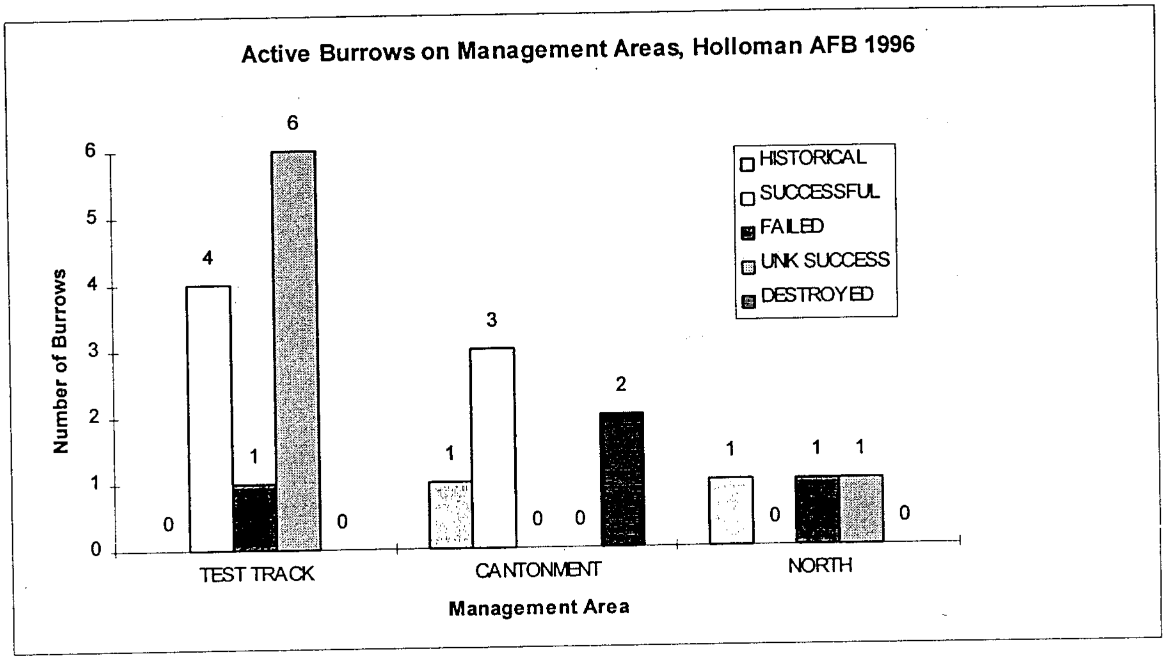
**Nesting Success by Management Area**

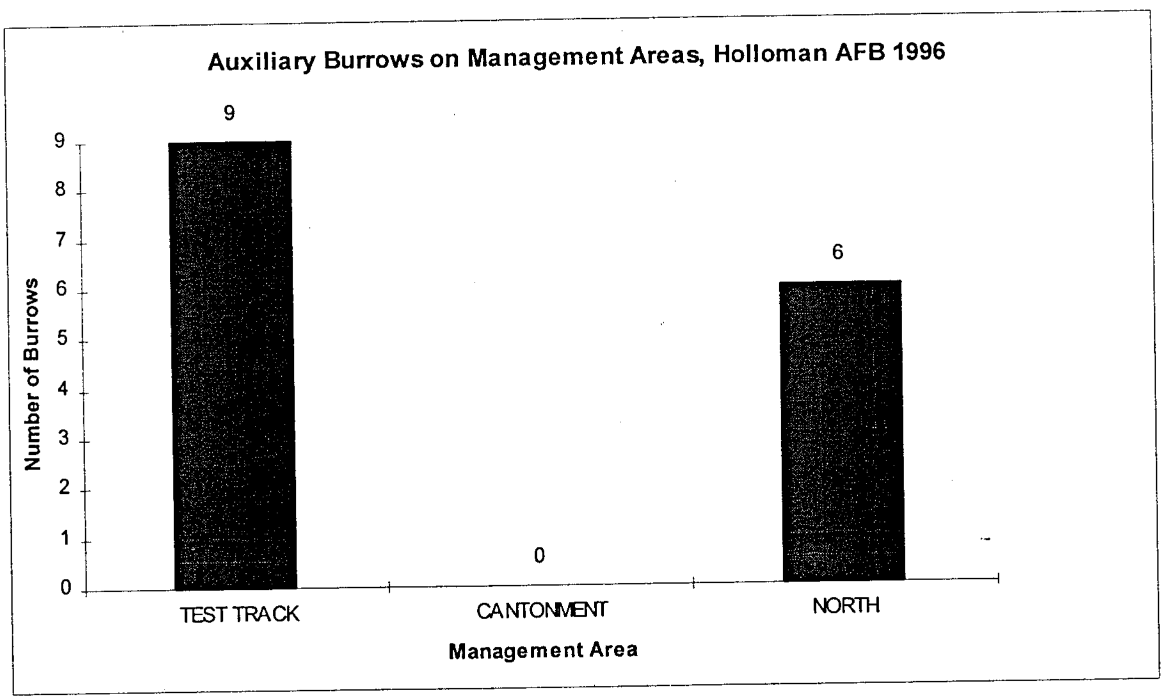
In spite of several nest failures due to military activities and natural events (see below), the owls on HAFB produced a minimum of 42 fledglings in 1996 and 1997 (Table **2**). The actual number of young produced is probably greater, due to gaps in the data. For 16 of the 37 nests we did not detect any fledglings. However, resources did not permit checking nests more than once or twice monthly, and some fledglings could have escaped our attention.

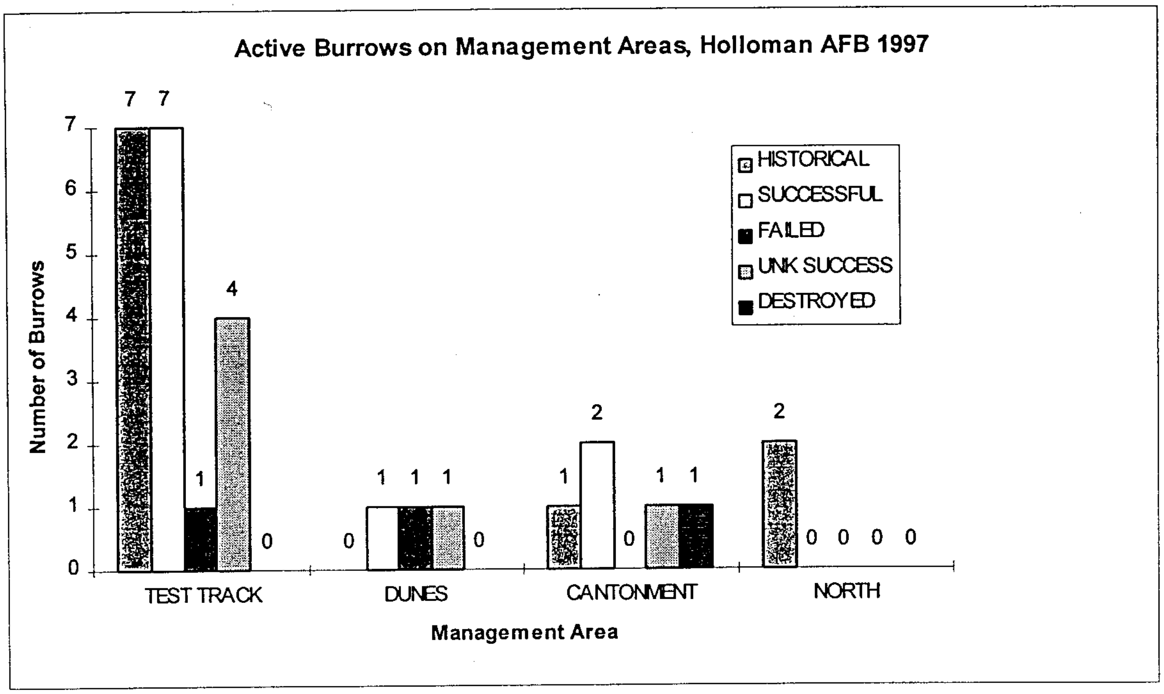
In 1996, the mean number of young fledged from nests known to be successful was 2.14 (range 1-4). For 1997 the mean number of young fledged was 2.7 (range 1-5, Table **2**). In 1996, 39% (7) of all nest burrows are known to have fledged young; in 1997, 53% (10) are known to be successful. However, in both years there were several nests for which we did not ascertain success. If only nests for which we know an outcome are included, success rates are 64% (N=11) for 1996 and 77% (N=13) for 1997 (Figure **4**).

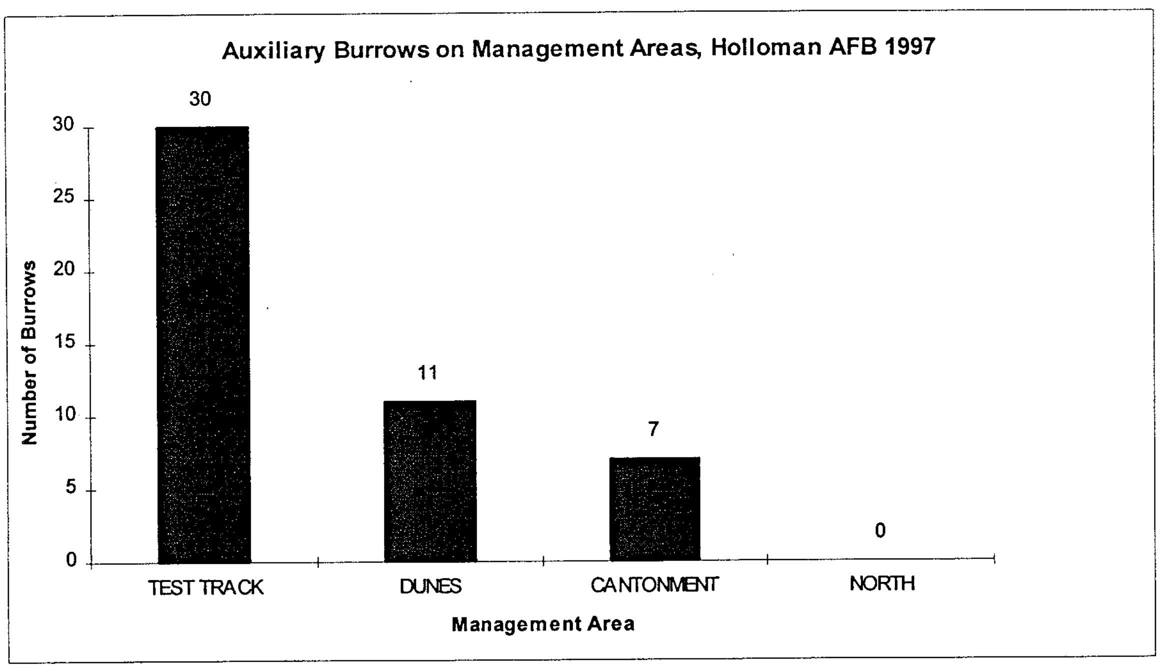
Fledging success was highest in the cantonment area in 1996 (60%) and the test track in 1997 (58%, Figure **4**). If only nests with known success rates are included, the highests success rates occurred at the test track in 1996 (80%) and 1997 (88%). Therefore, by both estimates of nesting success, the test track had the highest success rates, followed by the cantonment area.

**Figure 4**. Burrowing Owl burrows on HAFB, by management area, 1996-97.






## Disturbance and Abandonment

Nests were disturbed by natural events (N=3, 21%), such as flooding due to heavy rains, or human activities (N=11, 79%; Table 3), such as color-banding efforts, deliberate filling by maintenance crews, or vehicles parking nearby. Of all the nests that were disturbed by either natural events or human activities, 64% (9) were abandoned. Of the 11 that were disturbed by human activities, 55% (6), were abandoned. Thus, although owls tended to nest in areas where human activity was apparent, direct disturbance of nest burrows by humans, or human activities very close to burrows, resulted in high rates of abandonment.

**Table 3.** Causes of disturbance to Burrowing Owl nests on HAFB, 1996-97.

| Burrow ID | Date Owls Seen Before Disturbance | Date Dist. Discovered | Owl Response to Disturbance | Nature of Disturbance |
|---|---|---|---|---|
| **Test Track** | | | | |
| 0.03W (1580) | 6/23/96 | 7/28-8/1/96 | Abandoned | Semi trailer & port-a-potty within 10m from both burrows. |
| 69E (11265) | 7/31/96 | 1/29/97 | None, seen 2/16/97 | Yellow owl warning sign bent on ground with tire tracks on it. |
| 69E (11265) | 2/16/97am | 2/16/97pm | None, seen 3/22/97 | Burrows altered due to trapping. |
| 69W (11205) | 8/1/96 | 8/16-8/23/96 | Abandoned | Semi trailer 35m from burrow 3, tire tracks 15m from 2 & 3. |
| 77E (12487) | 2/16/97am | 2/16/97pm | None, seen 3/22/97 | Burrows altered due to trapping efforts. |
| F916 | 3/23/97 | 4/11/97 | Relocated to F916-C | 2 trailers parked 40m on each side of burrow. |
| F916-C | 4/11/97 | 6/12/97 | None, seen 6/12/97 | Grass mowed over burrow. |
| **Cantonment** | | | | |
| TXY1 | 8/22/96 | Prior to 12/7 | Abandoned | Burrow destroyed & filled by maintenance crew. |
| 48 RESCUE | 2/15/97 | 2/16/97 | Abandoned | Burrows altered due to trapping efforts. |
| 48TH (26) | 5/14/97 | 6/12/97 | Abandoned | Heavy rains have collapsed entire light conduit. |
| 16x22 | 5/11/96 | 7/12/96 | Abandoned | Heavy rains have collapsed entire pipeline. |
| BONG | 2/15/97 | 2/16/97 | None, seen 5/14/97 | Burrows altered due to trapping efforts. |
| 49er | 2/15/97 | 2/16/97 | Abandoned | Burrows altered due to trapping efforts. |
| DEZONIA S | 5/11/96 | 7/12/96 | Abandoned | Burrow filled due to rains. |

## Nesting Success, Natural, Disturbed, and Artificial Burrows

We looked at nesting success rates in areas with varying amounts of human activity and disturbance (Table **4**). In natural areas such as draws, dunes, and isolated areas near the test track, where human disturbance is low, known (minimum) success rates were also low: 0% (1996, N=5) and 28% (1997, N=7), although if unknown success nests are included, these rates could have been up to 80% and 71%, respectively.

**Table 4.** Actual and potential success rates of HAFB Burrowing Owl burrows by burrow substrate and degree of disturbance, 1996-97.

| Burrow Substrate | Degree of Dist. | N 1996 | N 1997 | % Success 1996 | % Success 1997 | % Pot. Success 1996 | % Pot. Success 1997 |
|---|---|---|---|---|---|---|---|
| Natural | Low | 5 | 7 | 0% | 28% | 80% | 71% |
| Natural | High | 8 | 8 | 50% | 75% | 87% | 100% |
| Artificial | High | 5 | 4 | 60% | 50% | 60% | 75% |

Some relatively natural areas had disturbance near nests, for example the test track. Success rates in these areas were much higher, 50% (1996, N=8) and 75% (1997, N=8), with potential rates up to 87% and 100%, respectively.

Finally, burrows that occurred in artificial sites such as pipelines and light conduits in the cantonment area were disturbed due to frequent human activity. Minimum success rates in these areas were 60% (1996, N=5) and 50% (1997, N=4), with potential rates up to 60% and 75%. Sample sizes are too small to allow for statistical tests of these data: however, it appears that areas of high human activity, which frequently resulted in abandonment, also yielded apparently greater nesting success.

**Burrow Availability**

Once we established a preference for burrows in areas of high human activity, we asked whether burrow availability would explain distribution of owl burrows. This question is best addressed using the GIS layers (Figure **5**). Using ArcInfo, we drew polygons in areas of high, medium, and low burrow availability, based on burrow availability counts done on transects. We overlaid the occupied-burrow layer to give the map shown in Figure **5**.

This map shows that there is not a direct correspondence between density of unused, suitable burrows and actual, inhabited burrows. For example, the transects on the northernmost part of the base had medium and high densities of available burrows, but almost no owls occupied these sites. The test track, with the highest number of active burrows of any management area on base, had active burrows scattered among areas with high, medium, and low availability. Burrow availability on the cantonment area was low on all transects (N=3). In spite of the apparently low availability of open burrows, the cantonment area had the second-highest concentration of active burrows.

**Burrow Attributes**

After establishing that Burrowing Owls prefer to nest in areas impacted by human activities, but that they are not choosing burrow based on burrow availability, we addressed the question of whether attributes of the burrows themselves may explain this preference (Tables **5** and **6**).

The means and standard deviations for vegetation measures, ground cover, and other burrow attributes around nests are given in Table **5**. The mean percent cover at active nests, including both years, was 11% for shrubs, 24% for grass and forbs, and 64% soil (including bare soil, soil with gravel, and soil with cryptograms). Thus, Holloman owls are found in typical Burrowing Owl habitat, with few shrubs, moderate amounts of grass, and the majority of the soil unvegetated.

Geology coverages of HAFB developed for the HAFB Integrated Natural Resource Management Plan allow us to lay burrow locations over the soil types layer, revealing the soil types in which owls nest. In 1997, two active and one auxiliary nest were situated on the edge of the dunes, in Active Duneland Gypsum soils (Arcview layers developed using Soil Conservation Surveys). All other burrows were situated in the Holloman-Gypsumland-Yesum Complex with 0-5% slopes. Given that all of HAFB, except for the dunes, draws, and limestone outcrop, is covered in this soil, this information does not provide significant insight into the influence of soils on Burrowing Owl nest site selection.

The newly-created Holloman vegetation map allows us to that owl burrows are found primarily in the gypgrass/alkali sacaton vegetation type, which can also be characterized by gypgrass/hairy coldenia (*Tiqulia hispidissima*, 57% of nests), followed by areas of military disturbance on gypsic crusts (26%), fourwing saltbush/gypgrass (14%), and monotypic alkali sacaton (0.01%).

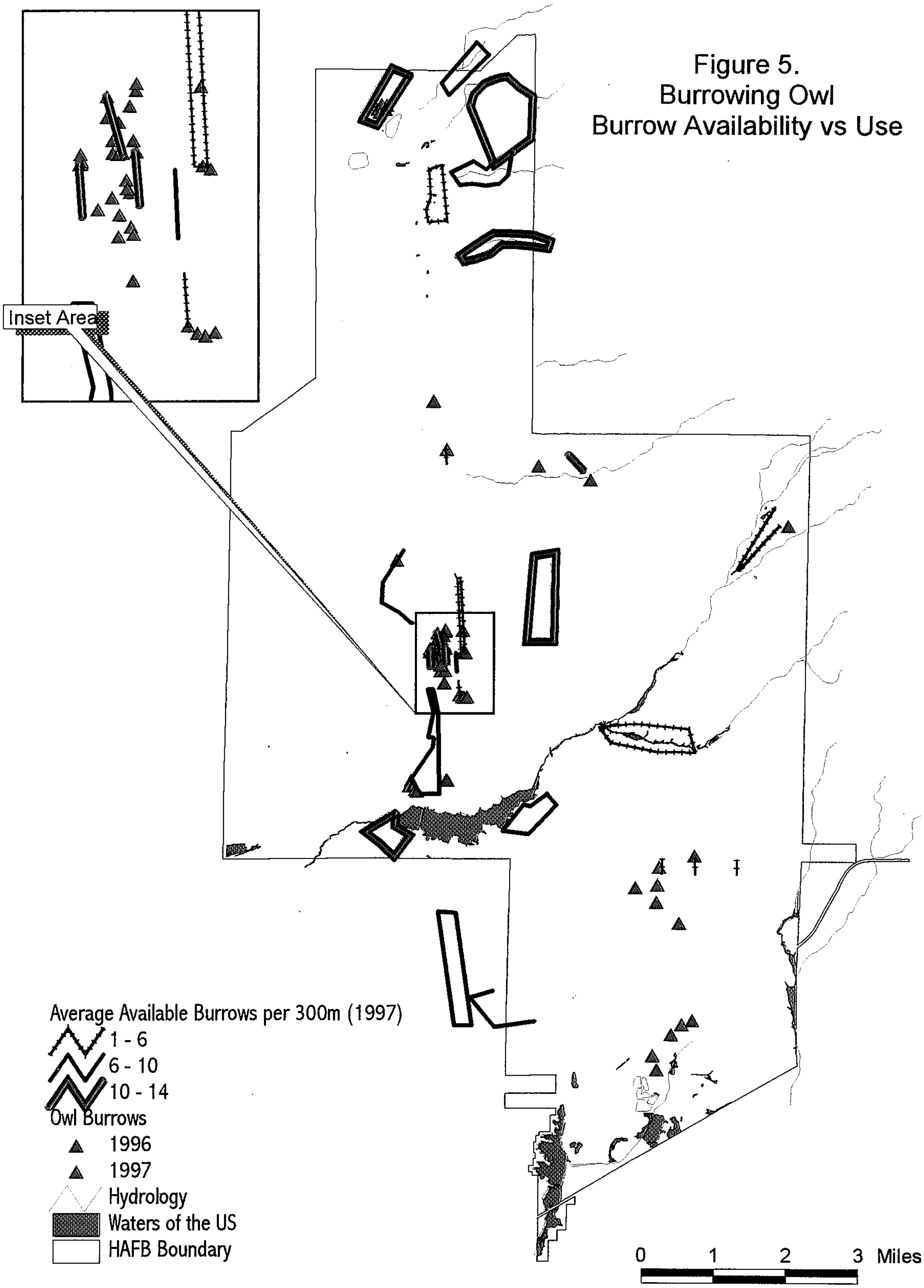


Figure 5.
Burrowing Owl
Burrow Availability vs Use
Inset Area
Average Available Burrows per 300m (1997)
1 - 6
6 - 10
10 - 14
Owl Burrows
1996
1997
Hydrology
Waters of the US
HAFB Boundary
0
1
2
3 Miles

**Table 5.** Attributes of active HAFB Burrowing Owl nests, 1996-97.

| **Percent Ground Cover (N=32 nests):** | **Mean** | **SD** |
|---|---|---|
| Four-wing saltbush | 9.78 | 7.76 |
| *Ephedra spp.* | 1.31 | 2.85 |
| **Total shrubs** | 11.09 | 8.32 |
| Alkali sacaton | 7.16 | 11.98 |
| Gypgrass | 8.91 | 8.05 |
| Forbs | 7.94 | 10.63 |
| **Total grass and forbs** | 24.00 | 13.69 |
| Soil with cryptogams | 38.13 | 31.00 |
| Soil with gravel | 6.84 | 14.13 |
| Bare soil | 18.88 | 34.10 |
| **Total soil substrate** | 63.84 | 26.20 |
| Litter (dead vegetation) | 1.09 | 5.35 |
| Pavement | 3.03 | 11.12 |
| | | |
| [1] **Distance (m) to tallest perch [N=31 nests]** | 31.84 | 18.49 |
| **Distance (m) to nearest burrow [N=30 nests]** | 11.28 | 13.29 |
| [2] **Number of available burrows [N=32 nests]** | 6.16 | 4.23 |
| **Distance (m) to nearest road [N=32 nests]** | 39.57 | 66.03 |
| | | |
| **Burrow entrance dimensions:** | | |
| Entrance orientation (deg) [N=31 nests] | 159.36 | 105.01 |
| [3] Entrance width (cm) [N=23 nests] | 16.35 | 4.80 |
| [4] Entrance length (cm) [N=24 nests] | 35.06 | 10.20 |
| | | |
| | | |

1 Natural or man-made perch within 200m radius of nest.
2 Open burrows with an owl-sized entrance within 40m radius of nest.
3 Measured at widest point of burrow entrance hole.
4 Length of excavated entry area.

**Table 6**. Attributes of HAFB Burrowing Owl nests in areas of high versus low disturbance, 1996-97.

| | **Distance to: (m)** | | | **Entrance Dimensions** | | | [1] **Available Burrows** | |
|---|---|---|---|---|---|---|---|---|
| | *Highest Perch | *Road | Nearest Burrow | Orientation (deg) | Width (cm) | Length (cm) | Open | No. With Sign |
| [2]High Disturbance | | | | | | | | |
| N= | 20 | 21 | 19 | 20 | 12 | 13 | 21 | 21 |
| Mean | 16.95 | 17.98 | 10.42 | 161 | 14.83 | 32.12 | 5.60 | 1.45 |
| SD | 16.33 | 19.80 | 10.81 | 114 | 3.47 | 6.21 | 3.17 | 1.85 |
| [3] Low Disturbance | | | | | | | | |
| N= | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Mean | 30.73 | 80.77 | 12.77 | 157 | 18.00 | 38.55 | 7.455 | 2 |
| SD | 19.62 | 99.42 | 17.26 | 91 | 5.63 | 12.97 | 5.47 | 2.00 |
| Total | | | | | | | | |
| N= | 31 | 32 | 30 | 31 | 23 | 24 | 32 | 32 |
| Mean | 31.84 | 39.57 | 11.28 | 159 | 16.35 | 35.06 | 6.26 | 1.65 |
| SD | 18.49 | 66.03 | 13.29 | 105 | 4.80 | 10.20 | 4.14 | 1.89 |

1 searched area within 40m radius of nest.
2 nests are located adjacent to frequently used roads and other high activity areas.
3 nests located along infrequently used roads or areas.
Mann-Whitney U test: * $p<0.05$

**Table 6**. (cont.) Attributes of HAFB Burrowing Owl nests in areas of high versus low disturbance, 1996-97.

| | Percent Ground Cover | | | | | Shrub Characteristics | |
|---|---|---|---|---|---|---|---|
| | *Shrubs | Herbs | Soil | Litter | Pavement | *Mean Dist (m) from Burrow | Mean Height |
| [1]High Disturbance | | | | | | | |
| N= | 21 | 21 | 21 | 21 | 21 | 20 | 20 |
| Mean | 7.67 | 26.05 | 64.43 | 1.43 | 4.62 | 21.22 | 73.59 |
| SD | 6.75 | 15.22 | 31.30 | 6.55 | 13.57 | 31.65 | 67.90 |
| [2] Low Disturbance | | | | | | | |
| N= | 11 | 11 | 11 | 11 | 11 | 12 | 12 |
| Mean | 17.64 | 20.09 | 62.73 | 0.45 | 0.00 | 3.41 | 48.62 |
| SD | 7.19 | 9.61 | 12.92 | 1.51 | 0.00 | 2.35 | 11.76 |
| Total | | | | | | | |
| N= | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Mean | 11.09 | 24.00 | 63.84 | 1.09 | 3.03 | 14.54 | 64.23 |
| SD | 8.32 | 13.69 | 26.20 | 5.35 | 11.12 | 26.32 | 55.01 |

1 nests are located adjacent to frequently used roads and other high activity areas.
2 nests located along infrequently used roads or areas.
Mann-Whitney U test:* $p<0.05$

Several variables were significantly different in high and low disturbance nests. The nearest high perch (within 100m of the nest) and nearest road were significantly closer to the nest in high as opposed to low disturbance nests ($U=59.5$, $p<0.05$, $N=31$; $U=53$, $p<0.05$, $N=21$, respectively, Table **6**). Percent cover of shrubs was significantly higher in low versus high disturbance nests ($U=36$, $p<0.05$, $N=32$, Table **6**). The mean distance from the burrow to the eight nearest shrubs (two in each direction) was higher in the high disturbance area ($U=177$, $p<0.05$, $N=32$, Table **6**).

The following variables were not significantly different between high and low disturbance nests: distance to nearest burrow, burrow width, burrow length, % forbs, % soil, % litter, % pavement, number of open burrows, number of burrows with owl sign, and height of shrubs (Table **6**). The orientation of burrow entrances did not differ from random in either high or low disturbance areas (Rayleigh's test, $R_{low}=2.62$, $R_{high}=1.99$, NS). There were no significant differences between nest attributes in areas of high versus low burrow density, for the tested variables (shrub cover, distance to road, perch, and shrub; Mann-Whitney U tests, all NS).

Badgers are a potential predator of Burrowing Owls on HAFB. Based on size and large scrape marks at the burrow entrance, we identified 10 active badger burrows on three transects in the north management area. The density of badger burrows per transect was 1.0 at Sheep Draw (N=7 transects), 0.67 at Tularosa Peak (N=3), and 0.5 at Allen Draw (N=2). We saw no badger burrows at any other management areas.

In summary, nests in high disturbance areas (where owls preferred to nest) were closer to high perches, closer to roads, further from shrubs, and had lower shrub cover than nests in low disturbance areas.

**Wintering**

Winter, 1996-97, visits to nests occupied in the 1996 breeding season revealed that some owls winter on Holloman and use the same burrows occupied during the summer (Table 7). Owls were not color marked, making it impossible to be certain the same individuals were seen in summer and winter. However, we suspect that wintering owls simply stayed at their previous-season nesting burrows.

Fresh owl sign was observed at five new burrows, four of which had been occupied during the spring-summer of 1996. Owls were seen at three burrows, two of which had been occupied in the previous breeding season. This gives a total of eight wintering burrows. Thus, at least six of eighteen (33%) 1996 nesting burrows were occupied the following winter, in addition to two newly occupied winter burrows. Owls nested in one of these two new winter burrows the following year (1997). At 69E and 77E, two adult owls were observed, suggesting that pairs overwinter together.

**Table 7**. Wintering Burrowing Owls at HAFB, December, 1996 to January, 1997.

| **Burrow ID** | **Max # Adults** | **Sign Only** | **Date 1st Seen** | **Success In 1996?** |
|---|---|---|---|---|
| | | | | |
| **Test track** | | | | |
| 69e (11265) | 2 | | 12/6/96 | Yes |
| 75e | | Yes | 12/6/96 | New, winter only |
| 77e (12487) | 2 | | 12/6/96 | Unknown |
| 181e (29500) | | Yes | 12/6/96 | Unknown |
| **Cantonment** | | | | |
| 48th Rescue | | Yes | 12/7/96 | Yes |
| Bong | 1 | | 12/7/96 | New, winter only |
| 49er | | Yes | 12/5/96 | Yes |
| **North** | | | | |
| New Hay | | Yes | 1/29/97 | Unknown |

## Conclusions

HAFB is home to a substantial population of Western Burrowing Owls. Even in the face of disturbance due to military activities and natural events, the HAFB owls produced a minimum of 42 fledglings from 37 nests in the two years of the study.

What factors determine Burrowing Owl distribution on HAFB? It is clear that a hypothesis of burrow limitation is not sufficient to explain owl distributions. Owls were virtually absent from areas of high burrow availability in the north area of the base, while heavily-occupied locations on the cantonment area had relatively few available burrows.

Owls appeared to prefer burrows in areas of human activity over those in more natural draws and dunes, and fledging success rates were quite high in the areas of highest human activity, the test track and cantonment areas. A second hypothesis suggested by these high success rates and nesting distributions is that predation is lower in areas of higher human activity. We found active badger burrows only in the north area, in which burrow availability was high, but few owls were present. No badgers were present in areas of high human activity such as the cantonment area and test track, where owl nests were relatively abundant. Further monitoring of nests in natural areas, combined with predator censuses, could address this question.

Burrowing owl nests on HAFB were found in areas with low shrub cover, a high proportion of unvegetated soil, and a moderate amount of shrub and short grass cover. These qualities are more often found in the disturbed areas that owls frequent than in more natural areas. This suggests a third hypothesis, that owl distributions on Holloman are related to attributes of the nest sites. However, the variables that differed between areas of high and low disturbance (shrub cover; distance to perch, road, and shrub), did not differ between areas of high and low burrow density, suggesting that a combination of variables; perhaps predator avoidance, burrow availability, and habitat characteristics; can explain Burrowing Owl nest site choice on Holloman.

When we look at the high failure rates of nests that experience direct disturbance by humans, for example due to vehicles parking near nests, capture and banding, and deliberate destruction of burrows, it is perhaps surprising that owls continue to prefer to nest in areas of high human activity. Apparently, the costs of nesting near human activity and direct human disturbance of nests do not outweigh the benefits such as reduced predation rates. Another possible benefit might be increased foraging success. For example, owls forage on insects attracted to lights in the cantonment area and toads attracted to standing water on the test track. Studies of Burrowing Owl diet and foraging efficiency, predator impact, and nesting success in natural vs. human impact areas could provide tests of these hypotheses.

This study suggests that Burrowing Owls are doing well on HAFB. The most obvious threat to nesting success is direct human impact on nesting owls. The solution to this problem would be, where possible, to restrict driving, training, and parking of trailers and vehicles in areas where owls are nesting or wintering.

Owls nesting in areas critical to the military mission, such as the airfield, may or may not impact military activities. For example, we have determined that owls are not a threat to aircraft engines. There remains concern that burrows of owls nesting in light conduits on the airfield may fill with water and cause airfield lights to short out, although this has not occurred in the years owls have been using these sites for nests. Our data suggest that when burrows are altered in the process of trapping owls, owls frequently abandon them. This casts doubt on the effectiveness of attempting to relocate owls to artificial burrows. Thus, although relocation is one approach that could be explored further, relocation should be attempted with care, and only when clearly necessary. These and other activities with potential to impact Burrowing Owls should be conducted outside the breeding season. Habitat use by wintering owls should also be considered when planning for owl management.

In general, because owls use disturbed areas for nesting, preserving natural habitat would not appear to be an effective management action. One possible approach to enhancing habitat might be to mow areas with appropriate shrub cover and abundant burrows, but that have high grass or too little unvegetated soil. However, this is an unproved tactic that should be tried on an experimental basis. It is possible that social, historical, or other behavioral factors also influence owl nest site selection. Therefore, until Burrowing Owl nest site choice is better understood, we do not recommend any major attempts at habitat enhancement. Rather, military activities should be restricted in areas where owls are already nesting, and we advise further research on topics suggested here.

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APPENDIX 1. Hawk species encountered during Burrowing Owl surveys in the Spring, Holloman AFB, 1997.

| SPECIES | SEX | COUNT | DATE | TIME | TRANSECT CODE | TRANSECT LOCATION | BEHAVIOR |
|---|---|---|---|---|---|---|---|
| American Kestrel | UNK | 1 | 4/9/97 | 930 | 10 | HENNIGER GRASSLAND | PERCHED (Yucca plant) |
| American Kestrel | MALE | 1 | 4/11/97 | 1240 | 14 | NW TRACK | PERCHED |
| American Kestrel | FEMALE | 1 | 4/11/97 | 1920 | 17 | WSMR 9 (MID GRAVEL RD) | PERCHED |
| American Kestrel | MALE | 1 | 4/11/97 | 1920 | 17 | WSMR 9 (MID GRAVEL RD) | PERCHED |
| American Kestrel | MALE | 1 | 4/6/97 | 900 | 23 | SHEEP DRAW | HUNTING |
| American Kestrel | FEMALE | 1 | 4/7/97 | 1120 | 27 | W. HAY | HUNTING |
| Golden Eagle | UNK | 1 | 5/13/97 | 1515 | 30 | TEST TRACK (20400FT) | PERCHED |
| Harris Hawk | UNK | 2 | 3/20/97 | 1630 | 5 | CARTER DRAW | LOW FLIGHT |
| Northern Harrier | FEMALE | 1 | 3/23/97 | 1645 | 2 | ALLEN DRAW | HUNTING (Morning Dove) |
| Northern Harrier | MALE | 1 | 4/11/97 | 730 | 3 | CAMERA PAD RD (F916) | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/4/97 | 815 | 3 | CAMERA PAD RD (F926) | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/8/96 | 900 | 7 | DILLARD DRAW | HUNTING |
| Northern Harrier | FEMALE | 2 | 4/9/96 | 1800 | 8 | LOST RIVER | HUNTING (Pounce) |
| Northern Harrier | FEMALE | 1 | 3/27/97 | 1500 | 11 | SE LOST RIVER DRAW (S HALF) | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/10/97 | 855 | 12 | WSMR 10 CORNER | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/11/97 | 1200 | 14 | NW TRACK | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/6/97 | 820 | 15 | TECH DATA CNTR RD | HUNTING |
| Northern Harrier | MALE | 1 | 4/6/97 | 1115 | 17 | WSMR 9 (N GRAVEL RD) | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/8/96 | 700 | 19 | W. RITAS | HUNTING |
| Northern Harrier | FEMALE | 1 | 3/26/97 | 820 | 21 | TULAROSA PEAK | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/5/97 | 1745 | 23 | SHEEP DRAW | HUNTING |
| Northern Harrier | MALE | 2 | 3/24/97 | 1020 | 26 | HAY DRAW (WSMR RD 9) | MOBBING (Swainson's Hawk) |
| Northern Harrier | MALE | 1 | 3/21/97 | 1725 | 28 | KELLY RD, RADIO TW | HUNTING |
| Northern Harrier | FEMALE | 1 | 4/11/97 | 815 | 30 | TEST TRACK | HUNTING |
| Swainson's Hawk | UNK | 2 | 3/27/97 | 905 | 6 | TOP CARTER DRAW | GRABBLING TALONS |
| Swainson's Hawk | UNK | 1 | 4/6/97 | 1112 | 17 | WSMR 9 (N GRAVEL RD) | HUNTING |
| Swainson's Hawk | UNK | 1 | 3/24/97 | 1020 | 26 | HAY DRAW (WSMR RD 9) | NESTING (Saltcedar) |