Lower Colorado River
Multi-Species Conservation Program

Balancing Resource Use and Conservation

Annual Report on the Elf Owl Detectability Study, 2010

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

August 2011

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Lower Colorado River Multi-Species Conservation Program

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ABSTRACT

Much of the project area for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) lies within the historic range of the Elf Owl (*Micrathene whitneyi*). Elf Owls were greatly reduced within the Lower Colorado River valley during the 20th century as a result of development, water diversion, and loss of riparian gallery forest (Halterman et al. 1989, Rosenberg et al. 1991). Recently, however, the LCR MSCP has begun to recover riparian vegetation along the Lower Colorado River, with the intent of creating habitat for Elf Owls and other covered species. To date, only one Elf Owl has been detected in the LCR MSCP project area during call-broadcast surveys, near Blankenship Bend in 2009 (Beth Sabin, *pers. comm.*). It remains unclear whether this rarity of detections is reflective of the actual rarity of Elf Owls, or is instead a result of inadequacies in the call-broadcast survey methods, low responsiveness of the species to call broadcasts (at least under some conditions). This two-year study addresses the need to evaluate and optimize the call-broadcast survey protocol by systematically testing the responsiveness of Elf Owls to call broadcasts as a function of different survey parameters, namely time of night, illumination, and distance between the call broadcast location and the owl. The nearest known Elf Owl population to the LCR MSCP project area occurs in the Bill Williams River NWR, where we conducted our study. We systematically tested the responsiveness of seven owl pairs found nesting in saguaro cacti located along the edge of the riparian corridor. We found that Elf Owls were highly responsive during the dusk-to-23:00 and 23:00-to-01:00 survey periods (80-100% percent of birds responded to call broadcasts), but they were less responsive during the two-hour predawn period. Responsiveness did not vary among the three tested distances (100 m, 250 m, and 450 m). Distances greater than 450 m were not evaluated, as the hearing acuity of human observers listening for a response begins to decrease enough to affect survey results. Interestingly, responsiveness appeared to be lowest during the gibbous (three-quarter) moon phase, but additional data are needed to clarify any responsiveness patterns related to illumination. During the project's second field season in 2011, we will place additional emphasis on finding and testing owls nesting within the riparian woodland interior, increasing our overall sample size for responsiveness trials, and providing additional information on home range sizes and other natural history information of the species. Our final recommendations for effective surveying and inventory of Elf Owls in or near the LCR MSCP riparian corridor will be based on both years of data collection. These final recommendations will specify the parameters of an optimized call-broadcast survey protocol, and provide estimated detection rates associated with the tested parameters.

INTRODUCTION

The "American Recovery and Reinvestment Act of 2009 Elf Owl Studies" project (hereafter "Elf Owl Detectability Project") was initiated in 2010 as part of the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). This report summarizes the methods and the findings of the first of two field seasons, which occurred in March – May 2010.

The LCR MSCP is "a long-term plan to conserve at least 26 species along the Lower Colorado River from Lake Mead to the Southerly International Boundary with Mexico through implementation of the Habitat Conservation Plan" (BOR 2006, p. 4). Much of the project area for the LCR MSCP lies within the historic range of the Elf Owl (*Micrathene whitneyi*). Elf Owls are small, insectivorous, nocturnal, migratory birds that nest in cavities excavated by other species, primarily woodpeckers (Henry and Gehlbach 1999). Although Elf Owls use some upland habitats that provide suitable nesting opportunities, particularly where saguaro cacti are present, the species also once occupied the riparian woodlands of the Colorado River system. Elf Owl populations along the river were greatly reduced during the 20th century as a result of water diversions, invasive plants, and development (Halterman et al. 1989, Rosenberg et al. 1991, Reclamation 2008). As a result, the Elf Owl is a covered species under the LCR MSCP, and under the program large patches of riparian woodlands are being created that may promote the return of riparian Elf Owls (BOR 2006).

Call-broadcast surveys conducted during the breeding season are the standard method used for detecting presence and estimating densities of Elf Owls (Boal and Bibles 2001). Elf Owl call-broadcast surveys were conducted in the LCR MSCP project area in the mid-2000s, and produced no detections of the species except a single owl that was detected near Blankenship Bend in 2009 (Beth Sabin *pers. comm.*). However, interpreting the lack of detections is problematic because responsiveness of riparian populations to call-broadcast surveys has not previously been studied. In order to determine whether LCR MSCP habitat creation projects benefit this species, it is important to be able to measure responsiveness of riparian Elf Owls to call broadcasts under controlled conditions, and to translate rates of responsiveness to species detectability estimates. In this report, "responsiveness" is used to refer to whether or not a given owl responds to call broadcasts. "Detectability" refers to the likelihood that Elf Owls, if present in a survey area, will be detected when implementing a particular call-broadcast protocol.

The primary goal of this project is to determine the effectiveness of call-broadcast surveys in the LCR MSCP environment by measuring Elf Owl responsiveness under controlled conditions, and to optimize the survey protocol to maximize overall detectability. Our approach included first determining Elf Owl locations and delineating approximate territories through area searches and initial call-broadcast surveys, and then subjecting these owls to different call-broadcast scenarios to record their responses. Within this study, key elements of the call-broadcast protocol, such as distance to bird and time of night, were systematically varied to determine their relative impact on responsiveness. The Bill Williams River National Wildlife Refuge (hereafter, refuge) was selected as a study area for this project because Elf Owls have been documented there in recent years, and because it contains large expanses of riparian woodland that approximate the historic conditions of the LCR MSCP riparian corridor.

The main goals identified for the Elf Owl Detectability Project are as follows:

1) Systematically quantify how distance, time of night, and habituation affect the responses of Elf Owls to call broadcast surveys
2) Recommend an optimized survey protocol, including the number of seasonal surveys and long-term survey effort
3) Quantify the overall likelihood of detection of the species (when present) if the recommended methods are implemented

Secondary goals included providing Reclamation with better information about Elf Owl home range, activity patterns, and habitat use within the study area.

During the first year of the project, we accomplished a significant subset of these goals. Most notably, the effects of distance and time of night on responsiveness were systematically tested, habitat use observations were collected, and a provisional optimized survey protocol was created. Further testing during year two will be required to refine and expand these findings.

METHODS

Study Area

Based on discussions with other researchers and agency personnel, we learned that an Elf Owl population was present in the Bill Williams River National Wildlife Refuge (Fig. 1) as recently as 2008. This population was chosen for the study because it is the nearest known population to the LCR MSCP project area, and because the riparian habitat in the refuge is comparable in many respects to historic riparian habitats in the LCR MSCP project area. Our study was conducted mostly on the western portion of the refuge, closest to the confluence with the Colorado River, but some work was conducted as far east as the Mineral Wash and the Planet Ranch access roads.

The refuge has a wide floodplain dominated by cottonwoods, willows, and tamarisk, bordered by a narrow band of riparian-influenced “uplands” containing mesquite, saguaro cactus, and other vegetation typical of Sonoran/Mojave interface. The hydrology of the Bill Williams River is controlled by Alamo Dam, and significant flooding can occur during dam releases.

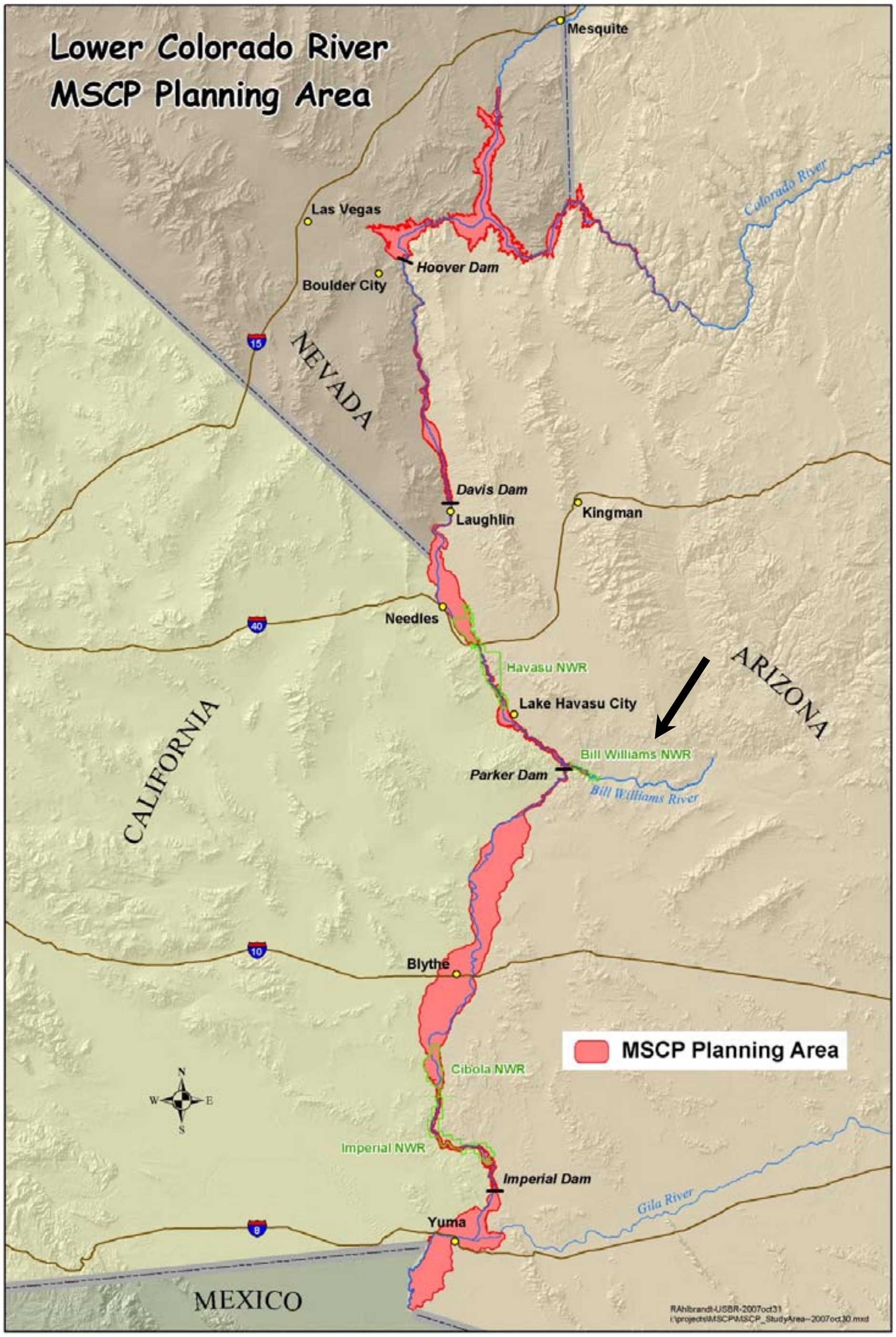

Figure 1. Location of the LCR MSCP project area (in red). The Bill Williams River NWR is indicated by the black arrow.

Study Plan

Field work occurred from 1 March – 2 June, 2010, a period that coincided with the Elf Owl's arrival on the refuge, territory establishment, mating, and the beginning of the incubation period.

The study protocol followed during the 2010 field season included:

1) Prepare, mark, and map a network of survey routes within and adjacent to the refuge's riparian zone

2) Perform passive listening and call-broadcast surveys along these survey routes to inventory Elf Owls and determine their nesting sites, territories, and/or activity centers

3) Capture and radio-tag Elf Owls to make preliminary observations of activity patterns and home range sizes, and to further pinpoint nest cavity locations and confirm pair behaviors

4) Conduct systematic responsiveness trials on owls in well-delineated locations using different combinations of distance and time of night

5) Calculate preliminary detectability rates for different call broadcast protocols

All data sheets used in the 2010 season of the Elf Owl detectability study are presented in Appendix 1. In order to systematically test responsiveness and explore the parameters that may cause it to vary (step #4), it was necessary to know the initial location of an individual owl before attempting to elicit its response with call broadcasts. We originally planned to pinpoint owl locations by using telemetry observations on radio-tagged birds. However, the small transmitters suitable for Elf Owls produced relatively weak transmissions and we discovered that they were subject to considerable signal bounce and attenuation, given the dense riparian vegetation and the presence of cliffs and rock outcrops. Thus, obtaining reliable position estimates by telemetry, while possible, would require multiple signal receptions per bird and substantial travel through difficult terrain causing bird disturbance, which reduces the practicality of telemetry for conducting controlled responsiveness tests in this particular study site.

For this reason, we explored alternatives for localizing owls for responsiveness testing. During preliminary surveys and thorough observations (step #2), we determined that once territories were established, owls were nearly always located within 50 m of their nest cavity, and often much closer. Therefore, simply knowing the location of a nest cavity gave us precise enough knowledge of an owl's position for our responsiveness testing regime. Additionally, presumed owl locations were confirmed during the responsiveness tests by using a second passive observer located close to the bird's presumed location (see below).

Preliminary Surveys

Because of the dense vegetation that characterizes the refuge's floodplain, a system of owl survey trails was prepared by clearing enough vegetation and downed wood to allow passage of surveyors. This trail system was designed to pass through habitat known to be suitable for Elf Owls based on previous surveys and published literature. To the extent possible, we used trails that had been previously prepared and marked during other research activities. However, several trail segments required additional clearing and marking, which was performed in accordance with requirements established by refuge personnel. Survey listening stations were established and marked at 50 m intervals.

Preliminary surveys to locate Elf Owls consisted of both passive listening and call-broadcast surveys conducted along this trail system. Passive listening surveys were conducted first, in order to minimize interference in the critical mate selection process in the early part of the breeding season. These passive surveys were performed by stopping for 3 minute periods at each listening station along a given trail segment. Surveyors listened quietly during this period and recorded the direction and estimated distance from which any Elf Owl vocalizations were heard.

Call-broadcast surveys were conducted after the initial round of passive listening surveys. At every third station (i.e., in 150 m intervals), 10 seconds of recorded Elf Owl chatter calls were played (consisting of 4 sequential call repetition cycles that were projected in each of the four cardinal directions), followed by a 50 second listening period. This cycle was repeated two additional times from the same location. Three minutes of passive listening was conducted on each intermediate (50 m interval) station. Call-broadcast equipment consisted of a small MP3 player attached to a pair of battery-operated Radio Shack clamshell speakers. At maximum volume, this system produced an average sound output of 65-70 db as measured by a handheld decibel meter located 1 m from the speaker. This output level was chosen for several reasons: 1) based on a literature review, it fell within the range of vocal output levels (60 – 80 db) measured for a variety of small owls (Western Screech-Owl *Megascops kennicottii* and Burrowing Owl *Athene cunicularia*), 2) our observers felt that it approximated the observed call output level of Elf Owls in the study area, and 3) louder calls may draw in birds from greater distances, complicating interpretation of findings and potentially causing greater disruption to breeding attempts. Some surveys (for example, Hardy et al. 1999) have used higher broadcast outputs (100-110 db) that clearly exceed natural owl vocalization volumes, but we chose lower levels for the above-mentioned reasons. Normal Elf Owl vocalization output levels will be directly measured in the field in 2011 to confirm this rationale.

Territory and Nest Site Determination

For each Elf Owl that was detected during the initial surveys, additional passive surveys that included dusk-emergence observations were conducted in the detection area over a period of several nights to localize that bird's nest cavity or center of activity, delineate its general area of activity, and determine whether a mate was present. In the case of radio-tagged birds (see below), telemetry was also used to help make these determinations.

Capture and Radio-Tagging

Radio-telemetry was primarily used to localize birds for the purposes of responsiveness testing (below), but we also deployed radio-tags to gather additional information on nest cavity locations, extent of owl movements, habitat use, and approximate home ranges.

For each capture attempt, a pair of mist nets (38 mm mesh size, 4-tier design, 12 m and 9 m in length) was installed before dark in a favorable location near a known owl nest cavity site. The nets were opened 30 minutes after dusk. Two speakers were placed on either side of the nets, and connected by extension cords to an MP3 player that was operated from a concealed location. This mist-netting technique was modified from methods used to capture Willow Flycatchers (*Empidonax traillii*; Sogge et al. 2001). When an owl was captured, it was removed from net, processed to obtain standard morphometric measurements, and fitted with a standard aluminum USFWS-issued bird band. Feathers in the interscapular zone (area of approximately 1 cm x 0.5 cm) were clipped to stubble length, the area was cleaned with an alcohol swab, and a small (ATS model A2445, less than 3% of adult body weight) glue-on radio transmitter was affixed to this area using cyanoacrylic glue. Two secondary tail feathers were collected for sex determination (Henry and Gehlbach 1999), and the owl was released. All transmittered birds were followed by passive observation and telemetry for at least 20 minutes after release to confirm their post-procedure status. All birds recovered from the procedure and appeared to be behaving normally by the end of the post-procedure observation period.

Telemetry

Radio-tagged owls were monitored periodically using telemetry receivers. The telemetry efforts were conducted on an ad-hoc basis, as opportunities arose during the course of the other field work. An exception to this general approach occurred for some birds that were tagged before their nest cavities and/or breeding status had been determined. In these cases, telemetry efforts were more systematic until nest cavity locations and mating status were confirmed.

Responsiveness Testing

Once each pair's nest cavity site or activity center was determined, formal responsiveness experiments were conducted. We chose to design these experiments to focus first on the effects of distance from the call-broadcast station to the bird and on effects of time of night. Distance to bird is a particularly critical parameter for detectability studies in that increasing distance is expected to lessen the likelihood of an owl response. Increasing distance also reduces the ability of the surveyor to hear a response. Therefore, we selected three different call-playback distances to test, 100 m, 250 m, and 450 m. The maximum distance was chosen because in our preliminary tests, this was the greatest distance at which a cross-section of typical observers could reliably hear our call broadcasts (which were approximately the actual volume of natural Elf Owl vocalizations, see above) under a range of natural conditions. We also divided the night-time hours into three periods, Dusk (30 minutes after sunset until 23:00h), Midnight (23:00-01:00h), and Predawn (0300h until 30 minutes before sunrise).

An experimental matrix was constructed whereby each owl (or pair of owls within each territory) was tested for each combination of distance and time of night. The order in which each permutation of distance and time was tested varied randomly among the owls tested, to prevent habituation effects from possibly biasing the results. No owl was subjected to responsiveness trials on sequential nights. All tests on a given bird were therefore conducted at least two days apart, and more often 3-4 days apart.

Each responsiveness test was conducted by a pair of researchers working together, one termed the “broadcast surveyor” and the other the “passive observer”. The passive observer quietly approached to within 25 m of the previously-determined activity center prior to the responsiveness test and took up an unobtrusive listening station. By passive listening, this observer could confirm that the owl was present at, or very near, its expected location (in the few cases where this could not be confirmed, the test was discontinued and repeated another time). The passive observer was thus able to detect responses to call broadcasts that may not be detected by the more distant broadcast surveyor. At a predetermined time, the broadcast surveyor, located at the correct experimental distance as determined by GPS, conducted the standard call broadcast protocol of four cycles, each consisting of 10 seconds of chatter calls followed by 50 seconds of listening. This was followed by another 11 minutes of passive listening. Volume parameters were the same as used for the initial surveys, and the call broadcasts consisted of the Elf Owls “short chatter”, described below. Both the broadcast surveyor and passive observers recorded the vocal responses of owls during this period. The passive observer was also able in most cases to note and record owl movements, especially when owls were vocal.

RESULTS

Timeline

Table 1 describes the timeline of major 2010 study activities.

Table 1. Timeline for major activity categories in 2010.

Activity	*Time Frame*
Survey routes cleared and marked, and survey stations way-pointed	March 1 - 22
Initial surveys to detect Elf Owls and additional monitoring to determine nest sites and/or activity centers	March 21 – May 12
Trapping attempts and radio-tag deployment	April 1 – 22
Responsiveness tests	9 April – 2 June

Preliminary Surveys and Territory Mapping

Unusual flooding occurred along the Bill Williams River throughout most of March, which greatly reduced access to most of the floodplain interior. As such, the survey trail system (Fig. 2) was first established in the more accessible areas along the margins of the floodplain. As flooding receded, additional trail segments were added within the flood plain interior.

Figure 2. Elf Owl survey points and trails in the Bill Williams River NWR in 2010. Each trail segment received at least two preliminary surveys.

The preliminary survey effort involved both passive listening surveys and call-broadcast surveys. Passive-listening surveys were initially used on all survey trails to detect Elf Owls. On survey route segments where no owls were detected during these passive-listening surveys, we began using call broadcasts in late March. Efforts to detect new birds continued until 12 May, although all of the owls that were ultimately subjected to responsiveness tests had been initially located before 20 April.

Initial detections during preliminary surveys most often involved males in the process of vocalizing spontaneously or responding to call broadcasts. In areas where an owl was detected during preliminary surveys, more focused follow-up efforts were made to determine mating status, territory establishment, and center of activity and/or the nesting cavity site. These follow up efforts involved a combination of additional passive and/or broadcast surveys, coupled with dusk emergence observations which were especially helpful in determining cavity locations. In addition, telemetry was used on a subset of tagged owls to help determine cavity locations and activity centers.

At least 12 different owls were detected during preliminary surveys. Of these, five owls that were initially heard in the Borrow Pit area and the NE portion of Fox Wash could not be re-located in follow-up surveys and have likely moved to other areas to establish territories. The remaining seven birds were ultimately successful in becoming mated and establishing territories in the study area (14 owls in all; Fig. 3). These seven territories were given place names that served to identify each nesting pair (Table 2). Although a substantial proportion of the survey trails were located within the riparian woodland interior, all seven of the established territories were located within 30 m of the riparian woodland edge. For six of these territories, the main nest cavity was either confirmed or strongly suspected in a saguaro cactus (see “Detailed Notes on Nest Sites and Male Roost Sites”, below). In three cases, the known or presumed nest cacti were located just outside the riparian woodland edge. Three others were located just inside the woodland edge, or within the narrow riparian-upland transitional zone. The nest cavity for the seventh territory was not precisely located, but was narrowed down to a small area containing both saguaros and mesquite trees.

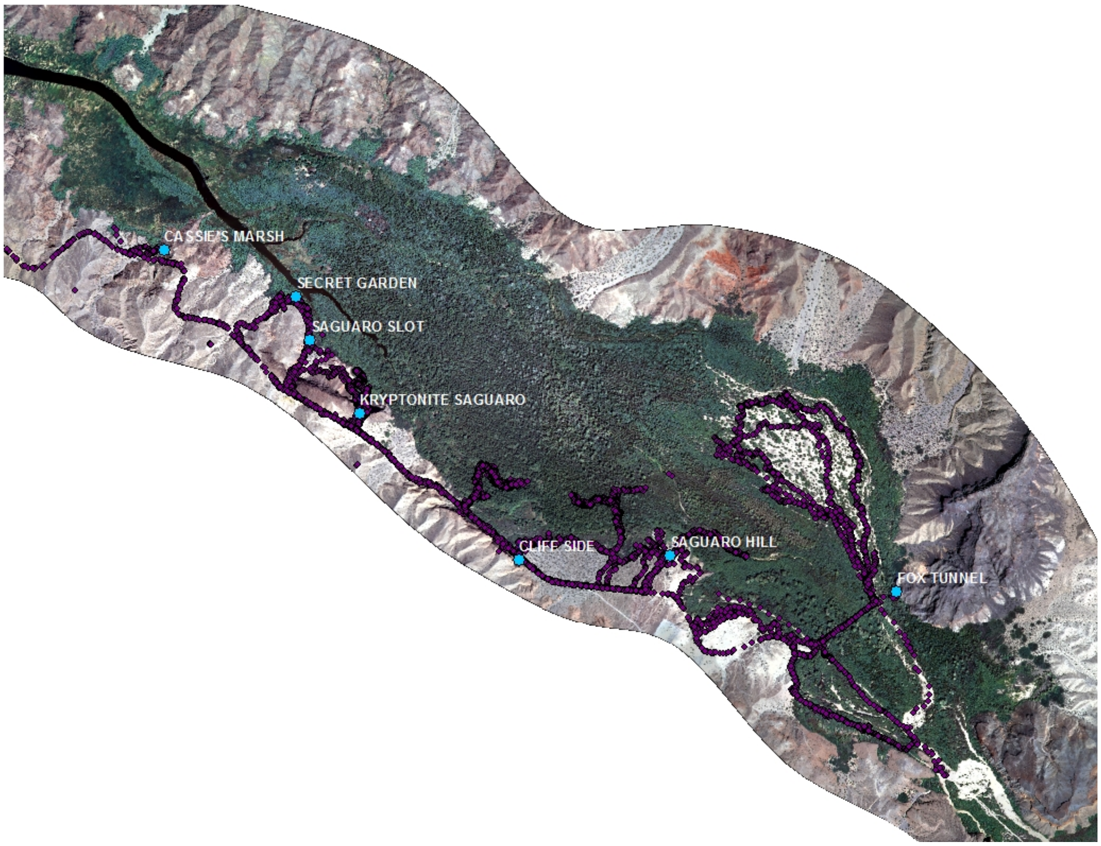

Figure 3. Location of nest sites or centers of activity (blue dots) for Elf Owls in relation to survey trails (red dots) in 2010.

Table 2. List of named Elf Owl territories, and corresponding abbreviations.

Territory name	*Abbreviation*
Cassie’s Marsh	CM
Secret Garden	SG
Saguaro Slot	SS
Kryptonite Saguaro	KS
Cliffside	CS
Saguaro Hill	SH
Fox Tunnel	FT

The SH, CS, SS, and KS Elf Owl pairs (Table 2) were found using passive listening surveys. The SG pair was initially detected by passive listening, but needed to be confirmed using call broadcast. The CM and FT pairs were found using call-broadcast surveys.

In the process of determining activity centers and cavity locations by means of follow-up surveys, dusk emergence observations, and telemetry, we were able to confirm that owls nearly always remained within 50 m of their cavity site or activity center. This corresponds well to Ligon's (1968) observation that Elf Owls have small home ranges during the nesting period, and that their forays away from the nest site appear to be brief.

Vocalizations

Several distinct types of Elf Owl vocalizations were heard during the study, as summarized below. They were initially assigned to different sexes based on published literature (Henry and Gehlbach 1999).

Chatter: A series of rising and then descending notes made by males.

Short Chatter: The most common response to call broadcasts, occurring in ~ 90% of all cases. The series usually includes about 5 notes repeated at 3-5 second, sometimes longer, intervals.

Long Chatter: A long series of notes, seemingly in more agitated males. The long chatter is more common in some individuals than others. May alternate with the short chatter.

Gurgle: A quick succession of gurgling notes heard exchanged between mated birds, sometimes prior to a chatter, but more often at the end of a series of chatters. Often heard as a prelude to chatter responses to call broadcasts, and also during evening emergence from the nest cavity. It is also possible that mates gurgle during an exchange at the nest.

Bark: A single hard note, reminiscent of a dog bark, made by males. This vocalization tends to occur when a male is investigating an intruder into his territory.

Peeu: A high-pitched descending note, made by females, usually in response to male chatter calls.

Scold: High pitched notes (with a "whiney" quality), made more often by females than males, and the most common female response to call broadcasts or territory intrusions. Scold notes can be made singly but are more commonly a series of 3-5 notes.

Nest Sites and Male Roost Sites

Nest cavity sites were found by narrowing down owl locations with repeated passive listening, and by making nest emergence observations at dusk. This process was generally straightforward because territories were small and contained only a few possible nest substrates. Sunset telemetry efforts on radio-tagged birds were also useful for confirming nest cavity locations. In saguaros, the nest cavity was usually the highest or second highest observed cavity in the plant.

Sex of birds could not be determined visually, but was often apparent based on vocalizations (see above) or behavioral context (see Henry and Gehlback 1999 and Ligon 1968). For instance, males are known to roost during daylight in a location other than the nest cavity. Thus, the bird first emerging from the nest cavity at dusk can be assumed to be the female. During the nesting season, females appeared to spend more time in the nest cavity than males, although we did not collect a detailed activity budget to substantiate this impression. Males periodically relieved females, however, occupying the cavity while females engaged in short foraging bouts. For much of the night, males were stationed at the same roost site within 50 m of the nest cavity. They usually returned to this roost site after foraging bouts, or after making forays to investigate surveyors or observers.

During the daytime, telemetry observations indicated that females were generally in the nest cavity, whereas males were usually at a distinct day-roost site. The day-roost sites of males were often located inside riparian woodlands, where cover was denser than in the uplands, but always within 50 m of the nest cavity.

Observations regarding specific nest and roost sites were as follows:

> At Saguaro Hill, owls were initially detected by passive surveys, and the nest cavity was confirmed by nest emergence observations. One owl of this pair was radio-tagged, probably the female, as the signal came from the nest cavity saguaro during the day. Passive observations and nest emergence observations indicated that the male of this pair had its main roost site within the riparian woodland nearby.
>
> At Cliff Side, we initially detected a single male during passive surveys that called from a saguaro along the road. This bird was consistently chattering for long periods (> 1 hour as determined by direct observation), and even after being disturbed, it quickly resumed vocalizations. Eventually this bird succeeding in securing a mate, and the nest cavity location was confirmed to be in the same saguaro. Both the male and female were captured by mist netting near the saguaro during an apparent nest attendance exchange. The roost site of the tagged male was subsequently located in mesquite patch 50 m from the nest site, in the riparian transition zone. The female was usually located in the nest saguaro during telemetry observations. Several nest-attendance exchanges were observed, some passively and some using telemetry, during which the male emerged from its

roost site, vocalized, flew to the nest saguaro, and then chattered at the nest site. After the exchange, the female was heard scolding while away from the nest saguaro.

The Kryptonite Saguaro owls were initially detected during passive surveys, and the territory was delineated with nest emergence observations and passive listening. The observations suggested that the nest cavity was located somewhere within a small mesquite patch, but because neither of these birds was radio tagged, the nest cavity itself was not located. The male roost site was located 50 m from nest area. Although a large saguaro was available within the territory, no flights to or from the saguaro were ever observed.

The Saguaro Slot pair was detected when they scolded at surveyors who entered their territory during a passive survey. The nest cavity was confirmed in a saguaro by nest emergence observations. One of these birds was captured and radio-tagged. This bird was probably a male, as its signal was often detected in a dense willow/tamarisk daytime roost site within the riparian corridor, at a distance of ~ 30 m from the nest site. This transmitter was lost within the nest cavity at some subsequent point.

At Secret Garden, owls were detected by passive listening during nest emergence and confirmed with call broadcast surveys. Both the male and female were caught and radio-tagged. The nest cavity was confirmed in a saguaro by nest emergence and telemetry. The male's roost site was located within 15 m of nest, but could not be precisely located due to dense vegetation.

At Cassie's Marsh, owls were detected with call broadcasts. Nest emergence observations were not successful, so the precise nest location could not be determined, although it was likely in one of two saguaros. Male vocalizations were heard mostly from a saguaro (the likely nest site) and from a mesquite patch near the road, which was a possible roost site. The female of this pair rarely vocalized. Neither bird was captured for radio-tagging.

The Fox Tunnel owls were detected with call-broadcast. The nest cavity in a saguaro was confirmed with nest emergence observations. Neither bird was captured or radio-tagged, and further observations did not reveal a likely roost site location.

Responsiveness Testing

To systematically test responsiveness of Elf Owls to call broadcasts, a series of tests were conducted using different combinations of distance from bird and time of night, as described in the Methods section. In practicality, these were primarily tests of male responsiveness, as males are more likely to vocalize in response to call playbacks. Female responses were recorded as well on some occasions, but for the purposes of determining overall detectability of the species during the breeding season, a focus of male responsiveness is warranted. Table 3 shows the experimental matrix for the responsiveness tests, and the dates on which each test was conducted. Early in the testing process, it became apparent that Elf Owls reliably responded to call broadcasts at the shortest testing distance (100 m). Therefore, completion of the planned tests for this shorter distance were de-prioritized to ensure that all tests for the intermediate (250 m) and longer (450 m) distances could be completed. At Kryptonite Saguaro (KS), however, the local topography did not allow us to conduct a test at the longest distance.

Table 3. Testing dates in 2010 for different permutations of distance to bird (100, 250, and 450m). O = permutations that were omitted, as explained above. X = permutations that could not be tested, as explained above.

Pair	*Dusk 100m*	*Dusk 250m*	*Dusk 450m*	*Mid-Night 100m*	*Mid-Night 250m*	*Mid-Night 450m*	*Predawn 100m*	*Predawn 250m*	*Predawn 450m*
CM	O	6/2	5/28	O	5/5	5/8	5/2	5/12	5/19
SG	4/26	5/13	5/28	5/31	5/18	5/10	O	5/1	5/6
SS	4/9	5/4	5/20	4/19	5/8	5/27	4/12	5/18	5/12
KS	5/19	5/12	X	5/5	5/28	X	5/1	5/9	X
CS	4/26	5/29	5/7	O	5/11	5/4	5/2	5/19	5/23
SH	O	5/13	5/20	5/31	5/10	5/27	5/1	5/18	5/6
FT	5/6	5/30	6/2	O	5/11	5/19	O	5/23	5/28

The points for responsiveness-test broadcasts were selected along a concentric rings of the appropriate radius, as shown in Figures 4 and 5. The specific points chosen were based on accessibility and absence of unusual features (most often rock outcrops) that might have influenced responsiveness distance. Each point was selected so that the line between surveyor and bird did not transect any rock outcrops or other topographic features, nor particularly dense clumps of vegetation, as these may influence detectability distance.

A total of 53 responsiveness tests were performed on the dates shown above in Table 3. Six additional tests were initiated, but aborted or discounted because audible wind conditions (> 12 km/h sustained) were present. Positive Elf Owl responses to call broadcasts were detected by the broadcast observer in 47 of the 53 tests.

With regard to effect of time of night on Elf Owl responsiveness, five of the six non-responses occurred during the pre-dawn survey period, as shown below in Table 4.

Table 4. Results of responsiveness tests by time of night, shown as # positive responses / # trails (percent positive responses).

Dusk	*Mid-Night*	*Predawn*
17/18 (94%)	17/17 (100%)	13/18 (72%)

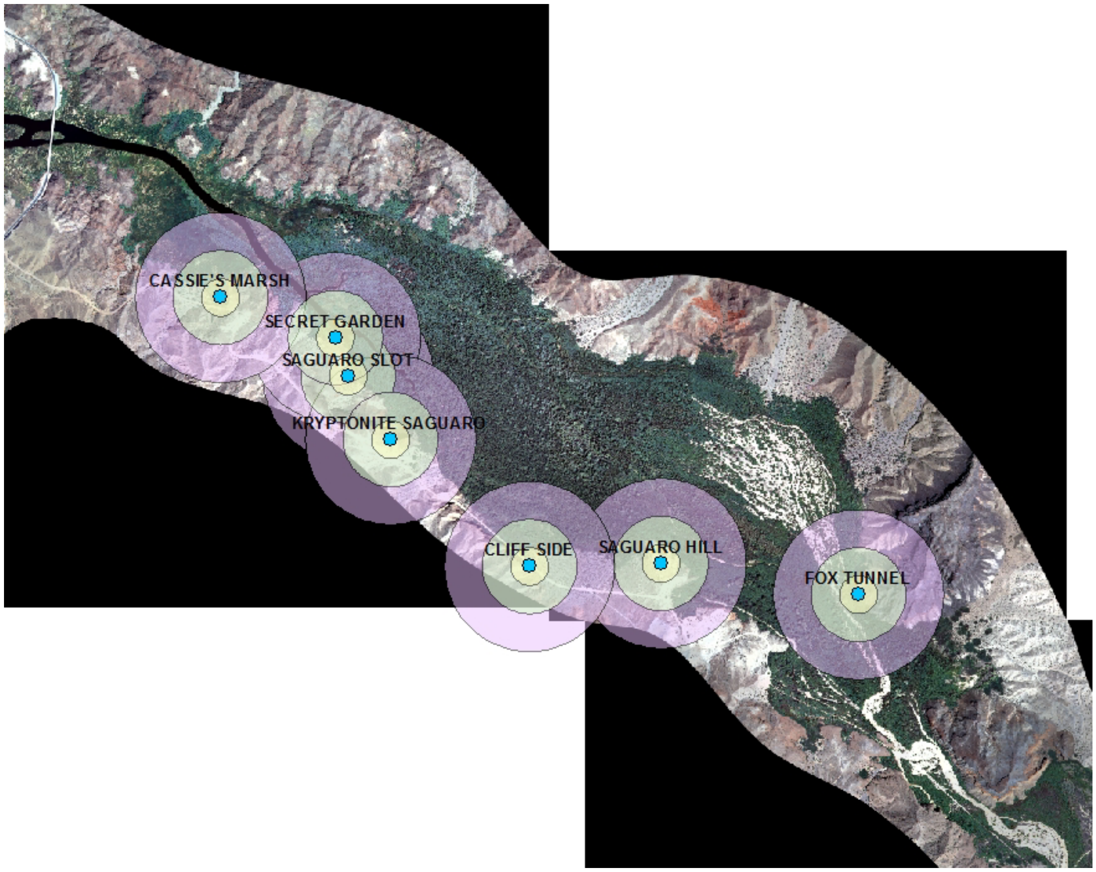

Figure 4. Responsiveness test distance zones corresponding to 100m, 250 m, and 450 m distances from Elf Owl nest sites or activity centers.

With regard to distance to bird, there was almost no difference among the three distances tested with regard to responsiveness, as shown in Table 5.

Table 5. Results of responsiveness tests by distance to bird, shown as # positive responses / # trails (percent positive responses).

100 m	*250 m*	*450 m*
12/14 (86%)	19/21 (90%)	16/18 (89%)

For all six non-responses recorded by the broadcast surveyor, the passive observer also noted non-responses, showing that the lack of responsiveness was real and not the result of inability of the surveyor to detect a positive response.

The six non-responses occurred on dates ranging from 2 May to 2 June, nearly the entire seasonal span of the responsiveness testing. Therefore, based on this first year of data collection, we found no evidence of seasonal effects on likelihood of response within the time span of our surveys.

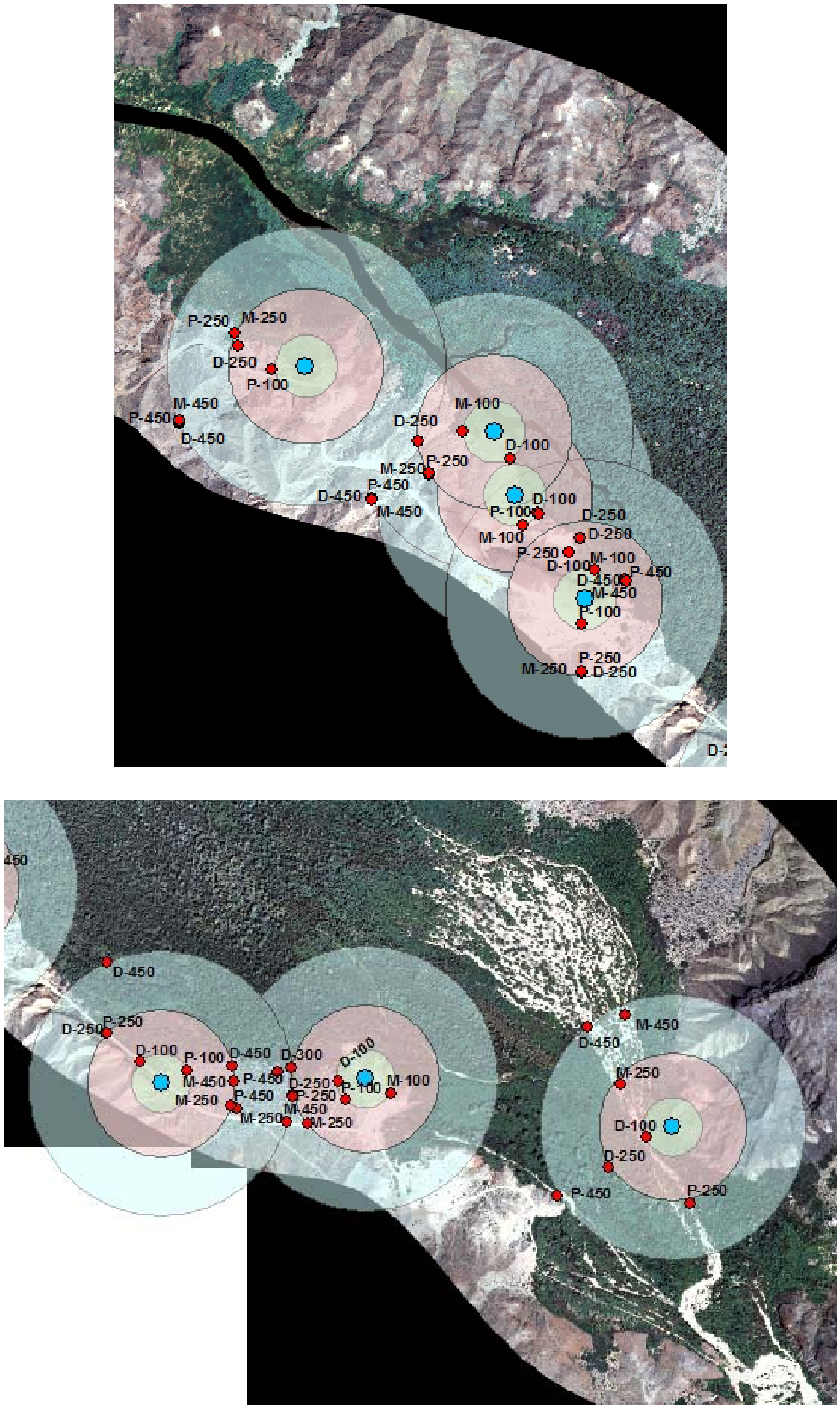

Figure 5. Locations of points from which call broadcasts were played during responsiveness tests. The west half of study area shown above, and the eastern half below. In each label, the prefix indicates time of night (D = Post-Dusk – 11 pm; M = 11 pm – 1 am; P = 3 am – Pre-Dawn) and the suffix indicates distance (in meters).

Although the responsiveness tests were not initially designed to investigate moon phase, these data were also collected and examined as a possible explanatory variable. Curiously, all six non-response outcomes occurred during periods of the gibbous (three-quarter) moon, as shown in Table 6.

Table 6. Results of responsiveness tests by moon phase, shown as # positive responses / # trails (percent positive responses).

Full	*Gibbous*	*Half*	*Quarter*	*New*
8/8 (100%)	11/17 (65%)	12/12 (100%)	14/14 (100%)	2/2 (100%)

Most of the detected responses came from males as either chattering or scolding calls. Females were less likely to respond vocally than males, but they did sometimes respond by quietly flying closer to the call broadcast to investigate, followed by scolding or peeuing vocalizations. In nearly every case where a positive response was recorded, the owl began responding during the four minute period while call-playbacks were being broadcast.

Capture and Radio-Tagging

Six owls were captured and radio-tagged over the course of seven nights of netting attempts. Netting attempts at the SG and CM territories failed, presumably because the nets were too visible in bright conditions. In these cases, owls approached the speakers and nets, but clearly avoided the nets themselves. Chatter and peeu calls appeared to be the most effective at drawing birds to the net, while scold calls were less effective. Although owls began responding to call broadcasts very quickly, it sometimes required an extended broadcast period before they could be lured into the net. All owls that were captured and radio-tagged flew strongly after release and resumed their pre-capture behaviors within a short period of time.

Telemetry

Telemetry observations were made on birds on an ad hoc basis depending upon other field work priorities. We used telemetry primarily to locate or confirm the location of nest cavities and male roost sites. Our first year of telemetry data were not sufficient to compute home ranges, but we usually detected birds within ~ 100 m of the nest site or activity center, although more extended forays (up to 400 m), often as a result of an owl investigating an observer or a call broadcast were occasionally noted.

The effective range of the radio transmitters used in this study was 120 m in unobstructed conditions, but much less in conditions where large rock outcrops, cliffs, or mixed topography affected the radio signal. The glue-on transmitters were poorly retained, and usually detached from the bird within a week. Therefore, other attachment methods need to be considered. Nonetheless, mist-netting and telemetry were very useful for determining nest cavity and roost site locations, for providing information about likely sex of the bird based on behavioral patterns, and for detecting movements made without vocalization.

Other Behavioral Observations

Responses to Observers

Elf Owls appear to follow observers silently through their territory in some cases, only scolding when they become agitated. If the observer remains near a nest for an extended period, the scolds may shift to chatters.

Seasonal Behavior

Males spontaneously chatter repeatedly and for long periods to attract mates or defend territories. After mating, spontaneous vocalizations still occur, but at a reduced frequency.

Emergence

Emergence from nest cavities and roost sites occurs shortly after sunset. Typically, emergence is followed by a nest-attendance shift between the mates, in which the male approaches the nest cavity, and after exchanging some vocalizations, takes the female's place in the cavity as she departs for a presumed foraging bout. In at least one observed instance, the male delivered food to the nest cavity at the nest-attendance shift.

DISCUSSION

As 2010 was the first year of the Elf Owl detectability study, our conclusions at this time are provisional and contingent upon the collection of a second year of field data. With this caveat, however, we found that Elf Owls were very responsive to call-broadcast surveys at all distances tested, provided that wind conditions are relatively calm, no major obstructions are between the bird and the broadcast system, and ambient noise levels are low. Responsiveness was high during the early and middle parts of the night, but was somewhat reduced in the pre-dawn hours, possibly as a function of lower temperatures. Interestingly, responsiveness was lower during periods when the moon was in its three-quarter phase than during other moon phases, a possible relationship that needs to be explored further during the second year of the study. We have no ready explanation for this phenomenon, but it does not appear to be attributable to seasonality based on the distribution of non-responses throughout the season.

Based on our findings to date, our preliminary recommendations for an Elf Owl survey protocol include:

1) Call broadcasts should consist of chatter calls at 70 db at 1 m distance from the speaker
2) Survey routes should be laid out with call-playback stations at approximately 600 m intervals. Routes should be configured so that no location with potential Elf Owl habitat is farther than 300 m from at least one call-playback station.
3) Surveys should occur between 20 April and 20 May within the proximity of the Bill Williams River NWR, possibly slightly earlier farther to the south
4) Surveys should occur only when sustained wind speed is < 12 km/h
5) Surveys should be conducted in the period beginning ~ 30 minutes after sunset through ~ 3 am. Ideally, within a given survey effort, time of night would be standardized as much as possible
6) Pending a possible amendment and an explanation for our findings, surveys may not be conducted when the moon is gibbous (three-quarter)
7) At each survey station, four call-playback cycles should be repeated. Each cycle consists of a series of chatter calls lasting ~ 10 seconds, followed by a listening period of 50 seconds. After the fourth cycle is complete, the observer should extend the final listening period for an additional 1- 2 minutes
8) Surveyors should have good hearing. Any significant level of hearing impairment will greatly compromise their ability to hear Elf Owl responses

One potential concern regarding our findings is that they were based on Elf Owls that used riparian edge habitat and nested in saguaros. In 2010, we were unable to search the riparian woodland interior as intensively as the edge areas because of unusually sustained flooding that persisted through most of March. However, significant survey time did occur in the woodland interior after the floods receded. Although two pairs were detected in the interior of the riparian woodlands, we were unable to relocate these pairs after their initial detections. It is unclear at this point how commonly Elf Owls in the Bill Williams River NWR actually nest in the woodland interior and in cottonwood cavities, or for that matter, how commonly they did so in the LCR MSCP project area historically. For instance, Rosenberg et al. (1991) reported that Elf Owls in the region were most likely to be found breeding in areas where riparian woodland interfaced with saguaro cactus uplands (see photo below), a conclusion that corresponds well with our findings in 2010. Regardless, we will spend additional survey efforts in the riparian woodland interior in 2011 to determine whether any riparian-nesting owls can be found. We also emphasize that, while the birds had no actual nest cavities in the riparian woodland interior, they spent significant amounts of time in the riparian corridor foraging and roosting and likely make significant use of riparian food resources during their nesting period. Because the LCR MSCP is particularly interested in providing habitat for Elf Owls as a result of riparian restoration, further effort is needed to explore these questions.

Elf Owl nesting territory in the Bill Williams River National Wildlife Refuge. Photo by Bureau of Reclamation, Lower Colorado Region.

Priorities for the 2011 Field Season

Focal areas for the 2011 field season include the following:

1) Making greater efforts to locate owls nesting in the riparian woodland interior and subjecting them to additional responsiveness tests
2) Incorporating habituation testing into the experimental design
3) Collecting additional data to better clarify the effect of moon phase and illumination on responsiveness
4) Gathering better data on home range size and habitat use using radio-tagged birds
5) Obtaining direct measurements of Elf Owl vocalization intensity and record local birds, in order to more precisely define preferred call-broadcast volume and to provide locally-generated recordings for future call-broadcast surveys

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APPENDIX 1

All data sheets used in the 2010 season of the Elf Owl detectability study at the Bill Williams River National Wildlife Refuge.

Data Sheet Definitions:

Surveyor(s): should include only the individual(s) who is/are doing the survey part for that survey (telemetry people not included)

Site Name: should include overall site (Bill Will) as well as route location (i.e. Mosquito Flats)

Date: self-explanatory

Time of Night: dusk, mid-night, and predawn

Moon Phase: **N**ew (0-5%), **Q**uarter (6-25%), **H**alf (26-50%), **G**ibbous (51-90%), **F**ull (91-100%)

Temp/humidity/wind/cloud cover (start and stop): taken from Kestrel; cloud will be in estimated percentages

Moon Position (start and stop): the level/location that the moon is sitting in the sky at the time of starting and stopping the survey (i.e. at horizon, not visible, 35-70 deg, or directly overhead)

UTM: same once established for survey route

Time: time of stop/playback

Set point #: name of survey route plus point # (same once established)

Distance (between points): Default 50m unless detection occurs on or between points.

Playback: yes or no if played/not played. Minimal playback will be used in early season while birds are still arriving and pair bonding is occurring to avoid disturbance. Playback at other times is yet to be determined, as most owls can (so far) easily be found by listening for them.

Number of elf owls detected: per stop; if owl calls consecutively within +/- 20˚, then same owl

Tape Repetitions: the number of 1 min segments played until an owl response is heard (loop of 4 calls with 50 second silences in between); if no response then all 3 repetitions of the tape loop should be recorded.

Detection Type: Audio, visual, or both

Response Type: divided into moving, call, both, and neither. This will be backed up with notes, and is general because we don't know what to expect as far as behavioral response. Only filled in if response observed after playback (to put neither would mean that you saw the owl and it neither called nor moved).

Call Response Type: the type of call the owl responds with which we will define more concretely once we have the Ligon paper (he breaks down/ defines/ explains the different call types in his research)

Bearing: the direction written as a compass bearing that the owl was seen or heard taken from the surveyor's location at time of detection

Distance: the estimated distance you think the responding owl is from you as the surveyor

Notes: any extra pertinent information

We have defined "**incidental**" as a detection of an owl while not on your survey route. If an owl is heard on your way from one 50 m stop to the next the distance can be crossed out and changed, though we think that the likelihood of this is low since its only 50m.

Elf Owl Preliminary Survey Form						**Page of**
Surveyor(s):	Site Name:		Date:		Time of Night:	
Start: Temp(˚F)	Wind:	Humidity(%)	Cloud Cover(%)	Moon position:		Moon Phase:
End: Temp(˚F)	Wind:	Humidity(%)	Cloud Cover(%)	Moon position:		
Total Elf Owls Detected:						

Datum	UTM E/ UTM N	Time	Set Point #	Distance btw pts.	Playback	# Elf Owls Detected	# Tape Reps	Detection Type (A, V, B)	Response Type (M,C, B, N)	Call Type (C, P, S, O)	Bearing	Distance	Note #
NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									
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NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									
NAD83				50m									

Notes:

Responsiveness Test Data Sheet

Date: _______________ Telemetry: yes or no

Territory Name	Surveyor	Dist and Bearing	Observer	Dist and Bearing

Time Period:	Distance:
Dusk	100 meters
Mid-Night	250 meters
Pre-Dawn	450 meters

Time into territory	Wind (mph)	Temperature °F	Moon Phase
Time left territory	% Clouds	% Humidity	Moon Position

Surveyor Notes: Broadcast start:

Observer Notes: Broadcast heard: Y, N

Plays before Response	Response: Mo, Ca, B, N	Detection: Vi, Au, B, N	Number of Owls Heard	Farthest Distance from Saguaro	Obstructions: owl to speaker

Elf Owl Responsiveness Test Data Sheet (Great Basin Bird Observatory 2010)

Owl Transmitter #________________________ USFWS Band#________________________________

Territory Center Site Name and UTM (NAD83):

____

Sex:	Wing Chord:	Blood Sample #
Weight:	Tail Length:	Breeding: confirmed/ not confirmed

Incubation start:	Nestling start:
Incubation end:	Nestling end:

Time Period: **Dusk**	**Distance: 100m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________	**Distance: 250m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________	**Distance: 450m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________
Time Period: **Mid-Night**	**Distance: 100m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________	**Distance: 250m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________	**Distance: 450m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________
Time Period: **Pre-Dawn**	**Distance: 100m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________	**Distance: 250m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________	**Distance: 450m** Date: Moon Phase: Response: Vocalized Moved Closer Moved Away None Response Time:_________

Notes:____

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Banding Data Sheet

CODE	
New Band	N
Band Destroyed	D
Band Lost	L
Band Changed*	C
Band Added*	A
*old band # in NOTES	

SEX	
Male	M
Female	F
Indeterminate	U
Not Attempted	X

AGE	
Local	L
HY, AHY, SY,	
ASY, TY, ATY	
Indeterminate	U
Not Attempted	X

HOW AGED / SEXED			
Skull	S	Feather Wear	F
CP	C	Mouth/Bill	I
BP	B	Eye Color	E
Juv. Pluma	J	Wing Length	W
Plumage	P	Tail Length	T
Molt	M	Other (NOTE)	O

CP	
None	0
Small	1
Mediu	2
Large	3
N/A	X

BP	
None	0
Smooth	1
Vasculariz	2
Heavy	3
Wrinkled	4
Molting	5
N/A	X

FAT SCORE
0 - 7

BODY MOLT
0 - 4

FF MOLT	
None	0
Adventitious	A
Symmetric	S
Juv. Growth	J

FF WEAR
0 - 5

DISPOSITION CODE	
OK	BLANK
Injured	I
Predation	P
Dead	D
Band Remc	X

STATUS	
banded & released	300
color banded & released	301

date	banders	alpha sp. code	capture time	band #	trans. freq.	age	how det.	sex	how det.	cp	bp	fat	B molt	FF molt	tarsus depth	hallux claw	retrices	exposed culmen	wing chord	flat wing	weight	dispo-sition	release time

Notes:

Telemetry Data Sheet

Date	Time	Telemetry Person	Survey Person	E Owl Band #	Territory UTM

Time Period:	Distance:
Dusk	100 meters
Mid-Night	300 meters
Pre-Dawn	500 meters

Time in territory	Moon Phase	Response: M, C
#plays	# owls resp.	Detection: V, A

Notes:____

Date	Time	Telemetry Person	Survey Person	E Owl Band #	Territory UTM

Time Period:	Distance:
Dusk	100 meters
Mid-Night	300 meters
Pre-Dawn	500 meters

Time in territory	Moon Phase	Response: M, C
#plays	# owls resp.	Detection: V, A

Notes:____

Date	Time	Telemetry Person	Survey Person	E Owl Band #	Territory UTM

Time Period:	Distance:
Dusk	100 meters
Mid-Night	300 meters
Pre-Dawn	500 meters

Time in territory	Moon Phase	Response: M, C
#plays	# owls resp.	Detection: V, A

Notes:____