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An Adaptive Management Plan
For The
Burrowing Owl Population
At Naval Air Station Lemoore
Lemoore, California

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Executive Summary

Because of the large number of listed species, the San Joaquin Valley is one of the primary regions for conservation of biological diversity in California. A substantial proportion of the burrowing owls in California inhabit the San Joaquin Valley. The burrowing owl is considered a federal Species of Management Concern, formerly classified as a Category II species. The U.S. Fish and Wildlife Service will be reviewing the owl's status in 1998, following the listing of the burrowing owl in Canada as an endangered species. In many western states, including California, burrowing owls are considered a species of special or critical concern.

A relatively large population of burrowing owls occurs at Naval Air Station Lemoore (NAS Lemoore), located in the northern limits of the southern San Joaquin Valley. At NAS Lemoore, burrowing owls nest in established wildlife areas, runway buffer strips, and adjacent to runways. They also occasionally nest in areas that may be scheduled for construction activities, such as the recently capped landfill. Owl conservation activities at NAS Lemoore have included an intensive demographic and space use research program that is part of a state-wide research effort, the protection of burrowing owls during construction activities at a recently capped landfill, and the creation of a native grassland designed to increase the number of burrowing owls nesting in the area. Further, mowing operations, prescribed burning, and the avoidance of discing grasslands has contributed to the large nesting population of burrowing owls at NAS Lemoore. To continue land management activities that are conducive to the protection of the burrowing owl at NAS Lemoore, the Engineering Field Activity West (EFA-West) of the Department of the Navy contracted with The Institute for Bird Populations to develop a plan for the management of the burrowing owl population at NAS Lemoore.

We conducted a complete census of burrowing owls at NAS Lemoore. We located 54 active nests. They were located in 5 primary areas clustered around the wildlife areas, runway strips in Air Operations, buffer strips near the runways, the capped landfill, and the receiver site. Many of the owl nest sites were located within 10 m of runways. With few owls nesting outside of the Station, but within 50 km, burrowing owls at NAS Lemoore likely constitute a sub-population, such that immigration and emigration between NAS Lemoore and outside populations is minimal relative to within population movements of young and adults.

Factors potentially limiting the population size at NAS Lemoore include availability of nesting burrows, vegetation structure, winter food availability, and pesticide exposure. The small populations of California ground squirrels at NAS Lemoore restricts the number of burrows and the dense vegetation limits the ability of burrowing owls to utilize existing burrows. We recommend a system of artificial burrows to increase the availability of nesting burrows and we suggest maintaining a short vegetation height in grassland areas. Vegetation structure is determined largely by plant species composition and water availability. Most areas are dominated by dense stands of annual grasses. Currently, these areas are mowed 3-5 times annually to reduce hazards to Air Operations and to reduce fire hazards. However, burrows utilized by nesting burrowing owls have made mowing difficult. Through our discussions with Air Operations and Public Works Transportation Department, we recommend maintaining vegetation height in grasslands at <12", an increase from the current guidelines of <6". This will reduce conflicts between mowing operations and the existence of natural burrows. Maintaining vegetation at <12" in height will also improve nesting and foraging habitat and will minimize production of seed thereby decreasing BASH in the area. We recommend a regime of prescribed fire and grazing, and mowing as a long-term solution to BASH, fire hazard, and grassland wildlife conservation. We recommend further research on methods for vegetation management strategies at NAS Lemoore.

A large number of conventionally used herbicides (including defoliants) and pesticides are used in the San Joaquin Valley. At NAS Lemoore, herbicides and pesticides are used by local farmers on lands leased through the agricultural out-lease program, as well as in the Station's operations and grounds management. Herbicides and pesticides that have demonstrated toxic effects to wildlife are discussed in detail in the plan. We provide a list of several pesticides and herbicides currently used in the San Joaquin Valley and at NAS Lemoore that are particularly toxic to wildlife, including the burrowing owl. We recommend a thorough evaluation of alternative chemicals as well as an emphasis on Integrated Pest Management (IPM). Although DDE, created from the metabolism of DDT, has been banned for use in the United States for over 20 years, research conducted on burrowing owl exposure to contaminants at NAS Lemoore identified high levels of DDE in eggs, but few other contaminants were identified in samples. Due to the high levels of DDE, we recommend minimizing the use of agents with similar egg-thinning effects, such as dicofol, which is used as a miticide on cotton. The high DDE levels require additional research in order to evaluate how broadly they are distributed at NAS Lemoore.

Although burrowing owls are unlikely an important species for bird air strikes, there are occasional incidents in which owls have been involved in incidents along the runway. Data does not exist to evaluate the likelihood of such incidences. However, many of the 54 owl pairs nest near the runway, so this species is potentially of concern for air operations safety. We recommend further monitoring of Bird Air Strike Hazards (BASH), and in particular, reporting of all known bird mortalities that resulted from aircraft collision to the Environmental Management Division. If research and monitoring results in a decision that burrowing owls pose a risk to aircraft and personnel, then their numbers near the airfields can be reduced by several non-destructive methods, including altering the habitat and blocking burrows that have developed near and adjacent to runways.

Management recommendations include the installation of artificial burrows, increased use of fire and other vegetation management strategies, use of native vegetation for reseeding efforts, and the establishment of a monitoring program. We recommend a goal of 72 pairs of burrowing owls in areas outside of Air Operations, and a trigger point of 27 pairs, which represents half of the number of owl nests located in 1996 throughout the Station. We suggest a monitoring strategy in which nest activity is determined for a sample of previously occupied nest sites. This strategy should reliably detect a 50% decline in the number of breeding pairs of burrowing owls. When this 50% point is reached (trigger point), we recommend that the Navy initiate an investigation to determine the reason for the decline.

Pro-active steps to manage burrowing owls on public lands in California , such as those taken by NAS Lemoore, will be critical to avert listing of the burrowing owl under the Endangered Species Act. The steps taken by the US Navy at NAS Lemoore to develop a management plan are one of the first in California. The large number of burrowing owls at NAS Lemoore suggests that this population is very important regionally due to the few other localized populations of burrowing owls in the northern San Joaquin Valley. This document represents an initial plan for the management of burrowing owls at NAS Lemoore. To be useful, this plan should be updated with results from research and monitoring activities. In this sense, this plan represents an initial step towards an adaptive management strategy for burrowing owls at NAS Lemoore. Land management activities at NAS Lemoore may serve as a model for conservation of burrowing owls in agricultural landscapes on private lands in the San Joaquin Valley. Regional efforts towards burrowing owl protection should ensure a safe future for the species and avert a need to formally list them under the Endangered Species Act.

Acknowledgments

The work presented in this management plan would not have been possible if it were not for the assistance of numerous talented professionals. Mr. John Crane, NAS Lemoore, was instrumental in furnishing us information on acreage estimates and pesticide use, as well as sharing the results of the soil samples which we presented in this report. Importantly, Mr. Crane provided logistical support which made possible our field activities. The staff at NASL also assisted in providing us information on mowing activities and BASH. Air Operations staff and security provided critical logistic support that allowed us to work safely near the runways. Mr. John Crane, Mrs. Noreen Roster (US Navy, EFA-West), and Mr. Richard Rugen (US Navy, EFA West), provided helpful comments that improved earlier drafts of this plan and assisted with directing the plan so that it would be most useful for managers at NAS Lemoore. Dr. Ellen Cypher provided us assistance with revegetation plans and helpful discussions on the vegetation at NAS Lemoore. Dr. Ted Donn, Tetra Tech, Inc., generously provided the digital GIS database that we used for mapping purposes. Information on burrowing owl ecology used in this report was possible from the agencies and the public that have funded the Burrowing Owl Research Program, a joint collaboration between The Institute for Bird Populations, and researchers with Oregon State University and San Jose State University. For continued funding of this research program, we thank The Bureau of Land Management (Bakersfield Field Office), US Navy (EFA West), US Fish and Wildlife Service (Region 1), California Department of Fish and Game and the Natural Heritage Program, and the National Fish and Wildlife Foundation. This is publication No. 95 of The Institute for Bird Populations.

•SECTION 1•

Introduction

1.1 Motivation for an Adaptive Management Plan

The western burrowing owl (*Speotyo cunnicularia*) is considered a federal Species of Management Concern, formerly classified as a Category II species when that classification existed. The U.S. Fish and Wildlife Service will be reviewing the owl's status in 1998 (T. Zimmerman, USFWS, pers. commun.), following the listing of the burrowing owl in Canada as an endangered species. In many western states, including California, burrowing owls are considered a species of special or critical concern. The California Department of Fish and Game is planning to develop a state-wide management strategy to prevent further declines (K. Hunting, California Dept. of Fish and Game, pers. commun.). In California, where large numbers of resident (breeding) and wintering owl populations exist, populations have been declining (DeSante et al. 1996, 1997; Trulio 1997). Because of these concerns, recent management and research efforts have been initiated to find ways to prevent further declines, and thus avert the need for federal listing of the species under the Endangered Species Act.

NAS Lemoore is located in the northern limit of the southern San Joaquin Valley. A large proportion (over 21%) of the breeding populations of burrowing owls in California exist in the San Joaquin Valley (DeSante et al. 1996). Most of the valley is in intensive agriculture, with few grasslands remaining. This has resulted in a large number of species listed as threatened and endangered (Williams et al. 1992; USFWS 1997). Because of the large number of listed species, the San Joaquin Valley is an area of concern and one of the target regions for conservation (Noss et al. 1995).

A relatively large population of burrowing owls inhabits NAS Lemoore. They are found in established wildlife areas, runway buffer strips, and adjacent to runways, where they could provide a bird air strike hazard (BASH). Burrowing owls at NAS Lemoore are also occasionally found in areas that may be slated for construction activities, such as the recently capped landfill. To continue land management activities that are conducive to the protection of the burrowing owl at NAS Lemoore, the Engineering Field Activities West (EFA-West) of the Department of the Navy contracted with The Institute for Bird Populations to develop a plan for the management of the burrowing owl population at NAS Lemoore. Aspects of this plan are intended to be incorporated into the Integrated Natural Resource Management Plan (INRMP) for NAS Lemoore by the Environmental Management Division, NAS Lemoore.

A recent concept in management is the Adaptive Management Strategy (Holling 1978, Walters 1986). This strategy accepts the notion that we will learn more about the system as we continue research and carefully monitor the effects of management practices, thus allowing plans to be modified to take into consideration the new findings. Current research on burrowing owls at NAS Lemoore and elsewhere will provide information that can augment this plan. This type of strategy should prove to be effective and cost efficient. Under such an approach, we offer this document as an initial set of recommendations for the management of burrowing owls, while ensuring the national defense mission of NAS Lemoore.

1.2 Current Activities to Promote Owl Conservation

NAS Lemoore has one of the largest owl populations in the San Joaquin Valley. Understanding the factors that have resulted in such a large population will provide critical guidance for implementing science-based conservation strategies throughout the Valley. Much of the research conducted on burrowing owls in California has taken place at NAS Lemoore. The first toxicology study conducted on burrowing owls in California was supported, in part, by the Navy and conducted at NAS Lemoore. The burrowing owl demography and space use study is being conducted at NAS Lemoore and three other study sites in California. Much of the understanding of burrowing owls provided in this report was from data collected from that study. In addition, a native grassland was created from a capped landfill at NAS Lemoore. Within the grassland, six clusters of 18 artificial burrows were established to augment the owl population. Owls have successfully nested in some of these burrows, and the population is likely to increase due to these efforts. The activities conducted at NAS Lemoore to promote conservation of burrowing owls serve as a model example of efforts to promote the successful integration of agricultural production and wildlife conservation. These and similar efforts will assist in averting the need for the listing of the burrowing owl under the Endangered Species Act.

1.3 Land Use Patterns at NAS Lemoore

Based on discussions with Mr. John Crane (Environmental Management Division, NAS Lemoore), land use of NAS Lemoore's 18,784 acres is allocated to five principle uses: (1) Air Operations, (2) Administration, (3) Housing, (4) Recreational and Wildlife, and (5) Agriculture. Approximately 75% of the land is allocated to agricultural production (14,119), the primary use of land in the San Joaquin Valley. Cotton is the principal crop at NAS Lemoore, covering approximately 9,244 acres (1998 crop data, J. Crane, Lemoore, NAS), representing 65% of the area in agricultural production. Much of the Air Operation's buffer strips and uncultivated land in the receiver and transmitter areas provide potential nesting habitat to burrowing owls. In addition, approximately 50 acres provide habitat for burrowing owls and other wildlife at the grassland site created from capping the landfill and subsequent revegetation with native plants (Section 4). Areas dedicated to wildlife habitat include approximately 406 acres, which includes both grasslands (200 acres) and wetlands (206). In addition, there is a total of approximately 846 acres in unimproved grasslands. From the estimates of grassland acreage in 1997 (J. Crane, pers. commun.), we estimate a total of 1,070 acres suitable as nesting habitat, not including the small patches of grass separating runways, taxiways, and buildings in Air Operations. With our preliminary findings from the burrowing owl research program, crop field, runways, taxiways, and roads are also used for foraging. Thus, most of the base provides habitat either as nesting or foraging habitat.

We have identified 8 areas in which burrowing owls nest at NAS Lemoore (Fig. 15). Area A is a large grassland located south east of runway 32L, and borders Reeves Rd. Area B is a grassland located in the northern section of NAS Lemoore, west of runway 32R. Area C is a Wildlife Area established originally for the Fresno Kangaroo Rat, and is located east of 32R. Area D and E are grassland patches which serve as sites for the receiver and transmitter, respectively. Tumble Weed Park serves as the primary site for the Fresno Kangaroo Rat, and consists of a medium size grassland. This site has had several prescribed burns and has been the most extensively studied site on the base in terms of the floral composition and response to treatments. The capped landfill now serves as a grassland, following rehabilitation efforts in 1997 and 1998. In 1998, native vegetation was established. The area inside Air Operations contains small patches of grasses; although small in size, a large number of burrowing owls inhabit these areas.

1.4 Overview of the Burrowing Owl Population at NAS Lemoore

A partial survey during the breeding season in 1991-1993 coordinated by The Institute for Bird Populations documented 9 pairs on the base (The Institute for Bird Populations, unpub. data; also reported in Morrison 1993a). These numbers were determined by surveys of areas of suspected occurrence, and were known as only a minimum number since the entire base was not censused. During fall 1993, Morrison (1993a) located 21 active burrow sites, and estimated there to be about 33 adults. Again, these estimates provided minimum numbers because the entire base was not censused. In 1996, 15 pairs of owls were located during the breeding season as part of the toxicology study conducted by The Institute for Bird Populations (Gervais et al. 1997). These numbers were again the minimum known, as only opportunistic censuses were conducted. As part of this management plan, we conducted what we believe to be a complete census of the breeding population of burrowing owls at NAS Lemoore. We found 54 active nests in which nesting was attempted (see Section 3). Nests were located in 5 primary areas clustered around the wildlife areas, runway strips in Air Operations, buffer strips near the runways (32L and 32R), the capped Landfill, and the receiver site (Fig. 1). A proportion, if not all, of the breeding owls at Lemoore are year-long residents; we have resighted owls marked during the breeding season during following winters. We also found that young of the year may nest the following year at sites adjacent to their natal burrow. With few owls located outside of the Station but within 50 km (Fig. 2), burrowing owls at Lemoore likely constitute a sub-population, such that immigration and emigration between Lemoore and outside populations is minimal relative to within population movements of young and adults. Further, the large number of breeding pairs suggests that this population is important regionally due to the few other localized populations of burrowing owls in the northern San Joaquin Valley.

1.5 Development of the Management Plan

This document was prepared with the goal of providing an initial plan for the management of burrowing owls at NAS Lemoore. We realize that the Navy's first concern must be national defense and that the agricultural out-lease program is an important component of the management of the land base at NAS Lemoore. Therefore, we have included only recommendations that we believed would accommodate these other critical objectives. Further, goals of land allocation on public lands may vary through time. As biological diversity increasingly becomes an issue in the San Joaquin Valley, and public lands are seen as a means to provide for this need (USFWS 1997), the allocation of lands devoted to agriculture versus wildlife may change. Economics may motivate a change in farming practices, for example, from high to low water use, with resulting changes in crops or even in the relation of crops to livestock. The result of changes of land allocation will alter the management of grassland species such as the burrowing owl. Additional research conducted locally and regionally should improve our knowledge of these systems. The knowledge gained at NAS Lemoore on the interplay between agricultural production and wildlife conservation should be of particular utility to the management of lands in the region. Conservation of grassland species in the San Joaquin Valley will be best served with a regional conservation strategy.

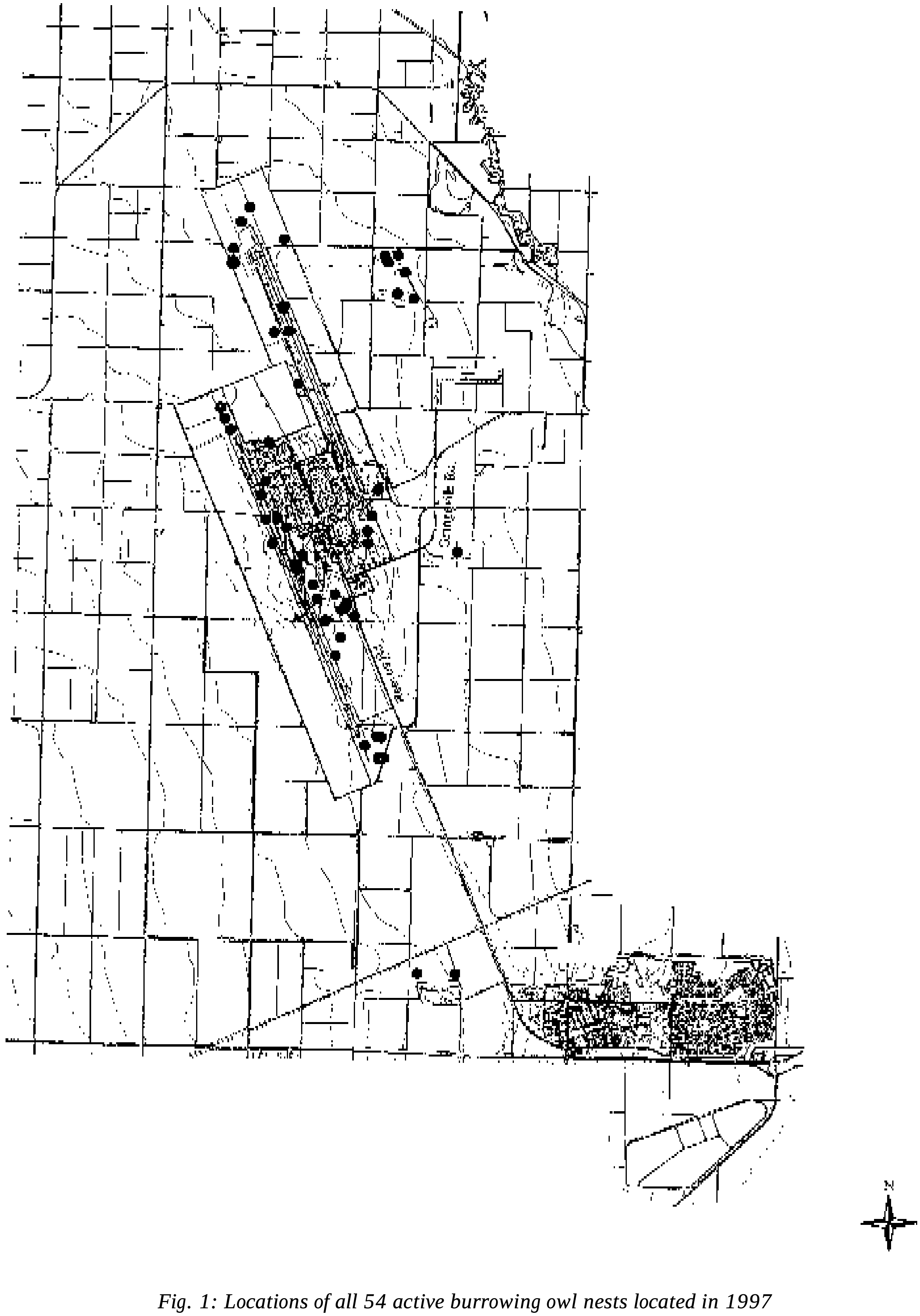


Fig. 1: Locations of all 54 active burrowing owl nests located in 1997 conducted as a complete census of burrowing owls at Lemoore NAS.

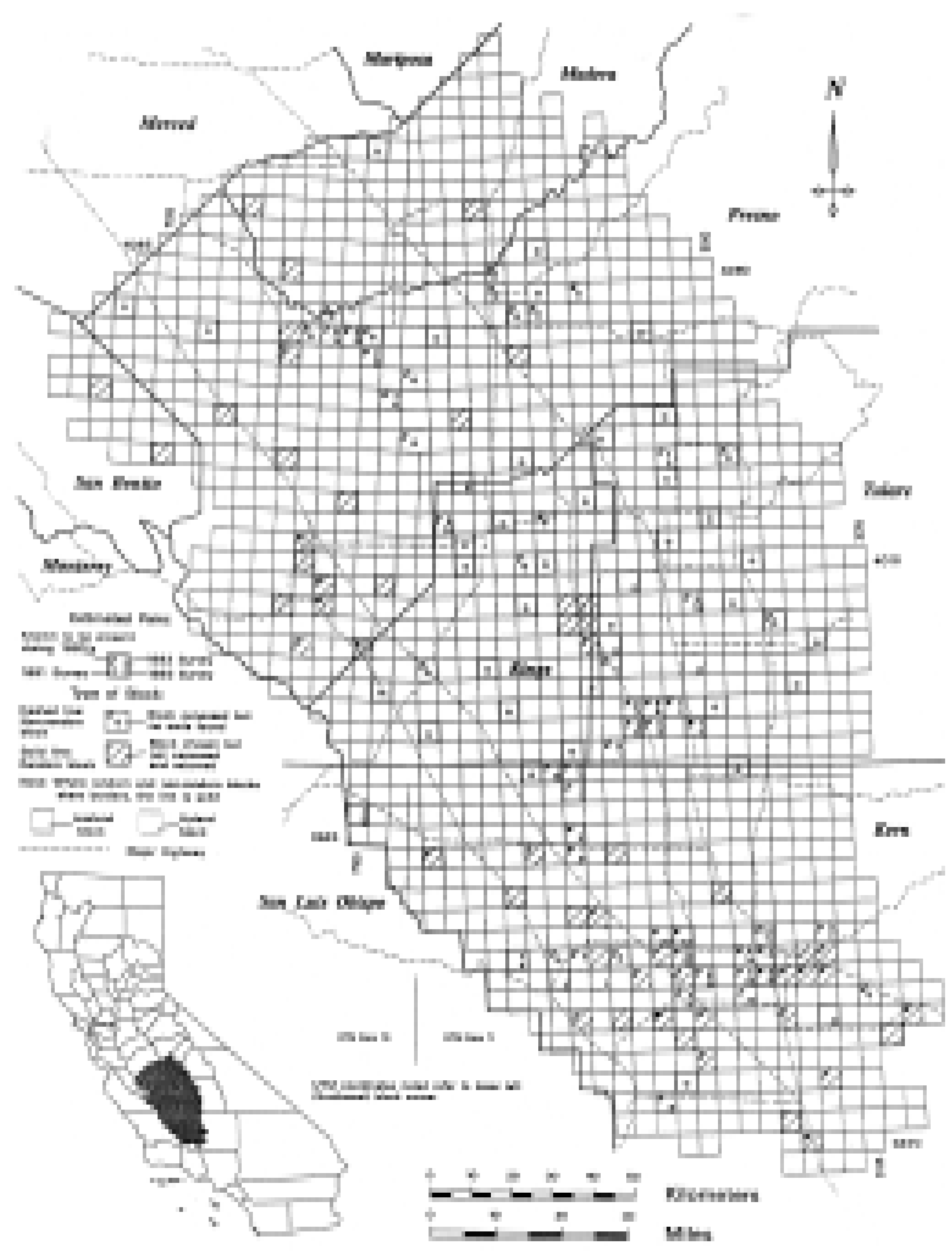


Fig. 2: Locations of burrowing owls in the southern region of California's Central Valley.

•SECTION 2•

Natural History of Burrowing Owls

2.1 Species Status

Burrowing owls were once widespread and fairly common over western North America. In recent decades, however, a number of populations appear to have declined or in some cases, disappeared altogether. Burrowing owls are now endangered in Canada (J. Schmutz, University of Saskatchewan, pers. commun.), and have declined in many parts of the United States (James and Espie 1997; DeSante et al. 1996, 1997). The species is now a federal and California state species of concern, and listed as endangered or threatened in a number of other states (James and Espie 1997). USFWS is considering a status review for the burrowing owl in 1998 (T. Zimmerman, USFWS, pers. commun.).

Juvenile burrowing owl and parent near their artificial nest burrow.

Depending on the population, burrowing owls are either year-round residents or migratory. Migratory populations appear to be primarily from the more northern parts of the species' range, while owls in California and east through New Mexico remain throughout the winter (Brenkle 1936, Ligon 1961, Thomsen 1971, Haug et al. 1993, Gervais and Rosenberg unpublished data), or appear to wander within the region during the winter months (Coulombe 1971, Martin 1973, Botelho 1996). Little is known about the winter ranges of migratory populations (Haug et al. 1993), although migratory owls are thought to augment resident populations in California during the winter months (Coulombe 1971), and it appears that the owls breeding the furthest north migrate the furthest south (James 1992). Christmas Bird Count data indicate that California is by far the most important state for burrowing owls in winter (James and Ethier 1989). The burrowing owl population at NAS Lemoore is composed of year-round resident breeding pairs, with possible winter migrants from more northern populations.

Space-use by burrowing owls at NAS Lemoore is being studied with radio telemetry.

2.2 Distribution in California

The range of the burrowing owl in California extends through the lowlands south and west from north central California to Mexico, with small, scattered populations occurring within the Great Basin and the desert regions of the southwestern part of the state (DeSante et al. 1996). Owls are absent from the coast north of Sonoma County and high mountain areas such as the Sierra and the ranges extending east from Santa Barbara to Santa Bernadino (DeSante et al. 1996). Owl populations have been greatly reduced or extirpated from the San Francisco Bay Area (Trulio 1997) south along the coast to Los Angeles. They have also apparently disappeared from the Coachella Valley (DeSante et al. 1996). A survey effort carried out between 1991 and 1993 indicated that major population densities remain in the Central and Imperial Valleys (DeSante et al. 1996).

2.3 Home Range, Site Fidelity, and Space Use

Home range size is variable both among individuals and between years (Haug and Oliphant 1990). Haug and Oliphant (1990) estimated home ranges in Saskatchewan, Canada to vary from 0.14 km2 to 4.81 km2, with the largest ranges estimated for late June and early July. A resident population in southern California had much smaller home ranges (C. Winchell, USFWS, pers. commun.). Winter ranges for these owls were four times the size of breeding ranges, and territoriality appeared to be absent outside of the breeding season (C. Winchell, USFWS, pers. commun.). Owls were detected up to 2.7 km from their burrows during nocturnal foraging in Saskatchewan (Haug and Oliphant 1990), and up to 400 m in California (C. Winchell, USFWS, pers. commun.). Our recent research at NAS Lemoore suggests home ranges tend to be quite large, with foraging trips extending beyond 3 km from the nest site.

During the breeding season, the owls' activity is tightly centered around the nest burrow. Owls defend the area immediately around the nest burrow (Martin 1973, Zarn 1974; Gervais and Rosenberg, unpubl. data). Defense of foraging areas is less clear, with some researchers indicating nonexclusive use of foraging areas (Thomsen 1971, Martin 1973, Zarn 1974), and others indicating some territoriality, such as the generally non-overlapping home ranges of owls in Saskatchewan (Haug and Oliphant 1990).

Although breeding season activities center around a nest burrow, owls will use additional burrows within their home range if available. Chicks will move from the natal burrow to others within the home range (Martin 1973, Thomsen 1971, Henny and Blus 1981, Gervais pers. obs.), and parents carry food to and perch at the auxiliary burrow containing some of the chicks (Gervais, pers. obs.). The use of numerous burrows by an owl family may be an anti-predation strategy; excavation of a burrow by a predator may not result in the loss of the entire brood. In the Carrizo Plain, we have noted that entire families will move up to 3 km away from natal burrows, despite the existence of abundant ground squirrel burrows in the area (Rosenberg and Gervais, unpubl. data).

During the nonbreeding season, burrowing owls remain closely associated with burrows, as they continue to use them as refuges and roost sites throughout the year. Resident populations will remain near the previous season's nest burrow at least some of the time (Coulombe 1971, Thomsen 1971, Botelho 1996, C. Winchell, USFWS, pers. commun.). This is true of the burrowing owl population at NAS Lemoore (Rosenberg and Gervais, unpubl. data).

Although natural burrow availability will vary depending on ground squirrel activity and the collapse of old burrows, reuse of nest burrows occurs in both migratory and resident owl populations. Owls in Idaho renested in the same burrow particularly if the previous year's breeding attempt was successful (Belthoff and King 1997); in other instances, migratory owls returning to the same breeding territories moved to nearby burrows (Belthoff and King 1997). Resident populations also appear to frequently reuse the previous year's breeding burrow. At NAS Lemoore, we have found that burrowing owls will reuse burrows that were formerly occupied by other pairs (Gervais and Rosenberg, pers. obs). Females seem more likely to change territories than males in some populations (Botelho 1996, Belthoff and King 1997, Rosenberg and Gervais, unpubl. data), but females exhibited more territory fidelity than males in Colorado (S. Lutz, Univ. of Wisconsin, pers. commun.). At Salton Sea National Wildlife Refuge and at NAS Lemoore, adult females have been found nesting in their natal burrows (Rosenberg and Gervais, unpubl. data). The birds do not mate for life, although pairs will remain together for more than one breeding season in resident populations (Rosenberg and Gervais, unpublished data). Of 62 breeding pairs in Colorado, however, none remated the following year (S. Lutz, pers. commun.). Preliminary results of our research at NAS Lemoore suggest high breeding-site fidelity and natal-site fidelity. Most adults nest at or adjacent to their previous year's nest site and young from the previous year often establish nest sites nearby (<300 m) their natal site. This has important management implications that will be discussed throughout the Plan.

2.4 Habitat

In their native environment, burrowing owls are restricted to grassland areas and semi-desert. They are found in open habitats with suitable nesting burrows, usually with short grasses and sparse shrubs, and will use washes and arroyos for nesting (Coulombe 1971, Zarn 1974, Rich 1985, Haug et al. 1993, Botelho 1996). Owls generally avoid thick, tall vegetation and brush (Rich 1986, Green and Anthony 1989, Plumpton and Lutz 1993a). They also appear to avoid areas near trees, perhaps because trees provide roosting and perching sites for other raptors, many of which will prey on burrowing owls (L. A. Trulio, pers. commun.).

Burrowing owls have proven to be quite adaptable, and have nested successfully at airports (Thomsen 1971) including military installations (e.g., NAS Lemoore and NAS North Island), and in areas adjacent to intense agricultural activity. Burrowing owls will readily adopt suitable nest boxes, and have also initiated nesting in irrigation pipes, dry spring boxes, and even the interior of a buried car (Green 1988). Burrow availability appears to be the major limiting factor in disturbed habitats within the species' range. Owls at NAS Lemoore have been found nesting in culverts, burrows of ground squirrels, abandoned coyote and badger dens, in piles of concrete rubble, and under runway equipment, as well as in artificial burrows (Rosenberg and Gervais, unpubl. data).

Foraging habitat includes agricultural fields, grazed pastures, and fallow fields within disturbed habitats (Haug and Oliphant 1990). Pellet contents indicate that owls will also use irrigation ditches and canals. We have just begun investigating the relative use of intensive agricultural fields and grasslands at NAS Lemoore. Preliminary results suggest the owls extensively forage within the agricultural fields and along paved areas adjacent to crop fields or grasslands.

2.5 Diet

Burrowing owls are ideal examples of opportunistic generalists. Prey items include a staggering array of taxa, including mammals, birds, reptiles, amphibians, fish carrion, insects, spiders, centipedes, scorpions, crayfish, and molluscs, as well as prey items of large species that were scavenged. Pellets also contain inedible items such as sand, rocks, and fragments of glass and plastic (Gervais et al. 1997). Small mammals tend to dominate the diet in terms of biomass although insects make up the majority of individual prey items (Thompson and Anderson 1988, Green et al. 1993, Plumpton and Lutz 1993b). There appears to be a seasonal shift from mammals to insects throughout the spring, perhaps due to increasing insect abundance (Green and Anthony 1989, Haug et al. 1993).

We have documented burrowing owls at NAS Lemoore preying on a number of rodent species, including young pocket gophers (*Thomomys bottae*) and California voles (*Microtus californicus*), although we have not yet verified that burrowing owls prey on the endangered Fresno kangaroo rat (*Dipodomys nitratoides*). However, it is likely owls do prey on this species, when available. Sparrows, horned larks, and meadowlarks were consumed, as were western toads. Insects in the diet were primarily grasshoppers and crickets (Orthoptera), and beetles (Coleoptera). We also found centipedes and remnants of crustaceans at burrow entrances, the latter indicating that the owls are visiting drainage and irrigation ditches during foraging trips (Gervais et al. 1997). Owls will also scavenge the carcasses of species too large to be prey, such as carp and large shorebirds (e.g., at the Salton Sea National Wildlife Refuge, Rosenberg and Gervais, unpubl. data).

Owls have also been documented eating each other, in the form of adults preying upon chicks. One adult owl was videotaped killing one of its chicks and feeding it to the remaining young (Botelho 1996), and the bands of chicks have been recovered in owl pellets at Lemoore (Rosenberg and Gervais, unpubl. data). It is not clear in these cases whether the young owls were scavenged or predated, but we suspect the latter when bands indicated that the chick was from another nest.

Survival rates of juvenile and adult burrowing owls are being studied at NAS Lemoore.

2.6 Survival and Reproduction

Longevity in wild burrowing owls is essentially unknown. The record currently goes to one banded wild owl which survived to the age of 8 years 8 months (Kennard 1975). To the best of our knowledge, only one demographic study has been completed to date, on a population of migratory owls at the Rocky Mountain Arsenal National Wildlife Refuge (S. Lutz, Univ. of Wisconsin, pers. commun.). They found that the survival rate for adults averaged 0.18 for the period 1991-1994, but was 0.71 for 1990-1991. The low survival rate found in this study may have been due to emigration from the study area or to factors not yet understood.

Return rates of bands also may be used to give conservative estimates of survival in the absence of other data. Return rates of banded birds varied from 33-58% for adult owls in

Active burrowing owl nest. "Nest decoration" lines the entrance.

Canada (Haug et al. 1993). Estimates of survival from band return rates for migratory populations in particular will be negatively biased, since birds may have returned to breed outside the study area and would therefore escape resighting efforts. Little band resighting has been done in the United States. Thomsen (1971) estimated adult survival rates of 81% in a resident population based on band resighting in an owl population numbering 21 adults, with chick survival roughly 30% based on 30 banded juveniles (Thomsen 1971). In central California, Johnson (1997) estimated an annual survival rate of 0.42 for adults, based on band returns. At NAS Lemoore, several adults are known to be at least 3 years old.

Reproduction in burrowing owls begins the year after hatching (Haug et al. 1993). The onset of egg laying varies according to the geographic region, with clutch initiation occurring in mid-late March in New Mexico (Martin 1973) and in the San Joaquin Valley (Rosenberg and Gervais, unpublished data), early to late April in Oregon (Henny and Blus 1981) and northern California (Thomsen 1971), and mid-late May in Saskatchewan (Haug et al. 1993). Florida burrowing owls have been documented to raise more than one brood a year (Millsap and Bear 1990), but this is not well known for the western burrowing owl, although clutches destroyed early in the season will be replaced (Haug et al. 1993; Gervais and Rosenberg, unpubl. data). The varied timing of egg-laying and courtship in the species has prompted the California Department of Fish and Game to consider February 1 to August 30 as the nesting season for burrowing owls in the state (California Dept. Fish and Game 1994).

Burrowing owl nest burrows are often distinctive, due to the species' habit of lining the entrance and tunnel with cow manure (Green 1988), coyote dung, insect parts, cotton, dead toads, plastic, tin foil, and other rubbish (Rosenberg and Gervais, unpubl. data). Manure and dung appear to serve an antipredatory function, perhaps by masking the owls' odor from mammalian predators such as badgers (Martin 1973, Green and Anthony 1989). The habit is so strong that when the dung is removed, the owls promptly replace it (Martin 1973). Much of the material used in human-altered environments has little odor and is actually very conspicuous, such as cotton and foil bits. Although cotton was the most frequent nest decoration at Lemoore, this population of owls appears to be fairly safe from ground predators, since large snakes, weasels, and badgers are either very rare or absent. We never observed any sign of coyotes digging out occupied nests. Owls may decorate nests to indicate occupation of a burrow; initiation of nest decoration typically occurs after the owls begin nesting.

Females lay up to 12 eggs, with average clutch size varying according to geographic region (Haug et al. 1993), but ranging from 7-9 eggs (Ehrlich et al. 1988, Haug et al. 1993). Only females develop a brood patch and incubate; laying rate and the onset of incubation remain unclear, with some researchers documenting laying rates in excess of 1 egg a day (Henny and Blus 1981), and others documenting much lower rates (Olenick 1990). Incubation may begin with the onset of laying (Thomsen 1971, Martin 1973), or be delayed until the clutch is complete (Haug 1985, Henny and Blus 1981). Incubation lasts between 21 and 30 days (Ehrlich et al. 1988, Haug et al. 1993). In the Imperial Valley, the intense heat inside the shallow artificial nest boxes may incubate the eggs and cause highly asynchronous hatching (Rosenberg, pers. obs.). Hatching success is variable, with rates between 55-90% recorded (Haug et al. 1993).

Young owlets are altricial, partially covered with down, and weigh between 6 and 12 grams at hatching (Haug et al. 1993). Females brood the young until they are capable of thermoregulating on their own (Haug et al. 1993). Young are fed within the burrow while they are still very young, and then move to the mouth of the burrow for food deliveries from their parents at about 10-14 days of age. Chicks have been known to move among burrows at this time (Henny and Blus 1981). They are capable of short flights by week 4, and fly well at week 6 (Haug et al. 1993), although chicks remain near the burrow at least until early September at NAS Lemoore (Gervais, pers. obs.).

Males feed females during incubation, and bring food for both the female and the chicks during the early nestling period (Haug et al. 1993). Thereafter, males bring food and present it either directly to the chicks (Gervais, pers. obs.), or to the female, who either consumes it herself or feeds it to the chicks. Both parents forage for the young in the more advanced nestling stage (Haug et al. 1993, Gervais, pers. obs.); the onset of this is probably dependent on food supply. Chicks will emerge from the burrow and mob the incoming adult for food (Botelho 1996, Gervais, pers. obs.); adult owls do not appear to discriminate among chicks for feeding purposes, with the first chick to reach the adult claiming the food (Botelho 1996). Brood reduction through selective feeding does not appear to occur in this species (Botelho 1996), with nest abandonment attributed to adults' inability to provide food for the entire brood (Green 1988). Food supply and predation are probably the most limiting factors affecting the number of fledglings.

Determining the number of fledglings in burrowing owl nests is difficult, because young frequently remain underground when not actively seeking food or practicing flying; at any given time, it is highly unlikely that all young will be at the burrow entrance and visible. The most common method of estimating fledging success has been to use the maximum number of emerged young as the estimate, although this will be biased low, and be very sensitive to the amount of time and effort exerted to watch the nest, as well as the density and height of vegetation around the burrow. Literature estimates of numbers of young fledged vary widely, no doubt partially as a result of these problems: 4.9 young per nest in a New Mexico study site (Martin 1973), 1.05 to 3.20 young in human-altered and natural environments in New Mexico, respectively (Botelho and Arrowood 1996), 5-7 fledglings in Oregon (Green 1988), and <3 in an urban site in California (Trulio 1997). Burrows with up to 6 fledged young have been observed at NAS Lemoore, with a mean of 3.1 chicks/nest, approximately 30% higher than at the Carrizo Plain study area, a natural grassland SW of NAS Lemoore (Rosenberg *et al.* 1997).

2.7 Factors Limiting Population Size

To date, little work has been completed on understanding the dynamics of burrowing owl populations, although studies are underway in California (Rosenberg and Gervais, unpubl. data) and Canada (J. Schmutz, University of Saskatchewan, pers. commun.). The major requirement of burrowing owls in all habitats appears to be the availability of burrows suitable for roosting and nesting. In some environments, territoriality may limit the population size, as unused burrows will be too close to established nests (Green and Anthony 1989). Other factors such as food availability (Green and Anthony 1989) and pesticides (James and Fox 1987, Gervais et al. 1997) also may limit burrowing owl populations. In addition, predation by domestic dogs and cats may further compromise populations in more urban environments. At NAS Lemoore, we believe that the single greatest limiting factor is the number of nest burrows. Further, food may be limited during winter at NAS Lemoore, when agricultural fields are without vegetation.

•SECTION 3•

Distribution and Abundance of Burrowing Owls At NAS Lemoore

3.1 The Census

The primary data-gathering effort for the managment plan was to identify all locations where burrowing owls were nesting in 1997 at NAS Lemoore. Two survey techniques were used to locate owls. The presence of owls was initially determined using nocturnal calling surveys (e.g., Fuller and Mosher 1987, Haug and Didiuk 1993) during April. Diurnal walking surveys were conducted from early April to mid May to locate nest burrows. Calling surveys were conducted from transects located along vehicle-accessible roads. Transects were located on farm roads along the perimeter of all grassy areas and adjacent to canals and drainage ditches. Whenever possible, these transects were within 0.5 miles of each other to maximize detection probabilities (see Appendix I for list of routes). Stations were located at the beginning of each transect and then approximately every 0.2 miles (measured by the research vehicle's odometer) along the predetermined route. Surveys were conducted between 0300 and 0600 or between 2000 and 2300. Surveys were not conducted when winds were in excess of 15 km/hr or during jet activity.

The territorial call of the burrowing owl (the "coo coo" call) was copied onto a loop cassette tape by the Cornell Laboratory of Natural Sounds. The calls were spaced at ten second intervals. The tapes were played through a portable cassette player (Sony Walkman Model WMA53) broadcast through a megaphone (Realistic Model 32-2030) which was preset to broadcast at 100±2 decibels at a one meter distance. At each station, the observer got out of the vehicle and listened for burrowing owls for one minute and then played one call in each cardinal direction. The observer listened for four additional minutes after the final call was broadcast. Calling survey transects covered 50 linear miles with a total of 293 call stations.

Walking transect surveys were used to determine the precise location of potentially active owl burrows. All suitable habitats (uncultivated areas which were not also adjacent to residential development, wetland, or predominantly covered with brush) were censused by visual searches along transects with observers walking a uniform distance apart (between 7 and 20 meters depending upon vegetation height and density). The two wildlife areas, the transmitter and receiver sites, all of the grassy easements along the runways, and all unpaved areas of air operations were walked. Active burrows were defined by one or more of the following criteria:

1.) Pair of owls seen at burrow
2.) Nest decorations present
3.) Egg shells present at burrow entrance
4.) Chicks seen
5.) Owls' behavior at burrow during disturbance
    a) Alarm call given upon human approach
    b) Owl reluctant to flush, allows close approach
    c) Behaves defensively (aggression toward human)
    d) Owl retreats into burrow

3.2 Results

A total of 54 active burrowing owl nests was located at NAS Lemoore. Nests were clustered into five areas (Fig. 1). A single nest was located in the radio receiver site (Fig. 3), 6 were located in the wildlife area of TumbleWeed Park (Fig. 4), two were located in the artificial burrows temporarily set up adjacent to the capped landfill (Fig. 5), 19 were located in areas outside of Air Operations along the grass fields bordering the runways, including Wildlife Areas No. 1 (Figs. 6 and 7), and 26 nests were located in areas within Air Operations (Fig. 8). Nests within Air Operations were located in the small parcels of grass fields between the runways and the hangars. Distances of nests from the runways ranged from 3 - 951m, with an average of 351 m (Fig. 9). Several nests were located on the edge of the tarmack and located in burrows under runway signs (Fig. 10).

The distribution of owls closely coincided with the availability of burrows. Nests were almost always located in natural burrows created primarily by ground squirrels and coyotes. Exceptions included a pair that nested in a culvert, in a cable slot in Air Operations, and owls that nested under signs along the runways. Coyote burrows were located only in Tumble Weed Park and south of 32 R. Most of the censused area did not contain burrows of any type; where burrows were abundant, owls were present. Our findings of ground squirrel evidence (Fig. 11), suggested ground squirrels were not common at NAS Lemoore despite apparently suitable habitat (see Section 7). However, they are present, and are clearly an important predictor of owl presence at NAS Lemoore, and elsewhere in California (DeSante et al. 1996). We discuss this relationship in Section 7. Fields within which owl nests were absent typically did not have burrows. Creation of burrows by construction of artificial burrows (Section 8), would likely result in increases in the size of the burrowing owl population at NAS Lemoore.

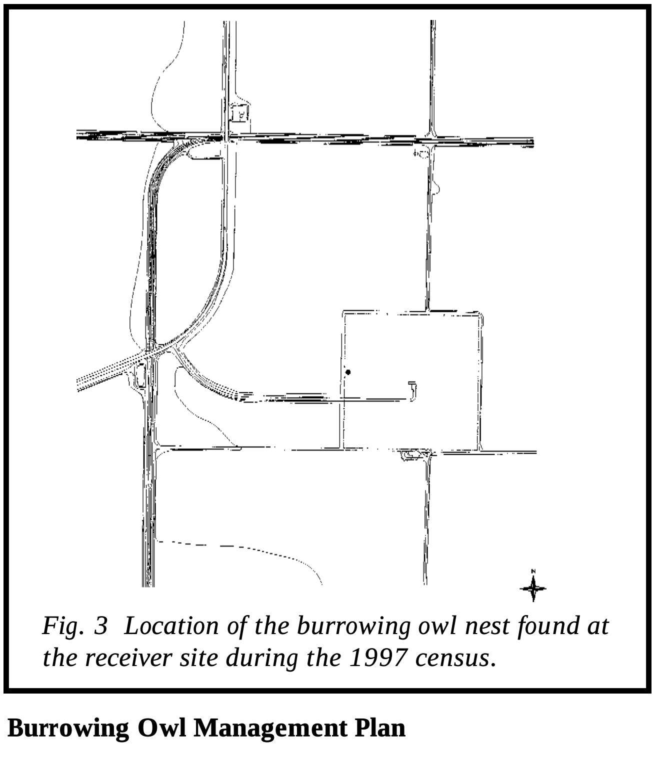


Fig. 3 Location of the burrowing owl nest found at the receiver site during the 1997 census.

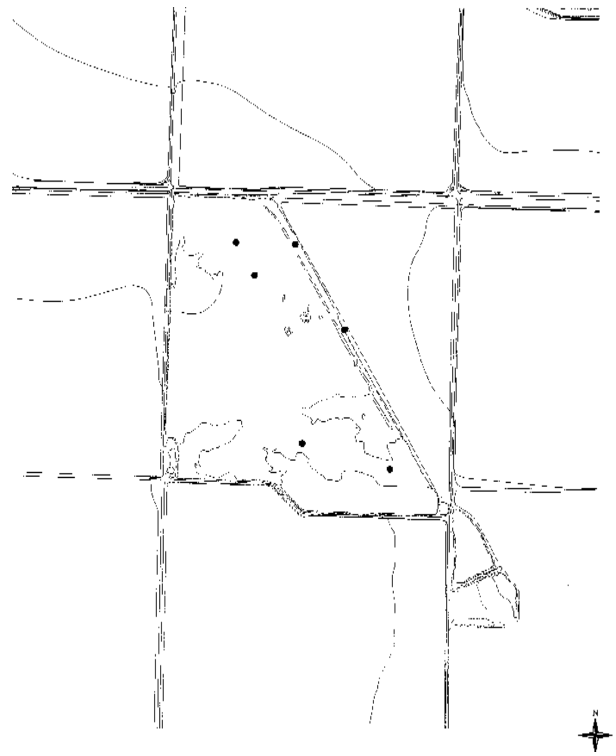


Fig. 4: Locations of burrowing owl nests within Tumble Weed Park from the 1997 census.

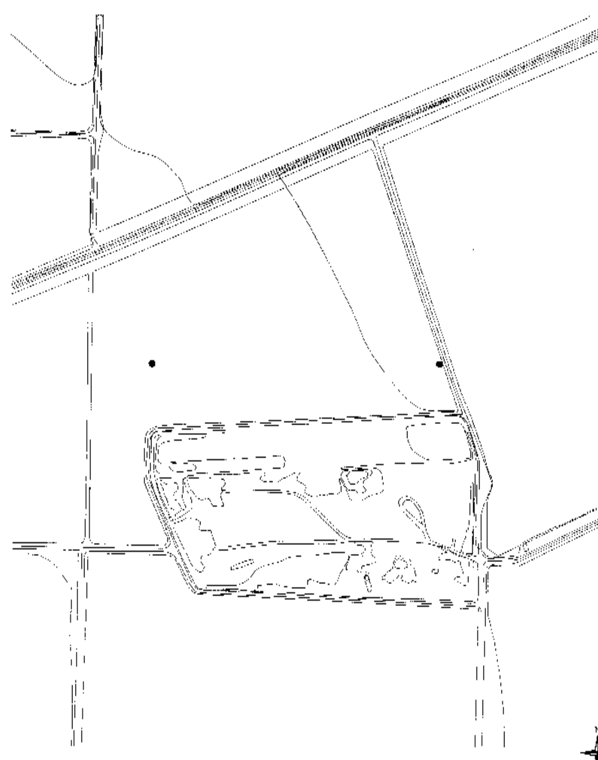


Fig. 5: Approximate location of the two nests in artificial burrows in the borrow pit adjacent to the landfill.

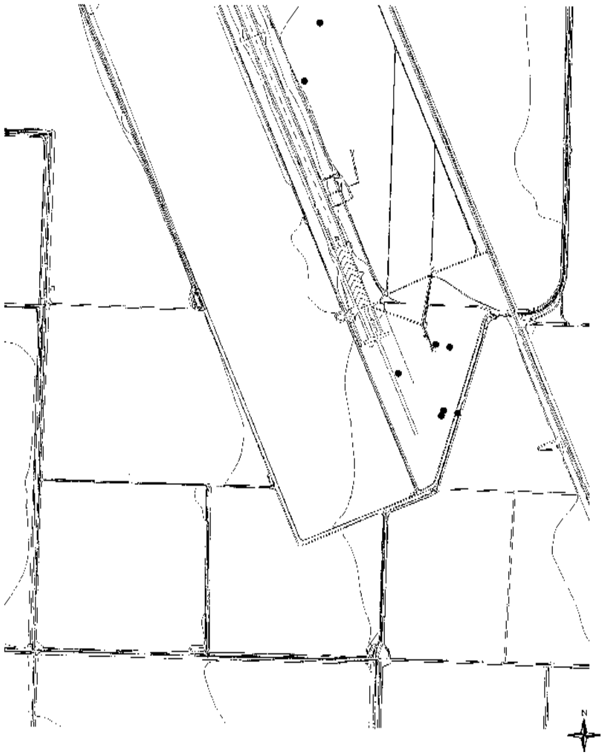


Fig. 6: Nests located at south end of 32L during the 1997 census.

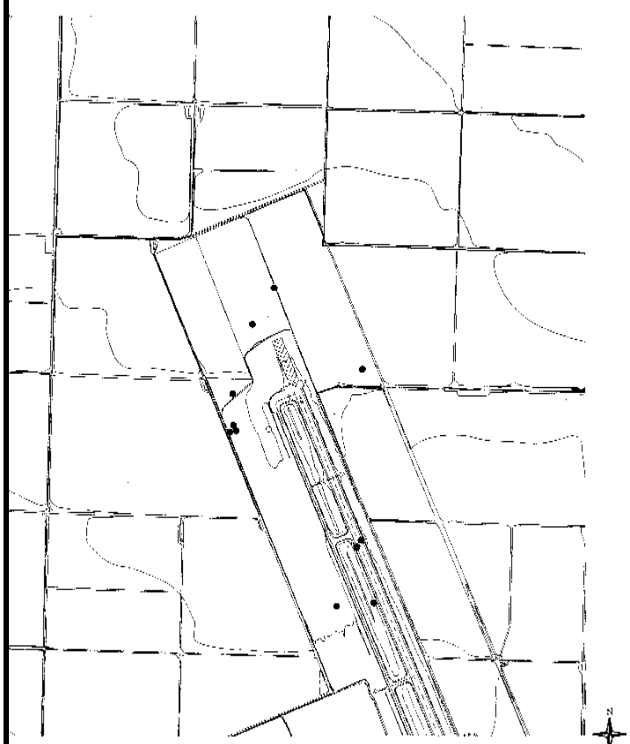


Fig. 7: Nests located at the north end of 32R during the 1997 census.

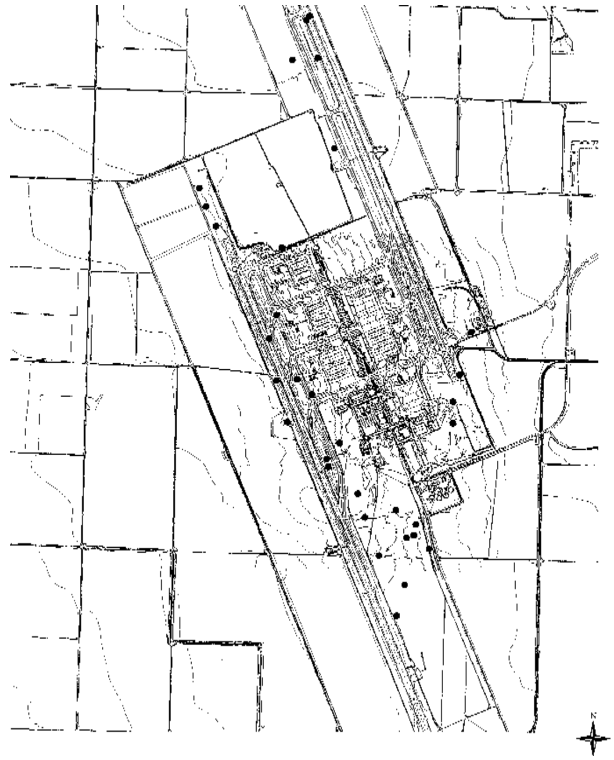


Fig. 8: Nests located within Air Operations during the 1997 census. Note that the southerly and northerly nests are also shown on Fig. 6 and 7, respectively.

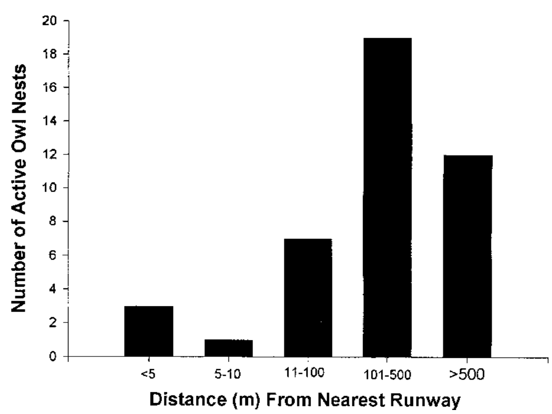


Fig. 9: Relationship between the number of nests located and distance to runways.

•SECTION 4•

Managing Grassland Systems

4.1 Historical and Present Condition

The native grasslands of California were greatly altered as a result of European contact in the 1700's, reducing grasslands from 8.9 million hectares to 800,000 hectares (Stromberg and Kephart 1996). The San Joaquin Valley contained much of California's grasslands. Prior to the expansive growth of industrial agriculture following the construction of the California Aqueduct, the San Joaquin Valley was a productive area of arid grassland vegetation. Current land use practices have further reduced California's native grasslands (Keeley 1990). The largest block of this vegetation type is the Carrizo and Elkhorn Plains, areas now designated by BLM as Areas of Critical Environmental Concern. Scattered small remnants occur elsewhere in the Valley, such as parts of the Kern and Pixley National Wildlife Refuge complex, located SW of NAS Lemoore. Most grasslands remaining in the Valley, however, are typically surrounded by intensive agriculture and comprised predominantly by introduced annual grasses. Alterations began so early in the historic period that the former condition of these grasslands will always be questionable (Wester 1981). California grasslands evolved under a regime of grazing by deer and antelope (Clark 1956). The area was not capable of withstanding the intensive cattle and sheep grazing that was followed by severe drought in the first half of the 19th century. The combination of these two factors was responsible for the transition from native to non-native dominated grasslands (Burcham 1957, Dasmann 1966). Perennial bunch grasses were likely abundant where exotic annuals are now present, leading to the conclusion that native California grasslands were dominated by perennial species (Wester 1981). Almost all of the native arid grasslands have been eliminated by agriculture in the San Joaquin Valley. The parcels remaining have been degraded by the expansion of introduced Eurasion species of annual grasses. The vegetation is primarily dominated by foxtail barley, bromes, and fescues (CNLM 1994), often forming very dense stands that increase the likelihood of wildfire and certainly inhibit the use of these areas by native arid community vertebrates such as burrowing owls.

Several species of wildlife have been affected by the altered grasslands and current land use practices. In the San Joaquin Valley, the structure of the exotic grasses is unfavorable for a number of species (USFWS 1997), including the blunt-nosed leopard lizard (*Gambelia silus*), kangaroo rats (*Dipodomys spp.*), San Joaquin kit fox (*Vulpes macrotis mutica*), and the burrowing owl. These species prefer the short stature and low density of vegetation that native perennial grasses provide. The exotic grasses grow much taller than the native grasses, which restricts the movement and foraging abilities of many animal species.

4.2 Current Conditions of Grasslands at NAS Lemoore

The grasslands at NAS Lemoore are typical of grasslands throughout the San Joaquin Valley, and fall into the category of "Non-Native Grasslands" by the California Native Plant Society and Natural Diversity Data Base (Kelly and Allenger 1996). Within NAS Lemoore, Tumble Weed Park has perhaps the best remaining examples of native species; however, introduced species predominate and include red bromes (*Bromus madritensis spp. rubens*), Mediterranean barley (*Hordeum murinum*, a foxtail), prickly lettuce (*Lactuca serriola*), and Mediterranean grass (*Schismus arabicus*) (Kelly and Allenger et. al. 1996). Native species that predominate include saltgrass (*Dictichlis spicata*). Outside of Tumble Weed Park, the grasslands are much more dense and more homogeneous, and dominated by only a few species, such as wild oats (*Avena* spp.), foxtail (*Hordium murinum*), and Bromes (*Bromus* spp.).

The high water table created by the subsurface geology of the region and exacerbated by irrigation (INRMP 1990) is at least partly responsible for the proliferation of the exotic grasses at NAS Lemoore. During wet years, such as occurred in 1998, plant biomass reaches its highest levels. The vegetation in the grasslands often reach such high densities and biomass that they are currently mowed 3-5 times per year at considerable expense (B. Fraley, NAS Lemoore, Transportation, pers. commun.). Further, the large amount of biomass that has developed over the years is contributing to a high risk of wildfire.

4.3 Retaining and Restoring Native Grasslands

Natural succession to native perennial grasses is unlikely in most cases because the native grasses cannot survive the intense competition with exotic annuals (Stromberg and Kephart 1996). Exotics have immense seed banks and a diverse set of plant growth forms and phenologies causing fierce resource competition for light and water (Menke 1992). Upon establishment, perennials are very strong competitors (Menke 1992). Strategies are necessary to reduce the competitive edge of introduced species in order for native grasses to persist. Herbivory and periodic fire are natural and necessary processes in grasslands (Menke 1992) and can reduce or eliminate the competitive edge of exotic species. Fire and grazing can influence grasslands and in turn, wildlife (Ivey 1996) such as the species of interest found in the San Joaquin Valley (USFWS 1997). The response by wildlife is dependent on the timing and intensity of fire or grazing (Ivey 1996).

Fire—Natural fires have been suppressed in most grasslands in the United States (Forde et al. 1984). Sophisticated fire fighting equipment has reduced fire frequency in grasslands, promoting invasion by a number of troublesome exotics (Hastings 1993). In recent years, improved understanding of natural functions of fires in ecosystems has increased the use of prescribed burning for resource management (Ivey 1996). Prescribed burning in late spring has been found to reduce exotic annual plant seed production and the resulting seed bank size. Prescribed fire lowers competition which increases perennial grass seedling establishment (Menke 1992). Summer burning causes substantial reductions in annual grasses and stimulates perennial bunch grasses to fragment into vigorous daughter plants (Menke 1992). Some perennials are lost in the fire but the benefits from greater native grass seedling establishment make up for this loss (Menke 1992). Kelly and Allenger (1996) reported a positive response with both native plant density and species composition at NAS Lemoore following experimental fire manipulations. Liability from potential fire escapes, smoke restrictions and time required to get permits makes burning as a management strategy difficult to implement in many situations (Menke 1992). These issues became apparent during prescribed burns conducted at NAS Lemoore (J. Crane, NAS Lemoore, pers. commun.). There have been two prescribed fires at Tumbleweed Park at NAS Lemoore since we began our studies of burrowing owls. In each year, owls were nesting at the time of burning. In both cases, there were no negative effects evident to the owls or their chicks. The habitat conditions seemed much improved following burning. Therefore, evidence suggests that burning is a very appropriate management tool for improving and maintaining burrowing owl habitat, even when burning occurs during the nesting season. The timing and frequency of prescribed fire will be important aspects to evaluate at NAS Lemoore. These questions should be addressed within an adaptive management framework.

Grazing-Historically, San Joaquin Valley grasslands were grazed in the winter and spring by large native ungulates. Today, used as an effective management tool, prescribed grazing can control the height and density of exotic grasses, reduce fire potential by reducing fuel volume, and promote the proliferation of some native species (CNLM 1994). These methods have been used at several sites within the San Joaquin Valley (CNLM 1994) and in the Carrizo Plain (pers. obs.). However, few reports exist as to the results of these case studies.

Intense grazing by domestic livestock has been responsible for habitat degradation by disrupting the cryptogamic soil crust, compacting the soil, removing vegetative cover, destroying rodent burrows and trampling vegetation. Domestic livestock also forage on endangered plant species. On the other hand, invasion from introduced plants results from the discontinuation of grazing (CNLM 1994). Thus, grazing can be an effective management tool if carefully managed and monitored. Our observations of burrowing owl ecology in areas that are grazed suggest that grazing is a very useful management tool for providing high-quality nesting and foraging habitat for burrowing owls. One of the highest densities of burrowing owls we have found in the San Joaquin Valley occurred in a privately owned small grassland that was heavily grazed, although not to the point of exposure of bare soil.

The use of grazing as a management tool is a complicated effort dependent on the interaction of soils, plant generation and seeding periods, animal requirements, fire frequency, and the proliferation of non-native species. The Center for Natural Lands Management Plan (1994) offered these considerations for a management program utilizing grazing:

> The manager should understand the soil structure and the potential natural plant community to determine which areas are particularly sensitive to grazing.
>
> The intensity of grazing should be low enough to leave sufficient cover to protect the soil and maintain or improve the quality and quantity of desired vegetation, but reduce the cover of exotic or invasive species enough to allow the seeds of native plant species to germinate and survive.
>
> Grazing intensity should be at a level that will allow enough stubble at the end of a grazing season to promote growth of green forage and winter growth of new seedlings. Stubble protects the new plants from drying winds and sun. The decomposing plant material partially intermixed with soil conserves moisture and promotes establishment and early growth of each year's seedlings.
>
> Grazing should be restricted to periods when there is sufficient foliage to both supply livestock and preserve ground cover.
>
> Grazing should not begin in spring until forage species are sufficient and soil conditions are such that no damage will occur as a result of animals.
>
> Techniques that encourage livestock to move regularly and graze uniformly help to maximize the benefits of grazing while reducing damage. These techniques include placement and movement of salt and water.
>
> Open herding reduces trampling of forage and compaction of soils. Closed herding is more damaging to foliage and soil structure.
>
> Alternate grazing of two or more areas may encourage growth of desirable native plant species.

Mowing- We are not aware of any relevant studies in which mowing as a tool for managing grasslands was evaluated, despite the common use of mowing as a means to control the height of vegetation. Mowing is an effective tool for the management of vegetation height for burrowing owl conservation as it does not typically disturb the structure of the nest. The use of large-tired mowers reduces the risk of nest damage, and the restricted use of mowing when young chicks emerge (May-June) prevents destruction of young. At NAS Lemoore, mowing appears to be an effective tool. The frequency and timing of mowing to control vegetation height, reduce seed production for reducing BASH, and to encourage native flora requires an active monitoring and research effort. Because mowing does not reduce residual dry matter, continued mowing without fire or grazing may increase risk of wildfire and limit opportunities for native plant establishment and maintenance. Therefore, mowing is a viable tool for vegetation control which is most useful when combined with fire and/or grazing.

Case Studies-Despite the clear importance of managing and restoring native grasslands in the San Joaquin Valley, there have been few studies conducted that provide management guidelines (USFWS 1997). Below, we discuss the few case studies we are aware of. The studies by Kelly and Allenger (1996) at NAS Lemoore were discussed previously. Results from their study, and other experimental manipulations of vegetation, will be critical in designing site-specific vegetation management recommendations for NAS Lemoore. The height and density of vegetation will be critical parameters to estimate during the studies.

Ivey (1996) reported that burrowing owl densities were highest in heavily grazed sites in northern plains grasslands that supported high populations of Richardson's ground squirrels (*Spermophilus richardsonii*). From our experience at Carrizo Plains Natural Area and in privately owned parcels in the San Joaquin Valley, livestock grazing and burrowing owls can be compatible. Obviously, the density of livestock will determine the likelihood of compatible management. We have also observed that burrowing owls, both adults and chicks, survive prescribed fire during the breeding season, and they clearly find recently burned areas to be suitable nesting habitat.

Hastings (1993) conducted burns at Sugarloaf Ridge State Park to control the invasive weed, yellow star thistle. Their results indicated that fire intensity was not a critical factor. Rather, burning during the appropriate stage of plant development to prevent seed production was important. Also documented during the study was an increase in the abundance and diversity of native plant species on burned sites. Cover by native species ranged from 11 percent on unburned sites to 25 percent on the site burned two consecutive years.

Hansen (1992) conducted three fall burns at The Nature Conservancy's Pixley Vernal Pools Preserve and four fall burns at the Creighton Ranch Preserve to compare the effects of fire and fire frequency on diversity, percent composition of grasses, legumes, and forbs, and percent composition of native and exotic species. Both preserves are located near NAS Lemoore. Diversity was increased by fire in 18 of 34 burn treatments. In 7 of the 16 burn treatments with reduced diversity, there was an increase in percent composition of natives. This is due to the fact that most native annual forbs are favored by fire; most introduced annual grasses are not fire adapted. Fire increased percent composition of natives in 24 of the 34 burn treatments.

In 1980, Forde et al. (1984) began a four-year study to evaluate the effects of a prescribed burning program in spring that was initiated at Wind Cave National Park, South Dakota. Immediate reductions in perennial species and the amount of dead material present were documented. Immediately after the fire, bare-ground coverage increased. The grassland species were historically subjected to fire and Wind Cave National Park was encouraged to continue its fire program using controlled burns.

An extensive research program on the effects of grazing and fire on plant and animal species is underway in the San Joaquin Valley (G. Rathburn, USGS, pers. commun.). Results from these experimental treatments of varying intensities of prescribed fire and grazing will be instrumental in determining appropriate vegetation management scenarios at NAS Lemoore.

4.4 Creation of Native Grasslands: Specific Recommendations for NAS Lemoore

Although restoration efforts including fire and grazing may be appropriate for sites with native plant species, such as Tumble Weed Park and the capped landfill, creation of grasslands should be attempted where and when it is feasible. The following are guidelines that were suggested for the creation of a native grassland as cover for the capped landfill at NAS Lemoore. The original plan was developed by Dr. Ellen Cypher as per a contract with The Institute for Bird Populations during the burrowing owl relocation work at the landfill. This plan was intended for both erosion control, use of native species favorable for grassland species such as burrowing owls, and as cover that minimizes depth of rooting material so to avoid penetration of the landfill barrier. Therefore, other mixes may be appropriate depending upon the conditions and objectives of the work.

Topsoil- Weed seeds must be killed before native species are hydroseeded onto a site to prevent the weeds from out-competing the natives. There are several options for killing the weed seeds. A common procedure is to apply a granular or liquid pre-emergent herbicide (for example, Amaze or Surflan). However, the following requirements must be met:

(1) the product used must control both grass and broad-leaf weed seeds.
(2) the treated soil must not be disturbed for at least 90 days after the pre-emergent is applied (longer if the label so indicates).
(3) native plant seed must not be sown for at least 90 days after the pre-emergent is applied (longer if the label indicates a greater duration of the herbicide).
(4) after the waiting period, the soil should be disced, then the native seed mixture may be sown

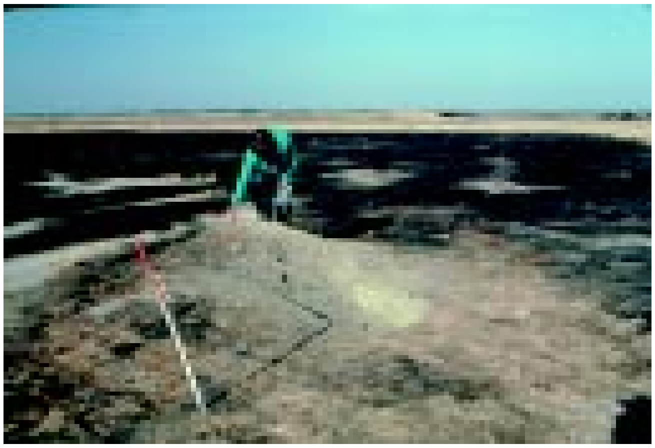
<u>Suggested Species</u> (percent composition in [ ])
dwarf goldfields [25](*Lasthenia chrysostoma*)
sky lupine [12] (*Lupinus nanus*)
plantain [50] (*Plantago insularis*)
pine bluegrass [12] (*Poa scabrella*)
nodding needlegrass [1] (*Stipa cernua*)
California buckwheat (*Eriogonum fasciculatum*) may be substituted for needlegrass.

<u>Suggested Species For Gently Sloped Areas</u>
white yarrow [18] (*Achillea millefolium*)
creeping wildrye[9](*Elymus triticoides*)
dwarf goldfields [9] (*Lasthenia chrysostoma*)
plantain[36] (*Plantago insularis*)
alkali sacaton [18] (*Sporobolus airoides*)
nodding needlegrass [10] (*Stipa cernua*)

<u>Additional species for gently sloped areas that can be used if rooting depth is not important</u>
California buckwheat [1] (*Eriogonum fasciculatum*)
Dwarf goldfields [25](*Lasthenia chrysostoma*)
Sky lupine[12] (*Lupinus nanus*)
Plantain [50] (*Plantago insularis*)
Pine bluegrass [12] (*Poa scabrella*)

The native seed mixtures should be sown during early fall to take advantage of natural rainfall. Seeds should be spread at a rate of 8 lbs per acre, approximately equal to 75 seeds per square foot, a rate that has been successful in the San Joaquin Valley. Seeds should be pure live seeds. Seed sources are best if local, but should always be from an area with <10 inches of rain per year and a Mediterranean climate. Fertilizer should not be used, as nitrogen promotes growth of exotic species. Use weed-free mulch (e.g., straw or hydromulch) to avoid introducing undesirable species. Using native, commercially available species, such as those suggested here, should not be more expensive than typically used exotic species such as brome, fescue, and rygegrass when applied at the proper rate. Note that sparse cover is desirable to create grasslands typical of the California grassland association. The lower application rate to achieve this condition requires fewer seeds/acre. This results in similar costs for using native species as compared to the non-native species. Estimated seed costs (1996) were approximately $212/acre.

Watering- Watering the surface after seeding will be necessary only if precipitation is considerably below average. The actual application rate (e.g., gallons per hour) will depend on soil permeability and must be adjusted accordingly by the operator of the water truck or other delivery system. Water should be applied at a rate that will allow it to soak in, rather than run off. If the Station has not received at least 1 inch of rainfall between 1 October and 1 December, apply 0.5" equivalent. After that, the revegetated area will need at least 0.5" of water every 2 weeks until 31 March. If this amount or greater falls naturally, no irrigation will be necessary. If less rain falls during any of the 2-week periods, apply enough additional water to bring the 2-week total to 0.5". No additional watering will be necessary after 31 March, regardless of rainfall.



Active burrowing owl nest burrow after prescribed fire at Tumbleweed Park.

4.5 Integrating the Needs of Air Operations, Ground Maintenance, and Burrowing Owls

Ground maintenance of vegetation, such as mowing operations, supports the needs of Air Operations by managing the vegetation for safe and efficient operations of the jets. This is the primary objective of vegetation management in areas near the runways. These same areas support many of the owls and other wildlife that are found at NAS Lemoore. Therefore, a secondary objective of vegetation management is to contribute to the Station's mission of natural resource management. On May 15, 1997, DKR met with staff of the Public Works Transportation Department to discuss vegetation management issues. Primary concerns of their Department were (1) the difficulty of mowing operations in areas inhabited by burrowing owls due to the raised ground at burrow entrances, (2) limitations placed on their ability to level fields by discing and thus facilitate mowing at a 4-6" height because of the presence of burrows occupied by burrowing owls, and (3) vegetation height management to provide for BASH and other Air Safety issues.

Currently, vegetation height in the grassy fields is kept to a maximum height of approximately 4-6 ", as per current guidelines (B. Fraley, NAS Lemoore, pers. commun.). Maintaining this short structure requires frequent mowing, resulting in high costs. This height restriction was due to the desire to meet Air Operations guidelines (B. Fraley, NAS Lemoore, pers. commun.). However, Air Operations staff believe that such a low height restriction is not necessary (finding from meeting with DKR and Air Operations staff, 1997). The primary concern of Air Operations

Fig. 10: Photo of owl nesting under runway sign in Air Operations

Capped landfill at NAS Lemoore, with a profusion of goldfields, after revegetation with native species.

regarding vegetation height is to minimize bird strikes. Because large agricultural fields near runways attract birds (Morrison 1993b), maintaining such a short vegetation structure is unlikely to reduce bird strikes. The primary need outside of agricultural fields would be to reduce the production of seed heads from non-native grain species, such as oats or foxtails. Maintaining vegetation heights at less than 12” should meet Air Operations safety needs. This height requirement would alleviate the difficulty mowing in areas with burrows, as this height can be safely achieved without damaging mowing equipment (S. Reinke, NAS Lemoore, pers. commun.). An 12" height maximum, if diversified by the presence of a species assemblage that consists of various heights and structures, should provide suitable nesting habitat for burrowing owls. It would be desirable for owl areas to be mowed by March 1, although rainfall may be too high during some years to allow this to occur. If mowing operations occur in owl areas during the early chick rearing period, May 20-July 1, then caution must be used to minimize accidental death to chicks that are outside of burrows and are not old enough to escape quickly. This has occurred once to our knowledge in the past three years.

We recommend that the maximum height of non-woody vegetation in grasslands be increased, thereby facilitating mowing operations where owls and their burrows are present. Under current conditions of dense, non-native grasses, vegetation height and density must not be allowed to achieve a level that will prohibit owls from nesting and foraging. Further it will be important to mow all areas including the areas adjacent to burrows. It is important to avoid creating small islands of tall vegetation that may act to attract predators near the nest. Although burrows are as shallow as 4" at Lemoore (pers. obs.), mowing equipment should be able to mow over nests without destroying burrows if carefully done. During our research at NAS Lemoore, there have been no burrows that have collapsed due to mowing operations. Our current research will provide further guidelines regarding maximum height and density that still allows owls to persist and successfully raise young. Results from these research efforts should be incorporated into the adaptive management plan as they become available. All of the concerns regarding vegetation structure suggest that a program of grazing, fire, and mowing will be required to properly manage the grasslands as both important areas for wildlife as well as to maintain areas at low fire risk and minimize BASH. Note, however, that any discing operations are potentially harmful to burrowing owls, and should be avoided until staff of the Environmental Management Division of NAS Lemoore are consulted regarding potential risk. Experimental research, such as has been carried out by Kelly and Allenger (1996) at NAS Lemoore and by Rathburn et al. (B. Rathburn, USGS, pers. commun.) in the southern San Joaquin Valley, will allow specific recommendations to be tested and modified for incorporation into management plans at NAS Lemoore. Experimental work should include the frequency of mowing, vegetation height, and the season of mowing, especially as timing relates to the nesting season of burrowing owls. An experimental program of mowing and monitoring effects on owl nest site use will provide the most appropriate data for the dual management of grasslands and owls at NAS Lemoore. We recommend a rigorous and coordinated vegetation management research effort as an important step to managing the grasslands at NAS Lemoore for wildlife conservation, air safety, and management efficiency.

•SECTION 5•

Herbicide and Pesticide Use at NAS Lemoore: Implications to Burrowing Owls

5.1 Overview of Regional Use and Effects on Wildlife

The southern San Joaquin Valley in particular encompasses some of the most intensively farmed agricultural lands in the US (Gilmer *et al*. 1982, Griggs 1992), and the agricultural out-lease areas at NAS Lemoore are similar in this respect. High agricultural contaminant levels continue to threaten many native species of plants and animals in the valley (Williams *et al*. 1992). Thus pesticide use at NAS Lemoore is a concern which must be addressed by the Management Plan. Our research group investigated contaminant exposure to burrowing owls at NAS Lemoore and elsewhere in California in 1996. Here we present an overview of pesticide and herbicide effects to wildlife and a summary of our findings and implications to the management of owls at NAS Lemoore.

Many of the pesticides both currently in use and previously used in the southern San Joaquin and Imperial Valleys have been found as contaminants in many species of wildlife, and have been documented to have detrimental effects. Organochlorine compounds in particular are notorious for their effects on the survival and reproduction of birds, causing eggshell thinning and embryo toxicity (Wiemeyer *et al*. 1989), impaired development (Fry and Toone 1981, MacLellan *et al*. 1996), and impaired nervous system function (Yamamoto *et al*. 1996). DDT and its analogs continue to be detected in the soils of California (Mischke *et al*. 1984), including those at NAS Lemoore (Table 1), and remain widespread as contaminants in wildlife, particularly in birds. Although banned over 20 years ago, DDE has been documented in the eggs of caspian terns, snowy egrets, black-crowned night herons, and Forster's terns in San Francisco Bay (Ohlendorf and Fleming 1988, Ohlendorf and Marois 1990, Hothem *et al*. 1995), and in black-crowned night-herons and great egrets in the Imperial Valley (Ohlendorf and Marois 1990). Ducks wintering in California also contained organochlorine residues, some of which were great enough to be potentially harmful (Ohlendorf and Miller 1984). Elevated levels of organochlorine compounds, including DDE, have been found in the eggs of prairie falcons in California's Pinnacles National Monument, and were associated with impaired reproduction (Jarman *et al*. 1996). Burrowing owls in Canada were contaminated with DDE (Haug 1985). Hunt and coworkers (1986) discovered DDE contamination in a number of other birds in California, including migratory short-billed dowitchers, western sandpipers, black-headed grossbeaks, violet-green swallows, and resident killdeer and starlings. The contaminant concentration at which these species' reproduction and survival are affected is not known, but in any case the concentrations found may bioaccumulate to dangerous levels in accipiters, falcons, and owls (e.g., Klaas *et al*. 1978).

Dicofol is another organochlorine compound that is widely used as a miticide in the San Joaquin Valley, primarily on cotton and citrus crops. In birds, exposure to dicofol can lead to eggshell thinning and embryo toxicity (Wiemeyer *et al*. 1989, Clark 1990, Schwarzbach 1991, Schwarzbach *et al*. 1991), and can therefore have profound effects on avian productivity. Dicofol has similar effects of egg shell thinning as does DDT because of their similar metabolites.

Organophosphorus and carbamate compounds have been implicated in the direct mortality of a number of wildlife species (Smith 1987, Mineau 1993). Burrowing owls in Canada disappeared from their breeding burrows following a nearby application of a carbamate insecticide (James and Fox 1987). The compound DEF (s,s,s-tributyl phosphorothithioate), a defoliant applied to cotton prior to harvesting, has the potential to bioaccumulate, and may cause neurotoxicity (Smith 1987). Other pesticides have been implicated in wildlife mortalities, as in the deaths of a number of redtail hawks in California following a winter dormant spray application (Hooper *et al.* 1989). These and other organophosphates (see "Local Use" below) are currently widely used in the San Joaquin Valley, including NAS Lemoore.

The burrowing owl's diet includes aquatic organisms taken from agricultural drainage ditches (Section 2). This makes the species vulnerable to selenium, a naturally occurring element that is leached from soils through irrigation. Selenium has caused substantial damage to populations of other bird species (Ohlendorf *et al.* 1986, 1987, 1988).

Owl reseacher Jennifer Gervais with burrowing owl egg for chemical analysis.

5.2 Local Use

Large amounts of agricultural chemicals that are potentially harmful to wildlife are used in the San Joaquin Valley, and therefore at NAS Lemoore as well. Of particular concern are the following chemicals, all of which are applied at NAS Lemoore within 1 km of burrowing owl nest sites, and often much closer (Gervais et al. 1997): Aldicarb, Chlorpyrifos, Def, Dicofol, and Metam sodium (Table 1). In addition, Diazinon, Endosulfan, Lindane, Methidathion, and Paraquat dicholoride fall into the same category; however, they were not sprayed at NAS Lemoore during our toxicology study in 1996. Large quantities of these chemicals are typically used in the San Joaquin Valley primarily for cotton production (Gervais et al. 1997). At NAS Lemoore, the rotation of cotton with grain crops for 2 of each of 5 years results in a lower use of most of these herbicides and pesticides than in the general region. Regardless, 65% of the agricultural production remains in cotton production (J. Crane, NAS Lemoore), similar to regional cropping patterns.

5.3 Summary of Pesticide Residue Study of Burrowing Owl Populations

We studied the contaminant residue levels in burrowing owl populations in central and southern California, including samples from NAS Lemoore. Egg, feather, and footwash samples were collected in 1996 and analyzed for most of the commonly applied herbicides and pesticides. Below, we summarize the findings from NAS Lemoore.

Eggs contained none of the organophosphorus compounds tested for (Gervais et al. 1997). The majority of organochlorine compounds tested for were also not found within the eggs, but the notable exception was p,p'DDE, a metabolic product of DDT. All eggs (n=9 eggs from different nests) analyzed from NAS Lemoore had detectable levels of DDE ranging from 1.5 to 33 ppm. The eggs from NAS Lemoore showed a great amount of variability in DDE concentrations; the second, third, and fourth highest concentrations were 18 ppm, 17 ppm and 9.4 ppm, respectively; the remaining eggs contained 5 ppm DDE or less (Fig. 11). Mean DDE concentrations at Lemoore was 10.91 ppm. BHC (ß-benzenehexachloride) was detected at 0.11 ppm in one egg, and mixed PCBs were detected in two eggs (1.6 ppm and 2.9 ppm). These same eggs contained 33 ppm, 4.8 ppm, and 4.8 ppm p,p'DDE respectively. Selenium was detected in most eggs, but in small quantities; these values were within the range considered normal for poultry eggs (California Veterinary Diagnostic Laboratory System 1997). Mean eggshell thicknesses varied among our study sites, with the thinnest shells occurring at NAS Lemoore.

Table 1. List of pesticides and herbicides used in the southern San Joaquin Valley and at NAS Lemoore that are of particular concern to wildlife species.

Chemical	Use	Crops	EPA Toxicity Class	Ecological Toxicity
Aldicarb	mites, aphids	particularly cotton	highly toxic	Highly toxic
Chlorpyrifos	mites,aphids, worms	Cotton and other crops	moderately toxic	Highly toxic to birds
Endosulfan	broad insecticide	many crops	highly toxic	Highly toxic
Dicofol	mites	cotton	moderately to low in toxicity	Causes eggshell thinning in birds; highly toxic to aquatic life
Diazinon	broad insecticide	many crops	moderately to low in toxicity	Highly toxic to birds and aquatic life
Methidathion	scale insects	many crops and others	highly toxic	Highly toxic
Def	defoliant	cotton	?	Believed to be highly toxic to wildlife

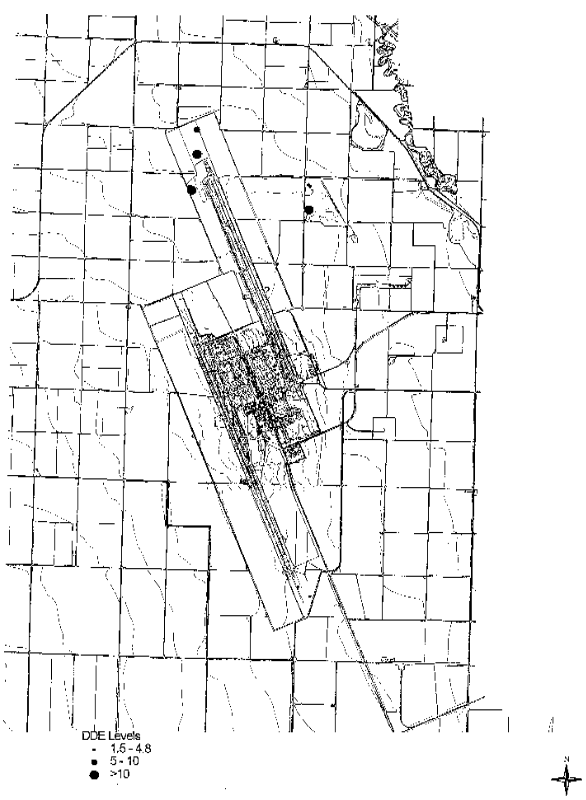


Fig. 11: Levels of DDE in burrowing owl eggs sampled in 1996.

Feathers did not contain any of the organophosphorus insecticides tested for in amounts greater than the minimum detectable levels. Most of the samples from Lemoore had traces of p,p'DDE (mean detectable limits = 0.1 ppm, % of samples below MDL= 25%, = 0.26 ppm, SE=0.075, range = 0.06-1.02 ppm, n = 12), but no traces were found in the Carrizo feather samples. DDE contamination in egg samples were correlated to feather samples collected from the same owls (r = 0.59, n = 10, P = 0.08); however this relationship was heavily influenced by the samples from one individual bird that had very high levels of DDE. When data from this owl were removed, there was no correlation between the remaining data (r = .27, n = 9, P = 0.48).

Footwash samples contained none of the organochlorine compounds tested for. The only organophosphorus compound detected was chlorpyrifos (MDL = 10ng, % samples below MDL = 58.8%, = 25.3 ng, SE = 4.46, range = 12.5-45.0, n = 7).

Following our findings of high DDE exposure, staff at NAS Lemoore sampled soil in 10 areas using a composite sampling design in which subsamples of the areas were pooled for

Table 2. Levels (ppb) of DDT, DDE, and the ratio DDT/DDE in soil samples collected from Naval Air Station Lemoore, December 1997[1]

Site	DDT	DDE	DDT/DDE (%)
Cluster Samples			
NW-6	ND[2]	8.6	0
NDD	ND	4.2	0
TWP	ND	4.7	0
WL	ND	ND	0
EG	ND	4.7	0
KRT	ND	2.8	0
EAS	ND	2.3	0
GBP	2.2	6.2	35.5
EAN	2.6	4.2	61.9
Individual Samples			
GBP-1	ND	2.3	0
GBP-2	2.2	33.2	6.6
GBP-3	3.8	6.4	59.4
GBP-4	5.3	11.8	44.9
GBP-5	4.9	10.6	46.2
EAN-1	17.3	8.6	201.2
EAN-2	ND	4.1	0
EAN-3	ND	3.7	0
EAN-4	ND	7.2	0
EAN-5	7.2	12.4	58.1

[1] Samples collected and provided by J. Crane, Env Mgmt. Div., NAS Lemoore.

[2] ND; not detected.

chemical analysis, then separated out upon finding high levels (J. Crane, NAS Lemoore, pers. commun.). Both DDT and DDE were found in most samples (Table 2). Importantly, the ratio of DDT/DDE was fairly high in some samples, indicating either recent use or low metabolism of the existing DDT. This suggests that high levels of DDE will not be significantly reduced in the near future by natural mechanisms since the metabolism of existing DDT will contribute to further DDE levels.

5.4 Implications to the Management Plan

Although traces of several insecticides were detected in samples from burrowing owls, the most significant finding was the high concentrations of DDE at NAS Lemoore in the owls' eggs. Despite a quarter-century ban on its use in the United States, DDT and its metabolites remain available for uptake and bioaccumulation in wildlife species in the San Joaquin Valley. The source for the contamination is from both residues in the soil and in the food chain. Burrowing owls appear to be less sensitive than other birds to the effects of DDE on reproductive success, as the levels of DDE detected in the eggs of this study would cause total reproductive failure in many other species of birds (Gervais et al. 1997). Since we were unable to closely follow reproductive success during the toxicology study, we could not determine whether the contamination levels we detected might be associated with lowered reproductive rates; however, given the 20.6% overall eggshell thinning since 1937 and the fact that the levels of DDE we found have caused decreased reproduction in other raptors, it seems plausible that at least some owl pairs are being adversely affected. Burrowing owls at NAS Lemoore are exposed to high levels of DDE and may suffer impaired reproduction or survival as a result. The contaminant load we documented has not led to total reproductive failure, but our work did not allow us to evaluate more subtle effects such as decreased reproductive rates, greater mortality, or impaired development, all of which could compromise population viability. In addition, the current load of DDE may make the birds far more susceptible to debilitating effects from pesticides still in use, such as dicofol and aldicarb. Our current research at NAS Lemoore has allowed us to begin to evaluate the more subtle effects of high DDE exposure. Preliminary results are encouraging: productivity and survival of both young and adults seems relatively high. Regardless of the effects on burrowing owls, the high levels of DDE we detected should be concern for other wildlife species as well.

DDT has not been legally applied in the United States since 1972 (Peterle 1991), and DDT contamination in dicofol was banned by 1989 (Clark 1990). North American wildlife may be exposed either by migrating abroad, where DDT use continues (Peterle 1991), or through residues that persist from past use in this country and which still are able to bioaccumulate. Burrowing owls are potentially exposed to both sources, although those breeding in the San JoaquinValley are year-round residents (Gervais, pers. obs.) and their toxicant loads would be a result of local contamination. DDT and its metabolites remain widely distributed in the agricultural soils of California statewide, particularly in the San Joaquin Valley. At NAS Lemoore, soil samples collected at 10 sites had DDE levels that ranged from 0 (not detectable) to 33.2 ppb and DDT from 0 to 17.3, with a ratio of DDT/DDE that ranged from 0 to 201% (Table 2). The variability in egg samples may therefore be a result of differential use of patchily contaminated habitat, with exposure occurring both from prey and from the soil directly. The results suggest there may exist "hot spots" of DDE contamination at NAS Lemoore (S. Schwarzbach, USFWS, pers. commun.).

Organophosphorus compounds primarily act on the nervous system by blocking neurotransmitter function, they generally are water-soluble and so do not bioaccumulate, and they have relatively low environmental persistence, unlike many organochlorine compounds (Smith 1987). Organophosphorus compounds are therefore unlikely to be detected in eggs, or impair reproduction through interfering with eggshell formation or embryo viability, as organochlorine compounds do. These compounds pose a threat to wildlife through direct mortality (Peterle 1991, Smith 1987, Grue et al. 1983). The incidence of chlorpyrifos in the footwash samples of burrowing owls and the spraying of aldicarb within 1 km of active nests at NAS Lemoore indicate that this population is at risk of exposure to organophosphate insecticides applied to the local farm fields. Since only aldicarb was sprayed just prior to our sampling, and the contaminant scans did not include carbamate compounds, we cannot assess the exposure risk to the owls based on these data. Further research into owls' use of agricultural fields and whether use shifts with spraying activity will help clarify the risk to local owl populations. It also does not appear that the birds were exposed to local, recently-applied chlorpyrifos, since none was reported as applied anywhere on NAS Lemoore in the months prior to our sampling. Organophosphorus contaminant samples must be collected soon after the spray event in order to document exposure, and the chemicals are used sporadically throughout the year. Sampling done in conjunction with habitat use studies and timed to coincide with spray schedules will be necessary to assess the exposure risk of owls living near fields where organophosphorus compounds are applied.

Despite the fact that owls at all sites we examined included aquatic invertebrates in their diets, selenium does not appear to be a threat to their reproduction and survival. This may be due to the fact that although we often found the remains of crustaceans in pellets, the vast bulk of the owls' diet consisted of terrestrial vertebrates and insects (Section 2), so that the overall intake of food items potentially contaminated with selenium is rather small.

5.5 Recommendations

Cotton is the primary crop grown in the southern San Joaquin Valley and at NAS Lemoore as well. Cotton production represents a threat to wildlife due to the large amount of pesticides and defoliants applied to conventionally grown cotton (CNLM 1994). In contrast to other cotton production sites in the Valley, cotton production at NAS Lemoore utilizes a rest from cotton for 2 of 5 years per field; this will reduce the levels of pesticides used in the area. Several of the pesticides deserve special attention as potentially negatively affecting wildlife, including burrowing owls (Table 3). These are Aldicarb, Chlorpyrifos, Def, Diazinon, Dicofol, Endosulfan, Lindane, Metam sodium, Methidathion, and Paraquat dicholoride. We recommend developing a plan for reducing the above listed pesticides and herbicides at NAS Lemoore. These chemicals should be highlighted during the Department of Defense's (DoD) planned policy goal of a 50% reduction of pesticide use on DoD lands by the year 2000. A thorough evaluation of alternatives, that includes costs and benefits is justified Identification of the pesticides of greatest concern and finding alternatives will be a positive step for the integration of agricultural production and wildlife conservation. In addition to currently used contaminants, DDE levels remain high at NAS Lemoore, as indicated by the levels in the eggs of burrowing owls. Research is needed to both evaluate the effects of the high DDE to the owls and, importantly, to locate the source of DDE within the food web, and to identify potential "hot spots" of DDE contamination. Once found and evaluated, it will then be imperative to evaluate if it is efficient to provide clean-up, recommend means to limit wildlife use of these areas, or other remediative measures.

•SECTION 6•

Bird Air Strike Hazards

Birds pose a potential hazard to aircraft, threatening both human lives and aircraft. Incidents involving loss of lives are rare but do occur (Burger 1985); more common are incidents in which damage to the aircraft results. Most incidents (>75%) occur near airports during take-off and landing. Although only 5% of air strikes with birds may result in aircraft damage (Burger 1985), this results in over 10 million dollars in damage annually. The recognition of this has led to plans to reduce bird air strike hazards (BASH). At NAS Lemoore, an initial study was conducted on BASH that evaluated the abundance of birds common in agricultural fields and potential habitat factors related to their abundance (Morrison 1993b). Owls have been responsible for a small percentage of collisions of aircraft with birds. In New York, near a coastal airport, Burger (1985) reported owls (short-eared and barn owls) represented 3% of the strikes. Because owls are most active at night, they pose a threat difficult to anticipate and avoid (Burger 1985). Burrowing owls are further likely to interfere with jets because of their proximity to runways and the ability of the powerful jets to "inhale" the birds from some distance away. These factors suggest burrowing owls deserve consideration in any BASH plan at NAS Lemoore, but do not necessarily require active management at this time. In this section we evaluate the evidence for a potential problem with burrowing owls, given our recent understanding of their distribution at NAS Lemoore. From documented deaths of previously marked (banded) burrowing owls in 1997 and 1998 (J. Crane, NAS Lemoore, pers. commun.), we now know that collisions between aircraft and burrowing owls do occur at NAS Lemoore. The primary interest in this section is to discuss issues related to Air Operations safety rather than conservation of owls in Air Operations. However, meeting both the critical needs of Air Operations safety and conservation of owls is desirable. Current management of the Air Operations area have met both of these goals.

On May 15, 1997 Dr. Daniel Rosenberg (The Institute for Bird Populations, Principal Investigator, Burrowing Owl Management Plan) met with Mr. John Crane (Environmental Management Division) and Air Operations staff (Mr. Don Gibson, Lt. Robert Craig, Lt. Ron Segerstrin, and ACC Anthony Betonio). From this meeting, we learned that there have been no major bird air strike incidents, although possibly minor incidents may have damaged jets. Therefore, we were left with the impression that Air Operations staff does not believe there to be a high risk of notable bird strikes. However, staff made clear their concern with the issue in general. Unfortunately, there has been little information collected regarding bird collisions, especially regarding the species involved, so it was difficult to assess the situation with clarity. Air Operations staff suggested that Field Support Division notify the Environmental Management Division upon finding bird bodies which can then be identified. This resulted in the recent findings of the marked burrowing owls noted above.

Burrowing owl nests located in Air Operations (Fig. 8) are as close as 3 m from runways, with many located within 500 m (Fig. 9), which is certainly within the home range of a nesting pair of burrowing owls (Section 2). One of the marked owls which died from collision with an aircraft nested 570 m from the runway where it was found. There are a total of 32 nests that were located this distance from a runway. Given an average reproductive success rate of 3 chicks/nest and two adult owls/nest, there are likely a total of 160 owls within this distance of runways during late summer when chicks begin to fledge.

We recommend further monitoring of BASH, and in particular, reporting of all known bird mortalities that resulted from aircraft collision to the Environmental Management Division.

Most species can be identified with a single feather, with assistance of local ornithologists. Thus, the condition of the bird should not be a deterrent for reporting incidents to the Environmental Management Division. If research and monitoring results in a decision that burrowing owls pose a risk to aircraft and personnel, then their numbers near the airfields can be reduced by several non-destructive methods, including altering the habitat and blocking burrows that have developed under runway signs and adjacent to runways. These actions may require permission from state and federal authorities. Our current research on burrowing owls at NAS Lemoore using a marked population, and the telemetry studies we are initiating in Spring 1998, will further assist minimizing BASH by identifying space use by burrowing owls.

•SECTION 7•

Relationship of California Ground Squirrels to Burrowing Owls

7.1 California Ground Squirrel Natural History

The distribution of burrowing owls in western North America coincides with that of ground squirrels and prairie dogs (Coulombe 1971). Ground squirrels and prairie dogs provide excavations which the owls can modify into nest burrows. These mammals further alter the environment in the vicinity of holes by grazing vegetation near burrows, thereby increasing horizontal visibility which can increase the probability of nest use by owls (MacCraken et al. 1985, Green and Anthony 1989). Many other wildlife species utilize ground squirrel burrows. Mammals found in their holes include coyotes, badgers, foxes, skunks, cottontails, pocket gophers, kangaroo rats, white-footed mice, pocket mice, rock mice, brush mice, and woodrats. Reptile and amphibian species which sometimes occupy squirrel burrows include rattlesnakes, king snakes, racers, gopher snakes, lizards, skinks, whiptails, toads, and salamanders. The only avian species which utilizes squirrel holes is the burrowing owl.

At NAS Lemoore, California ground squirrels are fairly uncommon, although they have been observed in most patches of grasslands during our survey in 1997 (Fig. 12). The California ground squirrel is the primary species that creates burrows that owls use for nesting and year-round use at NAS Lemoore, and in the San Joaquin Valley in general. Burrow longevity requires that ground squirrels maintain populations through time in order to provide a continuous supply of burrows, unless artificial burrows are used and maintained regularly. Where ground squirrels are present at NAS Lemoore, their numbers are sparse and the densities are much lower than in other grassland areas in the San Joaquin Valley (pers. obs.). These low numbers may be due to the hydrated soils characteristic of the irrigated lands of NAS Lemoore (INRMP 1990), possible poisoning on adjacent agricultural lands, or for reasons not apparent to us. Ground squirrels have not been commonly seen at NAS Lemoore for at least 40 years (L. Toss, Kings County Animal Control Office, pers. comm.). Understanding the biology of the California ground squirrel and factors affecting their low numbers are critical for properly managing the burrowing owl population at sites without artificial burrows.

7.2 Tolerance and Intolerance for California Ground Squirrels: Control Methods

As discussed, a healthy grassland ecosystem in the San Joaquin Valley requires populations of ground squirrels. However, it will also be imperative to implement a control program to protect specific areas from ground squirrel damage. Having an established plan for both retaining and controlling ground squirrels should reduce future difficulties.

California ground squirrels have long been thought of as a nuisance to farmers. The County Agricultural Commissioners Offices coordinated ground squirrel control programs in counties where these pests were a problem back in 1917. These findings resulted in extensive state-wide control programs (Marsh 1986, Marsh 1994). The objective of ground squirrel control programs is to reduce the population and maintain those lower numbers. Several methods which can be used for this purpose include shooting, trapping, poisoning with acute toxicants, poisoning with anticoagulants, and poisoning with fumigants (Salmon et al. 1982). In Kings County, anticoagulants and fumigants are usually used (L. Toss, Kings Co. Animal Control Office, pers. commun.).

Acute toxicants are compounds which are lethal in one dosage. Toxicants used to eliminate squirrels have included zinc phosphide, strychnine, and sodium fluoroacetate (Compound 1080), the latter of these no longer being registered for use for ground squirrel control (Marsh

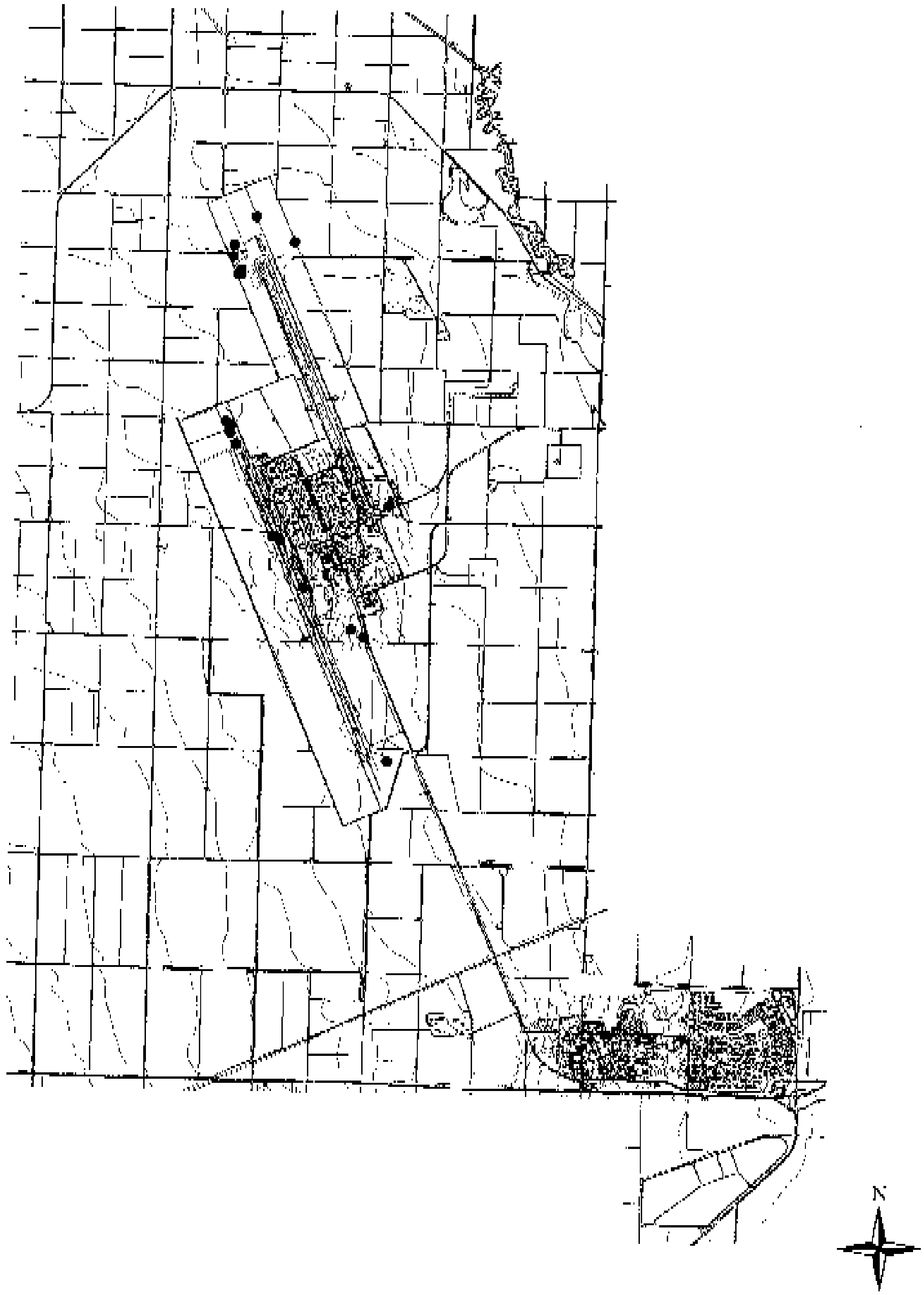


Fig. 12: Locations of ground squirrels during spring and summer 1997.

1994). Advantages to the use of acute toxicants include speed of effect, low cost, and minimal labor. One major disadvantage of this method is that animals may refuse to take bait after repeated applications, so the bait needs to be changed and/ or baiting needs to be done intermittently. In addition, species other than squirrels may be adversely affected. At NAS Lemoore , the primary species of concern regarding non-target species is the endangered Fresno Kangaroo Rat.

Anticoagulants are agents which produce internal hemorrhaging by interfering with animals' blood clotting abilities. Compounds currently used for ground squirrel control include chlorophacinone, diphacinone, Fumarin, Pival, and warfarin. Resistance to first generation anticoagulants such as warfarin led to the development of more effective second generation anticoagulants, including brodifacoum, difenacoum, and flocoumafen. These compounds are used primarily in bait forms. Their volatility is low and they have low solubility in water so concentrations in the air are low and the likelihood of water contamination is low. A study done by Odam et al. (1979) indicated that when wheat was treated with warfarin and kept in a bait box, there was no loss of warfarin after 12 months. The persistence of the poison when spread on the ground was variable and was determined by both soil conditions and rainfall. A further issue of concern is their effect on nontarget species. Non-target species are at risk to poisoning in two ways. Primary poisoning through the direct consumption of bait is possible, particularly since small pellets and whole grain baits are attractive to birds and other non-target rodents. This is another reason that baiting in boxes is preferable to spreading over the ground, which is an application restricted in some areas. Secondary consumption through the ingestion of poisoned rodents is also possible. Given the delay between the ingestion of anticoagulant bait and the death of the rodent, predators have ample opportunity to feed on poisoned rodents which remain above ground. Second generation anticoagulants induce a longer period of bleeding than earlier ones, increasing the time available for predators to prey upon afflicted rodents.

Secondary toxicity has been studied both in the laboratory and in the field and much of this research has focused on owls. In an experiment in which mice killed by diphacinone were fed to owls, all four owls showed symptoms of poisoning and death resulted (Mendenhall and Pank 1980). In the same study 36 barn owls were fed rats poisoned with six different anticoagulants. Owls fed rats killed with diphacinone, fumarin, and chlorophacinone survived while all owls fed brodifacoum-killed rats and one of six fed bromadiolone-killed rats died. All owls which died suffered severe hemorrhaging. Birds subjected to a longer feeding regime of rats killed by difenacoum survived but showed hemorrhage. Other studies have shown brodifacoum is more toxic to owls than difenacoum (Newton et al. 1990). Studies of wild owls have had similar results. Owls suffered high mortality when>20% of their home range was treated with brodifacoum (Hegdal and Colvin 1988). In observational studies, wild owls found dead often had difenacoum and/or brodifacoum residues in their tissues (Newton et al. 1990). In general, the application of anticoagulants requires much care in chemical choice, dosage, placement, and in evaluating the effects to non-target species.

Fumigants are toxic gases released within blocked burrow systems. Gases used to control ground squirrel populations include aluminum phosphide, carbon bisulfide, and methyl bromide. This technique is highly effective. On the down side, the use of fumigants is costly, labor intensive, and several of these compounds are toxic to plants and several are extremely flammable. Great care must be taken to ensure that the burrow does not contain non-targeted species.

This section was intended as an overview. The development of a control program, if ever necessary, should include discussions with local animal-damage agencies. We recommend the preparation of a management plan for ground squirrels at NAS Lemoore, emphasizing both maintenance of colonies in wildlife areas and control programs in areas that squirrels are not to be tolerated, such as munition bunkers.

•SECTION 8•

Mitigation Planning

Because of the burrowing owls' status as a Species of Management Concern federally, and as a Species of Special Concern in California, as well as its protection under the Migratory Bird Treaty Act, any disturbance to the owl's habitat that could result in harm must be planned with the appropriate state and federal agencies. Typically some type of mitigation is required or recommended in order to be in compliance with protective measures. Early actions will also avert the need to federally list this species under the Endangered Species Act. At NAS Lemoore, EFA West took such protective measures during the capping of the landfill in regards to burrowing owl protection. In this section, we discuss possible mitigation measures that can be taken to protect burrowing owls when actions affecting their habitat are scheduled.

If base activities disturb nest sites of burrowing owls, it may be necessary to relocate impacted owls or modify activities that would be likely to affect owls. If activities are likely to result in negative impacts to burrowing owls, the Environmental Management Division must be notified, at which time their department would make these determinations during the NEPA phase of any action. If such disturbances are deemed possible, then it may be necessary to contact state and federal wildlife regulatory agencies to develop an acceptable plan of action. A plan of action may include passive relocation, such as was carried out at the now capped landfill at NAS Lemoore , or enhancement of existing grasslands.

Passive relocation does not involve actual capture and removal. Rather, owls are enticed to artificial (or natural) burrows by providing such burrows and using one-way door "traps" that allow owls to leave the burrow of concern but will not let them reenter. Relocation is most successful if the added burrows are located nearby (e.g., < 200 m ; Gervais and Rosenberg, pers. obs.). If such actions are taken, it will be important to obtain written authority from state and federal regulatory agencies, such as US Fish and Wildlife Service and California Department of Fish and Game.

Other possibilities for mitigation would be the improvement and addition of owl habitat. Potential sites for native grassland restoration and inclusion of artificial burrows include the receiver and transmitter site. All of the grassland sites, potentially could be improved for burrowing owls, by encouraging native plant species and tolerating ground squirrels that are already present. The most likely areas for mitigation or other protective measures for burrowing owls and other grassland species are the agricultural fields adjacent to Tumble Weed Park. Increasing the size of Tumble Weed Park and developing buffer strips adjacent to Tumble Weed Park would likely benefit many species that are dependent on grasslands.

•SECTION 9•

Artificial Burrows

The availability of nesting burrows often limits the number of burrowing owls in grassland environments, particularly when ground squirrel numbers are low. Such is the case at NAS Lemoore. Burrowing owls readily nest in nest boxes constructed of wood or made of plastic, and buried in the ground or covered by a mound of soil. The use of artificial burrows at NAS Lemoore is particularly attractive because (1) concern exists over increasing ground squirrel numbers due to potential conflicts with base operations, including the agricultural outlease program, (2) artificial burrows facilitate monitoring owls, and (3) the number of nesting owls can be increased by the addition of artificial burrows because there are many locations where the boxes can be placed that do not have natural burrows but are adjacent to foraging areas.

9.1 Construction of Artificial Burrows

An inexpensive and easily assembled artificial burrow can be constructed from a standard irrigation box (“christie box”) and a 4" diameter perforated drainage pipe. A hole is cut in the box to allow insertion of a 6' section of drainpipe. Dirt is then heaped over the box so it is well-covered, and the tube is buried. The tube should be laid so that there is at least one 90' angle in it so light does not penetrate the nest box. A perch can also be provided, either a wooden post or a piece of PVC pipe (Fig. 13). The depth of dirt above the top of the box should be at least 12", to provide adequate protection from coyote excavation and insulation from heat stress.

A cluster of three boxes is preferred over a single burrow, and can be placed within the same mound to better imitate natural burrow systems (Fig. 14). More soil will be needed to adequately cover these systems, however. Young owls often move to nearby natural burrows soon after they emerge from the nest (Section 2). This may facilitate predator avoidance, nest overcrowding, or parasite loads. Although owls will successfully use a single box, a series of several boxes in the same mound may help increase survival and productivity. In locations where space is an issue, a single box can be used.

9.2 Maintenance

The most important maintenance requirement is to keep the vegetation around the burrows and on the mounds to height of no more than 12", which still allows owls good visibility for predator avoidance.. This is important because owls will abandon burrows that have become too overgrown.

In addition, occasional checks should be made each year to ensure that the drain pipes are not clogged or exposed by erosion, and that the mound is adequately covered and the perch post secure. Given the climate in the San Joaquin Valley, general condition checks should be made after most of the rains have fallen and before the owls begin breeding in early March. Any necessary repairs can then occur before egg laying commences. Vegetation removal will need to be done later in the spring as the vegetation grows, but can be discontinued in late spring as the summer drought prevents further growth. Visits to manage vegetation will require some disturbance to individual burrows; however, the low level of disturbance is justifiable given the detrimental effect tall, dense vegetation has on owl survival and site occupancy.

9.3 Suggested Locations

Several considerations should guide placement of artificial burrows at NAS Lemoore. First, access for installation and maintenance must be a priority in the decision process. Large amounts of soil will need to be placed over burrows and the burrows must be maintained periodically. Thus, for logistic reasons alone, burrows should be placed in areas accessible to vehicles. Secondly, box location should ensure high survival rates of chicks and adults, and not be located in areas that might compromise this. Preferred areas are those that minimize disturbance. This would entail avoiding areas adjacent to busy roads, as vehicle colllisions with owls, especially with chicks, do occur (D. Rosenberg,

Artificial burrow at NAS Lemoore for nesting burrowing owls.

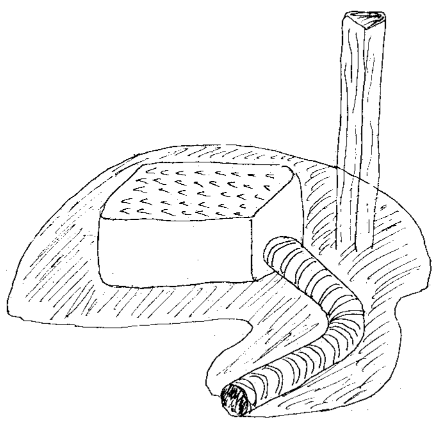


Fig. 13: Artificial burrow setup.

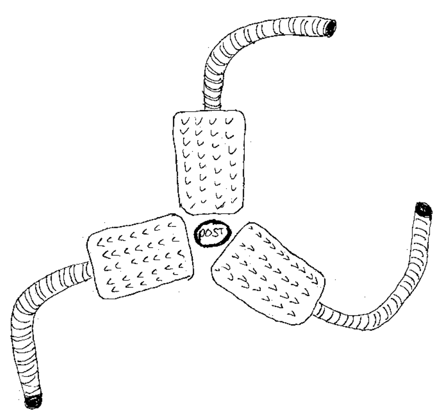


Fig. 14: Multiple artificial burrows in a single cluster, top view.

unpubl. data). We therefore recommend that boxes be placed at distances greater than 10 m from areas of frequent disturbance and from paved roads. Areas of frequent disturbance would include sites such as jogging paths. Third, artificial burrows should be placed at distances greater

Burrowing owl eggs in artificial burrow.

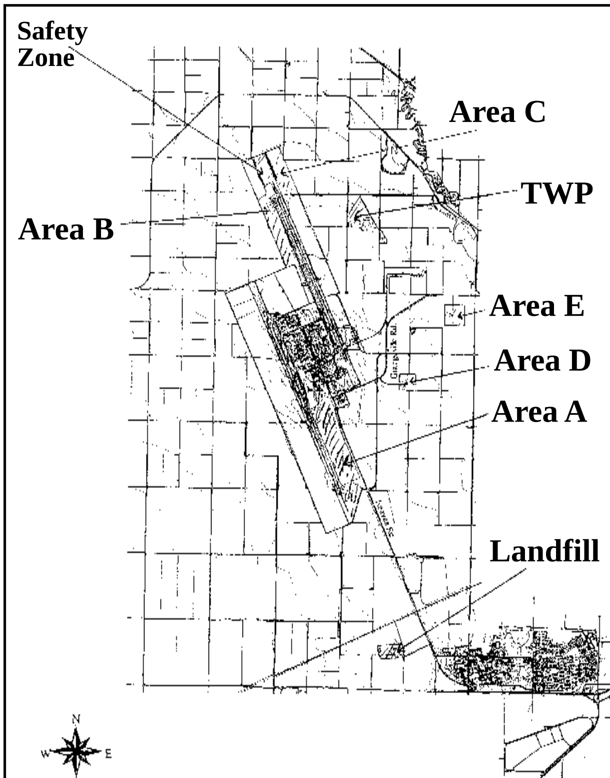


Fig. 15: Potential burrowing owl nesting habitat.

than 100 m from one another, thus increasing the likelihood of use; burrowing owls tend to nest more successfully if they are not very close to another nesting pair (Section 2). Fourth, burrows are more likely to be used if they are placed within one km of other active owl burrows because artificial burrows may provide nesting sites for dispersing young that are recruited into the population. Finally, sites that do not have natural burrows but that otherwise meet the needs for nesting burrowing owls should be candidate areas for inclusion into the network of

Table 3. Suitable burrowing owl nesting and foraging habitat, population goals, andsuggested number of artificial burrows, NAS Lemoore[a].

Location	Acreage[b]	No. Pairs (1997)	Density (pairs/100 ac)	Mgmt. Goal (pairs)	Artificial Burrows
Area A[c]	400	16	4.0	28	12
Area B	150	5	3.3	11	6
Area C	104	2	1.9	7	5
Area D	50	1	2.0	3	2
Area E	80	0	0	6	6
Capped Landfill	50	2	4.0	3	6[d]
Tumble Weed Park	86	6	7.0	7	0
Safety Zone	100	1	1.0	7	6
Air Operations[e]	76	21	21.0	NA	0
Total (mean)	1,096	54	(4.9)	72	43

[a] Area codes consistent with Morrison (1993a) and Fig. 15. Conservative estimate of foraging habitat; additional areas at Lemoore NAS may provide further foraging habitat but its type and quantity is unknown at this time.
[b] Based on estimates from Morrison (1993a) or NRMP (1990), with modifications from discussions with Mr. John Crane, Env. Mgmt. Div., NAS Lemoore.
[c] Includes area that extends into Air Operations.
[d] Artificial burrows were installed in 1997; those occupied (1997) are located in the borrow pit.
[e] Areas inside Air Operations that consist of grassy areas between runways and taxiways, and other suitable sites; estimate of acreage may be inaccurate.

artificial burrows at NAS Lemoore.

Numerous sites fulfil the criteria for optimal locations of artificial burrows. Both the Receiver and Transmitter Station sites would be ideal locations. They can be placed along the perimeter of the grasslands where both access is good and foraging areas are nearby. Another good site would be nearby Reeves Road from Administration to OPS. To the west of Reeves Road, there is a dirt road that parallels Reeves Road. Artificial burrows could be placed 10 m west of the dirt road. Because of the size of the grasslands along the south-east end of 32L and the length of the dirt road, a large number of artificial burrows could be placed here. Another area that would be ideal, both in terms of access, low availability of burrows, and access to foraging sites, would be the area between the North Wildlife Area (Area C, Fig. 15) and the Safety Zone. A road is often maintained that is passable between these two fields. There are numerous sites that would be suitable for artificial burrows within NAS Lemoore. The guidelines presented here should facilitate their location and occupancy. We suggest a total of 43 artificial burrows within burrowing owl habitat (Table 3). This recommendation was based on the difference between the population goals and the number of pairs at each site.

•SECTION 10•

An Adaptive Management Plan

10.1 Goals

The success of a management plan must be based on its achieving a set of objectives or goals. As an initial starting point, we set the optimistic goal that the burrowing owl population at NAS Lemoore will be increased to a density within all remaining non-residential grasslands equal to that in Tumble Weed Park, an 86 acre grassland parcel. In 1997, there were a total of 6 owl pairs in Tumble Weed Park. With a grassland area of 86 acres, there is a density of 7 pairs/100 acres. Based on estimates of grassland habitat outside of Air Operations and administration and housing at NAS Lemoore , we estimate there to be 1,070 acres of owl nesting habitat outside of Air Operations. We excluded Air Operations from contributing to the population goals because of the priority of national defense goals. Our population goal, therefore, given a density of 7 pairs/100 acres, is 72 pairs of adult, nesting owls (Table 3). In 1997, we estimated there to be 54 pairs of owls at NAS Lemoore, and of these, 28 were located outside of Air Operations. Thus, our optimistic goal of 72 pairs outside of Air Operations requires over a two-fold expansion of the population. Achieving this goal would require improvement to nesting habitat that may include the addition of artificial burrows (Section 9). The population goal should be met at all existing sites; that is, the goal is to achieve a density of 7 pairs/ 100 acres within all parcels (Table 3). The success of reaching the management goal of 72 pairs should be evaluated on a parcel by parcel basis.

A reasonable management objective would be to ensure that the population remains no less than a specified level. Without knowledge of the natural variability of population size for this species, we do not have an *a priori* proportion of the population that should be considered a trigger point for which management actions should be initiated. As an initial step, we suggest that the population at any time should be no less than 50% of the current number of owl pairs. The 50% trigger point is one that is measurable, and maintains a reasonable number of owl pairs given the current habitat conditions. The trigger point does not require habitat expansion or additional efforts, other than maintaining current conditions. A goal to maintain at least 50% of the current number of breeding pairs, thus 27 of 54 pairs, seems reasonable. It will be mutually agreed upon, funding and personnel resources available, that the Navy will initiate an investigation of the decline of burrowing owls once the trigger point is reached. Having a population goal and a point at which evaluation occurs provides a rigorous framework for an adaptive management plan.

10.2 Research

Adaptive management requires an iterative process of management, research, and monitoring. The Navy, through EFA-West, has been supporting research on burrowing owls at NAS Lemoore. We are conducting research on the ecology of burrowing owls at NAS Lemoore and at other sites in California that will provide management recommendations that will augment this Plan. Our on-going research includes the investigation of factors affecting reproduction and survival, home-range size, habitat selection and prey-use especially regarding predation on the endangered Fresno kangaroo rat (Dipodomys nitratoides exilis). As part of this research, we are developing methods for the estimation of population size. This particular research will prove to be very useful for evaluating and refining a rigorous monitoring program. Research on means to control the height and density of non-native plant species will contribute to improved management of burrowing owls and other grassland species at NAS Lemoore. A further research need is to estimate the levels of DDE in the soil and food webs. Our findings on DDE merit further evaluation.

10.3 Monitoring

In order to evaluate the success of management strategies, including steps taken to provide for burrowing owls, rigorous monitoring is required. Particular to this management plan is the monitoring of the presence and numbers of burrowing owls at NAS Lemoore. The key objective will be to determine accurately if the threshold number of 27 pairs is reached. However, estimating the population size will require resources that will likely not be available for a long-term monitoring program of burrowing owls at this time. Rather, we suggest that the monitoring goal be to evaluate if the trigger point is reached through an indirect method of quantifying the probability of reuse in a given nest site area. This requires the monitoring of the status of known nests. The sample of nests to monitor must be a representative sample, otherwise it will be difficult to draw inferences from the results of the monitoring program. From precise and accurate locations using dGPS (military corrected), all or a subset of the known nests should be monitored. These nests should be numbered and their locations indicated on a map. To date, all known nests are numbered and mapped. We recommend a random sample of 20 nests. Parameters to monitor should include the determination of activity status (Section 3) and reproductive success. This later parameter, reproductive success, may require more resources than may be available. For evaluating nest status, a minimum of three visits should be made during late April and three in late May/early June for nests not yet observed to be active. If an active nest is not found, then an area extending out 100 m from the nest in all directions should be searched, using walk surveys (Section 3). For evaluating nest success, three visits should be made in late May/early June. Each year, a different random sample from all nests can be used, and from this sample, the percent of nests still active can be determined. In any year in which greater than 50% of the initially (1997) occupied nests are no longer active, the trigger point has been reached and appropriate actions need to be taken. This method takes advantage of the high site fidelity of burrowing owls at NAS Lemoore (Section 2), and is the most time-efficient method that we believe will accommodate the goals of the monitoring program. We recommend that nest activity monitoring be conducted annually.

10.4 Recommended Initial Management Plan

On the facing page, we summarize our recommendations for the initial management plan for burrowing owls at NAS Lemoore. We expect research and monitoring of management activities to provide further insight that can be used to continually update these set of recommendations.

Recommended Initial Management Plan

Resource/ Objective	Current Activity	Additional Recommended Activities
Management Goal	none	72 owl pairs outside of Air Operations
Trigger Point	none	27 pairs or active nests (50% of current number of pairs)
Vegetation		
Area A (S. Airfield)	Frequent Mowing	Fire, Mowing
Area B & Safety Zone (N. Airfield)	Frequent Mowing	Fire, Mowing
Area C (Wildlife Area)	Frequent Mowing	Fire, Mowing
Area D (Receiver Station)	Frequent Mowing	Mowing, Grazing
Area E (Transmitter Station)	Frequent Mowing	Mowing, Grazing
Tumble Weed Park	Fire and Grazing	Fire and Grazing; Research
Resource/Objective		
Capped Landfill	None Planned	Grazing and Mowing; Research
Newly Created Areas	Mixed	Revegetation with Native Species
Ground Squirrels	None	Develop Management Plan
Artificial Burrows	Landfill	Landfill: Maintenance; Monitoring Areas Outside of OPS: Install and monitor burrows in selected sites; maintenance Public School: Locate and install burrow cluster
Bird Air Strike Hazards	Veg. height 4" max.	Monitor strike incidents; mow to minimize seed heads (<12")
Pesticides/Herbicides	Consistent with San Joaquin Valley applications; reduced through 2 of 5 years in rest rotation from cotton production	Evaluate high DDE levels with continued research; evaluate use of alternative chemicals; target selected chemicals (Table 1) for reduction consistent with DoD policy goals; strive for higher efficiencies of applications by improved technologies.
Education	School field visits	Provide artificial burrow at public school and in other high profile site; Install infrared video cameras within these burrows when active; provide information brochures or posters/kiosks
Public Relations	Incidental	Actively disseminate proactive actions taken by NAS Lemoore with burrowing owl conservation to public and conservation organizations
Research	Demography and Space Use Fire/Grazing Effects on Kangaroo Rats	Continue demography and space use study through 2000; augment with experimental vegetation research; DDE evaluation
Monitoring	Through IBP research	Implement nest reuse monitoring

•SECTION 11•

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Appendix I. NAS Lemoore call survey routes

NUMBER	START X-UTM	START Y-UTM	END X-UTM	END Y-UTM	LENGTH	# OF STA	DESCRIPTION
1	4017020	239130	4017500	241990	2.0	11	begin at dirt road junction and proceed around loop clockwise
2	4017140	238140	4016840	237480	0.8	5	begin at main road junction and go west
3	4018530	239170	4017120	235890	2.2	12	begin at jn with 25th Ave; stop at jn with 27th Ave
6	4020040	235960	4019250	239180	1.8	10	begin at north end; turn left onto Iona Ave; stop at jn with 25th Ave
7	4019250	239180	4020880	239250	1.0	6	begin at south end at Iona Ave jn; stop at Houston Ave jn
8	4020960	236600	4020880	239250	1.4	8	begin at west end by Houston/Gateway jn; stop at jn with 25th Ave
10	4020910	238430	4023300	238500	1.6	9	begin at jn with 8; stop at jn with 12
12	4023800	237900	4023290	239300	0.8	5	begin at southeast corner of receiver site; stop at jn with 25th Ave
13	4020960	236600	4024340	237710	2.6	14	begin at jn with 8/40/45; stop at jn with 18
14	4023710	236930	4023540	237440	1.2	7	begin at main road junction and go clockwise around receiver site
16	4025730	238810	4025400	238800	1.4	8	begin at north end access road and go clockwise around tran site
18	4024340	237710	4024260	239300	0.8	5	begin at west end at jn with 13; end at jn with 25th Ave
19	4023290	239300	4025720	239360	1.4	8	begin at jn with 12; stop at Grangeville Rd jn
20	4026540	239390	4027570	239040	0.8	5	begin at south end and go clockwise around wildlife area
21	4026540	239390	4028200	237000	2.4	13	begin at south end by wildlife area and go west
22	4028000	238460	4027950	237820	0.2	2	begin at east end at main road junction; stop at jn with 21
24	4025810	236110	4026230	238080	1.4	8	begin at jn with 25; go east on south side of magazine area
25	4028210	236170	4025810	236110	1.4	8	begin at north end at jn with 22/26; stop at jn with 24
26	4028210	236170	4027420	236150	1.6	9	begin at jn with 25/27 and go clockwise; stop at jn with 25
27	4028210	236170	4029080	234620	1.2	7	begin at jn with 25/26; go west and then north; stop at jn with 29/30
28	4029440	237390	4029960	237190	1.2	7	begin on highway and go clockwise around Sunset Lake
29	4028810	237000	4029080	234620	1.6	9	begin at east end; stop at jn with 27/30
30	4029080	234620	4029100	233750	0.6	4	begin at jn with 29; stop at jn with 34
32	4028400	234450	4024600	236050	2.8	15	begin at north end
33	4028320	233880	4026430	234650	1.2	7	begin at jn with 34; stop at jn with 36/37
34	4029100	233750	4028320	233880	0.6	4	begin at jn with 30; stop at jn with 33
35	4027460	234200	4026020	233750	0.8	5	begin at jn with 33; go around dogleg and go south to jn with 38/39
36	4026100	233920	4026430	234650	0.6	4	begin at jn with 37; stop at jn with 33/37
37	4026430	234650	4026100	233920	2.0	11	begin at jn with 33/36 and go clockwise; stop at jn with 35/36
38	4020110	236110	4026020	233750	4.4	23	begin at jn with 40; stop at jn with 35/39
39	4019800	235560	4026020	233750	4.6	24	begin at jn with 41 and go north around dogleg; stop at jn with 35/38
40	4020960	236600	4019800	235560	0.6	4	begin at jn with 8/13/45; stop at jn with 39
43	4021260	236440	4021180	236180	0.2	2	begin at main road and go west to end of road
44	4023550	236500	4024400	236440	0.8	5	begin at south end at main road jn and go north
45	4023240	235740	4020960	236600	1.4	8	begin at Ops gate and go south; stop at jn with 8/13/40

Appendix II. Active nest locations at Lemoore NAS[1].

NEST #	UTM-X	UTM-Y
1	237444	4023614
4	236249	4020513
5	236035	4020687
6	234053	4028184
9	234074	4027966
13	236278	4020811
14	236362	4028063
15	236413	4027971
16	236239	4020488
19	236545	4027502
20	236664	4027820
22	236791	4027430
23	234830	4028328
25	234305	4028805
27	234057	4027999
29	234035	4027960
30	234673	4026932
31	236315	4020501
32	236212	4020824
34	237383	4017258
35	236805	4017259
36	235040	4026158
37	234000	4025475
38	233912	4025645
40	233853	4025809
42	234531	4024119
43	234630	4023753
44	236088	4023936
45	236088	4023749
46	236249	4024550
47	235663	4022328
48	235437	4022583
49	235682	4022741
50	234895	4026951
51	234796	4027281
52	235590	4022055
53	235744	4022764
54	235762	4022858
55	235312	4022918
56	235585	4022984
58	234989	4023363
59	234974	4023434
61	234714	4024129
62	234468	4024485
63	234582	4025283
64	234535	4024694
65	234844	4023994
66	235089	4023573
67	235249	4023128
68	235879	4022641
72	236147	4024173
74	236557	4028080
75	234821	4027319
76	234174	4028592

[1] Locations determined by non-corrected GPS unit, thus has accuracy to within 100 m.