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Abstract: Edwards Air Force Base (AFB) scheduled the construction of a runway in the spring of 2007. The runway would be in an area that contained migratory birds and their habitat. The construction project would be near Edwards AFB main runway and had the potential not only to impact species protected under the Migratory Bird Treaty Act (MBTA), including the burrowing owl (*Athene cunicularia*), but also to increase bird and wildlife–aircraft strike hazards in the active flightline areas. To discourage nesting in the project area, reduce the potential for bird and wildlife–aircraft strikes, and maintain compliance with federal environmental law, more than 400 potential nesting burrows and nesting habitat (e.g., trees, shrubs, and cacti) were removed prior to the nesting season and construction activities. The project footprint was routinely resurveyed to ensure migratory birds did not move back into the project area. As of May 31, 2007, approximately 890 ha were surveyed, compliance with the MBTA was maintained, bird–aircraft strikes did not increase, and the project schedule was not impacted. Removing migratory bird nesting habitat prior to the nesting season was instrumental in reducing the potential for bird and wildlife–aircraft strikes and maintaining compliance with federal law. This removal strategy can be employed in other large-scale construction projects.

Key words*:* bird–wildlife aircraft strike hazard, burrowing owl, Edwards Air Force Base, human–wildlife conflicts, Migratory Bird Treaty Act, runway construction

Birds have posed a hazard to aviation since the beginning of powered flight (Zakrajsek and Bissonette 2005), comprising about 98% of all aircraft–wildlife strikes in the United States (Dolbeer 2006). Most are federally protected by the Migratory Bird Treaty Act (MBTA) of 1918, which protects the birds and their nests from harm or disposal without the proper permits. In addition, potentially hazardous birds may be protected by federal or state endangered species laws, further restricting the removal of the species from runway and flightline areas. To protect human safety, bird–wildlife aircraft strike hazards (BASH) at runways are managed through depredation and harassment permits that allow for the removal or coaxing of hazardous wildlife away from the area. Federal installations and airports are bound by federal environmental laws and operate under migratory bird depredation or harassment permits where nonlethal management of hazardous birds is the first course of action. Nevertheless, runway construction projects are not usually eligible for migratory bird depredation permits and have to adhere to the restrictions within the act.

Edwards Air Force Base (AFB) is home to the Air Force Flight Test Center (AFFTC) and is responsible for some of the foremost milestones in aviation history. Thus, aviation safety and diligent runway operations are core to AFFTC. In 2006, when the main runway at Edwards AFB needed refurbishment, a temporary runway first needed to be constructed so that flight operations could continue uninterrupted. Determining a location for the temporary runway posed many hurdles, including protecting both flight safety and natural resources. The undeveloped areas suitable for flight operations were occupied by wildlife that could be hazardous to flight safety. The final location chosen for the temporary runway allowed the air traffic and overrun access but would be outside the runway lateral clearance zone. The temporary runway construction project at Edwards AFB was scheduled to begin in spring of 2007 and would be in an area that contained migratory birds and their habitat. The construction project would be

near Edwards AFB main runway and had the potential to not only impact species protected under the MBTA, including the burrowing owl (*Athene cunicularia*), but also to increase bird and wildlife–aircraft strike hazards in the active flightline areas (Table 1).

Saltbush (*Atriplex* sp.) scrub habitat is found on areas adjacent to the Edwards AFB main runway. Saltbush scrub habitat is not favored by horned larks (*Eremophila alpestris*), the bird responsible for most wildlife aircraft strikes at Edwards AFB, and maintenance of native saltbush vegetation is one of the key flight safety strategies that keeps Edwards AFB BASH low (Hagan 1995).

Clearing and grading of native desert habitat around the Edwards AFB flightline increased the number of wildlife species including horned larks (Hagan 1995). Therefore, clearing, grading, and other project activities associated with the construction of the temporary runway had the potential to attract wildlife that could pose a hazard to aircraft movements. In addition, construction activities could impact migratory birds and their nests in the project footprint.

Preliminary surveys revealed that migratory bird species, including burrowing owls, were actively using winter roost in the area. The burrowing owl is protected under the MBTA and listed as a federal and California species of special concern (Polite 1999, U.S. Fish and Wildlife Service 2002). It roosts and nests in preexisting mammal burrows, culverts, and drainage pipes (Polite 1999) and can use multiple burrows (Larsen 2004). Burrowing owls can be found scattered throughout Edwards AFB and ar known to occur in southern California year-round (Rosenberg et al. 1998). The California Department of Fish and Game considers February 1 through August 30 the nesting season for burrowing owls.

Construction of the temporary runway for Edwards AFB required the cooperation of multiple agencies. Efforts were made to minimize the potential impact of the project's construction activities on migratory birds. The goal was to develop proactive measures to avoid increasing BASH and to discourage migratory birds, primarily burrowing owls, from nesting in the area.

Table 1. Top 10 species that generate the most cost in aircraft damage, U.S. Air Force total.[a]

Species	Strikes	Cost ($)
Horned lark (*Eremophila alpestris*)	3,161	5,871,953
American mourning dove (*Zenaida macroura*)	2,658	9,301,199
Perching birds	2,524	3,446,056
Barn swallow (*Hirundo* spp.)	1,886	11,309,352
Eastern meadowlark (*Sturnella magna*)	1,223	2,076,749
Killdeer (*Charadrius vociferous*)	1,190	4,340,466
American robin (*Turdus migratorius*)	1,029	2,012,909
Chimney swift (*Chaetura pelagica*)	963	868,289
American kestrel (*Falco sparverius*)	919	1,442,178
Red-tailed hawk (*Buteo jamaicensis*)	814	14,557,925

[a] U.S. Air Force BASH team, unpublished data.

Survey areas

Edwards AFB is located in southern California in the Antelope Valley region of the western Mojave Desert. The Mojave Desert climate was characterized by hot summers, cold winters, infrequent rainfall, frequent winds, and very low relative humidity.

The location chosen for the temporary runway was 609 m north of the Edwards AFB main base runway in moderately-disturbed saltbush scrub habitat. Survey areas were located in Township 9 North, Range 10 West, Sections 1 and 2; Township 10 North, Range 10 West, Section 36; and Township 10 North, Range 9 West, Section 31 of Edwards AFB.

The temporary runway would be parallel to and between the main base runway and the aircraft parking ramp. Survey areas were developed based on the anticipated project footprint, and guidelines provided in the Burrowing Owl Survey Protocol and Mitigation Guidelines (California Burrowing Owl Consortium 1993). Survey areas included 30- to 150-m buffers around the anticipated construction footprint to account for any adjacent migratory bird-nesting habitat that could be impacted by the noise and vibrations of heavy equipment. Survey areas totaled 570 ha along the temporary runway centerline,

taxiways, pug mill site, temporary waterline, and construction haul routes (Figure 1).

Methods

Methods focused on identifying and removing migratory bird habitat prior to the nesting season, with most effort devoted to burrowing owls. We conducted presence-absence and clearance surveys for migratory birds and other sensitive natural resources. We conducted the surveys by walking transects at an approximate 10-m spacing. We decreased transect spacing in areas of dense vegetation. We recorded all plant and wildlife species identified in the immediate and surrounding area. We recorded aboveground bird nesting habitat, burrow-nesting habitat, and migratory birds observed during the surveys using a global positioning system, and we stored the data in a global information system database for future reference.

We visually examined any ground bird-nesting habitat selected for removal, such as Joshua trees (*Yucca brevifolia*), tamarisks (*Tamarix parviflora*), and we visually examined shrubs for nests and then removed them with a skip loader; any nests found in the vegetation were confirmed to be void of eggs or young prior to removal. We excavated or covered potential bird-nesting areas in or on anthropogenic structures (e.g., drainage pipes, culverts, and military related structures).

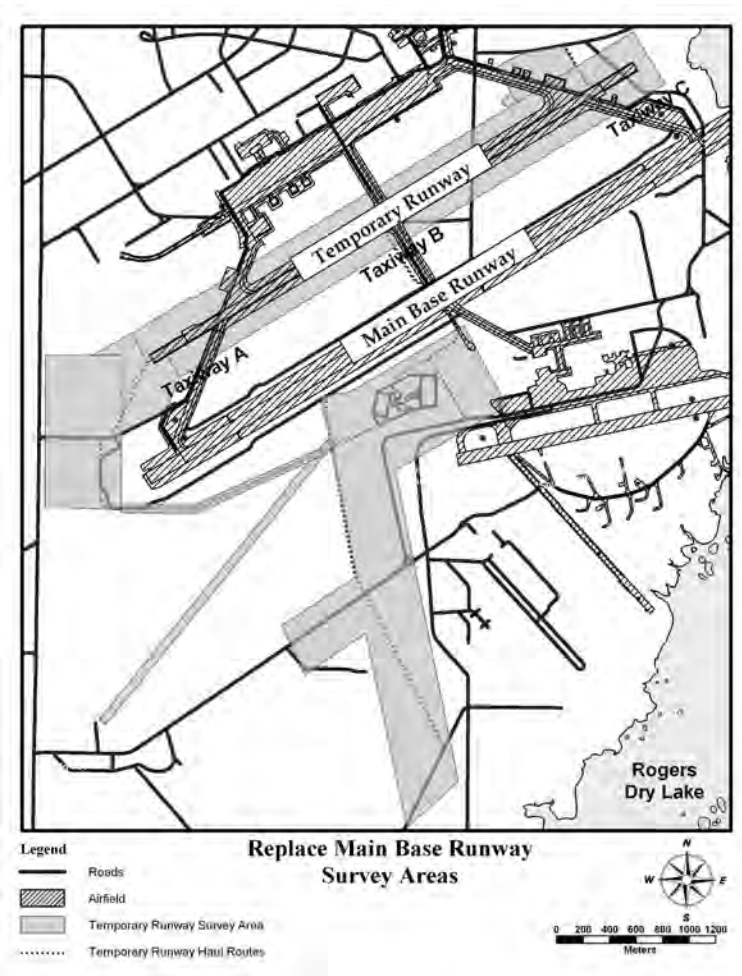

Figure 1. Migratory bird survey areas for temporary runway and infrastructure at Edwards Air Force Base, California.

We visually inspected all potential burrowing owl burrows (suitable for nesting or cover, but with no burrowing owl sign), to assure no animal was inside, then immediately blocked or collapsed them. A biologist determined all burrowing owl burrows by visual examination of the burrow apron, entrance, and immediate area for burrowing owl sign (e.g., pellets, scat, feathers, tracks, etc.). The activity level (recent or previous use) was also determined. We numbered, photographed, and measured each burrowing owl burrow before excavation. Prior to excavation, we scanned the area for any nearby burrowing owl. If an owl was present in the burrow and did not flush, a biologist returned at a later time. Potential burrowing owl burrows were removed first, followed by burrows with aged sign, and lastly burrows showing evidence of recent use.

We used the term owl burrow to include all cover sites containing burrowing owl signs. We excavated owl burrows within the project footprint that were void of eggs or young. We conducted excavations by removing horizontal sections of soil using hand tools. Once we removed the soil within 5 to 7 cm of

the burrow ceiling, we placed a shovel directly under the ceiling of the burrow and collapsed the ceiling onto the shovel. This assured that if an unobserved animal was inside, it was not crushed by a shovel or falling soil. We excavated all branches and chambers of the burrow until the end was reached or visual examination confirmed it was empty. We routinely resurveyed the project footprint as described to insure that migratory birds did not move back into the area before the onset of construction activities.

Project construction areas continued to develop after surveys had began. We left intact any burrowing owl burrows found after the onset of the nesting season that we could not visually confirm to be void of eggs or young. We marked these burrows using red flags or orange cones at a perimeter of 22 to 36 m. We used flags and cones to ensure project personnel stayed a reasonable distance from the burrows to avoid harassing nesting burrowing owls.

Results

Surveying and monitoring for project activities began in November 2006 and were concluded on May 31, 2007. Average temperatures during this period ranged from 5 to 21° C, with 1.8 cm of precipitation (USAF Edwards AFB Climatology Data 2007, unpublished data). We spent >900 hours in support of project activities, and surveyed approximately 890 ha. We observed a high number of abandoned burrows and digs of desert kit foxes (*Vulpes macrotis arsipus*), coyotes (*Canis latrans*), and American badgers (*Taxidea taxus*) throughout the survey areas and adjacent habitat. We observed burrowing owls, common ravens (*Corvus corax*), horned larks, Le Conte's thrashers (*Toxistoma lecontei*), loggerhead shrikes (*Lanius ludovicianus*), mourning doves (*Zenaida macroura*), northern harriers (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*), sage sparrows (*Amphispiza belli*), and white-crowned sparrows (*Zonotrichia leucophrys*).

During our surveys, we observed burrowing owls at 30 individual locations. Twenty four of the 30 observations were at or near an owl burrow. We observed 10 owls at a burrow prior to excavating the burrow. As of May 31, 2007, project schedules were on time, BASH numbers had not increased, and compliance with the MBTA had been maintained.

Aboveground-nesting habitat

By January 21, 2007, we removed more than 400 Joshua trees, tamarisks, golden chollas (*Opuntia echinocarpa*), and peach thorns (*Lycium cooperi*) from the survey areas. Unoccupied nests of cactus wren (*Campylorhynchus brunneicapillus*), common raven (*Corvus corax*), and a large owl (great horned [*Bubo virginianus*] or barn owl [*Tyto alba*]) were removed. We found 1 mourning dove nest in the survey area after the onset of nesting season, but it had been preyed upon prior to construction activities.

Burrow-nesting habitat

We found signs of burrowing owls in shallow cover sites and around burrows. Most burrows with owl sign were former burrows of a desert kit fox, but we also found burrowing owl signs in coyote and American badger burrows. By May 31, 2007, we identified 478 potential nesting burrows and nesting burrows in or near the temporary runway construction footprint.

Table 2. Summary of potential nesting burrows

	Potential burrowing owl burrows	Burrows with burrowing owl signs		
		Recent	Aged	Total
Number of collapsed burrows	369	49	47	465
Number of uncollapsed burrows	0	9	4	13
Total	369	58	51	478

Of these, 109 sites had burrowing owl signs, with 50% of the burrows located in the open (not associated with any shrub cover), and 53% having sign of recent use. Of the burrows with recent sign, 64% were in the open. An additional 10% of the 109 burrowing owl burrows were associated with anthropogenic structures. In one case, a burrowing owl had adapted an old drainage pipe under asphalt that could not be excavated using hand tools. To assure the owl was clear of the area before nesting season and the onset of project activities, we developed and installed a 1-way door.

We collapsed 465 nesting burrows and sites with nesting habitat out of the 478 potential sites. The remaining 13 sites were owl burrows that we found after the onset of nesting season or the project footprint changed. We could not determine these to be void of eggs or young by visual inspection, and thus we did not collapse them. We observed owls at 2 of these 13 burrows, and nine had recent signs of burrowing owls.

Discussion

The order and selection of habitat removed were both a product of the project timeline and species present. We removed trees and key shrubs first because they were the easiest habitat to identify and remove. Not all shrub species could be removed, so we removed only those that were high-quality nesting habitat or showed evidence of past nesting. The order in which burrows were collapsed was done with the intent of minimizing stress on burrowing owls by reducing the likelihood of repetitive displacement of the same owls within the project footprint.

We took a proactive approach to promote compliance with the MBTA, aviation safety, species protection, and maintain the project schedule. Removing nesting habitat was likely instrumental in reducing the potential to harm the native avian species. Our effort could not have been done without communication and coordination among Department of Defense planning staff, contractors, and Edwards AFB natural resource personnel prior to the beginning of construction activities.

The abundance of unoccupied mammal burrows around the temporary runway site demonstrated the availability of suitable burrows for burrowing owls that occur throughout the saltbush scrub community at Edwards AFB. However, similar runway projects may not have suitable nesting or cover sites for displaced wildlife. These situations may warrant the creation of artificial nesting habitat for displaced wildlife as a mitigation strategy. Creating artificial habitat as a mitigation technique can aid in species conservation (Collins 1977, Pagel 1989), and habitat removal or modification of the species habitat may increase the success of moving potential hazardous species out of an area (Washburn et al. 2004).

We suggest that additional measures be integrated into the contractor's project scope to discourage birds from inhabiting or nesting in the area in the future, including the elimination of water and wildlife habitat (e.g., debris and storage piles). Planners of large-scale construction projects can integrate this into their work scope prior to the onset of construction activities, especially in cases where a known sensitive species has the potential to occur in the area.

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