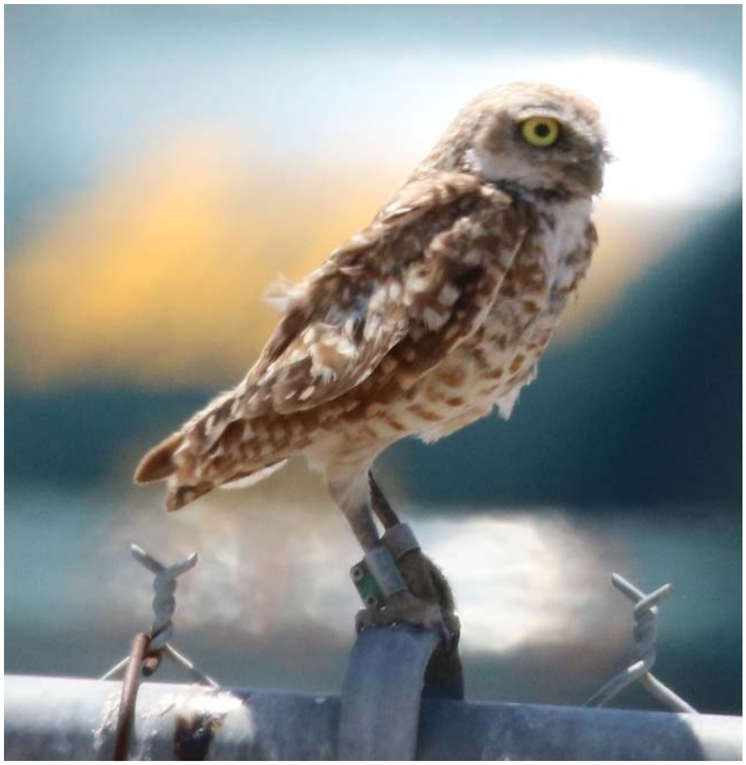

Project Report 2018
Advancing Burrowing Owl Conservation in San Diego County through Mitigation Measures using Science and Adaptive Management

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SAN DIEGO ZOO INSTITUTE FOR CONSERVATION RESEARCH

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Photo (preceding page): Translocated adult female 07 over X (who is at least 7 years old) on July 13, 2018 after her return to Brown Field from Rancho Jamul Ecological Reserve.

Executive Summary

Once widespread throughout grasslands in San Diego County, the western burrowing owl (*Athene cunicularia hypugaea*, BUOW) population has been reduced to a single breeding node in the Otay Mesa region. Continued threats, including development, invasive vegetation, burrow loss, and negative population growth rates, place this population in serious risk of extirpation. Because of this, BUOW are currently facing an uncertain future in San Diego County unless immediate recovery actions are taken (Lincer and Bloom 2003).

The Metropolitan Airpark Project (MAP) located at Brown Field Municipal Airport is projected to have impacts to BUOW breeding habitat, foraging habitat, and nesting and wintering burrows (ESA 2015). To ameliorate these impacts, a BUOW Mitigation Plan was prepared that identifies management actions using an adaptive management framework with "the goal of long-term sustainability of the species" (ESA 2015, p. 1). In 2016, the San Diego Zoo Institute for Conservation Research (ICR) submitted a proposal to achieve the long-term management and monitoring goals of the Mitigation Plan while advancing BUOW conservation in the region. Despite changes to the overall project timeline, we monitored the BUOW population in the Otay Mesa region in 2018 to ensure no gaps in knowledge regarding BUOW population status prior to project construction.

The 2018 tasks are summarized below:

Task A. Passive Relocation and Active Translocation. In 2018, no passive relocations occurred as part of MAP, but five pairs of BUOW were actively translocated from Brown Field Municipal Airport as part of a conservation translocation to establish a new breeding node in San Diego County. This translocation was also included in a larger regional study of translocation outcomes. ICR field observations coupled with the pre-construction survey carried out by ECORP Consulting initially identified two pairs of owls within the MAP Phase 1 footprint, both at the Tripad area. As a result, additional pairs from outside the impact area were identified as targets for translocation. A total of five breeding pairs (10 BUOW) were actively translocated between 20 Feb – 6 Mar, 2018.

Task B. BUOW Breeding Node. The actively translocated BUOW were moved to Rancho Jamul Ecological Reserve (RJER), where measures including the use of an acclimation period, installation of conspecific cues, and supplemental feeding through the breeding season were taken to optimize settlement, retention, survival, and future recruitment of BUOW at the site. The translocation was initially successful, with breeding attempts at all five hack sites. Chicks were fledged at three nests. Adult mortality levels were documented. The surviving BUOW have dispersed to overwintering sites and we will not have an accurate idea of population size at RJER until the next breeding season in 2019.

Task C. BUOW Survey. To establish a baseline of the resident BUOW population across Otay Mesa, we conducted a pre-construction population survey during the breeding season using standardized methods. Survey areas included Brown Field Municipal Airport, MAP on- and off-site mitigation areas, and surrounding areas conserved and/or restored specifically for BUOW. During the first survey from 12-18 April, 15 adult BUOW were documented across 10 different burrows on Brown Field. All active burrows were subsequently confirmed to be associated with nesting pairs. During the second survey from 25-31 May, additional adults (likely breeding females emerging from the nest burrow) as well as two juveniles were seen at or near nesting burrows, and one additional active burrow was identified. The final survey took place 9-12 July and documented a mix of adults and juveniles over a larger portion of the airport, consistent with the dispersal behavior of both age groups. The survey will be replicated in five years (2022) to compare pre- and post-construction results.

Task D. BUOW Monitoring. Population-level efforts were continued to capture, measure, and band adult and juvenile BUOW in order to re-sight banded birds during nest monitoring, camera trapping, wider area surveys, and reported sightings from the public. To provide a metric of success for future mitigation efforts and monitor BUOW population viability, study sites included all MAP on- and off-site mitigation areas, Brown Field, Lonestar Ridge West, Johnson Canyon/Lonestar Ridge East, Helix Lonestar, San Diego Habitat Conservancy (SDHC) Lonestar, Poggi VOR, and Lower Otay Reservoir Burrowing Owl Management Area (LORBOMA). During the 2018 breeding season, 29 breeding burrows were monitored with camera traps at Brown Field, Lonestar, and Helix Lonestar weekly from late-March through early September. A total of 102 BUOW were captured for banding, representing 36 families. Adult survival was found to be lower in 2017 and 2018, but juvenile recruitment and survival was the highest measured in 2018. We documented 28 confirmed BUOW mortality events across Brown Field, Lonestar, Johnson Canyon, and Helix Lonestar. The large overall number of mortalities, especially of juveniles, is most likely explained by decreased prey availability.

Task E. Habitat and Burrow Assessments. To meet the maintenance and monitoring requirements for MAP's BUOW mitigation plan, ICR is conducting habitat assessments at each of the mitigation sites, including surveys of soil texture and vegetation, assessment of predator and prey abundance, and burrow surveys. Assessments completed in 2017 indicate soil textures are relatively favorable for squirrel activity. Squirrel activity is localized and scattered. Very low levels of small mammal (prey) activity were detected. In terms of predator pressure, the scat density transects showed coyote presence across all on- and off-site parcels, with very high use of Area A. Relatively moderate levels of corvid and raptor presence were also detected at Area A and the Miller/Dart parcels. Predator perches and roosting sites are abundant across Otay Mesa and can be found adjacent to all MAP mitigation sites.

Task F. Ground Squirrel Establishment. Field surveys for California ground squirrel burrows were conducted at all on- and off-site mitigation areas between 26-28 Sept. The current level of ground squirrel activity on all mitigation parcels (pre-restoration) is low. While burrows were documented on all parcels except Area B, no burrows had evidence of recent activity, and seasonal activity patterns do not account for the absence of recent activity. The parcels with the greatest burrow density were the Corn (7.6%) and Miller parcels (2.5%). Area A also had significant numbers of inactive burrows. Most of the existing burrows are generally associated with habitat edges.

Task G. Recommendations. Recommendations are based on the findings of the ICR Burrowing Owl Recovery Program since 2011 and are aligned with the conservation and management goal of stabilizing the BUOW population on Otay Mesa given anticipated development activities. Regarding relocation timing, relocation (passive or active removal of BUOW) activities and grading to make the habitat unsuitable must be tightly coupled. Due to the history of BUOW occupancy and the importance of this site to the overall BUOW population, the probability of reoccupation is very high. If reoccupation occurs during the breeding season, development activities will be delayed. In terms of mitigation site timing, progress on the restoration of mitigation sites should be prioritized in 2019 in order to provide more options for BUOW relocation from Brown Field in the coming years. Modifications to the restoration plan are needed to make better use of the available space on Area A for BUOW, and to prepare Area B for foraging use. Strategies for initiating vegetation and squirrel management on the off-site mitigation areas are also provided and detailed.

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Introduction

In California, the western burrowing owl (*Athene cunicularia hypugaea*; BUOW) is listed as a Species of Special Concern, in part due to declining population numbers and loss of habitat. Once widespread throughout grasslands in San Diego County, the BUOW population has been reduced to a single breeding node in the Otay Mesa region. Continued threats, including development, invasive vegetation, burrow loss, and negative population growth rates, place this population in serious risk of extirpation. Because of this, BUOW are currently facing an uncertain future in San Diego County unless immediate recovery actions are taken (Lincer and Bloom 2003).

Concurrently, the presence of BUOW in development areas results in conflicts between conservation and economic activity. Avoidance, minimization, and conservation measures are used when land development displaces and/or negatively impacts resident species. When avoidance of BUOW impacts is not feasible, mitigation is used to reduce the effects. Environmental mitigation is a costly but essential component of development activities. The Metropolitan Airpark Project (MAP) located at Brown Field Municipal Airport is projected to have impacts to BUOW breeding habitat, foraging habitat, and nesting and wintering burrows (ESA 2015). To ameliorate these impacts, a BUOW Mitigation Plan was prepared that identifies management actions using an adaptive management framework with "the goal of long-term sustainability of the species" (ESA 2015, p. 1). In 2016, the San Diego Zoo Institute for Conservation Research (ICR) submitted a proposal to achieve the long-term management and monitoring goals of the Mitigation Plan. Although there have been changes to the overall project timeline, we continued to monitor the BUOW population in the Otay Mesa region so that there would be no gap in our knowledge of population status prior to project construction.

Based on the BUOW Mitigation Plan, we proposed to not only mitigate impacts of MAP, but to use the mitigation actions to further BUOW conservation in San Diego County. In doing so, we can achieve a win-win scenario for BUOW and MAP. This work is critically important for BUOW in San Diego County, particularly in light of increasing development and land use changes in the region. New knowledge from this study will help determine effective BUOW mitigation strategies that can be utilized when other projects occur in owl habitats. Thus, this project has direct implications for not only MAP, but a larger target audience including state and federal agency regulators, developers, and land managers.

ICR has had a long-term commitment to the species locally. From our previous 7 years of BUOW research and adaptive management actions, we have been able to accomplish the following: refined techniques to re-establish California ground squirrels (CAGS) on potential recovery sites for BUOW; explored ways to encourage natural squirrel dispersal into unoccupied areas to provide nesting burrows for BUOW; assessed BUOW population status and productivity; evaluated the effects of artificial burrows; and investigated BUOW nesting, foraging, and spatial ecology to help direct management efforts for population recovery in San Diego County. We developed a habitat suitability model to identify priority node locations, and a rapid assessment habitat protocol to rank the top sites; these tools will guide the inclusion or exclusion of specific Conserved Lands for BUOW recovery. In partnership with the SDMMP and multiple agencies, we have developed a BUOW Conservation and Management Plan that will guide recovery measures. In addition, San Diego Zoo Global has a long history of conservation breeding and reintroduction expertise with avian species such as California condor (*Gymnogyps californianus*), Ridgway's rail (*Rallus obsoletus*), and puaiohi (*Myadestes palmeri*). Throughout our work with BUOW and CAGS, we have followed an adaptive management approach wherein the outcome of management actions is documented scientifically, and there is continuous feedback between science and management. Using this approach, each lesson learned is incorporated into the next steps for both research and management, enabling constant adaptive revision of methods while maintaining a focus on a few key overarching goals.

The primary goal of this project is to implement mitigation and recovery measures to increase and stabilize the BUOW population. Building on our past adaptive management research program, we will (1) conduct both passive and active translocations within a robust experimental framework; (2) establish an additional BUOW breeding node through the use of active translocation; (3) monitor BUOW post-construction; (4) assess habitat and coordinate with MAP land managers for artificial burrow maintenance and vegetation management; (5) establish ground squirrel activity through encouraging natural squirrel dispersal and/or translocation; and (6) quantify our results and provide recommendations on mitigation and management. Our on-the-ground activities are intended to cultivate a higher degree of self-sustainability than other approaches to BUOW recovery (e.g., by managing habitat to encourage squirrel burrow creation rather than relying exclusively on artificial burrows which require more ongoing maintenance). By initiating these mitigation and recovery measures, this project will help fulfill the goals and objectives of the MAP BUOW Mitigation Plan, as well as the San Diego Management and Monitoring Program (SDMMP) Management Strategic Plan (San Diego Management and Monitoring Program 2013) and the BUOW Conservation and Management Plan for San Diego County (SDZ ICR 2017) and will have a significant positive impact on BUOW conservation in the region.

Project objectives in 2018 included:

1. Conducting active translocation of 5 BUOW pairs in support of establishing a new breeding node in San Diego County;
2. Conducting a BUOW population survey during the breeding season at Brown Field and all on- and off-site mitigation lands;
3. Monitoring BUOW at nesting sites in the Otay Mesa region throughout the breeding season;
4. Conducting habitat surveys, rapid assessments of prey abundance, and CAGS burrow surveys at each of the mitigation sites; and
5. Monitoring the presence of ground squirrels and other fossorial mammals at each of the mitigation sites and determining a strategy for ground squirrel establishment at each of the sites.

Personnel

Principal Investigators:
Lisa Nordstrom, Ph.D., Ron Swaisgood, Ph.D.

Field Team
Field Organizers: Susanne Marczak, Colleen Wisinski, M.S.
Field Technicians: Michael Stevens, Savannah Perez, Tracey Rice, Danielle Angel, Emily Lucero

Volunteers/Interns from San Diego Zoo Global (ICR in-kind contribution): Susan Carter, Kathleen Esra, Karin Kupka, Kate Lambert, Austin Parker

Genetic Analyses: Lindsay Sidak-Loftis; Brigid Moran

Data Analysis: Sarah McCullough Hennessy, Ph.D., Colleen Wisinski, M.S.

Permits

Fieldwork was conducted under the California Department of Fish and Wildlife (CDFW) Entity Scientific Collecting Permit SC-11839. BUOW banding, bleeding, and transmittering were conducted under the Federal Bird Banding Permit of Colleen Wisinski (24023) with Susanne Marczak (24023-A) as a subpermittee. BUOW translocations were conducted under SC-11839 and U.S. Fish and Wildlife Service Scientific Collecting Permit MB14619C-4. This project was approved by SDZG's Internal Animal Care and Use Committee (IACUC) and operates in accordance with all IACUC provisions under Project #17-006.

Study sites

The study sites were all located on public lands and conservation areas in San Diego County within Management Unit 3 of the Management Strategic Plan (San Diego Management and Monitoring Program 2013). We focused on priority sites that were identified in 2013 for monitoring BUOW nesting and foraging ecology, and included the on- and off-site mitigation areas for this project, along with Rancho Jamul Ecological Reserve (Figures 1 and 2).

1. Brown Field Municipal Airport, managed by City of San Diego Airports;
2. On-site mitigation sites Area A and Area B;
3. Off-site mitigation sites Dart, Miller, and Corn;
4. Lonestar Ridge West Mitigation Site, managed by California Department of Transportation;
5. Johnson Canyon/Lonestar Ridge East Mitigation Site, managed by California Department of Transportation;
6. Helix Lonestar, managed by Helix Environmental;
7. San Diego Habitat Conservancy (SDHC) Lonestar, managed by SDHC;
8. Poggi VOR, managed by the Federal Aviation Association;
9. Lower Otay Reservoir Burrowing Owl Management Area (LORBOMA), managed by City of San Diego Public Utilities;
10. Rancho Jamul Ecological Reserve (RJER), managed by California Department of Fish and Wildlife.

Brown Field Municipal Airport (Brown Field; 11S 501892m E 3603817m N; 637.4 acres) is characterized by managed non-native grassland habitat with highly disturbed human use areas. California ground squirrels occur in relatively high numbers and create natural burrows for the owls to occupy. All nest burrows that we monitored at Brown Field were natural burrows.

On-site mitigations sites (Area A; 11S 501002m E 3604438m N; 40.4 acres) and (Area B; 11S 501378m E 3604867m N; 6.5 acres) are located directly north of Brown Field. The vegetation in Area A is dominated by non-native invasive grasses, with the adjacent perimeter habitat coastal sage scrub. Area B is comprised of native shrubs and high densities of non-native grasses.

Off-site mitigation sites (Dart; 11S 503217m E 3602077m N; 10.9 acres) and (Miller; 11S 503217m E 3601881m N; 9.8 acres) form a contiguous site that has a diverse vegetation composition, ranging from non-native invasive grasses, tall mustard, and riparian-type plants. Off-site mitigation area Corn (11S 503164m E 3601245m N; 9.7 acres) is directly adjacent to the secondary border fence and is comprised of a mixture of non-native and native forbs, and non-native grasses.

Lonestar Ridge West Mitigation Site (Lonestar; 11S 503107m E 3604576m N; 154.9 acres) is a restored vernal pool and BUOW mitigation site established in 2012. The site contains 50 artificial burrows (25 plastic, 25 wood) with at least 25 additional starter holes and natural burrows on-site, particularly along the perimeter and eastern most portions of the site. Lonestar is characterized by tarplant (*Deinandra* spp.) and other native vegetation with some patches of native needle-grass (*Stipa* spp.). In 2015, a major effort was made to establish native grassland in the southern portion of the site with high success.

The Johnson Canyon/Lonestar Ridge East Mitigation Site (Johnson Canyon; 11S 504233m E 3604976m N; 52.4 acres) is a more established mitigation restoration site characterized by coastal sage scrub vegetation with patches of non-native grasses. The site contains 21 artificial burrows (all plastic). Cholla was planted on the artificial burrow mounds at this site as part of a restoration plan for coastal cactus wrens. As a consequence, woodrats have used the cholla to plug the entrances and chambers of the artificial burrows, making many of them unusable by BUOW.

The Helix Lonestar Mitigation Site (Helix; 11S 504116m E 3604731m N; 54.2 acres) is located directly south of the Johnson Canyon/Lonestar Ridge East Mitigation Site. Restoration efforts on the site began in 2017 and include 21 artificial burrows installed on two berms. Artificial burrows at this site were constructed utilizing ICR's design recommendations that resulted from previous research into optimal burrow designs that most closely mimic the humidity and temperature buffering effects of natural burrows. The chambers are made of wood, while the tunnels are constructed from plastic.

The SDHC Lonestar site (SDHC; 11S 504822m E 3604665m N; 24.5 acres) is directly east of the Helix site, helping make this segment of Otay Mesa a large contiguous habitat for BUOW. There are no artificial burrows at the SDHC site, but there has been effort by ICR staff to encourage natural dispersal of ground squirrels from adjacent areas into the site through strategic placement of brush piles for cover. Preliminary results show that the number of natural burrows on the site are gradually increasing over time due to the cover piles.

Poggi VOR (Poggi; 11S 501962m E 3608091m N; 51.7 acres) is characterized by managed non-native grassland habitat and contains ground squirrel burrows throughout the southwest corner of the site. While in previous years, squirrels were observed in high densities, in 2018 we observed a decrease in squirrel activity relative to other years. This may be due to changes in land management practices on the site.

Lower Otay Reservoir Burrowing Owl Management Area (LORBOMA; 11S 507934m E 3608091m N; 32.3 acres) is an artificial burrow site characterized by coastal sage scrub habitat with some areas of native and non-native grass. The site contains 23 artificial burrows (all plastic). A lack of burrow maintenance has resulted in an overgrowth of vegetation at burrow entrances that may discourage owls from utilizing them during the breeding season.

Rancho Jamul Ecological Reserve (RJER; 11S 513635m E 3615729m N) in Jamul, CA has a 54-acre Burrowing Owl Habitat Management Area (BOHMA), on which there are 25 artificial burrows of varying designs, as well as a large number of natural ground squirrel burrows. Historically, RJER has not had breeding pairs of BUOW on the property, but does periodically document wintering owls. Vegetation is characterized by a mix of native and non-native grasses and forbs, with a riparian area consisting of large trees running through the middle of the property. In recent years, a cattle grazing plan has been implemented to reduce vegetation load throughout the site, including the BOHMA. In 2018, five pairs of BUOW were translocated from Brown Field as part of a collaborative effort to establish an additional breeding node of owls outside of Otay Mesa.

Figure 1. Map of Otay Mesa burrowing owl study sites.

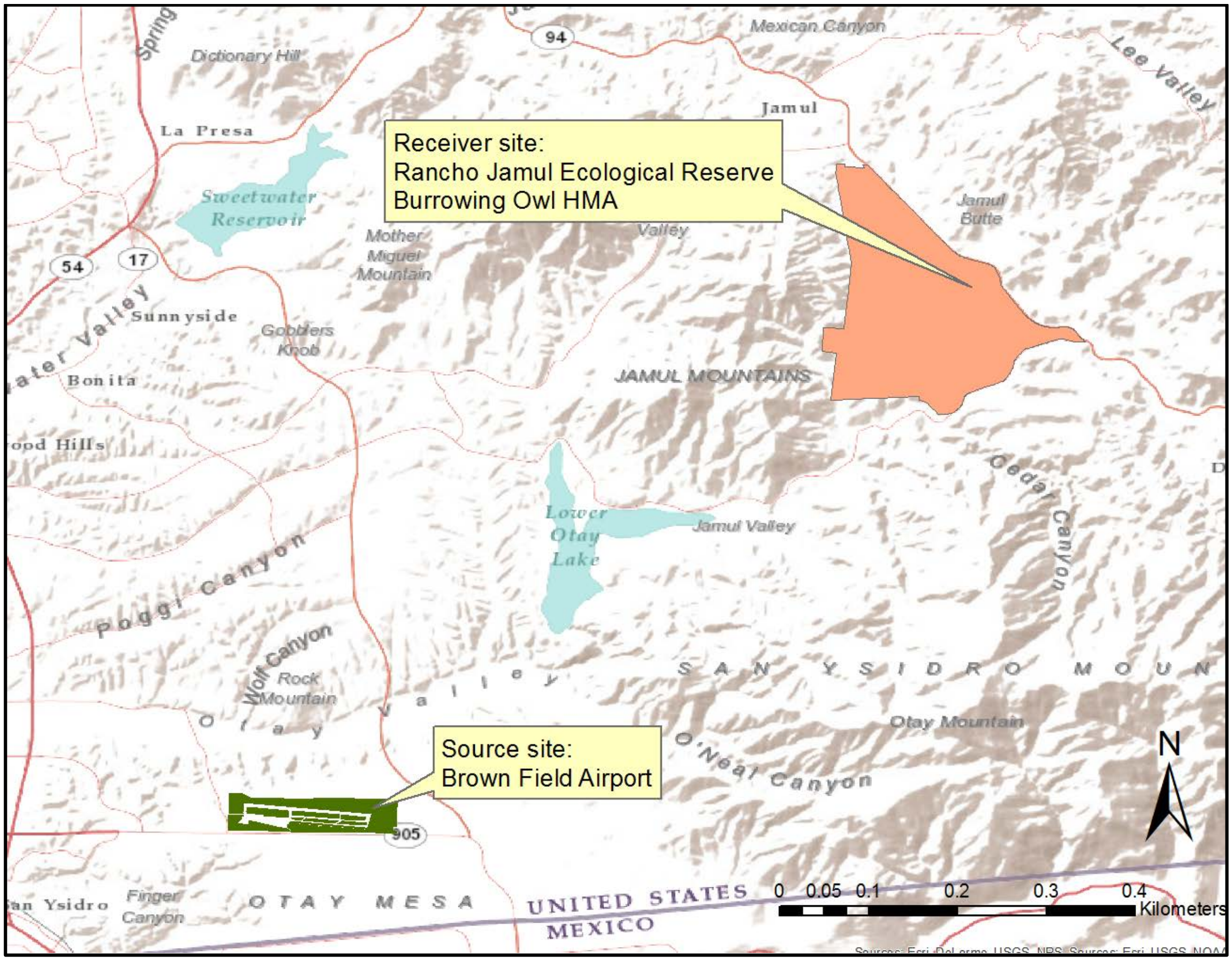

Figure 2. Map of Rancho Jamul Ecological Reserve location relative to Brown Field Municipal Airport source sites.

Task A. Passive Relocation and Active Translocation

CDFW recommends mitigation through the use of disturbance buffers (setback distances) and burrow exclusion (passive relocation, CDFG 2012). Active translocation of BUOW has also been used as a mitigation method in Arizona, Idaho, California, and Canada. However, the behavioral and demographic consequences of these mitigation methods have never been experimentally compared. As part of a larger regional project to determine the safest and most cost-effective BUOW mitigation method, we proposed to test both passive and active relocation for BUOW potentially impacted by MAP.

The three-year study assesses mitigation strategies for BUOW in southern California. The primary goal of the work is to improve wildlife mitigation strategies used for BUOW impacted by development, in order to decrease impacts on the species. The study measures and comparatively assesses the behavioral and demographic consequences of each mitigation method, and will provide recommendations on best practices and strategies for use of active versus passive relocation methods. The objective is to record and evaluate BUOW dispersal, mortality, and reproductive output in response to passive and active relocations, as compared to BUOW not planned for relocation.

The larger project fills an existing need for scientific data on the relative effectiveness of relocation as a conservation and mitigation tool for BUOW. As part of the study, several types of data are collected, including: post-disturbance site fidelity, movement patterns, survival, reproductive success, and habitat preference data. The inclusion of MAP increases study sample size and contributes to broader goals to increase the efficacy of BUOW conservation efforts.

Methods

Passive Relocation

Single (i.e. non-paired) owls observed within Phase 1 would have been considered candidates for passive relocation prior to ground disturbance from construction; however, due to the lack of construction activities in 2018, no individuals were passively relocated.

Active Translocation

Due to uncertainty in the start of project activities, an interagency group of stakeholders decided to proceed with a conservation translocation which decoupled the translocation timing from the onset of construction activities and allowed for more biologically-relevant timing to coincide with BUOW breeding. A target group size of five pairs was identified as the minimum number needed to initiate a new breeding node and to conduct a biologically-optimized effort to establish a new colony (see Task B). These five pairs of BUOW were also enrolled into the ongoing regional study of translocation outcomes.

Owl pairs located inside the Phase 1 development impact area were considered priority translocation candidates. However, pairs from outside the impact area were also considered to reach the minimum threshold of five pairs. Field observations were performed by the ICR team starting in late-January and continuing through the translocation period. Additionally, a pre-construction survey (walking transects) of the Phase 1 impact area was conducted by ECORP Consulting during 13 – 14 February to ensure no owls were missed immediately prior to translocation. These observations and surveys were used to identify target pairs and to confirm pre-breeding behavior.

Pairs were housed together in hacking cages at the RJER BOHMA. The hacking cages were 12 ft by 12 ft by 6 ft in dimension and were removed on 3 April after the minimum 30-day acclimation period. Water and food, comprised of rodent and invertebrate prey (crickets, mealworms) were provided approximately four times per week during the acclimation period.

See Task B section for further details about the translocation and monitoring methods.

Results and Discussion

ICR field observations coupled with the pre-construction survey carried out by ECORP Consulting initially identified two pairs of owls within the MAP Phase 1 footprint, both at the Tripad area. As a result, additional pairs from outside the impact area were identified as targets for translocation. A total of five breeding pairs (10 BUOW) were actively-translocated between 20 February – 6 March (Table 1, Figure 3). Initially, two pairs were moved from the Tripads, but a third pair also came from the Tripads as a result of reoccupation due to difficulty in excluding squirrels from the area. Two pairs from the southwestern portion of Brown Field completed the group of five pairs.

See Task B section for further results and discussion.

Table 1. Burrowing owls actively-translocated from Brown Field Municipal Airport to Rancho Jamul Ecological Reserve.

Source Burrow	Receiver Burrow	Adults (banded year)	Translocation Date	Transmitter	Deployed on	Transmission Start Date	Transmission End Date	Notes
Gravel Lot	Cage 1	F: 07/X (2013)	26-Feb	N/A	N/A	N/A	N/A	Last seen on camera 6/1/18; seen back at Brown Field on 7/13/18
		M: 27/Y (2015)	26-Feb	172940	27-Mar	3-Apr	27-May	Last seen on camera 5/27/18; presumed depredation
Tripad North	Cage 2	F: A/90 (2018)	26-Feb	172975	21-Aug	21-Aug	25-Sep	Last seen on BOHMA 9/24/18; transmitter recovered 11/28/19; likely depredated
		M: A/80 (2017)	26-Feb	163574	27-Mar	3-Apr	7-May	Poor health due to sticktight fleas; transmitter recovered on 5/7/18; likely depredated
Tripad East	Cage 3	F: 30/Y (2015)	1-Mar	N/A	N/A	N/A	N/A	Last seen on camera 4/8/18; whereabouts and condition unknown
		M: A/39 (2018)	20-Feb	165893; 172938	27-Mar (replaced on 5-Sep)	3-Apr; 5-Sep	9-Jun; 26-Nov	Last confirmed sighting on 11/19/18; transmitter recovered on 11/28/18; likely depredation
Tripad North	Cage 4	F: A/36 (2017)	6-Mar	N/A	N/A	N/A	N/A	Last seen on camera on 7/27/18; whereabouts and condition unknown
		M: A/54 (2018)	6-Mar	168075	27-Mar	3-Apr	8-Apr	Transmitter malfunction; Last seen on camera 4/4/18; presumed depredation
Flight School	Cage 5	F: A/42 (2018)	6-Mar	N/A	N/A	N/A	N/A	Last seen on camera on 7/6/18; whereabouts and condition unknown
		M: A/57 (2017)	5-Mar	172968	27-Mar	3-Apr	7-Jun	Transmitter removed on 6/7/18 due to malfunction; last seen on camera 6/27/18; band recovered 6/29/18; presumed depredation

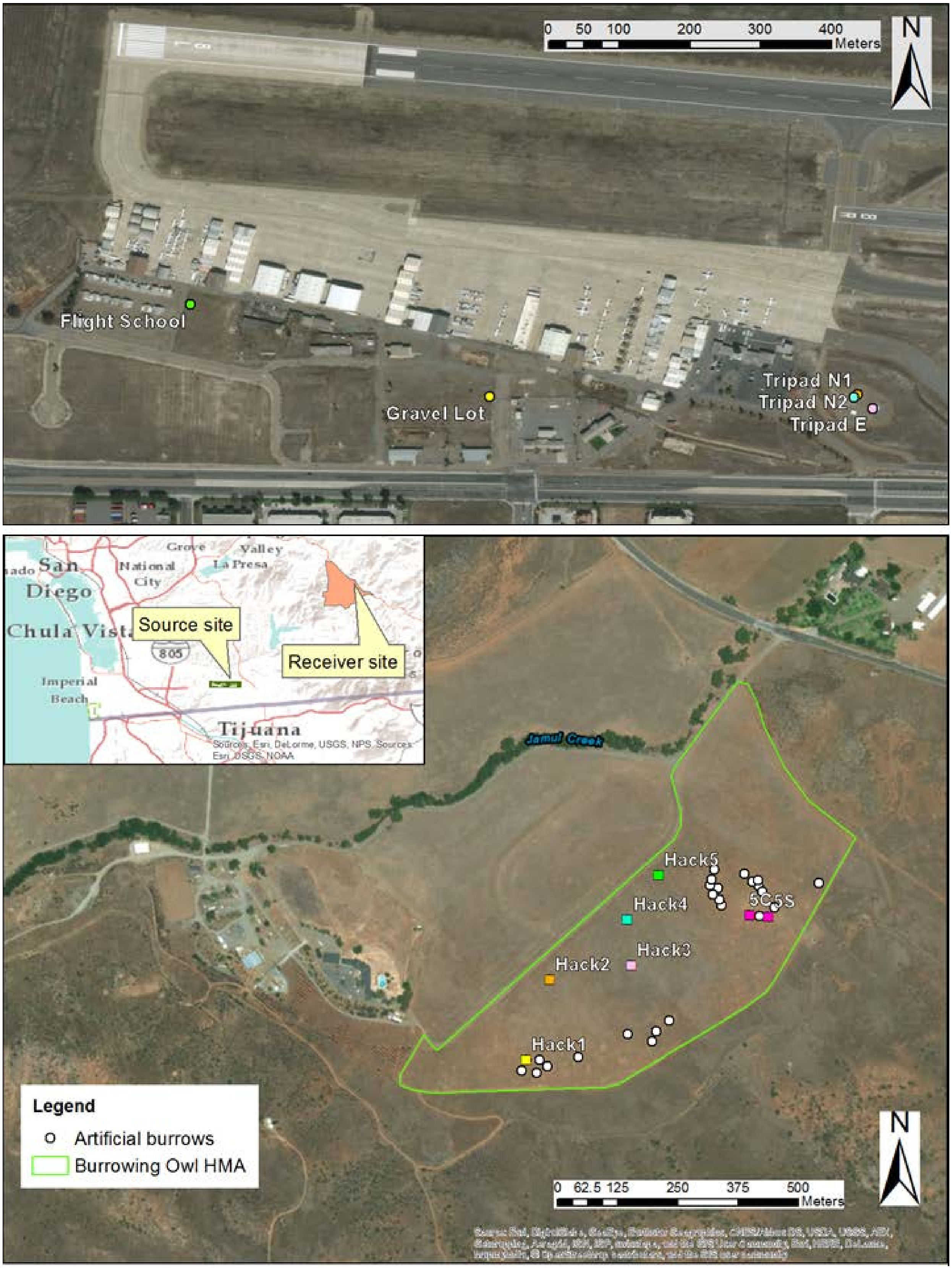

Figure 3. Translocation source locations (top) and receiver locations (bottom).

Task B. BUOW Breeding Node

The translocation of BUOW to RJER in 2018 initiated an effort to establish a new BUOW population recovery node, in alignment with the 2017 BUOW Conservation and Management Plan for San Diego County. In addition to helping meet mitigation requirements, this effort works toward the SDMMP Management Strategic Plan (MSP) goals and objectives for BUOW. The 2013 MSP sets a regional goal to **"**Increase the abundance of nesting BUOW to ensure that there are multiple interbreeding sub-occurrences of appropriate size (≥ 5 pairs) and distribution (primarily utilizing natural burrow systems) on Conserved Lands that will provide for BUOW persistence in the MSPA over the long-term (> 100 years)."

Perhaps one of the most significant obstacles facing successful animal relocations is the problem of long-distance movement away from the release site or "dispersal" (Stamps and Swaisgood 2007; Batson et al. 2015). Long-distance movements following release have been shown to increase risk exposure and mortality rates of several species (Stamps and Swaisgood 2007; Le Gouar et al. 2011; Shier and Swaisgood 2012). While holding animals in acclimation pens at the release site can reduce post-release dispersal (Bright and Morris 1994; Batson et al. 2015), this method alone does not always yield success (Shier 2006; Shier and Swaisgood 2012). Thus, a major consideration in animal relocation efforts is to find mechanisms to retain or "anchor" animals in suitable habitat at the release site.

Close attention to the species' behavioral and ecological needs can aid our understanding of factors driving post-release movements (Shier 2006; Stamps and Swaisgood 2007; Shier and Swaisgood 2012). A common misconception is that dispersers will find and occupy empty suitable habitat if it is present; however, even territorial and less social species often prefer to settle near conspecifics (Stamps 1988). The end result for reintroduction and translocation programs is that translocation efforts may fail at otherwise carefully prepared receiver sites if there are no signs that members of the translocated species inhabit the area. Thus, the deliberate manipulation of conspecific signals, or "cues," may be necessary to limit post-release dispersal, by providing the signal that released animals use to guide their decision to settle in new habitat. Using this theoretical framework, conservationists have used bird song playbacks to recruit songbirds to new areas (Ahlering et al. 2010), model decoys to attract terns to new colonies (Kotliar and Burger 1984), white wash (mimicking droppings) to attract vultures (Sarrazin et al. 1996), and rhino dung to encourage settlement in translocated black rhinos (Linklater and Swaisgood 2008). As a semi-colonial species, both audio and visual conspecific cues are likely important for BUOW.

While Leupin and Low (2001) found that released BUOW will settle at release sites, mortality from predation can be expected to be high in the first month after release. BUOW released to a new territory must successfully balance the effort invested in hunting with vigilance to survive. Supplemental feeding may be employed if monitoring reveals insufficient prey delivery; this short-term management action offsets mortality risk and increases nest success if prey becomes limited during the critical "anchoring" period. Establishment success for translocated individuals is measured through established quantitative metrics of owl settlement, survival, and reproductive success gathered through post-release monitoring.

Methods

Due to the overarching objective of establishing a new breeding node at RJER, visual and auditory conspecific cues were deployed at the BOHMA in order to optimize settlement, retention, survival, and future recruitment of BUOW at the site. While these methods are not typically used in a strictly mitigation-driven translocation, they may be cost-effective additions that result in better outcomes.

Active Translocation and Timing

Five pairs of BUOW were actively-translocated in early 2018 according to the methods described in Task A section. This group size was identified as the minimum number needed to initiate a new breeding node and to conduct a biologically-optimized effort to establish a new colony. Additionally, this number is in line with our estimated carrying capacity of BUOW at the BOHMA given its number of available burrows. The timing of the translocation (just prior to the initiation of nesting/egg-laying) was chosen so breeding would occur at the release site to: 1) anchor the adults and 2) take advantage of natal philopatry to maximize recruitment of any juveniles born there in 2018.

Banding and Telemetry

All translocated owls were banded with USGS and green alphanumeric color bands to allow for individual identification. Satellite GPS transmitters were attached 7 days before removal of hacking cages and owl release. GPS transmitters were attached using a backpack-style harness and the total weight of all attachments (GPS tag, backpack harness, bands) did not exceed 5% of body weight in accordance with the federal banding permit. GPS transmitters were programmed to take location fixes at 9:30, 16:30, and 21:30 PDT and the location data were downloaded weekly (or more frequently) to monitor locations and fates of tagged owls.

Supplemental Feeding and Conspecific Cues

In order to dampen dispersal and increase survival, supplemental feeding to all translocated BUOW and their offspring continued after the acclimation period, through the end of the breeding season. The frequency and amount of supplemental food was gradually decreased to wean the owls and encourage normal hunting behavior.

Additionally, conspecific cue treatments were utilized at the BOHMA to further promote settlement of translocated owls. The artificial cues were designed to indicate that other BUOW had settled in the area and found the habitat suitable using both visual and acoustic cues. Artificial visual cues consisted of simulated whitewash (non-toxic white latex paint), and acoustic cues consisted of playbacks of pre-recorded vocalizations created using online sources with permission or proprietary recordings. The playbacks primarily consisted of territorial “coo-coo” calls with a small number of alarm calls per looped recording. The looped recordings were played for 10 minutes per hour for 14 hours per day. The schedule was based on prior research examining BUOW vocalizations in southern California (ICR unpublished data).

Monitoring

Individuals were tracked remotely through satellite GPS points collected at least 3 times/day. Data were downloaded and processed remotely. Camera traps and visual surveys were used to monitor owl survival, nesting and productivity, and burrow occupancy. Camera traps were mounted on a 2-4 foot tall stake 1-3 meters from the burrow entrance. Approximately 500,000 photos were collected by the camera traps. Photo downloads and field observations were conducted at least weekly during the breeding season (March-August) depending on the supplemental feeding schedule and monthly during the non-breeding season (Sept-Feb).

Results and Discussion

Ten BUOW were translocated as described in Task A section (Table 1, Figure 3). All hacking cages were removed and owls released on 3 April. Each pair had initiated nesting (laid at least one egg) at the time of release.

Nesting, Settlement, and Survival

All five original nesting pairs laid eggs, but not all of them proved to be successful breeding nests (Table 2, Figure 4). Following removal of the hacking cages, a female from one burrow (Cage 3) and a male from another (Cage 4) abandoned their initial nests to start a new nesting attempt together. Ultimately, 3 pairs of BUOW successfully fledged 17 juveniles. A supplemental feeding strategy was implemented at the site throughout the entirety of the breeding season to ensure that success of nests was not prey-limited.

Documented mortality events were primarily of adult individuals (Table 3). We suspect that 2018 was a relatively difficult year for BUOW as there was likely a low prey base across all habitats due to low precipitation levels in the winter prior to the breeding season. The success of the initial translocation will be further evaluated in Spring 2019 when we revisit RJER to see if any surviving individuals return to breed on the site. Supplementation of additional breeding pairs to the site likely will be necessary given the probability that returning individuals may have a high degree of relatedness, increasing the risk for inbreeding. Additionally, we recommend translocating at least 4-5 pairs of breeding owls on the BOHMA so that individuals can benefit from the dynamics of a colony.

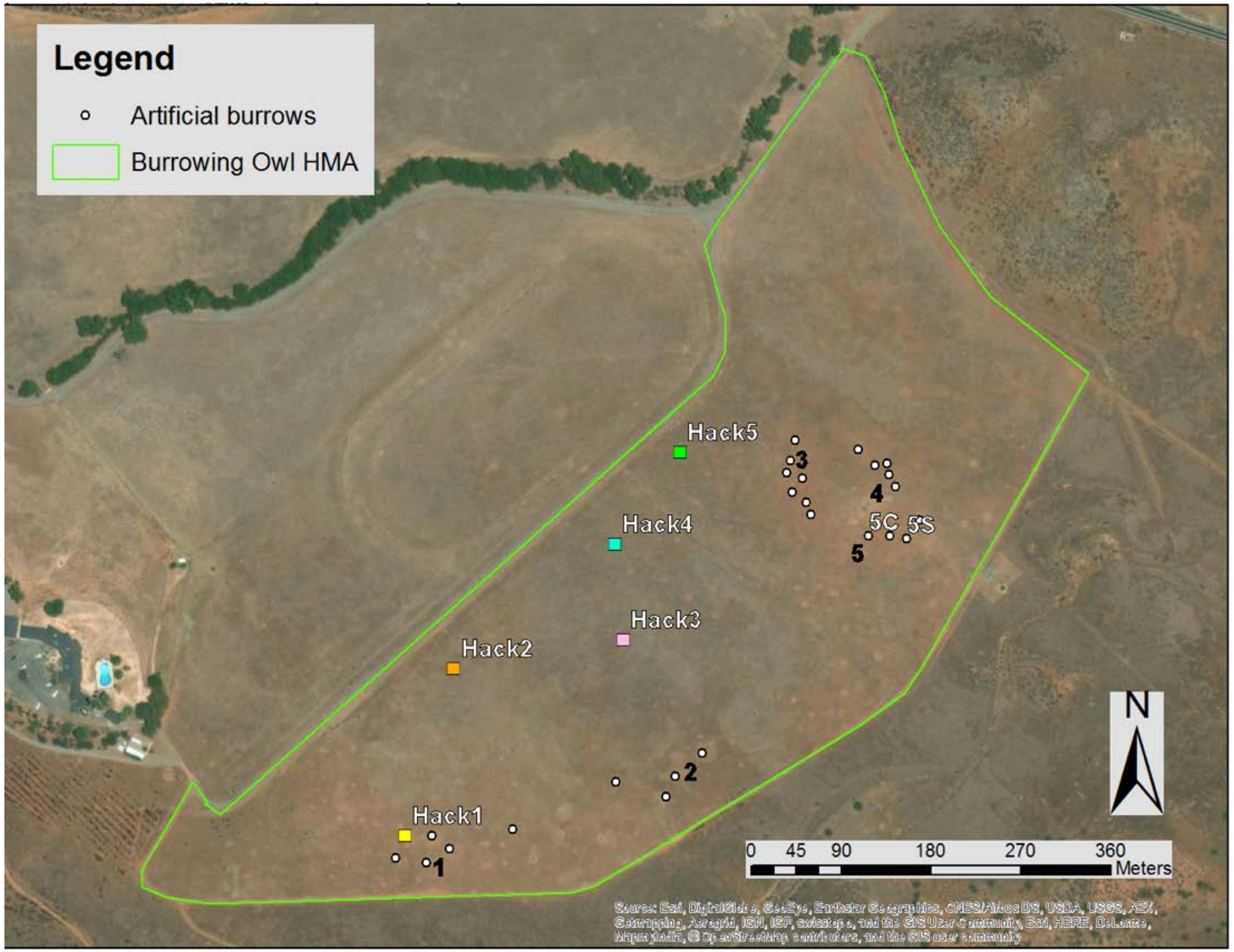

Figure 4. Map of 2018 burrowing owl nests and all other artificial burrows at Rancho Jamul Ecological Reserve. Numbers 1-5 in black refer to burrow complex numbers.

Table 2. Nesting and reproductive data for 2018 for burrowing owls actively-translocated to Rancho Jamul Ecological Reserve.

Burrow	Source Burrow	Adults (year banded)		Breeding Confirmed	Camera Dates	Estimated First Egg Date	Estimated First Hatch Date	Emergence Date	Max Eggs	Max Chicks	Juveniles Surviving 21 Days Post-Emergence	Juveniles Surviving 30 Days Post-Emergence (bands)
		Female	Male									
Initial Nesting Attempts												
Cage 1	Gravel Lot	07/X (2013)	27/Y (2015)	Yes	26 Feb - 5 Sep	22-Mar	N/A	N/A	11	0	0	0
Cage 2	Tripad North	A/90 (2018)	A/80 (2017)	Yes	26 Feb - 5 Sep	29-Mar	28-Apr	16-May	10	6	6	6 (B/21, B/32, B/43, B/54, B/65, B/76)
Cage 3	Tripad East	30/Y (2015)	A/39 (2018)	Yes	6 Mar - 19 Apr	29-Mar	N/A	N/A	5	0	0	0
Cage 4	Tripad North	A/36 (2017)	A/54 (2018)	Yes	5 Mar - 19 Apr	29-Mar	N/A	N/A	3	0	0	0
Cage 5	Flight School	A/42 (2018)	A/57 (2017)	Yes	5 Mar - 5 Sep	31-Mar	30-Apr	19-May	8	6	6	6 (B/17, B/28, unbanded, B/50, B/06, B/39)
Renests												
Complex 5_5S	Cage 3 / Cage 4	A/36 (2017)	A/39 (2018)	Yes	16 Apr - 5 Sep	12-Apr	N/A	N/A	4	0	0	0
Complex 5_5C	Cage 3 / Cage 4	A/36 (2017)	A/39 (2018)	Yes	2 May - 31 Jul	19-Apr	19-May	31-May	7	6	5	5 (B/51, B/98, B/66, B/87, USGS only)

Table 3. Mortalities of burrowing owls at Rancho Jamul Ecological Reserve in 2018.

BUOW ID (Band & Transmitter)	Mortality Date	Location Seen/Found	Mortality Cause/ Info.	Notes
A/80 (163574)	7-May	RJER BOHMA; north of Cage 2	Poor health due to sticktight fleas. Likely depredated by unknown predator.	RJER Cage 2 Male
Unbanded Chick	7-June	RJER BOHMA; AB5C	Unknown (camera trap photo shows individual standing and then next photo dead on ground). Raven eventually comes and takes carcass away.	RJER Complex 5 Chick
A/57 (172968)	29-June	RJER BOHMA; Complex 3	Unknown (band/feather piles found near Complex 3 in RJER BOHMA; band was misshapen, transmitter already removed). Likely depredated by unknown predator.	RJER Cage 5 Male
Unknown BUOW	13-July	RJER BOHMA; Complex 3	Feather pile found. No bands recovered. Feathers appeared to be of a juvenile BUOW.	Likely juvenile
A/90 (172975)	24 Sept – 22 Nov	RJER Field west of Quarry	Last seen on BOHMA 24 September. Transmitter data indicated patterns of mortality on 22 November. Likely depredated by unknown predator.	RJER Cage 2 Female
A/39 (165893; 172938)	26 - 28 Nov	RJER BOHMA; Complex 3 / 5	Transmitter data indicated patterns of mortality on 26 November. Likely depredation by unknown predator.	RJER Complex 5 Male (Originally Cage 3 Male)
Unknown BUOW	13 Nov	RJER Quarry	Feather pile, no bands found. Likely depredated by unknown predator.	Likely juvenile
Unknown BUOW	13 Nov	RJER Quarry	Feather pile, no bands found. Likely depredated by unknown predator.	Likely juvenile

Hacking Cage 1 The pair was composed of female 07/X and male 27/Y (transmitter 172940). Eleven eggs were laid; however, for unknown reasons, no eggs hatched. This pair of owls was a known pair at Brown Field since 2016, fledging 1 chick in that year. In 2017 they had two failed nesting attempts, the reasons for which are unknown; however, breeding was confirmed in the second attempt when camera trap photos captured the female removing an egg from the burrow. The female also had documented breeding success with two other males since 2013, when she was first banded as an adult. Little is known about senescence in BUOW, but infertility due to age may have been a contributing factor to nest failure in 2018. The adult male was last seen on camera on 27 May, the same day the last transmission was received from its transmitter. Those two events coupled together lead us to believe that this individual was likely depredated, but no remains or auxiliary items (i.e., transmitter, bands) were recovered. The female disappeared from the BOHMA a few days later and was observed approximately one month later on 12 July back at her pre-translocation burrow (Gravel Lot) at Brown Field. Interestingly, this situation demonstrates the role of pair bonding in helping anchor translocated individuals to a new site, even when breeding is not successful. In addition, fidelity of adults to their source site location is likely strong and may contribute to dispersal patterns of translocated owls.

Hacking Cage 2 The pair was composed of female A/90 and male A/80 (transmitter 163574). A total of 10 eggs were laid, with 6 hatching. Mortality of the adult male (likely due to predation) was confirmed on 7 May just after the pair's chicks hatched. Upon review of camera trap photos, we found the male was heavily infested with sticktight fleas (*Echidnophaga gallinacea*) and in very poor condition just prior to his death (see Task D section for more details regarding sticktight fleas). The female remained at the nest and successfully raised the chicks due to the supplemental feedings, resulting in 6 fledged juveniles. All juveniles at this burrow were banded. The female received a transmitter (transmitter 172975) 21 August and was last observed using the western portion of the BOHMA on 24 September, with the last points transmitted on 25 September. On 22 November we received a cluster of data points from this transmitter that were indicative of a possible mortality event. On 28 November, the transmitter of this individual was discovered in a field approximately 1.5 km northwest of the BOHMA. No remains were recovered at the site. Because of the lack of visual sightings and data transmissions after 25 September, we are unable to determine a more specific date or circumstances of mortality.

Hacking Cage 3 The pair was composed of female 30/Y and male A/39 (transmitter 165893). A total of 5 eggs were laid (4 in one burrow chamber, 1 in the other) but none hatched, most likely due to nest abandonment by the adults. The female disappeared soon after release (last seen on camera on 8 April), and her fate and location are unknown. The male remained at the BOHMA and formed a new pair with the Cage 4 female (see Complex 5 below).

Hacking Cage 4 The pair consisted of female A/36 and male A/54 (transmitter 168075). A total of 3 eggs were laid, but none hatched, most likely due to nest abandonment by the adults. The male disappeared soon after release, seen last on camera on 4 April; predation is suspected as the reason for the disappearance because the transmitter stopped sending signals at the same time. The female remained at the BOHMA and formed a new pair with the Cage 3 male (see Complex 5 below for further information).

Hacking Cage 5 The pair was made up of female A/42 and male A/57 (transmitter 172968). A total of 8 eggs were laid, with 6 hatching. All juveniles fledged. All but one of the juveniles at this burrow were banded. The male's transmitter was removed on 7 June due to malfunction (it never transmitted after deployment); however, after retrieval, we found the transmitter had been logging location data onboard, but not transmitting via satellite. Mortality of the male (likely due to predation) occurred between 27 – 29 June after the surviving juveniles fledged.

Complex 5 This pair was formed by the female from Cage 4 (A/36) and the male from Cage 3 (A/39). They moved to the Complex 5 area and initially attempted to nest in artificial burrow (AB) 5S, laying four eggs, none of which hatched. They renested in AB 5C, laying 7 eggs and successfully fledged 5 juveniles. The female was last seen at the BOHMA on 27 July and the male remained on the BOHMA until the last confirmed sighting on 19 November. On 22 November we received a cluster of data points from this transmitter that were indicative of a possible mortality event. On 28 November the transmitter was recovered on the BOHMA, and a feather pile was collected from a location between Complex 3 and Complex 5.

Dispersing juveniles from the Cage2, Cage 5 and Complex 5 families were documented utilizing PVC and metal pipes on the ground near a quarry on RJER property, approximately 1.5 km north of the BOHMA. A group of at least five individuals began using the area as late as 9 August, when they were first observed. Two banded juveniles were last documented in the area on 28 November.

Telemetry

All five translocated males were outfitted with GPS transmitters on 27 March (one week prior to release), but two of the tags (from Cage 4 and Cage 5) malfunctioned immediately so we were only able to track three of the males in real time. However, upon removal of the transmitter of the Cage 5 male, we discovered it was datalogging during its entire deployment allowing us to add his spatial data to our dataset. No females initially received telemetry equipment because all were gravid so handling was minimized. In one case, after the transmittered male at Cage 2 died, the female of that pair was fitted with a transmitter on 21 August in the hopes of continuing to track the fate of the individual beyond the breeding season. Although we had some problems with the GPS tags, they were useful for monitoring post-release survival and we were able to gather movement data through the breeding season (Figure 5). We found the owls used areas near their breeding burrows (they used the BOHMA almost exclusively), but much of the data were collected during the period of supplemental feeding which may have influenced their home range sizes and space use. Further spatial analysis is on-going and will be useful for informing management actions in the future.

Current status

There have been no recent observations of translocated adults at the BOHMA. However, we have been unable to confirm the fates of three adult females and two adults males, so there is a possibility that we will see translocated adults return to the site for the 2019 breeding season. Additionally, 2-3 fledglings have been documented continuing to use the quarry area. On 20 November, CDFW staff placed additional pipes and rock piles in the quarry area to give the BUOW more cover from predators after at least two were found to have been depredated. There have been sightings of likely wintering BUOW at RJER including one at the BOHMA, one near the Pio Pico Campground, one just west of the BOHMA, and one at the Jamul Central CAGS translocation plot. At this time, we do not plan to place transmitters on any BUOW that return to RJER for nesting, but will instead track them using camera traps and regular field observations. We will attempt to remove non-functional transmitters from any returning BUOW when possible.

Any surviving BUOW have dispersed to overwintering sites and we will not have an accurate idea of population size at RJER until the spring return and initiation of breeding. The non-breeding season is a time of high mortality for first-year BUOW so we will not know how successful this initial translocation is until we see who returns to breed in 2019. We also will not be able to measure the success of the overall effort to establish a new breeding node for several more years. Supplemental translocations will be required to achieve a functional and sustainable breeding population at RJER.

It is important to note that management actions to improve habitat suitability are ongoing and have included grazing along with efforts to increase California ground squirrel activity levels across the BOHMA. In 2018, the number of burrows increased but the footprint of colonization on the BOHMA did not change. This may have been due to low precipitation leading to poor vegetation conditions that likely kept the squirrel population from growing and expanding. Ongoing management strategies to increase both squirrel and owl populations will be necessary to ensure both populations are resilient to stochastic climate conditions.

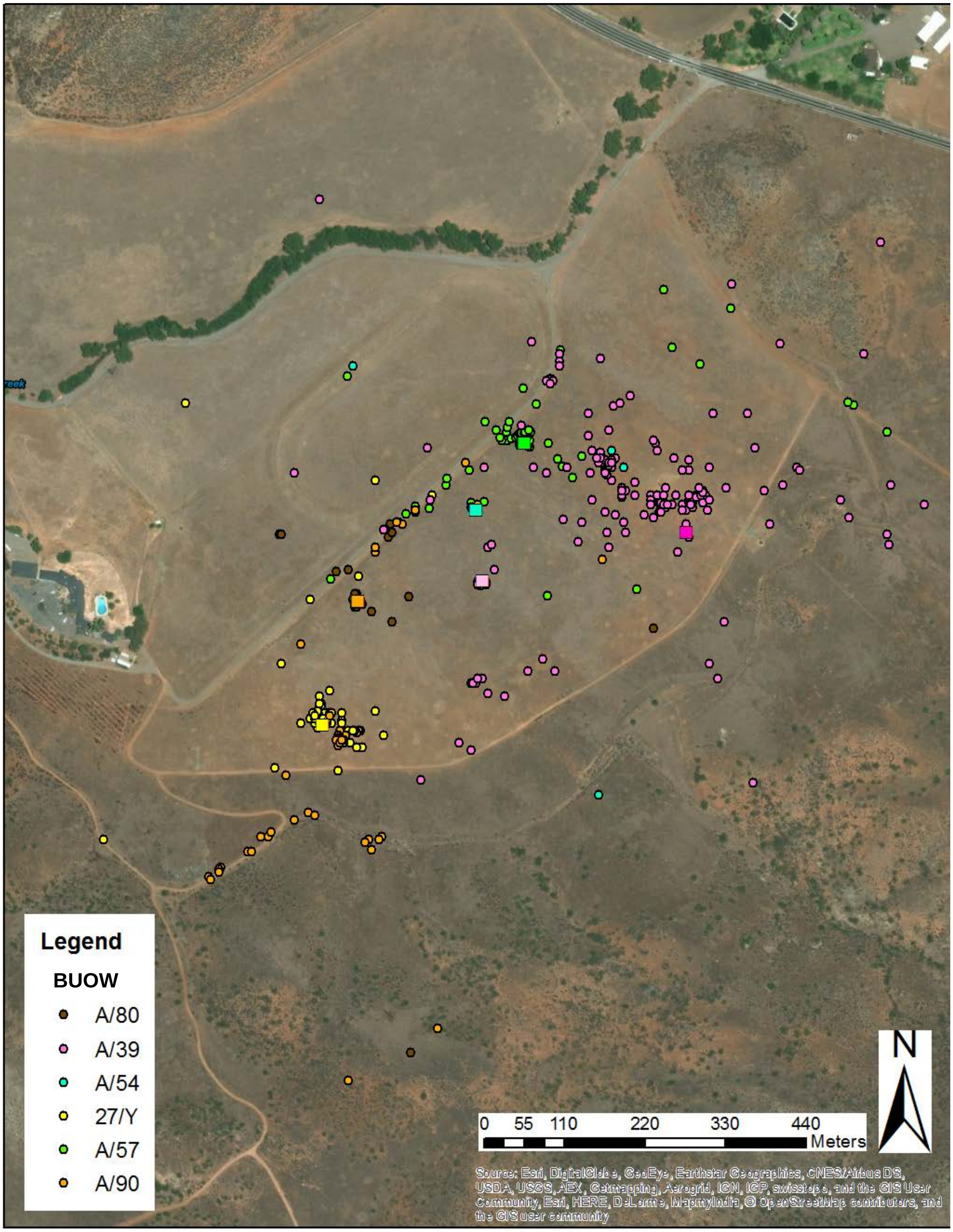

Figure 5. Satellite telemetry points for BUOW actively-translocated to Rancho Jamul Ecological Reserve during April-October 2018.

Task C. BUOW Survey

Standardized population surveys are useful to detect changes in population size over time. To establish a baseline of the resident population, we conducted a pre-construction population survey during the breeding season using standardized methods. The timing of the survey during the breeding season is critical since the population is partially migratory in this region. Survey areas included Brown Field Municipal Airport, MAP on-site mitigation areas, MAP off-site mitigation areas (Miller, Dart, and Corn parcels), and surrounding areas conserved and/or restored specifically for BUOW (Johnson Canyon, Helix Lonestar, and SDHC Lonestar). By including not only the area within the construction footprint, but also the surrounding area, we will be better able to assess population changes as a result of development and mitigation actions. The survey will be replicated at five-years post-construction activities. Survey timing and protocols have been standardized so that comparisons in population estimates can be made between pre-and post-construction (i.e., year 1 vs. year 5).

Methods

The population survey for BUOW was conducted during the breeding/nesting season, defined as 1 February through 31 August (Thomsen 1971, Zarn 1974) at Brown Field, all mitigations sites, as well as conserved areas in the Otay Mesa region (Johnson Canyon, Helix Lonestar, SDHC Lonestar).

Three survey visits, at least three weeks apart, were conducted between 15 April and 15 July, with at least one visit after 15 June. Surveys were conducted 12 - 18 April, 25 - 31 May, and 9 - 12 July. Surveys were conducted between morning civil twilight and 10:00 AM and two hours before sunset until evening civil twilight (CDFG 2012). Surveys were conducted by ICR staff and volunteers that are familiar with BUOW and their ecology. Line transects were walked 7 - 20 m apart, with width adjustments made if vegetation height impeded ground visibility. Transect lines were digitized for use in a tablet and ArcGIS online database collection system so that the exact transects can be repeated in future surveys. At the beginning of each transect, and every 100 m, optical scans using binoculars were made of the entire visible project areas to look for BUOW and potential predators. While walking transects, any BUOW or sign (white wash, cast pellets, molted feathers, burrow decoration material, or prey remains) at burrows, was documented. Predator species observed during transects were also noted. When BUOW were observed, age and sex classifications were recorded if identifiable; care was taken to minimize disturbance near occupied burrows during surveys.

We avoided conducting surveys in poor weather conditions such as fog or precipitation that could negatively affect the ability of surveyors to detect BUOW. In order to have greater detection probability, surveys were conducted when ambient temperatures were >18ºC and winds <12 km/hr. Surveys were conducted during ideal weather and visibility conditions and during times of the day that BUOW are most likely to be seen.

Following a preliminary survey, if an area was determined to not be suitable BUOW habitat, the area was not surveyed again in subsequent surveys. BUOW habitat generally includes, but is not limited to, short or sparse vegetation (during at least at some time of year), and the presence of burrows or burrow surrogates (such as culverts, piles of rubble, pipes or similar structures).

Results and Discussion

The preliminary survey was conducted only on Brown Field Municipal Airport and the on- and off-site mitigation areas (Table 4, Figure 6-10). For subsequent surveys, we incorporated additional sites in the Otay Mesa region that are conserved specifically BUOW habitat (Johnson Canyon, Helix Lonestar, SDHC Lonestar). Due to a lack of suitable habitat for BUOW, surveys were not conducted a second time at the Johnson Canyon site. Surveys were not conducted on the Lonestar Ridge West mitigation site due to the already extensive amount of monitoring conducted by ICR and CalTrans staff through weekly visits, camera trap monitoring, and trapping.

Table 4. Results from 2018 burrowing owl population survey in Otay Mesa, CA.

Survey Date	Brown Field	Area A	Area B	Dart	Miller	Corn	Johnson Canyon	Helix Lonestar	SDHC Lonestar
12-18 April	15 BUOW (10 active burrows)	0	0	0	0	0	Not surveyed	Not surveyed	Not surveyed
25-31 May	26 BUOW (12 active burrows)	0	0	0	0	2 BUOW (1 Burrow)	0	2 BUOW (1 Burrow)	0
9-12 July	41 BUOW (3 active burrows)	0	0	0	0	1 BUOW (1 Burrow)	Not surveyed	2 BUOW (2 Burrows)	0

During the first survey from 12 - 18 April, 15 adult BUOW were documented across 10 different burrows on Brown Field. All active burrows were located on the east side of the airport and were confirmed to be associated with nesting pairs after camera traps were set up for breeding season monitoring. During the second survey from 25 - 31 May, additional adults as well as two juveniles were seen at or near nesting burrows. The additional adults seen were likely to be females of breeding pairs that were beginning to spend more time outside of the nest burrow chamber following the hatching of eggs within the burrow. The final survey on 9 - 12 July documented a mix of adults and juveniles over a larger portion of the airport. This is consistent with the dispersal behavior of both age groups. An adult owl seen at a burrow at the Tripads was confirmed to be a dispersing adult male from a breeding burrow at the Helix Lonestar site (A/42, Helix 2 Family). Additionally, the surveys led to the discovery that the adult female who was translocated from the Gravel Lot burrow to the Rancho Jamul Ecological Reserve in February 2018 had returned to her burrow of origin (See Task B and D for more detailed descriptions of these individual owls).

Figure 6. 2018 BUOW survey results for Brown Field (west).

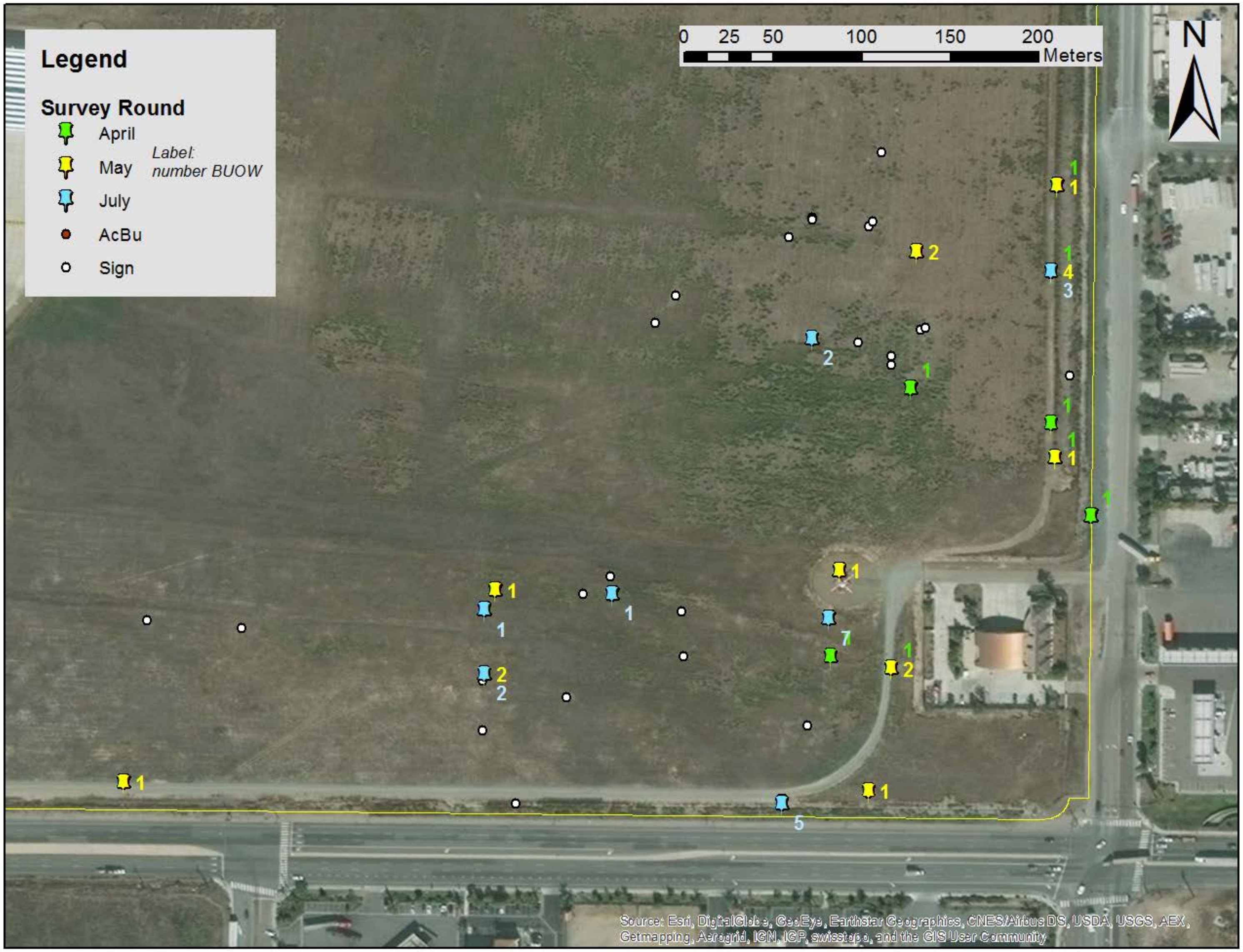

Figure 7. 2018 BUOW survey results for Brown Field (southeast).

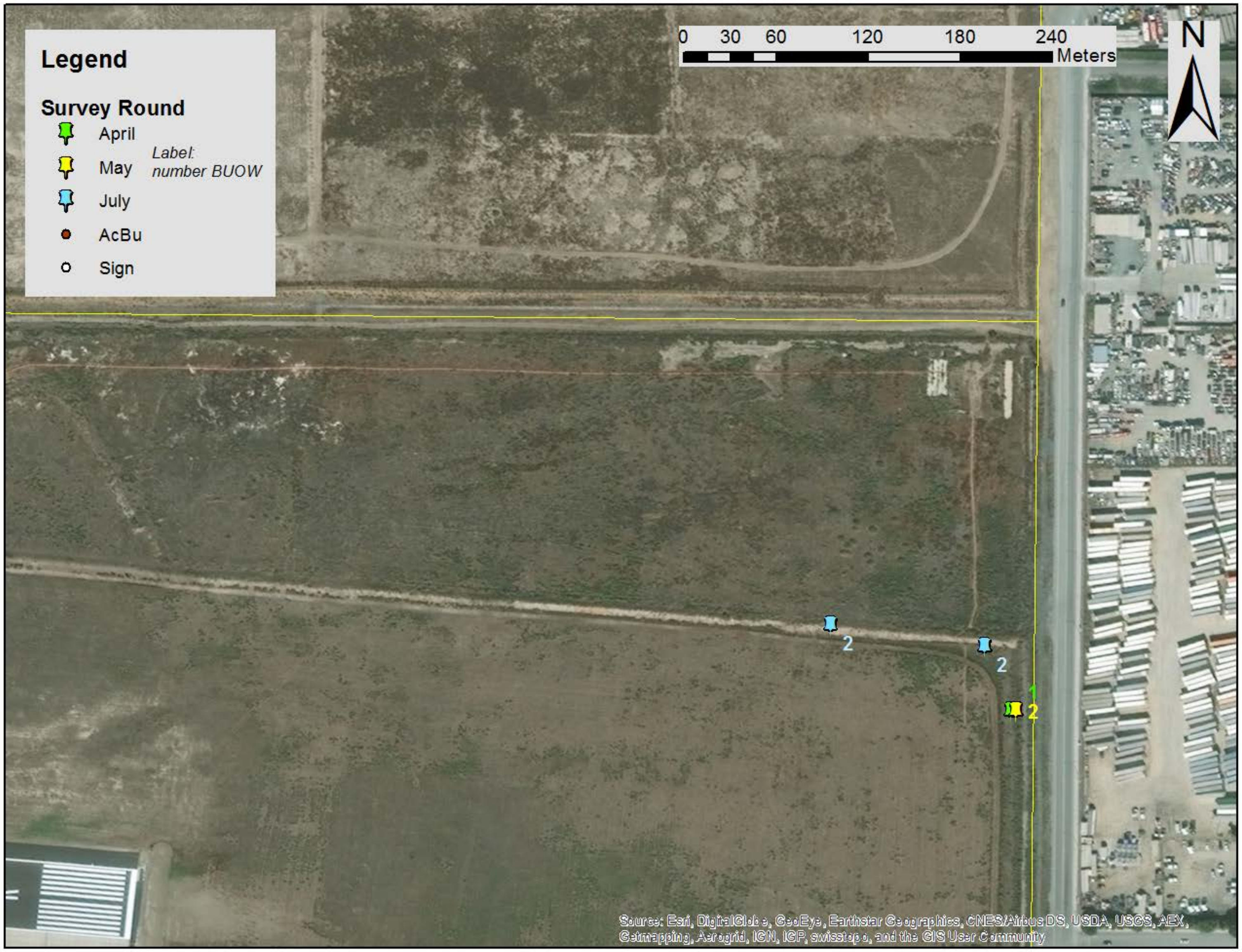

Figure 8. 2018 BUOW survey results for Brown Field (northeast).

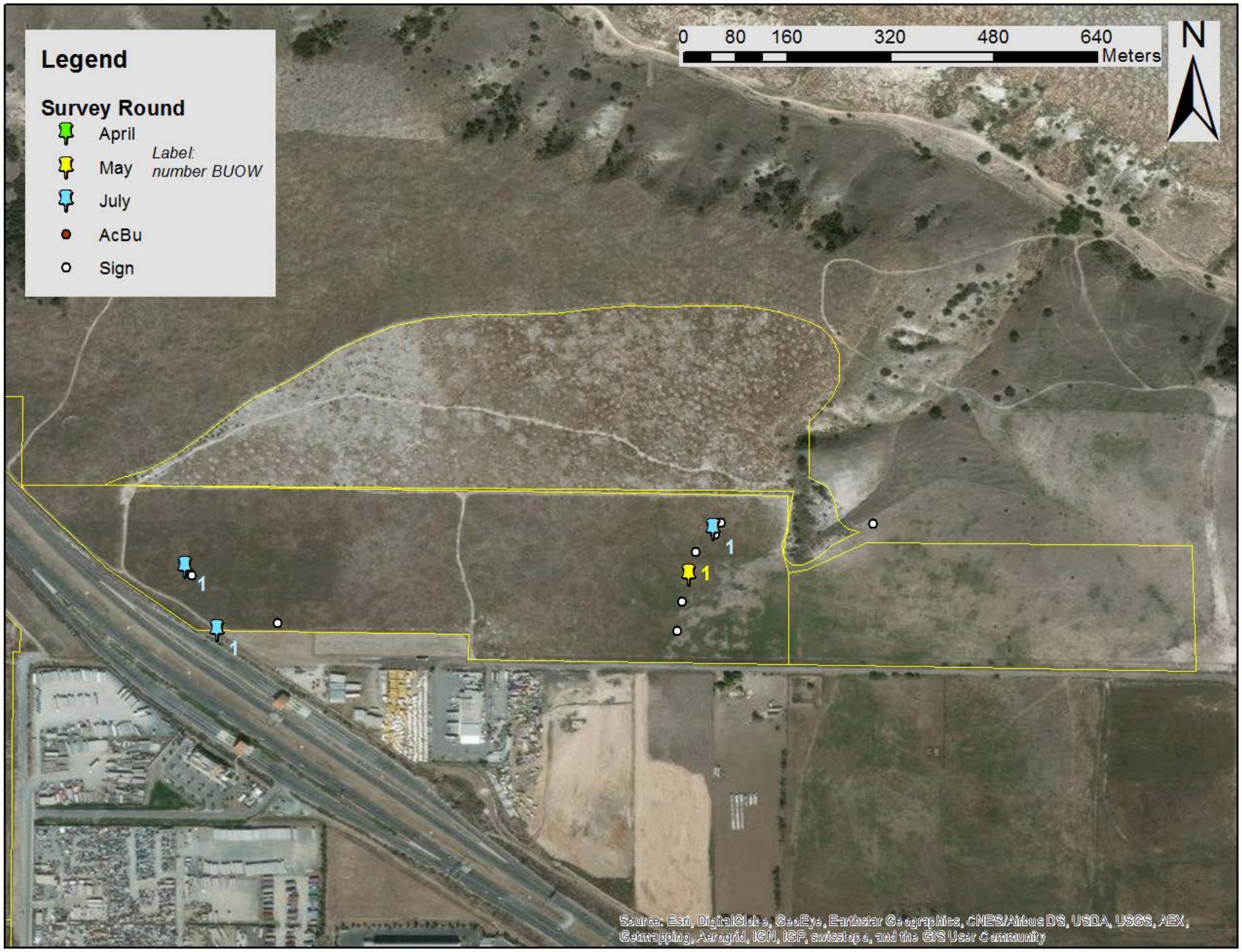

Figure 9. 2018 BUOW survey results for Helix Lonestar, Johnson Canyon, and SDHC Lonestar.

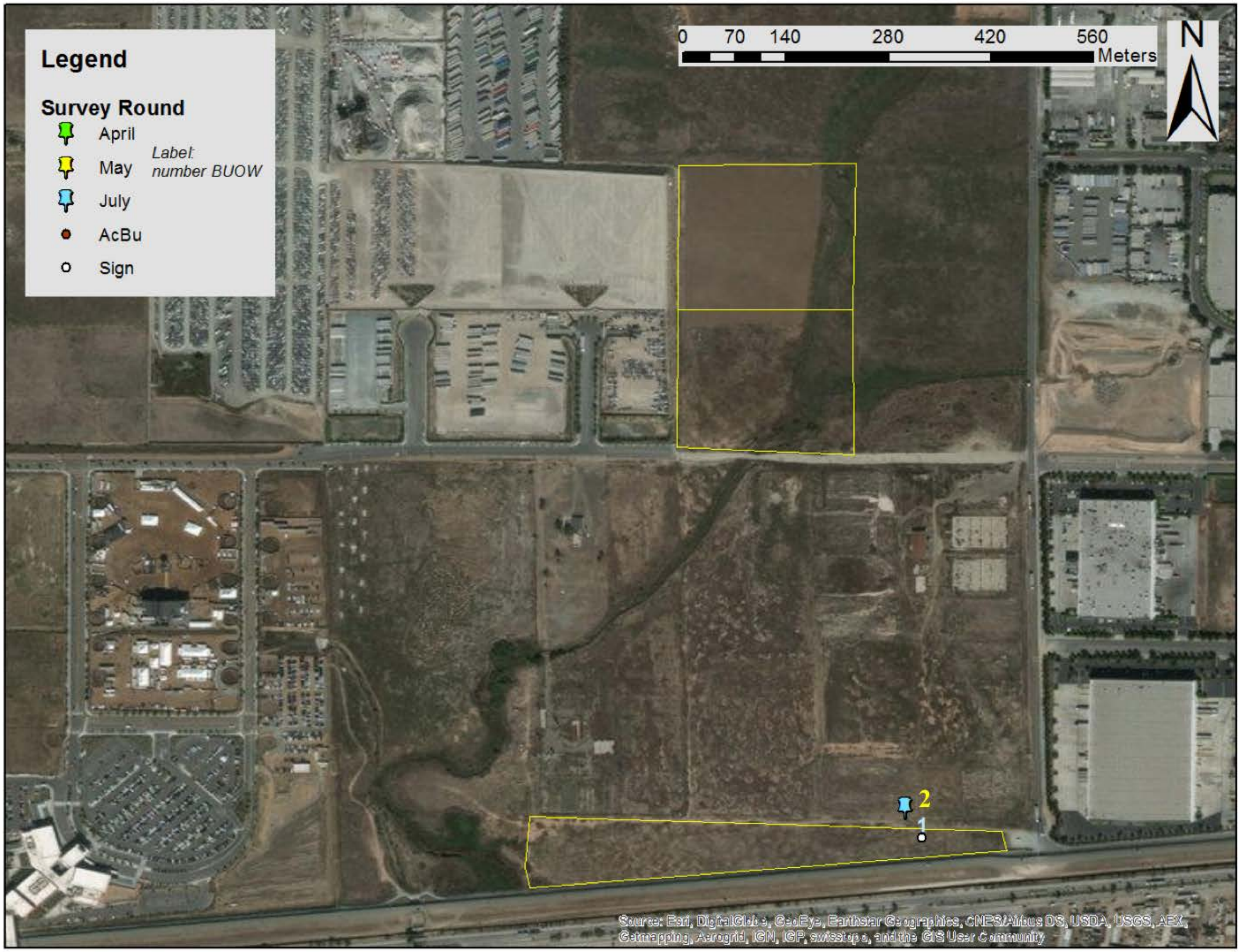

Figure 10. 2018 BUOW survey results for off-site mitigation areas Dart, Miller, and Corn.

A variety of potential predator species were documented during surveys:

American crow
American kestrel
Common raven
Coyote
Feral dog
Great blue heron
Merlin
Northern harrier
Peregrine falcon
Red-tailed hawk
Loggerhead shrike
Turkey vulture
White-tailed kite

Common ravens and coyotes are likely to pose the largest predation pressure on juvenile BUOW given their increased prevalence in urban landscapes. Adult BUOW are most likely to be depredated by other raptor species, especially at night when hunting away from the safety of a burrow. It should be noted that because surveys were conducted during the day in order to increase probability of BUOW detections, there is a bias towards detecting diurnal predator species. Nocturnal species such as barn owls, great horned owls, racoons, and skunks are known predators of BUOW, and would not have not been detected given the survey method.

Task D. BUOW Monitoring

Funded by the San Diego Foundation Otay Mesa Grassland Mitigation Fund, ICR initiated BUOW nest monitoring and banding in the Otay Mesa region in 2011. This program was expanded in 2013-2017 with comprehensive annual nest surveys and a focused banding effort to increase our knowledge of survival, recruitment, and movement of BUOW in southern San Diego County (Wisinski et al. 2014, Swaisgood et al. 2015, Hennessy et al. 2016, Wisinski et al. 2016, Marczak et al. 2017). Color-banding BUOW allows us to individually recognize birds from known nest sites. Without known individuals, we would not be able to obtain data on demographics, particularly survivorship and number of fledglings. This information provides the critical components for population models and data for population viability analysis to help identify the factors that most strongly influence population growth. Return of previously banded young also provides insights into recruitment, dispersal, and settlement patterns. This existing dataset both contains the most complete information available on preconstruction population levels, and captures ongoing trends in the overall Otay population. This dataset will be critical in achieving the project objectives and overall goals listed in the Mitigation Plan, and will be leveraged to provide evidence-based answers to questions about project impacts (or absence thereof) on the Otay Mesa BUOW population.

In 2018, we continued our efforts to capture, measure, and band adult and juvenile BUOW with the goal of re-sighting banded birds during nest monitoring, camera trapping, wider area surveys, and reported sightings from the public. To evaluate the success of future mitigation efforts and monitor BUOW population viability, study sites included all MAP on- and off-site mitigation areas, Brown Field Municipal Airport, Lonestar Ridge West, Johnson Canyon/Lonestar Ridge East, Helix Lonestar, San Diego Habitat Conservancy (SDHC) Lonestar, Poggi VOR, and Lower Otay Reservoir Burrowing Owl Management Area (LORBOMA). Our work to date indicates that owls move among these areas and should be viewed as part of a larger inter-dependent metapopulation. Monitoring across this larger area will allow us to assess the viability of the BUOW population within the Otay Mesa node, to track the fates of individuals that move between sites, and to compare results from the mitigation sites; this will give the results at the mitigation sites better context, as some inter-annual variation in apparent success may be driven by owl movements rather than survival. Genetic samples were also collected during capture and handling, and stored for genetics analyses. Nest success, offspring survival, presence of predators, and predation and infanticide events were monitored using camera traps. Monitoring nesting success yields important insights for BUOW population dynamics and is required for informed guidance on needed management actions for mitigation measures and population recovery in this region. It is particularly important since the BUOW population in the Otay Mesa region represents our only current population node. By tracking BUOW population performance, we will be able to provide information needed to continue to manage this critical population node while we identify and establish other recovery nodes throughout San Diego County. Furthermore, monitoring the status of BUOW will help fulfill the objectives of the BUOW Mitigation Plan to achieve the ultimate goal of long-term sustainability of the species.

Methods

Below are the methods for BUOW nest and population monitoring. Methods and results presented in this section pertain only to the Otay Mesa node and do not include data or analysis from RJER BUOW.

Nest monitoring

In 2018, we focused our nest monitoring at sites in the Otay Mesa region due to a lack of breeding BUOW at Poggi and LORBOMA; however, we continued to monitor Poggi and LORBOMA for BUOW on a monthly basis throughout the breeding season. Additionally, many artificial burrows at Johnson Canyon were deemed unusable by BUOW due to having chambers and tunnels blocked with cholla by woodrats.

All known nest burrows at the study sites (Figures 11-13) were checked weekly and were monitored using camera traps. Other known locations of owls on private lands (Figures 14-15) were monitored opportunistically. The number of BUOW seen, sex and age class of the owls, and the presence of ground squirrels or predators were recorded during each site visit. In addition, incidental BUOW sightings and sign at private lands in Otay Mesa were recorded throughout the study period.

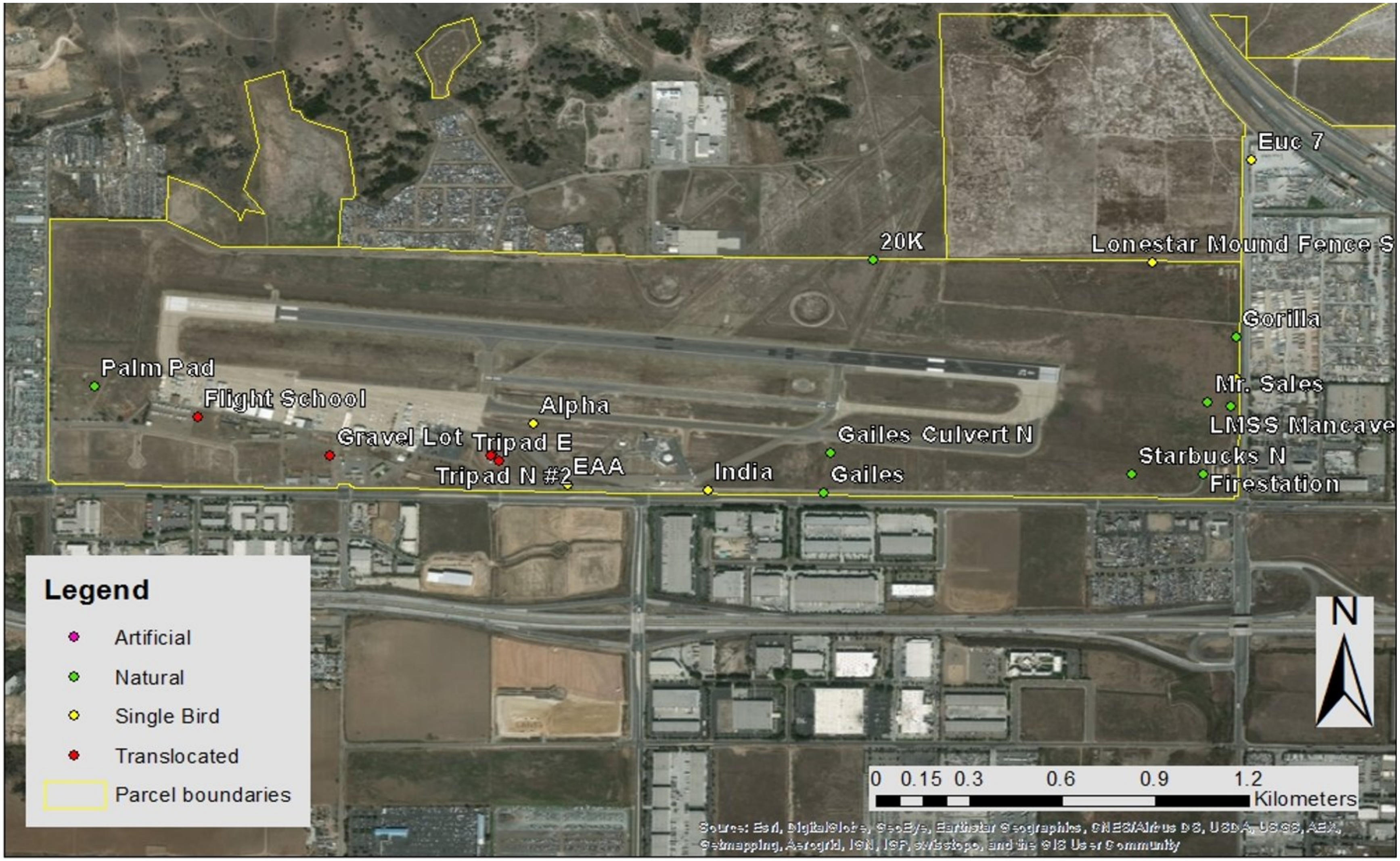

Figure 11. Monitored nest locations in 2018 at Brown Field Municipal Airport.

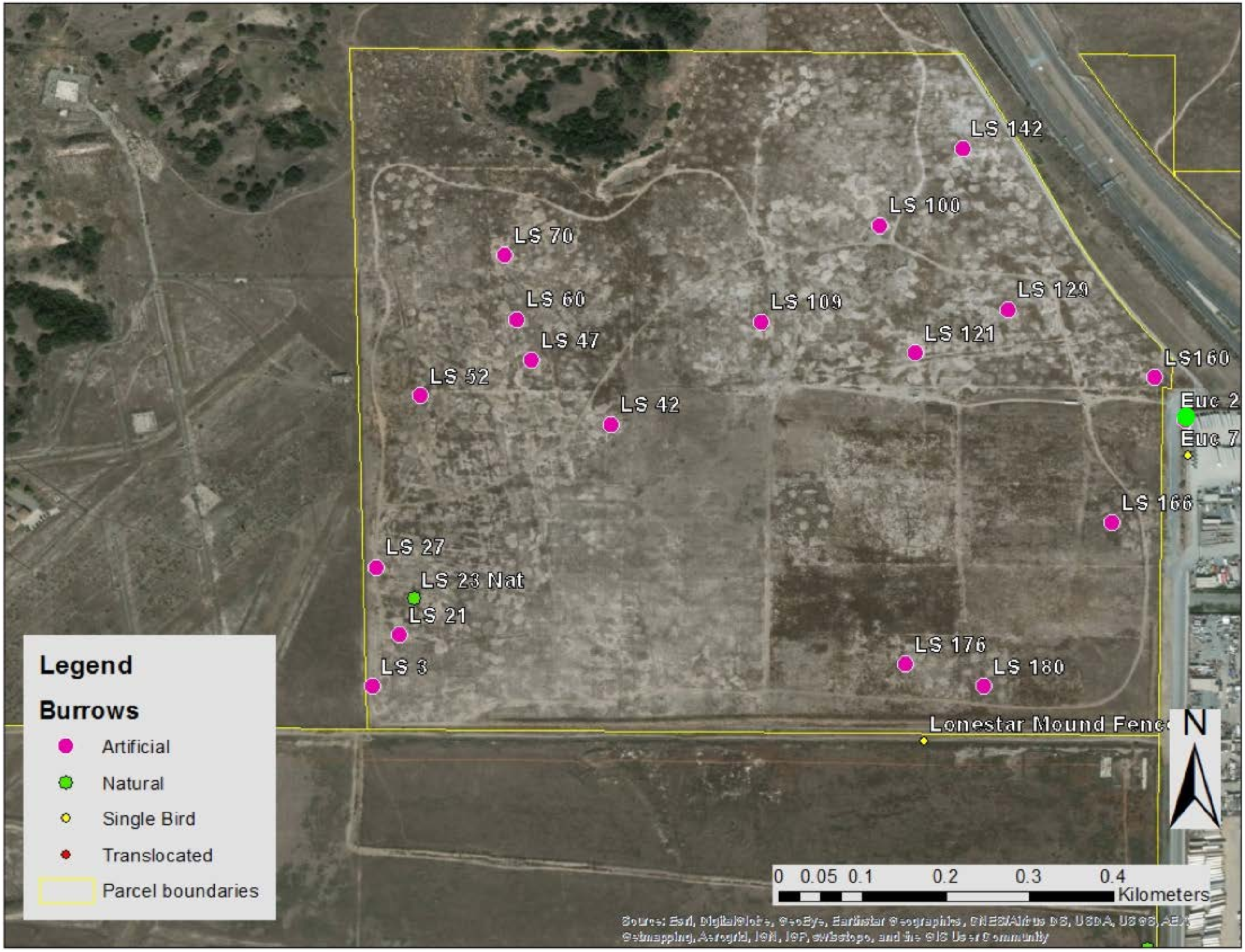

Figure 12. Monitored nest locations in 2018 at Lonestar Ridge West.

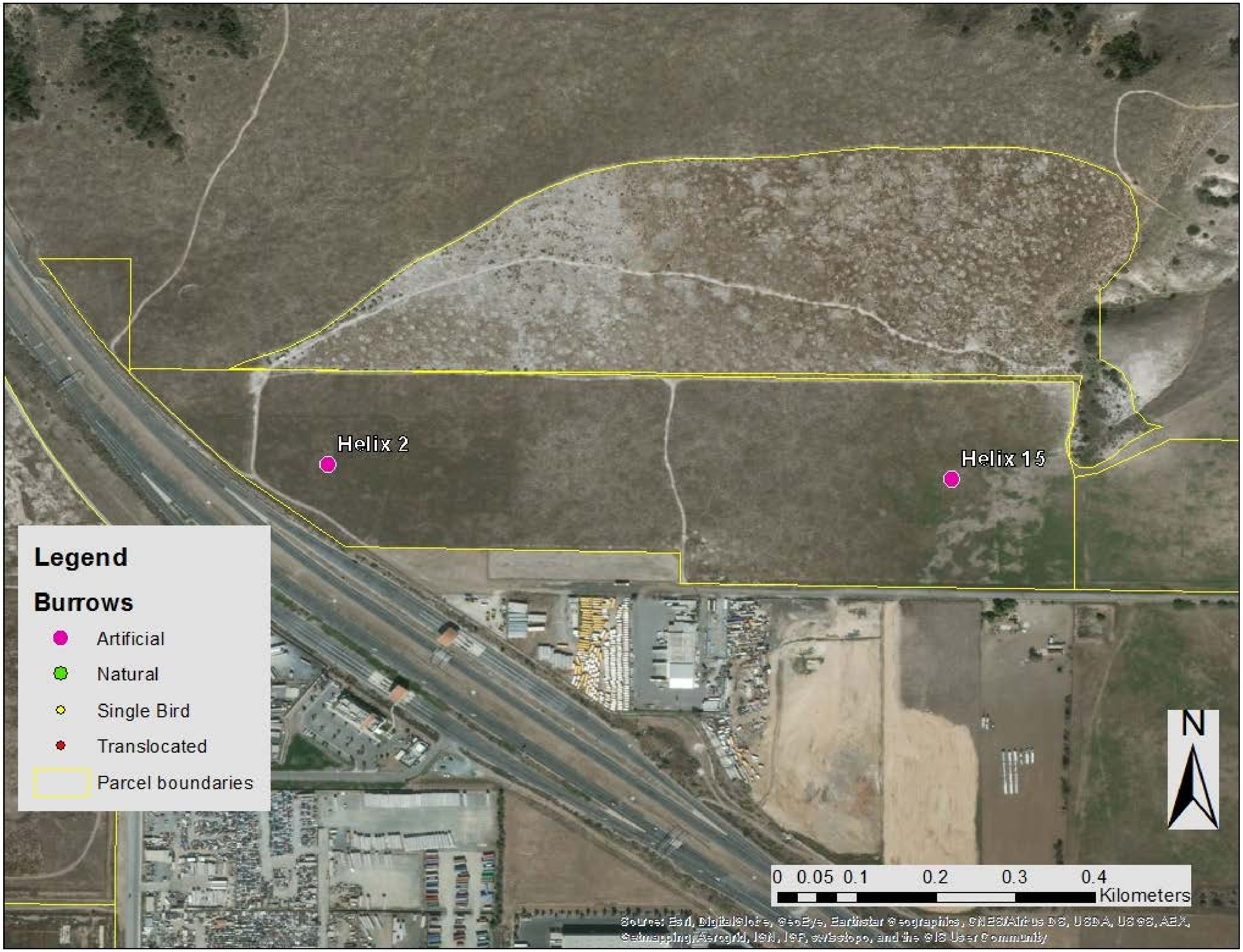

Figure 13. Monitored nest locations in 2018 at Helix Lonestar.

Figure 14. Monitored nest locations in 2018 on private lands in Otay Mesa (west).

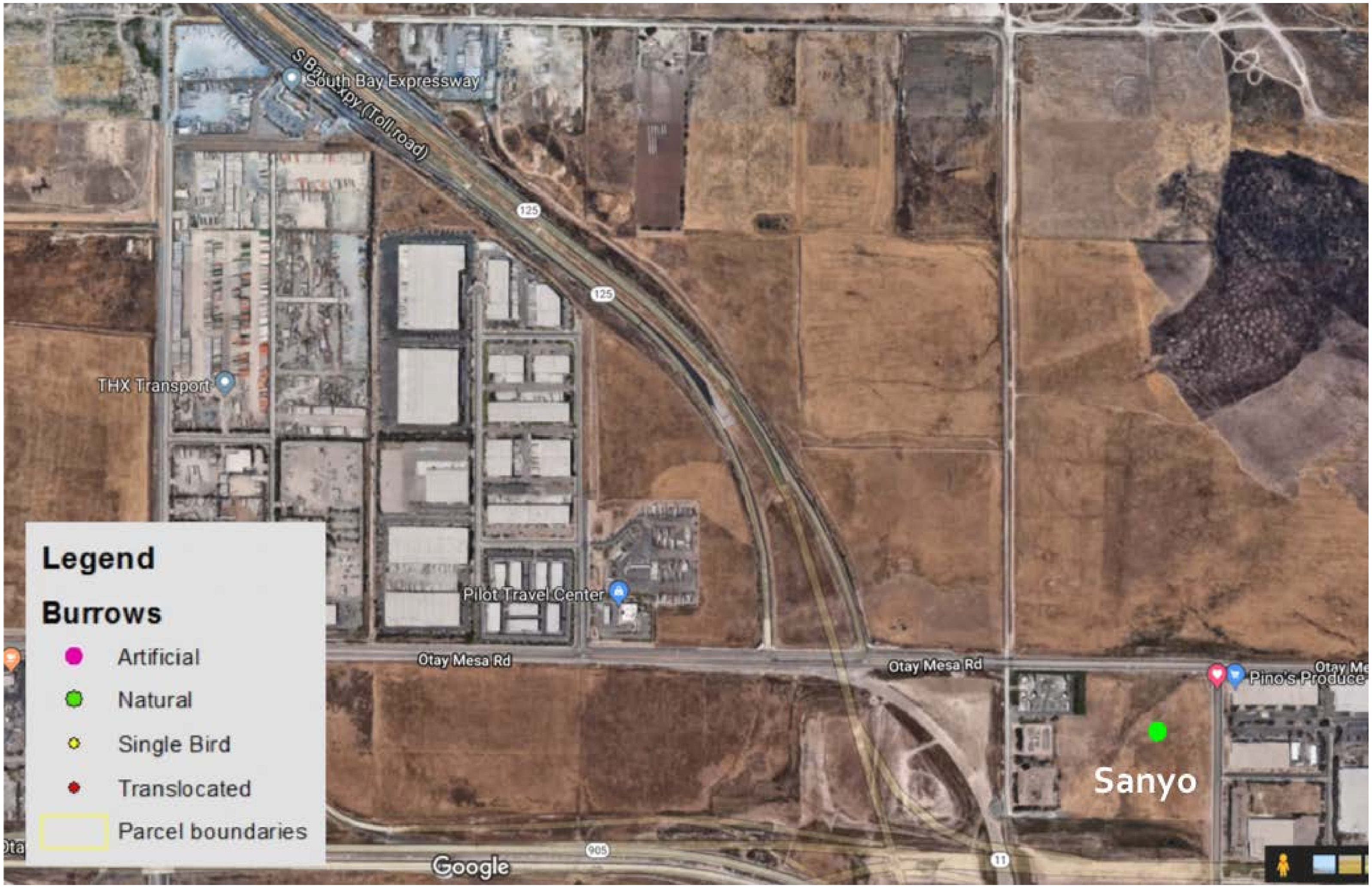

Figure 15. Monitored nest locations in 2018 on private lands in Otay Mesa (east)

Camera trapping

We set cameras at burrow entrances (typically one for natural burrows and two for artificial burrows due to the number of entrances) when we suspected the presence of eggs or chicks (through direct observation of the nest chamber or behavior of the female). In 2018, camera traps were established at all nest burrows at the study sites. We used Reconyx® PC900 remote camera systems to monitor the entrances of occupied nest burrows. We also used Bushnell® NatureView cameras with an adjustable focal length lens at a small number of the burrows. Each camera was placed 1-3 m from the burrow entrance 0.5-0.75 m above the ground and focused on the entrance and apron area of the burrow. Cameras were programmed to take 3 pictures per motion-triggered event with a 30-second rest period in between trigger events. We changed camera batteries and retrieved SD data cards once per week to coincide with the weekly nest visit. We moved or placed additional cameras if the juveniles moved to a satellite burrow.

Camera trap data processing and analysis

All camera trap photos were organized by burrow and date. We used Adobe® Bridge to examine all of the photos and tag each photo with pertinent information such as the presence of non-BUOW visitors (including predation events and humans). We recorded the maximum numbers of adults and juveniles, respectively, along with the identities of any banded owls. We re-examined all tagged photos a second time for quality control. Volunteers were recruited and trained, and completed the first tier of photo processing; quality control was completed by experienced staff. We recorded each independent predation or burrow visit event. Events were considered independent if more than an hour elapsed between visits by other species (e.g. rabbits). Predation events were much more discrete and easier to identify as independent. Using the daily maximum juvenile counts, we determined the maximum numbers of chicks (post-emergence to fledging, defined as survival to 30 days post-emergence from burrows) and the maximum numbers of fledglings at each burrow. We used 2-sample t-tests to test for differences in productivity by burrow type. We excluded the data from any burrows where we were not able to confirm that eggs had been laid.

Banding

During the nestling and fledgling stages of the breeding season, we captured, banded, and took genetic samples (blood and/or feathers) from BUOW at or near their nest burrows. We used one-way door traps at the burrow entrances as our primary capture technique for juveniles and adult females at natural burrows. Because of the modified design (access chimney) implemented on artificial burrows at Lonestar and Helix, we were able to capture the majority of juveniles and adult females by hand directly from the nesting chamber. If individuals were in a tunnel of an artificial burrow, we utilized a burrow scope to examine the tunnels and coax birds into the nesting chamber where they could be retrieved. We included the use of call playback to more efficiently capture adult males. Bow nets were used to capture fledglings and adults late in the breeding season. Standard morphometric measurements were taken for each bird. Blood samples were taken from the brachial vein; in the case of very small nestlings, body feathers were taken. All blood, feather, and tissue samples are being stored in the Frozen Zoo® at the Beckman Center, San Diego Zoo Institute for Conservation Research. Unbanded owls received two aluminum bands: a USGS band and a green alphanumeric Acraft band.

We used mark-resight data from 2011-2018 to model and estimate apparent annual survival using a Cormack-Jolly-Seber model in Program MARK (White and Burnham 1999). Due to small sample sizes in some groups, we used a relatively simple model to allow us to estimate confidence intervals. The underlying model allowed survival (ϕ) to vary by age (adult vs. juvenile) and year, but held the recapture probability (p) constant throughout the study period {ϕ(a2−t/t)p.}. We structured the model in this way because there were not enough data to estimate the recapture and survival probabilities for each capture occasion, and the parameters of interest were age- and year-specific survival rates.

Results and Discussion

Nest monitoring & camera trapping

During the 2018 breeding season, we monitored 30 breeding burrows with camera traps at Brown Field, Lonestar and Helix Lonestar weekly from late-March through early September. We confirmed breeding (by presence of eggs or chicks) at 29 of the 30 burrows. We opportunistically checked burrows located on private land that were visible from public rights of way. An additional three burrows where breeding was confirmed were monitored on private lands, with observations occurring from the nearest road. We were not able to confirm breeding at the other burrows for two main reasons: (1) we were not able to confirm the presence of eggs in natural burrows, so if a failure occurred before chick emergence, we could not confirm whether breeding had taken place; or (2) if a burrow occurred on private land, we observed it from the nearest road and only revisited it as time allowed during the rest of the season and could only confirm breeding through direct observations of chicks at or around the breeding burrow entrance.

We observed 32 nesting attempts at Brown Field, Lonestar and Helix Lonestar, including renests (11 at natural burrows and 21 at artificial burrows) using camera traps, but some had limited data due to nest failures or finding the nesting attempt late in the cycle. In one case, nesting attempts were made at the same burrow (LS 42) by two different breeding pairs over the course of the breeding season. Camera traps ran from 27 March to 6 September for a total of over 3300 camera days (including secondary cameras at satellite burrows) and collected approximately 2.6 million photos.

Banding

We banded BUOW at Brown Field Municipal Airport, Lonestar, Helix Lonestar, and MAP mitigation areas as part of our monitoring efforts during the period of 10 May to 8 August. We captured a total of 102 BUOW throughout our Otay Messa study sites (Table 5, Appendix 1). We took blood and/or feather samples from every bird that was captured. The owls that were captured represented 36 families, with 43 of them caught at natural burrows, and 59 of them caught at artificial burrows.

Table 5. BUOW Banded in Otay Mesa, CA in 2018. Asterisk indicates a bird banded in a previous year that was recaptured in 2018. Parentheses indicate a bird banded in a previous year that was resighted but not recaptured in 2018

	Adults			Family Total		Genetic Samples	Previously Banded (Year)	
Burrow[1]	**Female**	**Male**	**Juvs**	**New**	**All**	**2018**	**Female**	**Male**
Initial Nesting Attempts								
Palm Pad	1*	A/23	6	7	8	8	02/Z (2016)	
Gailes Culvert North	(1)	(1)	0	0	2	0	A/52 (2017)	01/Z (2016)
Fire Station	(1)	(1)	5	5	7	5	A/91 (2017)	44/Z (2016)
Starbucks North[2]	(1)	(1)	2	2	4	2	A/97 (2017)	A/75 (2017)
LMSS Man Cave	1*	A/45	4	5	6	6	B/E (2011)	
Mr. Sales	(1)	A/48	3	4	5	4	A/15 (2017)	
Gorilla	(1)	(1)	6	6	8	6	A/02 (2017)	A/13 (2016)
20K	1*	1*	3	3	5	5	A/33 (2017)	A/89 (2017)
LS 3 (A)[2]	1*	(1)	2	2	4	3	A/85 (2017)	A/96 (2017)
LS 21 (A)	1*	(1)	1	1	3	2	A/27 (2017)	A/26 (2017)
LS 23 Natural	(1)	(1)	3	3	5	3	A/81 (2017)	USGS only (2017)
LS 27 (A)[3]	1*	1*	2	2	4	4	56/Z (2016)	A/92 (2017)
LS 42 (A)[3]	1*	1*	3	3	5	5	73/Y (2015)	59/X (2016)
LS 47 (A)	1*	(1)	0	0	2	0	A/28 (2017)	A/74 (2017)
LS 52 (A)	(1)	(1)	0	0	2	0	70/Z (2017)	05/Z (2016)
LS 60 (A)	(1)	(1)	4	4	6	4	87/X (2014)	30/Z (2016)
LS 70 (A)	(1)	(1)	0	0	2	0	A/16 (2017)	60/Z (2017)
LS 100 (A)	(1)	(1)	0	0	2	0	82/Y (2016)	49/Y (2016)
LS 109 (A)	A/88	A/99	3	5	5	5		
LS 121 (A)	1*	(1)	1	1	3	2	66/Z (2017)	A/07 (2017)
LS 129 (A)	(1)	1*	1	1	3	2	38/Z (2016)	06/Z (2016)
LS 142 (A)	(1)	(1)	0	0	0	0	50/Z (2016)	32/Z (2016)
LS 160 (A)	1*	(1)	0	0	2	0	86/Y (2016)	29/Y (2015)
LS 166 (A)	(1)	(1)	6	6	8	6	76/Y (2016)	14/Z (2016)
LS 176 (A)	(1)	(1)	4	4	6	4	03/Y (2014)	94/Y (2015)
LS 180 (A)	(1)	(1)	5	5	7	5	A/69 (2017)	A/17 (2017)
Helix Lonestar 15 (A)	(1)	1*	4	4	6	5	A/70 (2017)	A/49 (2017)
Helix Lonestar 2 (A)	1*	A/43	6	7	8	8	A/08 (2017)	
Big Toy Depot	DC[4]	(1)	0	0	1	0	Unbanded	A/61 (2017)
Ice Field Northwest	(1)	DC	0	0	1	0	A/00 (2017)	Unbanded
Sanyo	DC	(1)[5]	0	0	1	0	Unbanded	4-/Z (2016)
Renests (RN)								
Gailes -- Gailes Culvert North RN	(1)	(1)	0	0	2	0	A/52 (2017)	01/Z (2016)
Euc 2 -- LS 160 RN	1*	(1)	2	2	5	3	86/Y (2016)	29/Y (2015)
LS 42 (A) -- LS 47 N	1*	(1)	2	2	4	3	A/28 (2017)	A/74 (2017)
LS 70 (A) -- RN	(1)	(1)	0	0	2	0	A/16 (2017)	60/Z (2017)
Non-breeding/Unknown								
Alpha1	DC[6]		0	0	0	0	Unbanded	
India	DC[6,7]		0	0	0	0		Unbanded
Euc 7	n/a	(1)	0	0	1	0		72/X (2014)
Ice Field East[8]	DC	DC	0	0	0	0	Unbanded	Unbanded
Corn	A/77	DC	0	1	1	1		Unbanded
East Berm	(1)[6]		0	0	1	0		A/86 (2017)

[1]Artificial burrows indicated with (A).
[2]Sibling pair. Both adults were juveniles from 2017 LS Mound nest.
[3]Family brought to Safari Park veterinary hospital for treatment of sticktight fleas.
[4]DC = Did not capture.
[5]Partial band resight only. Could be 41/Z, 43/Z, 45/Z, 47/Z, 48/Z (All banded in 2016).
[6]Sex Unknown.
[7]Likely a wintering bird
[8]Breeding status unknown. Likely to have been displaced by primary border fence construction activities.

Population dynamics

Using banding return rates, we can estimate juvenile recruitment rate and site fidelity for adults. We adjusted previously reported return rates to account for adjustments in the data. The 2018 return rate for adults banded in the previous year was approximately 50% (Table 6A), which is lower than recent years. The return rate for juveniles banded in the previous year (recruitment) was approximately 42%, the highest we have measured since our banding effort began. This rate measures the percentage of juveniles banded in 2017 that survived to be part of the adult population in 2018. This may be due to the above average rainfall we experienced in 2017 which likely resulted in a higher prey base that helped fledglings survive dispersal and their first winter (a time of high mortality for first year birds).

We used the banding and resighting data from 2011-2018 to model apparent annual survival for adults and juveniles (Table 6B). It should be noted that estimates for 2011 and 2012 are not true representations of survival due to different levels of survey effort for those two years compared with later years. We found adult survival was similar across years with a dip in the 2016/17 survival rate (64% vs. 50%) and a slight rebound in 2017/18 (57%). Juvenile survival rates have been more variable between years; the 2017/18 rate was higher than any other period of our study (45%). Like the observed recruitment rate, this is likely due to the favorable weather pattern experienced in 2017. There are a number of potential explanations for the lower observed adult survival rates in 2017 and 2018, including displacement because of high productivity in 2016 and 2017, a natural cycle in the population due to “aging-out” of a cohort, dispersal to other areas with suitable habitat, an artifact of our sampling, or a combination of these or other factors. At this time, we do not know what caused this dip in survival, but will explore it further with additional data.

We were able to band a high proportion of the population within our study sites in 2018. No known breeding adults or juveniles at our Otay Mesa study sites remained unbanded. Out of the 4 pairs of BUOW we were able to periodically monitor on private lands, 1 adult female (Ice Field NW) was banded in 2017 as a juvenile from Brown Field, and two adult males (Big Toy Deport, Sanyo) were banded from Lonestar in 2017, and from Lonestar/Brown Field in 2016, respectively. This demonstrates dispersal distances when suitable habitat is available.

Table 6. (A) Percentage of birds seen 1, 2, 3, 4, 5, 6, and 7 years, respectively, after banding. (B) Estimates of apparent annual survival and 95% confidence intervals using a Cormack-Jolly-Seber model with constant recapture probability (p=0.94, 95% CI=0.88—0.97). For both analyses, birds identified through genetic analyses were also included.

A

	% resighted after:						
	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	6 yrs	7 yrs
Adults (n)							
2011 (8)	0.38	0.50	0.13	0.13	0.13	0	0
2012 (0)	--	--	--	--	--	--	--
2013 (20)	0.35	0.15	0.05	0.05	0.05	--	--
2014 (22)	0.95	0.50	0.27	0.09	--	--	--
2015 (16)	0.81	0.44	0.19	--	--	--	--
2016 (10)	0.60	0.70	--	--	--	--	--
2017 (10)	0.50	--	--	--	--	--	--
Juveniles (n)							
2011 (14)	0.21	0.29	0.14	0.07	0.07	0.07	0.07
2012 (0)	--	--	--	--	--	--	--
2013 (56)	0.14	0.07	0.04	0.04	0	--	--
2014 (38)	0.21	0.11	0.05	0.03	--	--	--
2015 (43)	0.37	0.09	0.05	--	--	--	--
2016 (81)	0.27	0.15	--	--	--	--	--
2017 (71)	0.42		--	--	--	--	--

B

	S	95% CI
Adults		
2011/12	0.63	0.29—0.88
2012/13	0.90	0.43—0.99
2013/14	0.64	0.44—0.80
2014/15	0.64	0.49—0.77
2015/16	0.64	0.50—0.76
2016/17	0.50	0.37—0.63
2017/18	0.57	0.43—0.69
Juveniles		
2011/12	0.29	0.11—0.56
2012/13	0.45	n/a (n=1)
2013/14	0.15	0.08—0.28
2014/15	0.22	0.11—0.38
2015/16	0.38	0.25—0.54
2016/17	0.28	0.19—0.39
2017/18	0.45	0.33—0.57

Mortality & Morbidity

We documented 28 confirmed BUOW mortality events across Brown Field, Lonestar, Johnson Canyon, and Helix Lonestar (Table 7). Of those, two were adults (88/Y and 98/Y) that had died within artificial burrow chambers, likely during the non-breeding season prior to the start of our breeding season monitoring efforts. While the mortalities and disappearances of adults were presumed to be likely due to predation, only a single adult predation was confirmed through observation; two ravens were seen killing and eating an adult BUOW at the Lonestar site on 1 June. Although neither bands nor remains were recovered, we suspect this to have been the LS 21 adult male (A/26) because he was last seen on camera 31 May.

The large overall number of mortalities, especially of juveniles, is most likely explained by the decreased availability of sufficient prey items in the habitat. In cases of low prey availability, it is not unusual for adult BUOW to kill their own chicks. Fourteen of the 23 confirmed juvenile mortalities at monitored sites were due to either inter- or intra-nest infanticide by adult BUOW. This is in stark contrast to our 2017 nest monitoring efforts, when we documented no cases of infanticide, siblicide, or inter-nest predation of juvenile BUOW. In two instances, common ravens were documented on camera traps depredating juveniles. No other predation events on juveniles by non-BUOW species was documented.

As in previous years, at the artificial burrows where we could check the nest chambers, there continued to be a discrepancy between the number of eggs laid and the number of chicks that emerged (Table 8) suggesting that we are still missing a significant cause of juvenile mortality before emergence. Additionally, there are juvenile mortalities that are not documented on camera, especially when chicks are very young. Causes of such mortalities cannot be confirmed but are most likely due to starvation from being out-competed by older siblings.

Table 7. All mortality events recorded in 2018.

Site	Location Seen/Found	Age	Mortality Date	Mortality Cause/ Info.	Notes
Brown Field	20K	Juvenile	31-May	Infanticide	Infanticide of unbanded juvenile by adult female A/33 (mother)
		Juvenile	4-Jun	Infanticide	Adult BUOW attacking unbanded juvenile on camera
	Mr. Sales	Juvenile	23-May	Raven	Unbanded juvenile
	Gailes	Juvenile	1-Jul	Infanticide	Infanticide of unbanded juvenile by adult female A/52 (mother)
	SE Corner	Unknown	29-Jun	Likely predation	Feather pile found ~150 m west of Starbucks North
	SE Corner	Juvenile	10-Jul	Likely predation	Feather pile found ~150 m west of Starbucks North; Starbucks North juvenile B/18
Helix Lonestar	Helix 1 (A)	Unknown	17-Oct	Likely predation	Feather pile; unknown BUOW
	Helix 2 (A)	Juvenile	10-May	Unknown - Possible health condition or starvation	Unbanded BUOW juvenile seen dying inside chamber
Lonestar	LS 3 (A)	Juvenile	3-Jun	Raven	Unbanded juvenile
	LS 21 (A)	Juvenile	3-Jun	Infanticide	Adult female A/27 (mother) feeding dead unbanded chick to other chick
		Juvenile	3-Jun	Infanticide	Adult female A/27 (mother) feeding on unbanded dead chick
		Juvenile	22-Jun	Infanticide	Adult female A/27 (mother) killing USGS-only banded chick
	LS 23 Nat.	Juvenile	24-Jun	Unknown	BUOW chick seen with carcass of other BUOW chick (one leg unbanded); carcass was not fresh
	LS 27 (A)	Juvenile	2-Jun	Inter-nest infanticide	LS 27 adult BUOW brings juvenile chick from another burrow as a prey item
		Juvenile	2-Jun	Inter-nest infanticide	LS 27 adult BUOW brings juvenile chick from another burrow as a prey item
		Juvenile	3-Jun	Inter-nest infanticide	LS 27 adult BUOW brings juvenile chick from another burrow as a prey item
		Juvenile	3-Jun	Inter-nest infanticide	Adult BUOW brings juvenile chick from another burrow as a prey item
	LS 42 (A)	Juvenile	30-May	Inter-nest infanticide	New LS 42 adult (formerly LS 47 BUOW) is seen attacking USGS-only banded chick of original LS 42 pair
		Juvenile	30-May	Raven	USGS-only banded juvenile
	LS 47 (A)	Adult	1-Jun	Predation	Two ravens seen carrying, killing and eating 1 adult; likely LS 21 adult male A/26
	LS 100 (A)	Juvenile	16-May	Likely starvation	Dead hatchling found inside burrow chamber
		Juvenile	16-May	Likely starvation	Dead hatchling found inside burrow chamber
	LS 142 (A)	Adult	13-Apr	Unknown	Bands of 98/Y found at burrow
		Juvenile	15-May	Infanticide	Infanticide of hatchling by adult female 50/Z (mother)
		Juvenile	16-May	Infanticide	Infanticide of hatchling by adult female 50/Z (mother)
		Juvenile	17-May	Infanticide	Infanticide of hatchling by adult BUOW
	LS 166 (A)	Juvenile	16-May	Unknown	Found 2 legs of dead BUOW chick; no bands recovered
	LS 201 (A)	Adult	7-Apr	Unknown	Adult BUOW 88/Y found inside chamber. Possible broken wing.

Table 8. Nesting stage dates and productivity for 2018 at burrows monitored with camera traps or direct observation.

Family[1]	Bred	Successful[2]	Camera Dates	Max Eggs	Estimated 1st Egg Date[3]	Est Hatch Date[4]	1st Emergence Date[5]	Max Chicks Emerged	Fledge Date	Number Fledged[6,7]	Notes
Brown Field - Initial Breeding Attempts											
Palm Pad	Y	Y	18 Apr - 6 Sep	Unk	24-Mar	23-Apr	7-May	6	6-Jun	6	
Gailes Culvert North	Likely	N	18 Apr - 14 May	Unk	N/A	N/A	N/A	N/A	N/A	0	Copulations occurred. Nest may have been abandoned due to increased activity in the area.
Firestation	Y	Y	2 Apr - 29 Jun	Unk	1-Apr	1-May	15-May	5	14-Jun	3	
Starbucks North	Y	Y	25 Apr - 29 Jun	Unk	5-Apr	5-May	19-May	6	18-Jun	3	
LMSS Mancave	Y	Y	14 Apr - 6 Sep	Unk	12-Mar	11-Apr	25-Apr	4	25-May	4	
Mr. Sales	Y	Y	19 Apr - 6 Jun	Unk	3-Apr	3-May	17-May	6	16-Jun	2	
Gorilla	Y	Y	10 May - 6 Sep	Unk	31-Mar	30-Apr	14-May	6	13-Jun	6	
20K	Y	Y	24 Apr - 17 Jul	Unk	9-Apr	9-May	23-May	6	22-Jun	3	
Lonestar - Initial Breeding Attempts											
LS 3 (A)	Y	Y	13 Apr - 6 Sept	7	10-Apr	10-May	28-May	4	27-Jun	2	
LS 21 (A)	Y	N	25 Apr - 6 Sep	7	11-Apr	11-May	19-May	4	18-Jun	1	
LS 23 Natural	Y	Y	7 Apr - 6 Sep	Unk	8-Apr	8-May	22-May	6	21-Jun	5	
LS 27 (A)	Y	Y	7 Apr - 6 Sep	9	4-Apr	4-May	See notes	2*	N/A	2	Family brought to Safari Park for treatment of sticktight fleas.
LS 42 (A)	Y	N	7 Apr - 29 May	7	2-Apr	2-May	17-May	3	16-Jun	0	Family brought to Safari Park for treatment of sticktight fleas.
LS 47 (A)	Y	N	7 Apr - 1 Jun	8	31-Mar	30-Apr	N/A	0	N/A	0	Nest failure likely due to sticktight infestation of female.
LS 52 (A)	Y	N	7 May - 8 Jul	4	5-May	4-Jun	18-Jun	1	N/A	0	
LS 60 (A)	Y	Y	7 Apr - 6 Sep	7	31-Mar	30-Apr	14-May	4	13-Jun	3	
LS 70 (A)	Y	N	27 Mar - 6 Sept	8	N/A	N/A	N/A	N/A	N/A	0	
LS 100 (A)	Y	N	27 Mar - 22 May	6		N/A	N/A	N/A	N/A	0	Nest failed after disappearance of adult female (sticktight fleas).
LS 109 (A)	Y	Y	19 Apr - 3 Aug	Unk	27-Mar	26-Apr	10-May	6	9-Jun	3	Nested in tunnel, could not monitor eggs.
LS 121 (A)	Y	Y	30 May - 6 Sep	Unk	Unk	Unk	Unk	Unk	Unk	1	Nest not discovered until later in season after the chick had emerged.
LS 129 (A)	Y	Y	13 Apr - 8 July	6	6-Apr	6-May	21-May	5	20-Jun	1	
LS 142 (A)	Y	N	24 Apr - 30 May	6	8-Apr	8-May	N/A	N/A	N/A	0	Adult female captured on camera consuming hatchlings.
LS 160 (A)	Y	N	27 Mar - 13 Apr	4	20-Mar	N/A	N/A	N/A	N/A	0	
LS 166 (A)	Y	Y	27 Mar - 6 Sep	9	20-Mar	19-Apr	3-May	7	2-Jun	5	
LS 176 (A)	Y	Y	13 Apr - 6 Sept	7	6-Apr	6-May	19-May	5	18-Jun	3	
LS 180 (A)	Y	Y	27 Mar - 3 Aug	9	22-Mar	21-Apr	4-May	8	3-Jun	5	
Helix Lonestar - Initial Breeding Attempts											
Helix 15 (A)	Y	Y	19 Apr - 21 Sep	9	31-Mar	30-Apr	14-May	4	13-Jun	3	
Helix 2 (A)	Y	Y	19 Apr - 17 Jul	8	21-Mar	20-Apr	4-May	6	3-Jun	6	
Private - Initial Breeding Attempts											
Big Toy Depot	Y	Y	None	Unk	Unk	Unk	18-Apr	3*	Unk	3[8]	3 juveniles seen on 3-May were likely fledges; Emergence date estimated.
Corn	Unk	N	None	Unk	Unk	Unk	Unk	Unk	Unk	0	
Ice Field NW	Y	Y	None	Unk	Unk	Unk	7-May	7*	6/6/18	7[8]	7 juveniles seen on 6-Jun were likely fledges; Emergence date estimated.
Sanyo	Y	Y	None	Unk	Unk	Unk	Unk	4*	Unk	4[8]	4 juveniles seen on 17-July were likely fledges.
Brown Field – Renests (RN)											
Gailes - Gailes Cul N RN	Y	N	14 May - 17 Jul	Unk	16-May	14-Jun	22-Jun	4	22-Jul	0	Nest failed after adults female disappeared for unknown reasons.
Lonestar – Renests (RN)											
LS 42 (A) - LS 47 RN	Y	N	29 May - 21 Sep	6	30-May	29-Jun	13-Jul	3	12-Aug	0	LS 47 pair took over LS 42 pair territory while they were at Safari Park.
Euc 2 – LS 160 RN	Y	Y	7 May - 6 Sep	Unk	22-Apr	22-May	5-Jun	2	5-Jul	1	
LS 70 (A) - RN	Y	N	27 Mar - 6 Sep	5	28-Apr	N/A	N/A	N/A	N/A	0	

[1]Artificial burrows indicated with (A)
[2]Nests were considered successful if 1 or more juveniles fledged (reached 45 days of age).
[3]When we were not able to determine the first egg date by direct observation, it was determined by back-dating 30 days from the estimated hatch date.
[4]When we were not able to determine the hatch date by direct observation, it was determined by back-dating 14 days from first chick emergence date.
[5]First date chicks were seen on camera trap.
[6]Juveniles were considered fledged if they reached 45 days of age.
[7]At burrows without cameras, the # fledged is a minimum based on weekly visit data. For burrows with cameras, the # fledged is the maximum number of juveniles seen on camera after the estimated fledge date (30 days after the first emergence date).
[8]Number fledged used for maximum number of chicks for statistical analysis.

Sticktight Fleas

The sticktight flea (*Echindnophaga gallinacea*) is a common and widespread ectoparasite with a broad host range, including BUOW. Chicks and adult females are particularly susceptible during continued and concentrated exposure to flea eggs laid within their nesting burrows. Typically, the prevalence of fleas on owls decreases over the course of the breeding season as juvenile owls grow larger and spend less time within the burrow. Since we began monitoring breeding BUOW in San Diego County in 2013, we have witnessed varying levels of flea infestations that owls recovered from over time. However, in 2018 we observed an outbreak of sticktight fleas on both juvenile and adult BUOW at our study sites in San Diego County.

We documented declines in body conditions of owls due to atypically high levels of fleas, potentially resulting in decreased survivorship of both adult and juvenile individuals. While no remains were recovered, the disappearance of the LS 100 adult female (82/Y) shortly after eggs had hatched, points to the strong possibility of depredation. This particular individual had been observed on camera trap photos as being highly compromised by sticktight fleas, which likely negatively affected her health and may have made her more susceptible to predation.

Review of camera trap photos documented that the females at LS 47 (A/28), LS 42 (73/Y) and LS 27 (56/Z) were also highly infested with sticktight fleas. Following the nest failure at LS100 due to the disappearance of the adult female, a management decision was made to utilize a variety of methods to treat wild owls and their burrows. Because the LS 47 nest had failed, the female was no longer spending a large amount of time within the nest burrow being re-exposed to the breeding cycle of the fleas. Burrow chambers and tunnels were treated with an insecticide (Delta Dust [deltamethrin]) at LS 47 and LS 40 where the adult female had been observed. Following reduced exposure to the fleas, as well as exposure to the applied insecticide treatment, we saw improvements to her condition.

The conditions of the juveniles and females at LS 27 and LS 42 was deemed to be so severe, that a decision was made to trap the entire families for treatment at the Harter Veterinary Medical Center at the San Diego Zoo Safari Park. Blood samples revealed high levels of anemia in the juveniles and adult females. Individuals were housed and treated at Harter Veterinary Medical Center from 20 May to 29 May. During that time, the entrances to the artificial burrows in the field were blocked to prevent other animals from entering the burrows.

After the release of the LS 42 family back into their burrow following treatment, camera traps revealed that both the adult female and male abandoned the nest within an hour of release. We believe this may have been due in part to increased stress levels of the birds in captivity. Camera trap photos also showed that the LS 47 pair had moved to LS 42. The mortalities of two of the three LS 42 chicks were documented on camera traps: one due to predation by a common raven, and one due to infanticide by the LS 47 female. The third chick was presumed depredated, but the exact cause is unknown.

The release of the LS 27 family proved to be more successful, with both juveniles fledging. However, the adults of the LS 27 family were documented depredating juvenile BUOW from other nests. Both the LS 42 and LS 27 families were provided with food items at release. However, the low availability of natural prey items in the habitat likely resulted in the depredation of the neighboring BUOW chicks.

In the case of infestations at other burrows, owls were directly treated with ophthalmic triple antibiotic ointment on infested areas, and their feathers were treated with Delta Dust. Burrow chambers were also treated with Delta Dust in order to disrupt the life cycle of the fleas within the soil of the chambers. In addition, we applied diatomaceous earth in the tunnels of all nest burrows.

We are unable to ascertain the precise cause of this particular outbreak of sticktight fleas. However, this issue was documented throughout southern California. Differences in weather patterns compared to years past may be a contributing factor; the 2017-2018 winter was particularly warm. Additionally, there might be a higher prevalence of fleas within artificial burrows in comparison to natural burrows. Longer term research will be needed to understand how the life cycle of these particular invertebrates are affected by ecological and climatic factors in order to best make informed management decisions to decrease their detrimental impact on owls.

Reproductive success

There was a wide range of estimated dates of first egg-laying (12 March—16 May, Table 8) and hatching (11 April—14 June); these dates include renesting attempts. There were four confirmed second nesting attempts. For all confirmed nesting attempts combined, the overall average maximum number of chicks per burrow was 3.8 (SE = 0.41, n=34) and the overall average maximum number of fledglings per burrow was 2.4 (SE = 0.37, n=34). The average maximum number of fledglings per burrow was higher in 2017 at 3.1 (SE = 0.40, n =25).

We found that fledging success (percent of burrows where at least one juvenile fledged) for confirmed first nesting attempts was variable across sites. Apparent fledging success was 88% at Brown Field (7/8), 61% at Lonestar (11/18), and 100% at Helix Lonestar (2/2). Johnson Canyon, Poggi, and LORBOMA did not have any nests in 2018. We recorded 4 renesting attempts (1 at Brown Field and 3 at Lonestar), only 1 of which was successful (1 at Lonestar).

Productivity

In 2018, the proportion of emergent chicks that fledged was 64% (Table 9). This metric has varied over the years with the highest in 2017, a year with above average rainfall, and the lowest in 2014, a year of extreme drought (NOAA 2018). The proportion fledged and the annual rainfall totals in 2018 were in the middle of these two values. We suspect the number of chicks that survive to fledging is probably due to synergistic effects of a number of factors such as weather, nest density, habitat quality, and prey. We will further examine covariates that are likely related to productivity with the goal of informing management of the species under different conditions.

Table 9. Proportion of emergent BUOW chicks that fledged per year, excluding RJER.

Year	# Nests	Max # Chicks	# Fledged	Proportion
2013	38	78	49	0.63
2014	36	68	30	0.44
2015	34	70	38	0.54
2016	37	107	83	0.78
2017	39	96	79	0.82
2018	44	127	81	0.64

Artificial vs. Natural Burrows

In past years, we have found that productivity can vary by burrow type, and that was the case again in 2018 (Table 10). When we excluded RJER, due to potential confounding effects from supplemental feeding, we found that both the average maximum number of chicks (t(32)=2.4, p=0.02) and the average number of fledglings (t(32)=2.7, p=0.01) were significantly lower at artificial burrows than at natural burrows.

Table 10. BUOW productivity in 2018 by burrow type, excluding RJER.

		Max Chicks		Fledged	
Burrow Type	n	Mean	SE	Mean	SE
Artificial	21	3.0	0.49	1.7	0.79
Natural	13	4.9	0.63	3.5	0.55

When we examined Lonestar by itself (the only site with all three burrow material types), the average maximum number of chicks was 2.8 (SE=0.68, n=14) at wood burrows, 2.8 (SE=1.4, n=5) at plastic burrows, and 4.0 (SE=2.0, n=2) at natural burrows. The average number of fledglings was 1.3 (SE=0.44, n=14) at wood burrows, 1.6 (SE=0.92, n=5) at plastic burrows, and 3.0 (SE=2.0, n=2) at natural burrows. These differences were not significant for 2018 ($F_{2,18}$=0.78, p=0.47).

All of these results together continue to suggest that when conditions (e.g. habitat quality, prey availability) are better, burrow design and material may be less important to productivity than in years when food is scarce or weather/climate conditions are suboptimal. However, to guard against the potential negative effects of burrow design and material during suboptimal years, we continue to recommend the modified burrow design detailed in the 2016 report (Marczak et al. 2017).

Task E. Habitat and Burrow Assessments

Previous BUOW research in San Diego County has focused on burrows, vegetation type and structure, prey abundance and availability, and predation as primary drivers of BUOW population persistence (SDZ ICR 2017). A positive correlation between prey delivery rates and number of fledglings provided insight into local factors driving differences in reproductive success across sites (Wisinski et al. 2014, Swaisgood et al. 2015, Hennessy et al. 2016, Wisinski et al. 2016). Our current understanding is that prey availability may limit offspring survival, particularly at sites that have recently undergone restoration activities and currently lack established vegetation to support adequate prey. Restoration projects have required as many as four years of habitat development before the prey base was large enough to support BUOW productivity. Habitat and burrow assessments are useful for making recommendations for management of BUOW sites.

To meet the maintenance and monitoring requirements for MAP's BUOW mitigation, ICR is conducting annual habitat assessments at each of the mitigation sites, including vegetation surveys, rapid assessments of prey abundance, and burrow surveys. A rapid assessment approach to these measures was established in 2016-2017. Rapid assessments are designed to rapidly collect accurate information on several metrics of interest. As such, there is an inherent tradeoff between the number of metrics included and the intensity of data collection. The strength of the rapid assessment approach is in the ability to efficiently answer a variety of questions about a site. The data provide a snapshot of current conditions and enable qualitative comparisons of the relative levels of multiple habitat metrics across sets of sites. Conversely, the intensity of data collection in the rapid assessments may not be sufficient for statistical analysis. In addition, measures of abundance from rapid assessments should not be interpreted as absolute measures, as would be captured by longer term or higher intensity sampling. For the purpose of quickly filling in gaps in knowledge, however, rapid assessments are useful.

Data gathered through the habitat assessments will also be used as covariates in our analyses of BUOW nesting success. By increasing our understanding of habitat around the burrow and larger landscape characteristics, we will better understand what constitutes optimal habitat for reproduction and survival at the mitigation sites. This will serve as an important recovery tool for BUOW in San Diego County.

In addition, once the mitigation sites have been restored, vegetation condition and artificial burrows will be inspected prior to each BUOW breeding season to evaluate maintenance needs. The inspections will identify artificial burrows that require cleaning or repair and recommended vegetation management actions to improve BUOW breeding habitat.

Methods

This rapid assessment included metrics representing prey availability (small mammals), predator pressure (raptor and coyote), vegetation and soil suitability. Sampling was randomized in order to support inference. Implementation of the rapid assessment involves an initial GIS analysis to generate randomized sampling points, as described below, and data collection, which occurs in three or four site visits over a 10-day period.

Rapid assessments were conducted during 2016-2017 across San Diego County on lands expected to be managed for conservation values in perpetuity (SDZ ICR 2017). During 2017, the MAP mitigation sites were also assessed using the same methodology (Figure 6). The assessments were conducted from late May to late September. The MAP surveys are reported here to provide a pre-mitigation benchmark for condition on each mitigation parcel. Annual post-mitigation assessments using the same methodology are anticipated once MAP proceeds.

All sampling points were randomly generated in ArcGIS 10.3 to maintain statistical independence and to support inference. For each site, the areas to be assessed were delineated in GIS according to 1) presence of grassland vegetation community and 2) slopes less than 10˚. All sampling except the coyote transects occurred at these points (i.e., small mammal, California ground squirrel, raptor/corvid surveys, soils, vegetation). Therefore, sampling was focused on the most suitable grassland areas of each site, rather than all lands within preserve boundaries. A consistent level of survey effort was maintained across sites of varying sizes by holding the sample point density constant at 1 point/12 hectares.

Soils and Vegetation

Soil sampling was conducted to assess suitability of soils for squirrel burrowing activity at each sampling point, one sample per point. Samples of approximately 100 g from the top 8 cm of soil were collected and assessed for soil texture and gravel content. Soil texture is reported as percent clay, percent sand, and percent gravel. Previous SDZ ICR studies have shown that the likelihood of squirrel presence increases with increasing percent sand (Wisinski et al. 2013).

Vegetation sampling was conducted to assess the current composition and structure of the plant communities within the delineated grassland areas of suitability described above. Grassland structure varies significantly throughout the growing season with respect to vegetative height and percent cover. Since sampling occurred late in the growing season (as grasses were senescing), ocular estimates of percent cover and height within $10m^2$ plots were taken to provide a snapshot of the vegetative condition at each sampling station. The sampling included estimated percent cover of bare ground and all dominant grass species, with a specific focus on recording the presence of wild oats (*Avena barbata, A. fatua*), ripgut (*Bromus diandrus*) and foxtails (*Bromus madritensis*). In San Diego County, these particular species impact BUOW more than any other non-native grassland species. The two species of wild oats grow to more than a meter tall, while both brome species grow very densely and create thick layers of thatch.

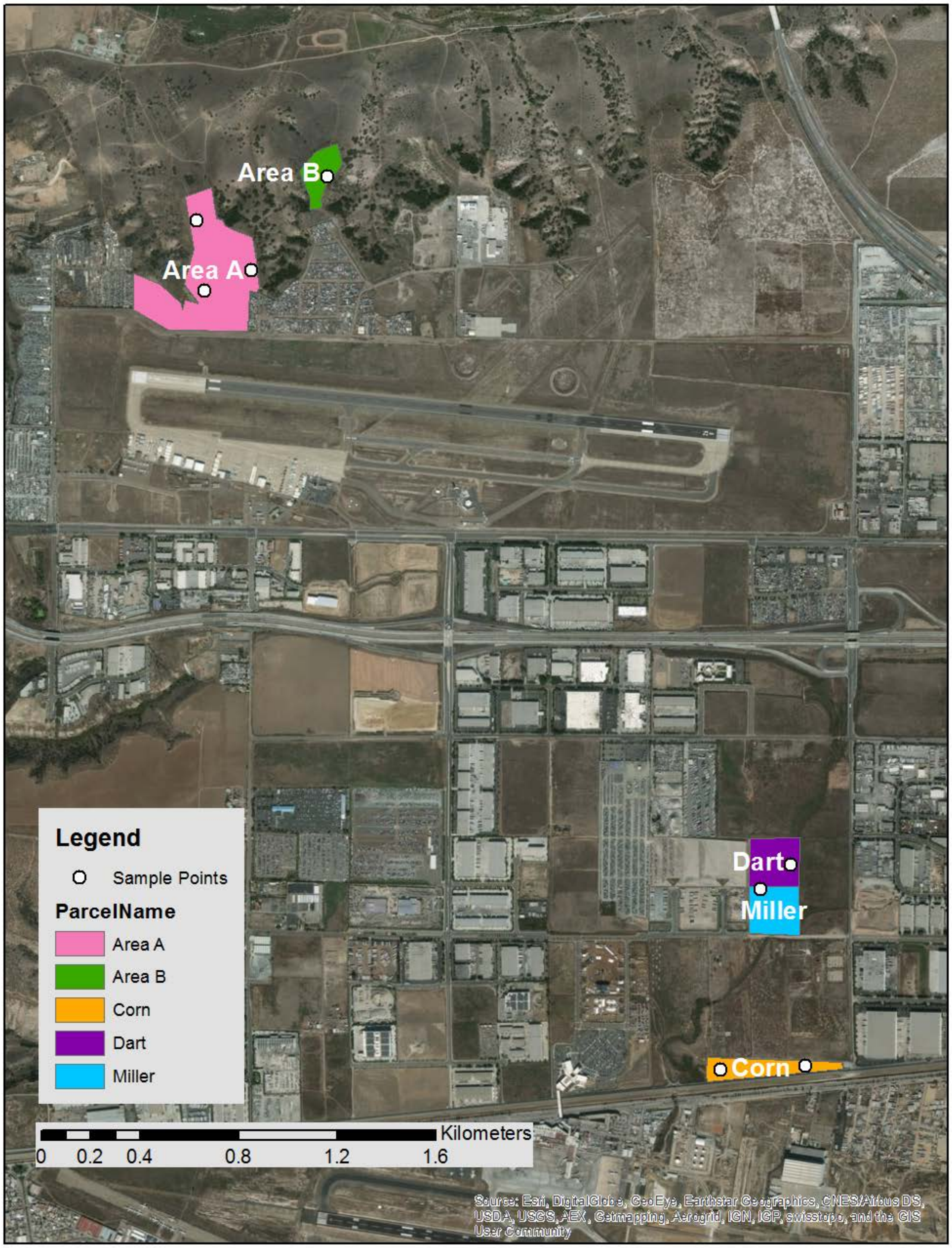

Figure 16. Mitigation parcels evaluated with rapid assessment methodology in 2017.

Prey availability, Gophers, and Squirrels

Prey availability sampling focused on small mammals rather than invertebrate prey, and was collected with camera traps and belt transects. Field data collected in 2013-2015 indicate that local prey/productivity relationships rely on small mammal prey to support higher productivity (Hennessy et al. 2016). Gophers are an important prey item in southern California, and BUOW also opportunistically prey on a variety of mice and kangaroo rat species. Conversely, the data from 2014-2015 indicated a significant negative relationship between productivity (i.e., maximum number of chicks and number fledged) and the proportion of invertebrates delivered to the breeding burrow. Both findings are consistent with an approach to prey availability sampling that focuses on small mammal species. A relative abundance measure of California ground squirrels was also included due to the obligate relationship between owls and squirrels in this region.

Mouse/kangaroo rat sampling Camera stations were established at the randomly sampled independent points. Bushnell Trophy Cams were mounted on a wooden stake about 20 cm above the ground, and sterilized millet seed was left at a bait station 2 m in front of the camera. The cameras were set on the low sensitivity trigger setting, and collected 15 sec of video at 30-sec intervals. Cameras sampled a minimum of 10 nights. The resulting video data were processed using Adobe Bridge, and occupancy estimates were calculated in the software program Presence using a simple single-season model. Occupancy estimates represent a measure of the proportion of sampling points occupied by a species. In this context, the occupancy values can be interpreted as a relative index of abundance between sites. Concerns that baited stations may skew abundance measures upwards by attracting individuals from greater distances apply when the objective is to estimate population levels. However, baited stations may be used for relative measures of abundance, as long as the stations are implemented consistently across sites.

Gopher sampling At each camera station, three 25-m transects were set out along three of the four cardinal directions, making sure to avoid large obstructions. A line-intercept method was used to measure areas of bare or disturbed ground resulting from gopher activity, with additional notation for recent digging activity. Ground cover was measured to the nearest 5 cm (precision). Individual segments of bare ground began when the transect first intercepted bare ground, and were ended when the transect intercepted vegetation, so that measurements were limited to bare ground. The segment lengths were totaled and used to calculate a percentage of the overall transect length (75 m) that intercepted gopher-disturbed areas. The percentage of gopher-disturbed ground was averaged by site to produce mean and standard error estimates which indicate relative abundance of gophers by site.

California ground squirrel presence Along each of the aforementioned 25-m transects, a 4-m-wide (2 m on either side of the centerline) buffer was established to determine the abundance of California ground squirrel burrows present at each sampling location. Squirrel burrows falling within the belt were tallied with a simple count to indicate presence and relative abundance of California ground squirrels.

Predator pressure

The rapid assessments of predator pressure included both aerial predators (raptor and corvids) and ground predators (coyotes). Camera traps at nest burrows in San Diego have recorded predation events, and the data show that these are the most significant predators of BUOW in this region. Great horned owls and barn owls are also known predators that should be included in the assessment if feasible.

Raptor and corvid surveys For these surveys, corvids were defined as crows and ravens. Raptors were defined as any diurnal raptor species that could reasonably be expected to prey on BUOW, including hawks, falcons, and eagles. Turkey vultures and BUOW were excluded from the raptor counts. Surveys were conducted on two separate occasions at each camera station. The surveys were 10 minutes in duration and timed to fall between the morning hour when raptors began catching thermals (roughly three hours after sunrise) and noon, when activity declined due to heat. The 10-minute interval was long enough to detect the raptors in the viewshed, and short enough to limit accidental double counting as individuals moved around. Weather and the number of each species observed, including unknowns, was noted. The data were summarized by first selecting the survey date at each camera with the greater sum of raptors and corvids observed, and then averaging across all camera stations on-site to produce relative abundance site estimates.

Coyote transects Roads and trails were walked or driven at 2-3 mph. We recorded the number of coyote scats and examined the contents of each. Fresh scat was noted (based on moisture level) and scats were classified by content (fur and bone/seeds and vegetation). The ends of transects were recorded with GPS to enable calculation of scat density per kilometer. Scats within 0.3 m of one another were counted as the same scat, unless there was a difference in age or composition. These counts provided a relative index of coyote activity levels, which would be expected to be more tightly associated with predation levels than estimates of coyote population size.

Results and Discussion

Soils and Vegetation

Soil texture on both on-site mitigation areas were categorized as loams based on soil sampling (Table 11). Previous work in the region has utilized a maximum of 10% gravel as a threshold for ground squirrel burrowing activity (Hennessy et al. 2018). At Area A, gravel content was 12.7%. The highest gravel fraction at any MAP site was measured at Area B (21.8%). For the off-site mitigation areas, soil textures varied from sandy loams to clay loams but contained smaller fractions of silt than the on-site parcels. At all three off-site parcels the gravel fraction was near or below 10%.

Table 11. Soil sampling results for MAP mitigation sites.

Parcel	N	% Clay	% Sand	% Silt	% Gravel	Soil texture
Area A	3	21.4	35.9	42.7	12.7	Loam
Area B	1	25.3	35.0	39.6	21.8	Loam
Dart	1	12.3	59.1	28.7	10.2	Sandy loam
Miller	1	23.5	49.4	27.1	6.5	Sandy clay loam
Corn	2	25.7	44.5	29.8	6.2	Clay loam

Previously on Otay Mesa, squirrel translocation was attempted at the Lonestar Ridge West site, but the translocation was not successful in part due to heavy clay soils (samples ranged from 30-57% clay). Relative to Lonestar Ridge West, the MAP sites have soil textures with lower clay contents, which suggests they will better support squirrel burrowing activities. The exception may be Area B, with its higher gravel content.

At the time of sampling, Area A had been mowed, leaving short stumps of exotic forbs and grasses that were not identified to species. The randomly sampled point at Area B was dominated by *Avena fatua*, and Area B also supports coastal sage scrub shrub species. The most informative values at the current time are percent cover bare ground and percent cover exotic grass (Table 12). Area A and Corn were dominated by exotic forbs. While large portions of the Dart parcel were also dominated by a monoculture of forbs greater than 1 m tall, the randomly sampled vegetation plot was 80% exotic grass.

Table 12. Percent vegetation cover values sampled in 2017.

		Bare Ground			Exotic Grass		
Parcel	n	Mean	SD	Range	Mean	SD	Range
Area A	3	43.3	44.8	15 - 95	0	0	0 - 0
Area B	1	0			99		
Dart	1	1			80		
Miller	1	3			98		
Corn	2	10	7.1	5 - 15	4.5	4.9	1 - 8

Prey availability, Gophers, and Squirrels

Despite the more favorable soils, squirrel and gopher activity were not detected at any of the off-site mitigation areas (Table 13). Squirrel and gopher activity also were not detected at Area B. However, both types of activity were present at Area A at relatively low levels (relative to the range of activity levels measured across the set of all 2016-17 rapid assessment sites). During the rapid assessments, very low levels of other small mammal activity (mice, kangaroo rats) were detected with camera trapping. Area A was the only mitigation parcel with a positive detection (Table 13).

Predator Pressure

In terms of predator pressure, the scat density transects showed coyote presence across all on- and off-site parcels, with very high use of Area A. Relatively moderate levels of corvid and raptor presence were also detected at Area A and the Miller/Dart parcels. Predator perches and roosting sites are abundant across Otay Mesa, and can be found adjacent to all MAP mitigation sites.

Habitat Suitability Index

Mean habitat suitability index (HSI) statistics were calculated for each mitigation parcel. The HSI for the Dart/Miller parcels is in the highest 5% of the index, and the HSI for Area A is within the top 10% of the index (Figure 17, Table 13). Area B produced a much lower habitat suitability value. Please note that while Corn also produced a numerically low result, the calculation was likely impacted by the proximity of the parcel to the international border, which was also the edge of the modeled area. In general, the edge pixels of the model all produced low HSI values. However, multiple BUOW observations have been recorded at the Corn parcel in recent years, so the habitat value of this parcel should not be undervalued.

All rapid assessment protocols will be repeated at the mitigation sites in 2019.

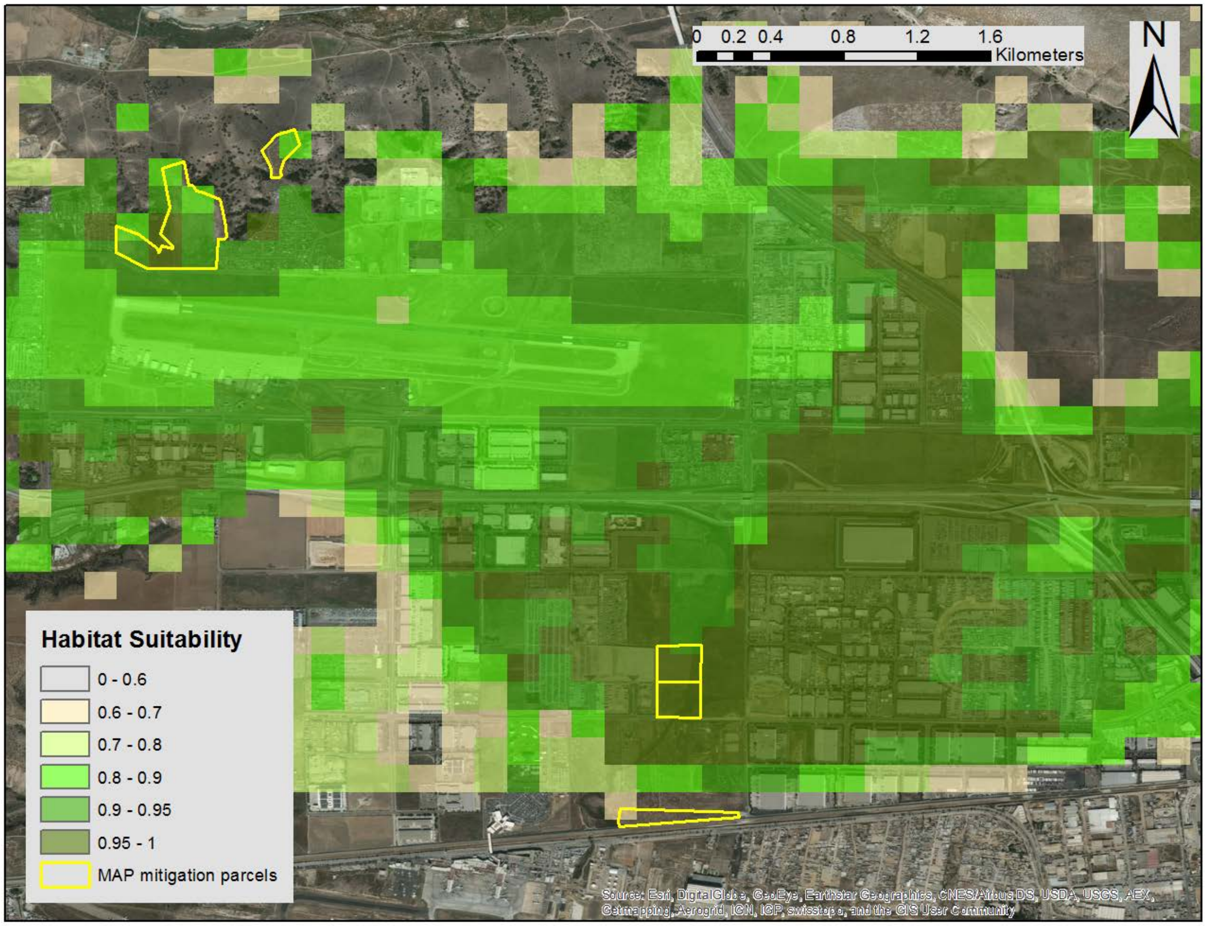

Figure 17. Habitat suitability index for each mitigation parcel.

Table 13. Summary of rapid assessment results for prey availability, predator pressure, and habitat suitability index by site.

Site		**Mouse/ k-rat**	**Gopher**		**Squirrels**		**Ground predators**	**Corvids**	**Raptors**				**HSI**	
		Presence/ Absence	*% disturbance along 75 m transect*		*burrow count, 75 m transect*		*density of coyote scat/km*	*Counts averaged by sample points*	*All raptors*	*BUOW*	*Red-tailed Hawk*	*Cooper's Hawk*	*Habitat suitability index*	
	2016-17 SD Range		*0-20%*		*0-12*		*0-60*	*0-14*	*0-4*				*0-1*	
	Samples	Detection/ cam trap nights	*Mean*	*SE*	*Mean*	*SE*	*scat/km*	*Count*	*Count*	*Count*	*Count*	*Count*	*Mean*	*SD*
Onsite														
Area A	3	1/39	7%	0.8	0.7	0.7	56.4	6	2	0	2	0	0.901	0.063
Area B	1	0/13	0	0	0	0	13.0	1	0	0	0	0	0.453	0.288
Offsite														
Dart/ Miller	2	0/26	0	0	0	0	16.2	6	0	0	0	0	0.974	0.024
Corn	2	0/26	0	0	0	0	9.9	2	2	0	2	0	0.01	-

Task F. Ground Squirrel Establishment

California ground squirrels (*Otospermophilus beecheyi*) play a key role in engineering grassland ecosystems (Hennessy et al. 2018), yet this species has received little attention in conservation planning and policy. The decline of fossorial mammals also has been implicated as a key factor for the decline of BUOW in San Diego County (Lincer and Bloom 2003). Without ground squirrels, nesting resources for BUOW become limited. The establishment and maintenance of a healthy squirrel population provides a continuous supply of natural burrows which do not require annual maintenance and potentially improve BUOW reproductive success.

The microclimate of natural burrows may also provide significantly more suitable conditions for nesting owls than artificial burrows. During 2014-2015, assessment of burrow microclimates indicated that natural burrows provided better buffering from outside conditions compared to artificial burrows (Hennessy et al. 2016). Lower numbers of chicks were produced from artificial burrows, and microclimate may have affected hatching success (Wisinksi et al. 2016).

The first goal of this task is to establish baseline measures of squirrel presence and activity across the mitigation parcels, in terms of ground squirrel occupancy and numbers of burrows. We will then monitor for the presence of ground squirrels and other fossorial mammals at each of the mitigation sites annually. The data will enable further recommendations for the potential use of passive or active squirrel translocation methods at each mitigation parcel.

Methods

Field surveys for California ground squirrel burrows were conducted at all on- and off-site mitigation areas between 26-28 September. Grid plots measuring 10 m by 10 m were examined for burrow presence and activity level status throughout the parcels. All parcel perimeters were included in the survey due to frequent ground squirrel occurrence along parcel edges. Burrows were required to be at least 7 cm in diameter in order to be included in the assessment as squirrel burrows. Burrow activity was recorded as either 1) None, 2) Inactive, or 3) Active. Burrows with signs of recent activity (claw marks and fresh digging, piles of seeds, latrines with feces) were considered active. Burrows with none of these signs and/or cobwebs across the entrance were considered inactive. Completely collapsed burrow entrances or other trace signs of a burrow were not recorded because they did not provide potential burrow habitat for BUOW. If a combination of inactive and active burrows were found within a plot, the plot was marked as Active.

Surveyors recorded data in ArcGIS Collector on Samsung Galaxy tablets. Surveyors walked a grid pattern through each parcel. The grid was created with ArcGIS 10.5 before the field surveys, and published on ArcGIS Online, to provide dynamic map-based guidance during the field surveys. Areas of activity were measured as a percentage calculated from the area of grid plots with positive detections divided by total grid area by parcel.

Results and Discussion

The grid-based protocol detected localized areas of ground squirrel activity that were not captured by the rapid assessment transects in Task E. The current level of ground squirrel activity on all mitigation parcels (pre-restoration) is low (Table 14). While burrows were documented on all parcels except Area B, no burrows had evidence of recent activity (e.g. having fresh squirrel feces, a clear tunnel entrance, or presence of fresh digging). Seasonal activity patterns do not account for the absence of recent activity. Previous surveys have shown that fall surveys usually detect greater numbers of burrows than spring surveys (Wisinski et al. 2016). At the end of the summer breeding season, juveniles disperse away from their natal burrows and begin to create their own burrows.

The parcels with the greatest burrow density were the Corn (7.6%, Table 14) and Miller parcels (2.5%). Most of the existing burrows are generally associated with habitat edges. At Corn, burrows extend along the southern length of the parcel and the international border fence (Figure 18). The border fence has been observed to provide productive squirrel habitat in other locations on Otay Mesa as well. At Miller, squirrel burrows are found along the western and southern parcel boundaries, where a dirt road delineates the parcel from additional open land to the south (Figure 18).

Table 14. California Ground Squirrel Burrow Presence at Mitigation Areas.

Parcel	Survey area (Acres)	Inactive burrows	No burrows
Area A	40.4	1.9%	98.1%
Area B	6.5	0.0%	100.0%
Corn	9.7	7.6%	92.4%
Dart	10.9	0.5%	99.5%
Miller	9.8	2.5%	97.5%
Total	**77.3**	**2.3%**	**97.7%**

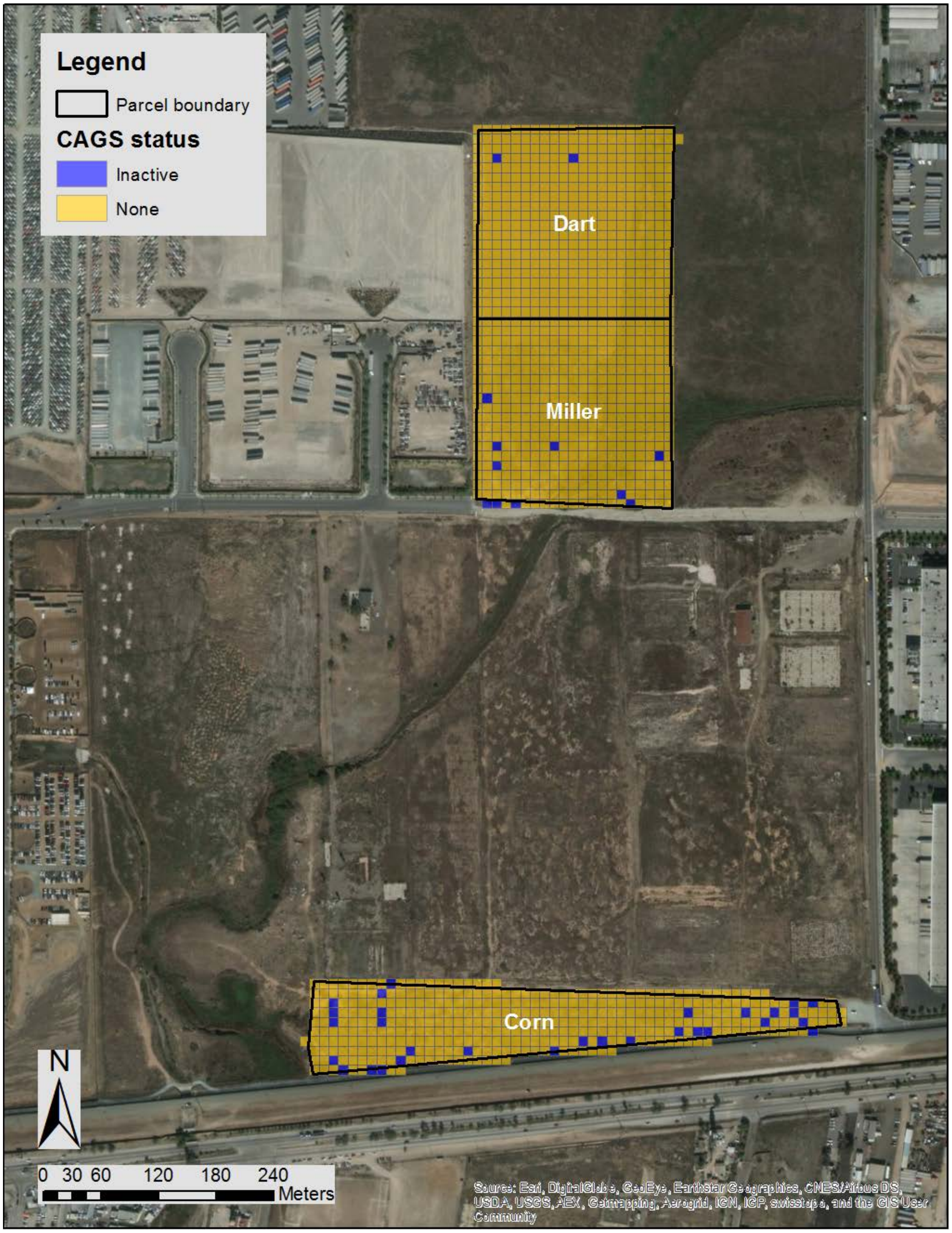

Figure 18. Detections of CA Ground Squirrel burrows at Dart, Miller, and Corn off-site mitigation areas in September 2018.

The numerically lower burrow density at Area A is due in part to the larger acreage of this parcel. The location of existing burrows suggests that squirrels access the parcel from the canyon to the north and from the auto lot to the east (Figure 19). Both Area A and Corn have documented squirrel populations in directly adjacent properties.

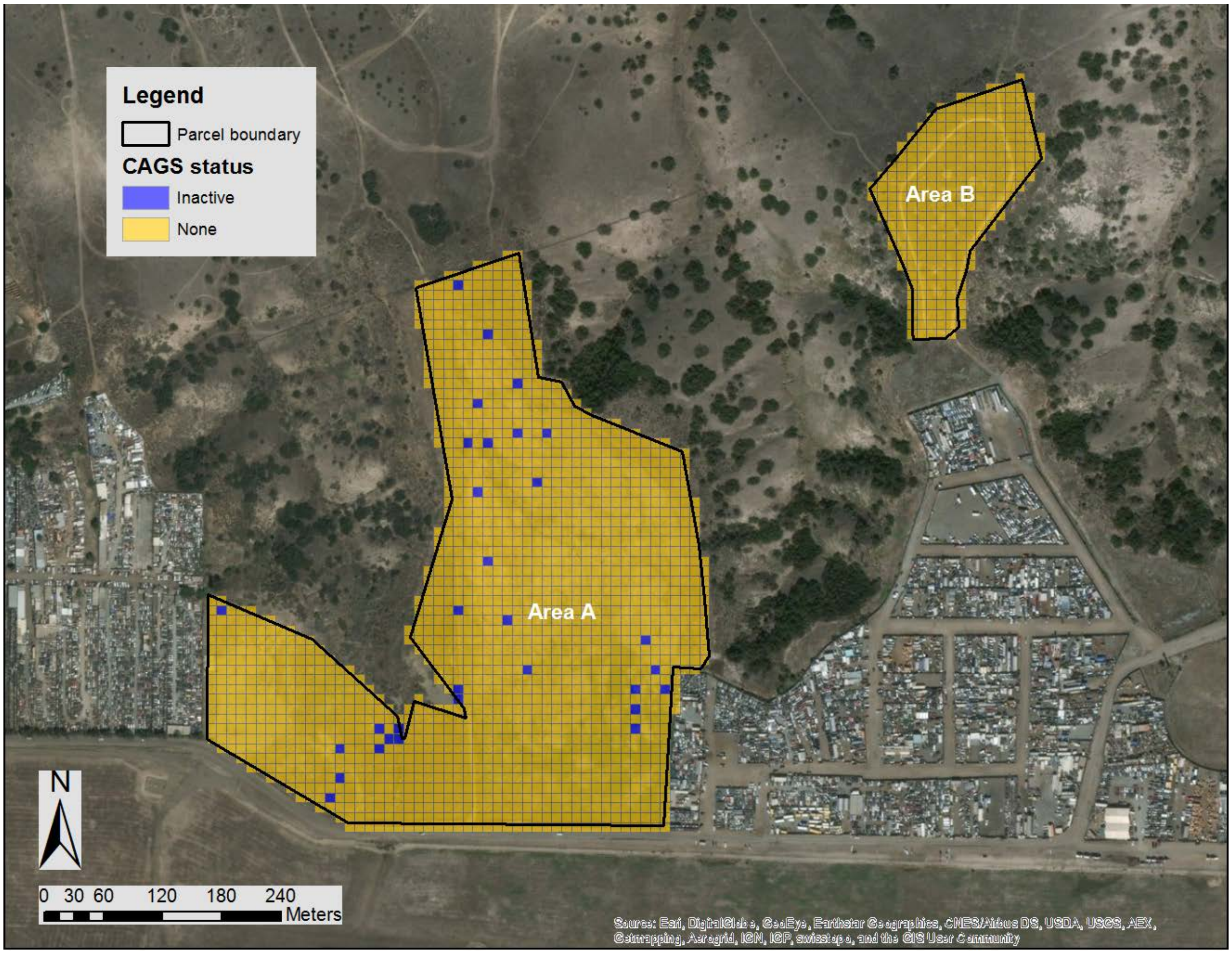

Figure 19. Detections of CA Ground Squirrel burrows at on-site mitigation Areas A and B in September 2018.

Techniques for Squirrel Establishment

If an abundant population of resident squirrels is in close proximity to a target mitigation site, natural squirrel colonization can be encouraged through vegetation management and establishment of cover. In a study of a newly cattle-grazed area adjacent to a resident squirrel population near human structures, squirrels began to colonize the newly available areas of short, open grassland at a slow pace (Swaisgood et al. 2015). In addition, the placement of cover piles made of wood or other materials was associated with increased squirrel use in the study of colonization by resident squirrels, and with better establishment success in squirrel translocations (Wisinski et al. 2014, Swaisgood et al. 2015). Spacing multiple rubble or brush piles at increments of 50 meters can effectively encourage squirrels to move across previously unoccupied areas (Wisinski et al. 2016). The brush piles effectively provide refugia from predators for ground squirrels while they construct burrow systems and conduct daily foraging. Source squirrels can additionally be encouraged to disperse across target areas with the creation of soil berms or mounds made of soil that is attractive for digging (SDZ ICR 2017).

When squirrels are absent or present at densities too low to enable colonization at adequate rates, active translocation can be implemented using the enhanced squirrel translocation protocol developed through field experiments conducted during 2011-2015 (Shier et al. 2016). The protocol utilizes soft-release techniques including a release group comprised of socially familiar individuals, provision of debris for cover from predators, supplemental feeding during the establishment phase, and on-site acclimation in artificial burrows with above- and below-ground cages for one week. Success is measured by ground squirrel occupancy and burrow counts/densities.

When there is a source population of squirrels near the target location, passive attraction of squirrels to the target location is preferred to active translocation. Active translocation requires much greater inputs of time and effort to establish viable new squirrel populations. However, passive attraction of squirrels requires a nearby source population in order to be an effective strategy.

Specific recommendations for each mitigation area are based on the field surveys reported above, and are provided in Section G.

Task G. Recommendations

The following recommendations are based on the results of the ICR Burrowing Owl Recovery Program since 2011 and are aligned with the conservation and management goal of stabilizing the BUOW population on Otay Mesa, given anticipated development activities in the region.

Relocation Timing The timing of the relocation (passive or active removal of BUOW) from Brown Field locations and grading to make the habitat unsuitable must be tightly coupled. Due to the history of BUOW occupancy and the importance of this site to the overall BUOW population, the probability of reoccupation is very high. If reoccupation occurs during the breeding season, development activities will be delayed. For example, the 2018 translocation identified the Tripad N burrow as a preferred source. The resident BUOW pair was captured and translocated and the burrow was blocked using sand bags, but squirrels immediately opened the burrow. A second pair moved in to the burrow within one week, and was subsequently trapped and translocated. The burrow was blocked again, but squirrel activity created new burrows at the Tripads. Later in the breeding season, a dispersing adult male from Helix 2 was found occupying one of these burrows.

If reoccupancy does occur, seasonal timing will determine whether the BUOW can be safely moved. Once the breeding season (Feb 1-Aug 31) begins, it is impossible to guarantee the safety of BUOW relocation from natural burrows without negative impacts to eggs or chicks that may already be in the burrow. The complexity of natural burrows prevents the access needed to both examine all nest chambers that the BUOW may be utilizing and to remove any eggs/chicks inside.

Mitigation site timing Progress on the restoration of mitigation sites should be prioritized in 2019 in order to provide more options for BUOW relocation from Brown Field in the coming years. In terms of vegetation communities, restoration plantings may require up to four years of growth before supporting an adequate prey base for BUOW. However, all opportunities to initiate the creation of BUOW burrow habitat should be pursued. At some of the mitigation sites, strategic initiation of burrow creation decoupled from subsequent vegetation restoration may be desirable. Initiation of limited vegetation management may also encourage burrow creation. Specific recommendations are summarized by site.

Area A The restoration plan should be modified to make better use of the available habitat for BUOW. As the largest mitigation site at 35 acres, the site could potentially support 7 BUOW pairs (14 individuals). In order to accommodate this target number, the number of installed artificial burrows should be increased to 21-28 burrows. Currently, artificial burrow installation is planned for the smaller western section of the parcel. However, this area is closer to the road, trees, and auto lot, which will increase risks for both BUOW (predation, vehicle collisions) and CAGS (rodenticide, vehicle collisions). The contiguous grassland on the eastern section of the parcel provides a larger buffer from the road and more space for the installation of the needed artificial burrows. This modification would include shifting some of the vernal pools planned for the eastern side to the western section. The compacted soils and gravel of the western section are less suitable for burrows, but would be compatible with vernal pool creation. The addition of a berm along Aviator Road to serve as a visual and noise buffer is also recommended. The timing of the grading required for the vernal pools on Area A will be contingent on permitting, and the likelihood of initiating work in 2019 is uncertain.

Once restoration proceeds on Area A, passive attraction of squirrels should be utilized to increase squirrel presence and activity levels. Since squirrels have been observed in the southeast quadrant of Area A, encouragement of natural squirrel dispersal with berms and brush piles is recommended. The existing source population of squirrels is likely to move further across the parcel with restoration and the placement of features such as berms and brush piles. Active translocation is not recommended for Area A. In a previous active translocation to a similar and nearby mitigation site adjacent to the Otay River Canyon, translocated squirrels quickly dispersed into the canyon and squirrels failed to establish on the site.

Area B Since Area B has no existing squirrel activity, encouraging natural dispersal into the parcel is not recommended at this time. Squirrels are likely present nearby in the canyon and in the adjacent auto lot, and the lack of any activity in the parcel suggests that it currently contains habitat that is unsuitable for squirrels. Since the parcel has an existing remnant coastal sage scrub (CSS) community, restoration could be limited to weed removal in order to support the CSS, rather than creating new vegetation specifically for squirrels and BUOW. Due to the small size of the parcel and isolation from contiguous BUOW habitat, we do not recommend the installation of artificial burrows at this site. However, clearing tall non-native grasses from the parcel may increase foraging and wintering habitat and prey availability for BUOW.

Miller and Dart All opportunities to initiate vegetation and squirrel management in 2019 on the offsite mitigation parcels should be pursued, as these sites could serve as receiver sites for active translocation. Squirrels are present along the edges of the parcel and across the dirt road bounding the southern end of the parcel. Passive techniques to attract natural squirrel dispersal are recommended. Squirrels have successfully been attracted across edges such as roads elsewhere on Otay Mesa, and the impacts of vehicle traffic on the dirt road in this area are relatively lower than elsewhere on the Mesa. Vegetation management through mowing would encourage squirrel activity. The placement of soil berms and brush piles should also occur as part of restoration activities. However, if squirrels are not moving quickly enough across Miller and Dart to create adequate burrow supplies for BUOW, then active relocation of squirrels will also be required.

Additional risks to BUOW are present in the form of illegal dumping, and trees/fencing on adjacent parcels along the western boundary. Modifications will be needed to help lower risks to BUOW.

Corn Squirrels are present on the edges of the Corn parcel and across the roads bounding the parcel. Passive attraction of squirrels should be utilized to increase squirrel presence and activity levels on Corn. It is anticipated that the existing source populations of squirrels will move further across the parcel with restoration and the placement of features such as berms and brush piles.

Additional risks to BUOW are present in the form of illegal dumping, and fencing provides predator perches. Modification of the present configuration may be limited by proximity to the international boundary, but any opportunities to remove perches and to prevent dumping should be pursued.

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Appendix 1. 2018 BUOW Banding Data

Site	Family / Capture Burrow	USGS Band	Aux Band ID	Sex	Age (2018)	2018 Capture?	2018 Genetics?	Date Captured	Year Banded
Brown Field	Palm Pad	1004-18360	02/Z	F	Adult	Yes	Yes	23-May-18	2016
Brown Field	Palm Pad	1094-22137	A/23	M	Adult	Yes	Yes	23-May-18	2018
Brown Field	Palm Pad	1094-22138	B/35	Unk	Chick	Yes	Yes	23-May-18	2018
Brown Field	Palm Pad	1094-22139	B/46	Unk	Chick	Yes	Yes	23-May-18	2018
Brown Field	Palm Pad	1094-22140	B/57	Unk	Chick	Yes	Yes	23-May-18	2018
Brown Field	Palm Pad	1094-22141	B/68	Unk	Chick	Yes	Yes	23-May-18	2018
Brown Field	Palm Pad	1094-22142	B/79	Unk	Chick	Yes	Yes	23-May-18	2018
Brown Field	Palm Pad	1094-22143	B/90	Unk	Chick	Yes	Yes	23-May-18	2018
Brown Field	Fire Station	1094-22077	A/91	F	Adult	Yes	Yes	5-Mar-18	2017
Brown Field	Fire Station	1094-22161	B/05	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Fire Station	1094-22162	B/16	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Fire Station	1094-22163	B/27	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Fire Station	1094-22164	None	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Fire Station	1094-22165	B/38	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Starbucks North	1094-22174	B/18	Unk	Chick	Yes	Yes	13-Jun-18	2018
Brown Field	Starbucks North	1094-22197	B/29	Unk	Chick	Yes	Yes	15-Jun-18	2018
Brown Field	LMSS Man Cave	1084-05304	B/E	F	Adult	Yes	Yes	10-May-18	2011
Brown Field	LMSS Man Cave	1094-22100	A/45	M	Adult	Yes	Yes	14-May-18	2018
Brown Field	LMSS Man Cave	1094-22098	B/71	Unk	Chick	Yes	Yes	10-May-18	2018
Brown Field	LMSS Man Cave	1094-22099	B/82	Unk	Chick	Yes	Yes	10-May-18	2018
Brown Field	LMSS Man Cave	1094-22110	B/93	Unk	Chick	Yes	Yes	14-May-18	2018
Brown Field	LMSS Man Cave	1094-22111	B/10	Unk	Chick	Yes	Yes	14-May-18	2018

Site	Family / Capture Burrow	USGS Band	Aux Band ID	Sex	Age (2018)	2018 Capture?	2018 Genetics?	Date Captured	Year Banded
Brown Field	Mr. Sales	1094-22153	A/48	M	Adult	Yes	Yes	30-May-18	2018
Brown Field	Mr. Sales	1094-22182	B/13	Unk	Chick	Yes	Yes	6-Jun-18	2018
Brown Field	Mr. Sales	1094-22183	None	Unk	Chick	Yes	Yes	6-Jun-18	2018
Brown Field	Mr. Sales	1094-22184	B/02	Unk	Chick	Yes	Yes	6-Jun-18	2018
Brown Field	Gorilla2	1094-22157	B/36	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Gorilla2	1094-22158	B/47	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Gorilla2	1094-22159	B/58	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Gorilla2	1094-22160	B/69	Unk	Chick	Yes	Yes	31-May-18	2018
Brown Field	Gorilla2	1094-22179	B/80	Unk	Chick	Yes	Yes	6-Jun-18	2018
Brown Field	Gorilla2	1094-22180	B/25	Unk	Chick	Yes	Yes	6-Jun-18	2018
Brown Field	20K	1094-22075	A/33	F	Adult	Yes	Yes	13-Jun-18	2017
Brown Field	20K	1094-22064	A/89	M	Adult	Yes	Yes	13-Jun-18	2017
Brown Field	20K	1094-22173	B/20	Unk	Chick	Yes	Yes	13-Jun-18	2017
Brown Field	20K	1094-22120	B/48	Unk	Chick	Yes	Yes	13-Jun-18	2017
Brown Field	20K	1094-22175	B/75	Unk	Chick	Yes	Yes	14-Jun-18	2017
Lonestar	LS 3	1004-22060	A/85	F	Adult	Yes	No	25-May-18	2017
Lonestar	LS 3	1094-22104	B/99	Unk	Chick	Yes	Yes	20-Jun-18	2018
Lonestar	LS 3	1094-22105	B/88	Unk	Chick	Yes	Yes	20-Jun-18	2018
Lonestar	LS 21	1094-22044	A/27	F	Adult	Yes	Yes	28-Jun-18	2018
Lonestar	LS 21	1094-22169	None	Unk	Chick	Yes	Yes	5-Jun-18	2018
Lonestar	LS 23 natural	1094-22170	B/56	Unk	Chick	Yes	Yes	5-Jun-18	2018
Lonestar	LS 23 natural	1094-22178	B/67	Unk	Chick	Yes	Yes	6-Jun-18	2018
Lonestar	LS 23 natural	1094-22181	B/78	Unk	Chick	Yes	Yes	6-Jun-18	2018
Lonestar	LS 27	1004-18358	56/Z	F	Adult	Yes	Yes	17-May-18	2016
Lonestar	LS 27	1094-22017	A/92	M	Adult	Yes	Yes	19-May-18	2017

Site	Family / Capture Burrow	USGS Band	Aux Band ID	Sex	Age (2018)	2018 Capture?	2018 Genetics?	Date Captured	Year Banded
Lonestar	LS 27	1094-22144	B/14	Unk	Chick	Yes	Yes	28-May-18	2018
Lonestar	LS 27	1094-22145	B/03	Unk	Chick	Yes	Yes	28-May-18	2018
Lonestar	LS 42	1004-15569	73/Y	F	Adult	Yes	?	19-May-18	2015
Lonestar	LS 42	1004-18315	59/Z	M	Adult	Yes	Yes	19-May-18	2016
Lonestar	LS 42	1094-22122	None	Unk	Chick	Yes	Yes	19-May-18	2018
Lonestar	LS 42	1094-22146	None	Unk	Chick	Yes	Yes	19-May-18	2018
Lonestar	LS 42	1094-22147	None	Unk	Chick	Yes	Yes	19-May-18	2018
Lonestar	LS 42 (LS 47 renest)	1094-22103	A/28	F	Adult	Yes	Yes	8-Aug-18	2017
Lonestar	LS 42 (LS 47 renest)	1094-67740	None	Unk	Chick	Yes	Yes	8-Aug-18	2018
Lonestar	LS 42 (LS 47 renest)	1094-67739	None	Unk	Chick	Yes	Yes	8-Aug-18	2018
Lonestar	LS 60	1094-22148	B/94	Unk	Chick	Yes	Yes	29-May-18	2018
Lonestar	LS 60	1094-22149	None	Unk	Chick	Yes	Yes	29-May-18	2018
Lonestar	LS 60	1094-22150	B/72	Unk	Chick	Yes	Yes	29-May-18	2018
Lonestar	LS 60	1094-22151	B/61	Unk	Chick	Yes	Yes	29-May-18	2018
Lonestar	LS 109	1094-22125	A/88	F	Adult	Yes	Yes	22-May-18	2018
Lonestar	LS 109	1094-22124	A/99	M	Adult	Yes	Yes	22-May-18	2018
Lonestar	LS 109	1094-22152	B/31	Unk	Chick	Yes	Yes	30-May-18	2018
Lonestar	LS 109	1094-22155	B/53	Unk	Chick	Yes	Yes	31-May-18	2018
Lonestar	LS 109	1094-22156	B/64	Unk	Chick	Yes	Yes	31-May-18	2018
Lonestar	LS 121	1094-22042	66/Z	F	Adult	Yes	Yes	5-Jun-18	2017
Lonestar	LS 121	1094-22171	B/91	Unk	Chick	Yes	Yes	5-Jun-18	2018
Lonestar	LS 129	1004-15589	06/Z	M	Adult	Yes	Yes	27-Mar-18	2016
Lonestar	LS 129	1094-22106	None	Unk	Chick	Yes	Yes	21-Jun-18	2018
Lonestar	LS 166	1094-22112	B/00	Unk	Chick	Yes	Yes	16-May-18	2018
Lonestar	LS 166	1094-22113	B/22	Unk	Chick	Yes	Yes	16-May-18	2018

Site	Family / Capture Burrow	USGS Band	Aux Band ID	Sex	Age (2018)	2018 Capture?	2018 Genetics?	Date Captured	Year Banded
Lonestar	LS 166	1094-22114	B/11	Unk	Chick	Yes	Yes	16-May-18	2018
Lonestar	LS 166	1094-22123	B/33	Unk	Chick	Yes	Yes	22-May-18	2018
Lonestar	LS 166	1094-22127	B/44	Unk	Chick	Yes	Yes	22-May-18	2018
Lonestar	LS 166	1094-22154	B/55	Unk	Chick	Yes	Yes	30-May-18	2018
Lonestar	LS 176	1094-22166	None	Unk	Chick	Yes	Yes	5-Jun-18	2018
Lonestar	LS 176	1094-22168	B/19	Unk	Chick	Yes	Yes	5-Jun-18	2018
Lonestar	LS 176	1094-22167	B/08	Unk	Chick	Yes	Yes	5-Jun-18	2018
Lonestar	LS 176	1094-22172	B/30	Unk	Chick	Yes	Yes	12-Jun-18	2018
Lonestar	LS 180	1094-22115	B/01	Unk	Chick	Yes	Yes	16-May-18	2018
Lonestar	LS 180	1094-22116	B/12	Unk	Chick	Yes	Yes	16-May-18	2018
Lonestar	LS 180	1094-22119	B/23	Unk	Chick	Yes	Yes	19-May-18	2018
Lonestar	LS 180	1094-22121	B/34	Unk	Chick	Yes	Yes	19-May-18	2018
Lonestar	LS 180	1094-22126	B/45	Unk	Chick	Yes	Yes	22-May-18	2018
Lonestar	Euc 2 (LS 160 Renest)	1004-18338	86/Y	F	Adult	Yes	Yes	14-Jun-18	2016
Lonestar	Euc 2 (LS 160 Renest)	1094-22176	B/59	Unk	Chick	Yes	Yes	14-Jun-18	2018
Lonestar	Euc 2 (LS 160 Renest)	1094-22177	B/70	Unk	Chick	Yes	Yes	14-Jun-18	2018
Helix	Helix Lonestar 15	1004-22032	A/49	M	Adult	Yes	Yes	3-May-18	2017
Helix	Helix Lonestar 15	1094-22117	B/04	Unk	Chick	Yes	Yes	17-May-18	2018
Helix	Helix Lonestar 15	1094-22118	B/15	Unk	Chick	Yes	Yes	17-May-18	2018
Helix	Helix Lonestar 15	1094-22128	B/26	Unk	Chick	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 15	1094-22129	None	Unk	Chick	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 2	1094-22041	A/08	F	Adult	Yes	Yes	23-May-18	2017
Helix	Helix Lonestar 2	1094-22136	A/43	M	Adult	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 2	1094-22130	B/41	Unk	Chick	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 2	1094-22131	B/52	Unk	Chick	Yes	Yes	23-May-18	2018

Site	Family / Capture Burrow	USGS Band	Aux Band ID	Sex	Age (2018)	2018 Capture?	2018 Genetics?	Date Captured	Year Banded
Helix	Helix Lonestar 2	1094-22132	B/63	Unk	Chick	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 2	1094-22133	B/74	Unk	Chick	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 2	1094-22134	B/85	Unk	Chick	Yes	Yes	23-May-18	2018
Helix	Helix Lonestar 2	1094-22134	B/96	Unk	Chick	Yes	Yes	23-May-18	2018
Corn	Corn	1094-67707	A/77	F	Adult	Yes	Yes	28-Jun-18	2018
RJER Active Translocation									
Brown Field	Gravel Lot --> Cage 1	1004-15514	07/X	F	Adult	Yes	Yes	26-Feb-18	2013
Brown Field	Gravel Lot --> Cage 1	0804-19707	27/Y	M	Adult	Yes	Yes	26-Feb-18	2015
Brown Field	Tripad North --> Cage 2	1094-22097	A/90	F	Adult	Yes	Yes	26-Feb-18	2018
Brown Field	Tripad North --> Cage 2	1094-22069	A/80	M	Adult	Yes	Yes	26-Feb-18	2017
RJER	Cage 2	1094-22191	B/21	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 2	1094-22192	B/32	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 2	1094-22193	B/43	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 2	1094-22194	B/54	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 2	1094-22195	B/65	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 2	1094-22196	B/76	Unk	Chick	Yes	Yes	7-Jun-18	2018
Brown Field	Tripad East --> Cage 3	1004-15568	30/Y	F	Adult	Yes	Yes	1-Mar-18	2015
Brown Field	Tripad East --> Cage 3	1094-22023	A/39	M	Adult	Yes	Yes	20-Feb-18	2017
Brown Field	Tripad North --> Cage 4	1094-22021	A/36	F	Adult	Yes	Yes	6-Mar-18	2017
Brown Field	Tripad North --> Cage 4	1094-22102	A/54	M	Adult	Yes	Yes	6-Mar-18	2018
RJER	Flight School --> Cage 5	1094-22003	A/42	F	Adult	Yes	Yes	6-Mar-18	2018
RJER	Flight School --> Cage 5	1094-22101	A/57	M	Adult	Yes	Yes	5-May-18	2018
RJER	Cage 5	1094-22185	B/06	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 5	1094-22187	B/17	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 5	1094-22188	B/28	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	Cage 5	1094-22189	B/39	Unk	Chick	Yes	Yes	7-Jun-18	2018

Site	Family / Capture Burrow	USGS Band	Aux Band ID	Sex	Age (2018)	2018 Capture?	2018 Genetics?	Date Captured	Year Banded
RJER	Cage 5	1094-22190	B/50	Unk	Chick	Yes	Yes	7-Jun-18	2018
RJER	AB5C (AB5S renest) (Cage3_4renest)	1094-22198	None	Unk	Chick	Yes	Yes	15-Jun-18	2018
RJER	AB5C (AB5S renest) (Cage3_4renest)	1094-22199	B/51	Unk	Chick	Yes	Yes	15-Jun-18	2018
RJER	AB5C (AB5S renest) (Cage3_4renest)	1094-22200	B/98	Unk	Chick	Yes	Yes	15-Jun-18	2018
RJER	AB5C (AB5S renest) (Cage3_4renest)	1094-67701	B/87	Unk	Chick	Yes	Yes	15-Jun-18	2018
RJER	AB5C (AB5S renest) (Cage3_4renest)	1094-67702	B/66	Unk	Chick	Yes	Yes	15-Jun-18	2018