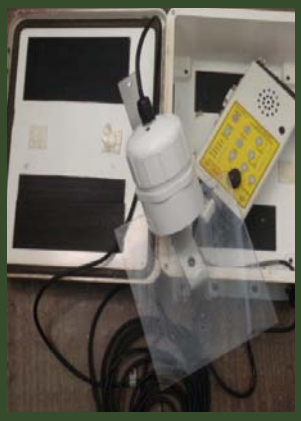

las vegas wash coordination committee

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Habitat and Food Preferences of Bats along the Las Vegas Wash

March 2011

SOUTHERN NEVADA WATER AUTHORITY

Las Vegas Wash Coordination Committee

Habitat and Food Preferences of Bats along the Las Vegas Wash

SOUTHERN NEVADA WATER AUTHORITY
Las Vegas Wash Project Coordination Team

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ABSTRACT

A goal of many vegetative restoration projects is to improve or expand wildlife habitat. Quantifying the benefits to specific animal groups, however, is often complex and poorly understood. The objective of this study was to determine how vegetation changes associated with restoration impact bat populations along the Las Vegas Wash. Three sites representing different restoration stages were used to compare bat activity: a pre-restoration site dominated by salt cedar, an active revegetation site, and a passively created wetland area. Acoustic analysis of 1,902 bat calls recorded across all three sites during the study period showed a preference for habitat type among species with *Antrozous pallidus* preferring a cottonwood dominated revegetation site and *Myotis yumanensis* preferring a passively created wetland site. Analysis of 402 guano pellets collected from 70 captured bats showed no foraging preference between sites. It appears that for *A. pallidus* and *M. yumanensis* habitat types, structure, and location have greater effect on bat activity than prey choices or prey availability.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The Las Vegas Wash (Wash) is the primary conveyance for treated wastewater and stormwater from the Las Vegas Valley in Clark County, Nevada. Formerly an ephemeral channel, urban development in the area beginning in the 1950s increased the flows from both wastewater and stormwater resulting in creation of wetland and riparian areas. These newly created vegetation areas allowed for the establishment of many wildlife species that would otherwise not be present. As the base flows and periodic but occasionally substantial stormwater flows increased through the 1980s, extensive erosion of the channel occurred, resulting in a loss of wetlands and therefore wildlife habitat.

In the late 1990s, the Las Vegas Wash Coordination Committee (LVWCC) was formed as a collaboration between federal, state, and local agencies, businesses, environmental advocacy groups, and citizens to address the environmental degradation of the Wash. The LVWCC prepared the Las Vegas Wash Comprehensive Adaptive Management Plan (CAMP; LVWCC 2000) to address the long-term stabilization and environmental enhancement of the Wash. The CAMP calls for the removal of non-native species such as salt cedar (*Tamarix ramosissima*) and replacement with plant material native to the area. These revegetation activities intend to create an ecosystem similar to other riverine systems in the Southwest, as well as encourage the establishment, reestablishment, or protection of wildlife living at the Wash. In addition, the CAMP and the subsequent Las Vegas Wash Wildlife Management Plan (Shanahan et al. 2008) calls for gathering information on wildlife (such as baseline quantification of species currently found at the Wash), sources, and potential remedies to disturbances, and research needs.

To date, over 265 acres have been revegetated along the Wash (Eckberg 2011). It is often assumed that riparian restoration, and more specifically the replacement of non-native vegetation with native vegetation, will benefit wildlife. Riparian restoration is believed to be beneficial for many bat species by creating greater structural diversity (Fenton 1997). However, the actual benefits of restoration projects similar to and including the Wash are unclear (Sogge et al. 2008).

Riparian corridors located within a desert ecosystem, such as the Wash, offer an excellent location to study resource partitioning (Williams et al. 2006). The vagility of bats gives them the ability to access and selectively forage in varied habitats (Crome and Richards 1988). The Las Vegas Wash Wildlife Management Plan (Shanahan et al. 2008) calls for "(monitoring) the effectiveness of invasive plant removal and native plant revegetation at enhancing wildlife habitats." This study aims to test whether restoration practices are improving wildlife habitat for bats in the Wash ecosystem by assessing their foraging preferences between pre- and post-restoration areas.

2.0 MATERIALS AND METHODS

Three sites were selected to compare insect and bat diversity: a revegetated riparian site, a passively created vegetation wetland site and a non-native salt cedar site (Appendix A and B). The salt cedar site represents a pre-restoration state that the majority of restoration sites along the Wash once resembled. Sites were chosen within close proximity of each other, within 600 m, and contained well developed flight corridors for bat foraging activity. The general goal for

sampling sites close to each other was to allow bats foraging in the area an equal opportunity to choose any of the three areas.

The pre-restoration site, dominated by salt cedar, was a mature site over 50 years old. This site was approximately 175 m from the main Wash channel and had a good flight corridor formed by an abandoned dirt road through the site. The riparian revegetated site was planted in 2001 with species native to the Wash area. Dominated by cottonwoods (*Populus fremontii*), this site is about 30 m from the Wash with the flight corridor here naturally formed by the growth of trees. The passively created wetland was less than five years old and dominated by common reed (*Phragmites australis*) and Goodding's willow (*Salix gooddingii*). A backwater channel off of the main Wash channel formed the flight corridor that would allow bats to drink and glean (Appendix A and B).

Bat capture equipment included one triple high mist net (three mist nets stacked on top of each other). Mist nets were made from polyester mesh (38 mm) with a height of 2.6 m and lengths either 6 m or 9 m. Nets were stretched between two poles and then raised up using a pulley system. Placing the nets on top of each other extended the net height to 7.8 m. Expanding the net height was intended to increase the ability of catching high flying species while still catching the lower flyers. Nets were set up at dusk and checked every hour for a minimum of 4 hours (typically 4-6 hours). Once captured, bats were placed into canvas bags for a minimum of one hour, so that guano could be collected. When removed from the bag the bats were weighed and external measurements were taken (ear, tragus, and hind foot). Sex, age and reproductive status were also documented prior to their release. Guano was collected from the canvas bags and placed into labeled Ziploc bags. Each site was monitored one night a month for a six month period (May-October), for a total of 18 nights.

Bat acoustic units were used to collect bat calls. Each unit consisted of a weather proof National Electrical Manufacturers Association (NEMA) case, a microphone, reflector plate and an Anabat SD1 bat detector unit (Titley Electronics, Australia). The NEMA case was placed on the ground close to the high net. The Anabat unit inside the NEMA case was connected to the microphone that was placed on top of the NEMA case with the reflector plate pointed to the sky. The acoustic data was recorded onto a secure digital card and downloaded nightly. Depending on the frequency of the bat call, the acoustic unit recorded all bat activity in the immediate presence of the triple high mist net.

Analysis of acoustic data was performed by Tetra Tech Inc. (Portland, Maine) using Analook (Version 4.7j, Titley Electronics, Australia). Program settings included having a five second maximum time between calls, a minimum line length of five milliseconds, and a smoothing factor of 50. Call sequences containing fewer than four pulses of sound were not able to be confidently identified to species; these sequences were rather categorized as low, mid, or high frequency calls. Calls identified as feeding calls were separated for analysis as such.

Identification of bat species was done by visual comparison of bat call sequences of sufficient length compared to a reference library of bat calls per O'Farrell et al. (1999), O'Farrell and Gannon (1999), and O'Farrell (1997). Call sequences were also run through consecutive filters based on specific characteristics (Szweczak et al. 2008) and known species call sequences (hand

released and zip-line individuals). Only those call sequences with suitable quality and duration were included in data analysis, (i.e. call pulse(s) exhibited entire spectrum of frequency modulation produced by a bat and a minimum of four pulses).

Bat Index of Activity (IA) was calculated to compare relative activity levels of bats between habitats (Miller 2001). IA values were based upon the amount of time call sequences were present within the data set compared to the total amount of time the detectors were operational (IA = # minutes with activity/#minutes of operation *100).

A UV light (Bioquip, Rancho Dominguez, CA) was positioned a minimum of 20 m from the mist net to attract invertebrates in order to ascertain the relative abundance of bat prey similar to Lee and McCracken (2004). Lee and McCracken (2004) used a UV light trap whereas we suspended a UV light approximately 1.5 m above the ground in front of a white sheet. The sheet was draped over a rope tied between two trees to maximize the surface area illuminated by the light. This method is known to have biased results as only positively phototactic insects will be collected. However, it is a very effective method of determining insect diversity (Black 1974, Verheijen 1960, and Taylor and Carter 1961). Overall abundance of invertebrates attracted by the UV light was determined by taking digital photographs of the sheet at the first collection time each night prior to specimen collection. Later collections were not photographed due to skewing of the data by specimens collected. Specimens were collected hourly from dusk for no less than four hours. Specific attention was given to collecting those invertebrates unidentifiable in the photographs and previously undocumented species. Kill jars containing 70% ethyl acetate were used to euthanize specimens. Once euthanized, specimens were placed into labeled vials for future identification. Identification was done using standard field guides (Evans and Hogue 2006, Glassberg 2001, Paulson 2009, Evans 2008, and Capinera et. al. 2004) as well as online sources such as www.bugguide.net. Smaller specimens were identified using a stereoscopic zoom microscope with attached digital camera system (model SMZ1000; Nikon, Melville, NY).

Guano collected from captured bats was analyzed under a stereoscopic zoom microscope. Each pellet was teased apart and insect parts were identified to order. Insect specimens collected with the UV light were used to help in identification. Multiple parts of insects in the same order were commonly found in a single guano pellet. Samples were designated to have one positive result per order found in a single sample. However, if multiple orders were found in a single pellet, each order would have a single positive result.

Two 15 m diameter circular relevé plots centered on the mist net and the UV light locations were used to characterize the vegetation at each of the three sites. Species richness and the dominant and co-dominant species were determined for each area based on the average cover of the two samples. Cover was calculated using the cover class method (Eckberg 2011).

A Spearman correlation coefficient was calculated to determine if there was any correlation between IA for any given species and the abundance or diversity of prey at a given site. A two-tailed t-test was used to determine how IA of bat species compared between sampling sites. Comparison of abundances of invertebrates collected with the UV light, and the relationship to those collected in guano was also tested using a two-tailed t-test. Multivariate analysis of variance (MANOVA) was used to compare quantity of bat acoustic calls between sampling sites. All statistical analysis was done using Sigma-Stat software (Sigma-Stat, Jandel Scientific, CA).

3.0 RESULTS

Vegetation monitoring yielded a total of nine plant species recorded at the revegetation site with cottonwoods being the dominant species and Goodding's willow being the second most dominant. In addition to these two trees, salt cedar was also found on the site, although it had less than 1% cover. There were four forbs on the site as well as two shrubs. The passive site had a total of 19 species identified. These included the dominant Goodding's willow and common reed, which was the second dominant. Like the revegetation site, cottonwood, and a small amount of salt cedar were also on the site. There were ten forbs, three shrubs, and two graminoids, common reed, and cattails (*Typha domingensis*). The pre-restoration site had only salt cedar present.

Antrozous pallidus and *Myotis yumanensis* were the only two bats captured in mist nets at all three study sites. However, acoustic data show that four additional species were active at all three sites; *Eptesicus fuscus*, *Myotis californicus*, *Parastrellus hesperus*, and *Tadarida brasiliensis*. *A. pallidus* is a protected species in the state of Nevada (NAC 503.030).

The acoustic units recorded more than 4,200 monitoring minutes with 1,232 minutes of bat activity. Acoustic data included a total of 1,902 call sequences across the three study sites. Thirteen species were able to be positively identified (Table 1). The largest number of call sequences was recorded at the passive site (55.8%); the revegetation site had the second most recorded (25.7%), while the pre-restoration site had the least amount (18.5%). Five species had more than 100 call sequences with *M. yumanensis* having the most call sequences (n=900; 47.3%) out of the total calls collected from all three sites (n=1,902).

M. yumanensis had significantly higher ($P<0.05$) number of acoustic calls than *Nyctinomops macrotus* and *M. thysanodes* at the passive site. *A. pallidus* had significantly higher ($P<0.05$) number of calls than *M. ciliolabrum*, *N. macrotus*, *Lasiurus xanthinus*, *M. thysanodes*, and *Lasiurus blossevillii* at the revegetation site. No other species had significantly higher numbers of acoustic calls than any other species at any site. The pre-restoration site had the largest species richness (11). The revegetation site had the lowest species richness with seven species identified. There were no statistical differences in species richness among the three sites ($P>0.05$).

The passive site had the highest IA overall, as well as during most months (except for May when the revegetation site had the highest IA and August when the pre-restoration site had the highest). There were 44 feeding buzzes recorded across all three sites during the study. The majority of these feeding buzzes occurred at the pre-restoration site (77.3%) and the fewest at the passive site (6.8%).

A total of 70 bats consisting of five species were captured using mist nets; they are identified in the acoustic unit data (Table 1). More than half of all bats were captured at the passive site (65.7%) with *M. yumanensis* making up 41 of the 47 individuals. *A. pallidus* made up the majority at the revegetation sites (17 of 20 captures). Only three individuals were captured at the pre-restoration site - two *M. yumanensis* and one *A. pallidus*.

Scientific Name	Common Name	Species Codes	Capture Site[4]		
			PA	PR	RE
Antrozous pallidus[12]	Pallid bat	ANPA	x	x	x
Eptesicus fuscus	Big brown bat	EPFU	x	x	x
Lasionycteris noctivagans	Silver-haired bat	LANO			x
Lasiurus blossevillii[23]	Western red bat	LABL	x		
Lasiurus cinereus[1]	Hoary bat	LACI		x	
Lasiurus xanthinus[1]	Western yellow bat	LAXA	x	x	
Myotis californicus[1]	California myotis	MYCA	x	x	x
Myotis ciliolabrum	Western small-footed myotis	MYCI	x	x	
Myotis thysanodes	Fringed myotis	MYTH		x	
Myotis yumanensis[1]	Yuma myotis	MYYU	x	x	x
Nyctinomops macrotus	Big free-tailed bat	NYMA		x	
Parastrellus hesperus	Canyon bat	PAHE	x	x	x
Tadarida brasiliensis[2]	Brazilian free-tailed bat	TABR		x	x

[1]Captured in mist nets as well as on acoustic units

[2]State of Nevada protected species

[3]State of Nevada sensitive species

[4]PA = Passive site, PR= Pre-restoration site, RE= Revegetation site

Table 1. Bat species identified through acoustic recordings.

Captured bats had relatively equal distribution of sexes: 33 females and 35 males (two unknown). More than half of the bats captured were in a reproductive state and 69% of the reproductive bats were male. *A. pallidus* was the only species with pregnant females. There were only two species with reproductive males: *M. yumanensis* and *A. pallidus*.

A total of 18,159 individual invertebrates consisting of 13 different orders were collected or otherwise identified. The majority was in the order Hemiptera (true bugs; 59.1%). The second most prominent order was Diptera (flies; 13.2%), followed by Lepidoptera (moths and butterflies; 11.3%), Trichoptera (caddisflies; 5.9%), and Coleoptera (beetles; 2.0%). All other invertebrate orders identified consisted of less than 1% of the total collected. June had the highest number of invertebrates collected (58%. Due to technical problems with the invertebrate collection equipment, no invertebrates were collected using the UV light in August. The passive wetland site had the greatest percentage of collected invertebrates (54.9%), followed by the revegetation site (34.6%), and the tamarisk site had the fewest (10.5%). Although there were more invertebrates collected at the passive site compared to the other sites and more were collected at the revegetation site compared to the pre-restoration site, analysis indicate that there was no significant difference between any of the three sites ($P \geq 0.077$). There was also no significant difference for abundance of any specific order of invertebrate ($P \geq 0.271$).

Total invertebrates collected at each site and total bats identified by acoustic analysis had no significant correlation at the passive site (P=0.950) or revegetation site (P=0.350), but there was a significant difference at the pre-restoration site (P=0.017). The comparison of diversity (Shannon-Weiner) however, showed no statistical difference between bats and insects found at the pre-restoration, revegetation, or passive sites (P=0.301, 0.421, and 0.322, respectively).

A total of 402 guano pellets were collected from the five different bat species captured over the course of this study ranging from 0 to 38 pellets collected from a single individual (mean 7.9 ± 8.5). There were 356 positive identifications of invertebrate orders within these pellets. A small amount of these were the result of more than one order being identified within a single pellet with the remaining pellets having no insect parts present. The number of positive identification of invertebrate parts by order for the two bat species collected at all three sampling sites (*A. pallidus* and *M. yumanensis*) is shown in Table 2.

	Pre-restoration		Revegetation		Passive	
Prey Order	ANPA	MYYU	ANPA	MYYU	ANPA	MYYU
Coleoptera	-	4	37	8	5	39
Diptera	-	-	28	-	-	4
Hemiptera	-	-	-	-	-	6
Hymenoptera	2	2	2	1	-	42
Lepidoptera	-	10	4	3	-	43
Unidentified Insecta	-	-	10	2	-	60

Table 2. Diet comparison between *Antrozous pallidus* (ANPA) and *Myotis yumanensis* (MYYU) between three habitat areas.

The *L. xanthinus* captured at the revegetation site did not have any guano collected from it. *L. cinereus*, which was only captured at the passive site, had eight pellets collected from the single capture. All eight pellets contained parts of species in the Diptera order. Only one of the two *M. californicus* captured at the passive site had any guano collected. There were 10 pellets collected from this individual. Two of the pellets had Coleoptera parts, five had Hymenoptera, and three pellets had insect parts that were unidentifiable. The single *M. californicus* captured at the revegetation site had four pellets collected. One pellet had Coleoptera parts, two had Hymenoptera, and one had unknown insect parts.

Abundance and diversity of invertebrate prey did not correlate with bat IA at any of the three sample sites during any month (Spearman correlation coefficient, $.656 < r_s > -.689$). *A. pallidus* had significantly higher IA at the passive site compared to the pre-restoration site. No other species had significant differences of IA between sampling sites.

Analysis of guano pellet content collected from *A. pallidus* at the revegetation site show no significant differences in the quantity of insects in their diet (P>0.05) when compared to their respective availability, with the exception of dipterans. Abundance of dipterans in *A. pallidus* diet were significantly lower than expected by their availability (P=0.049). Contrary to this, at the passive site, there were significant differences between Hymenoptera, Coleoptera, Lepidoptera, Diptera, and Hemiptera found in the guano of *M. yumanensis* ($P \leq 0.025$) compared to those caught with the UV light. Lower capture rates of bat species besides *A. pallidus* at the

revegetation site and *M. yumanensis* at the passive site, made statistical comparisons impossible between diet and insect availability.

4.0 DISCUSSION

Analysis of activity and diet of the two bat species found in all three sampled habitats does not support the hypothesis that restoration activities along the Wash are improving habitat. Bat species however, may select restored areas for activity and feeding as represented in calls recorded at these sites. *A. pallidus* showed a preference for the cottonwood dominated revegetation site while *M. yumanensis* was most prominently found at the passive site with open water. These results are consistent with Foster (in prep.) which monitored acoustic bat activity throughout the Wash from 2005-2009.

Hemiptera was the predominant invertebrate collected at the passive and revegetation sites and the second most abundantly collected at the pre-restoration site. However, only six guano samples contained parts of Hemiptera, all from *M. yumanensis*. This is likely explained by the majority of Hemiptera collected using the UV light being *Atomoscelis onustus*, which are typically between 1 and 2 mm in size and would not be considered an adequate food source for either bat species (Buchler 1976 and Black 1974). Further, the majority of Hemiptera were collected in just one month (June: 73.7%), and therefore would not be a stable food source for any bat species.

Coleoptera were the preferential food choice in our study area for *A. pallidus* (Table 2) despite only making up 2.5% of the total invertebrates collected at the pre-restoration and revegetation sites and 1.6% at the passive site. Johnston and Fenton (2001) reported that the diet of *A. pallidus* varied by location and individual foraging behavior finding 54.5% of the dietary volume consisted of Coleoptera at one site while Orthoptera made up 53.7% of the diet at another. Others have concluded that *A. pallidus* is an opportunistic feeder, choosing larger prey which requires less effort (Bell 1982) with dominant food sources ranging from sphinx moths (Bell 1982, Grinnell 1918) to Jerusalem crickets and scorpions (Hatt 1923). While our findings show that *A. pallidus* has a varied diet along the Wash, it suggests that there is more of a selective feeding choice than previously documented. This may also be explained by *A. pallidus* primarily gleaning prey (Barbour and Davis 1969; Hermanson and O'Shea 1983) as the invertebrates collected in higher numbers than Coleoptera were all primarily aerial species (Hemiptera, Diptera, Lepidoptera, and Trichoptera).

Because Coleoptera were found in similar numbers across all three sites in our study, this does not explain why *A. pallidus* was found predominantly at the revegetation site. It appears that the characteristics of the site itself may be the over-arching factor that resulted in *A. pallidus* having significantly higher IA than many of the other species here. Dominated by mature cottonwood trees, there is little understory with much of the inter-tree space consisting of unvegetetated gravel, ideal conditions for gleaning.

The food choice of *M. yumanensis* was more evenly distributed with the majority of prey being in Lepidoptera followed by Coleoptera and Hymenoptera. In addition, their habitat choice was the passively created wetland habitat with large stretches of slow moving open water.

Lepidoptera and Hymenoptera were observed in swarms in the area, and lady beetles (Family Coccinellidae) in Coleoptera were in large numbers on this site, primarily feeding on aphids who were in turn feeding on the second most dominant plant on the site, common reed (*Phragmites australis*). While the specific ordinal prey selection differs, these findings are consistent with the conclusions of others (Brigham et al. 1992, Fenton and Morris 1976) that *M. yumanensis* is an opportunistic feeder often harvesting prey from swarms of insects in aquatic habitats.

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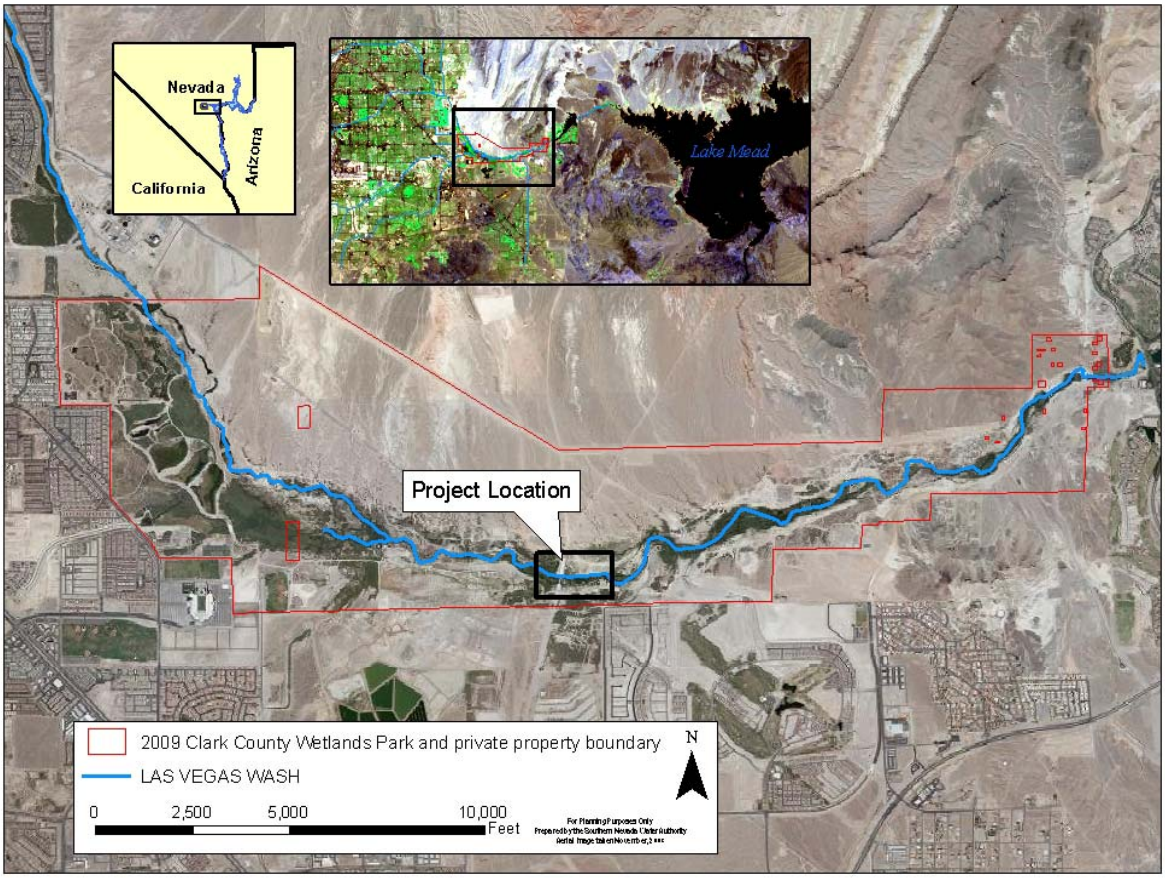
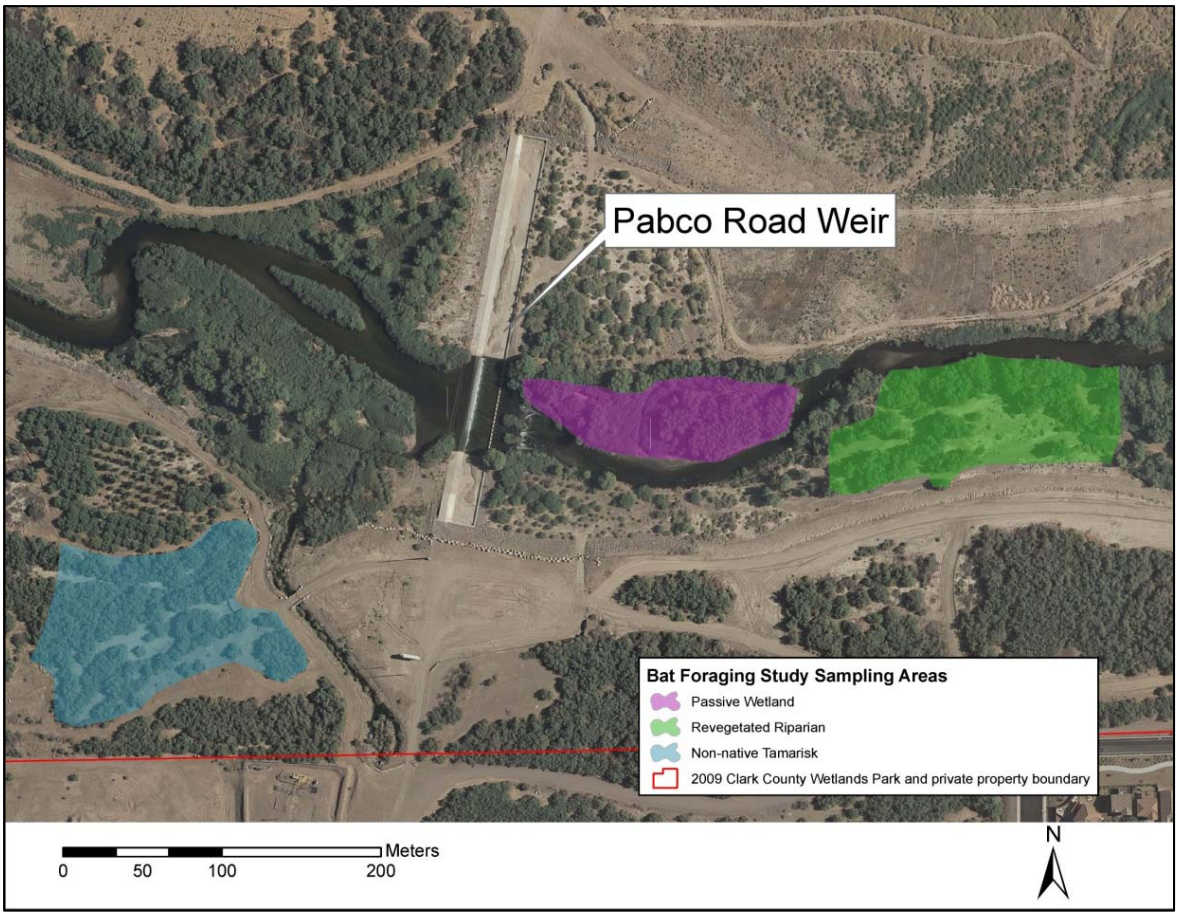
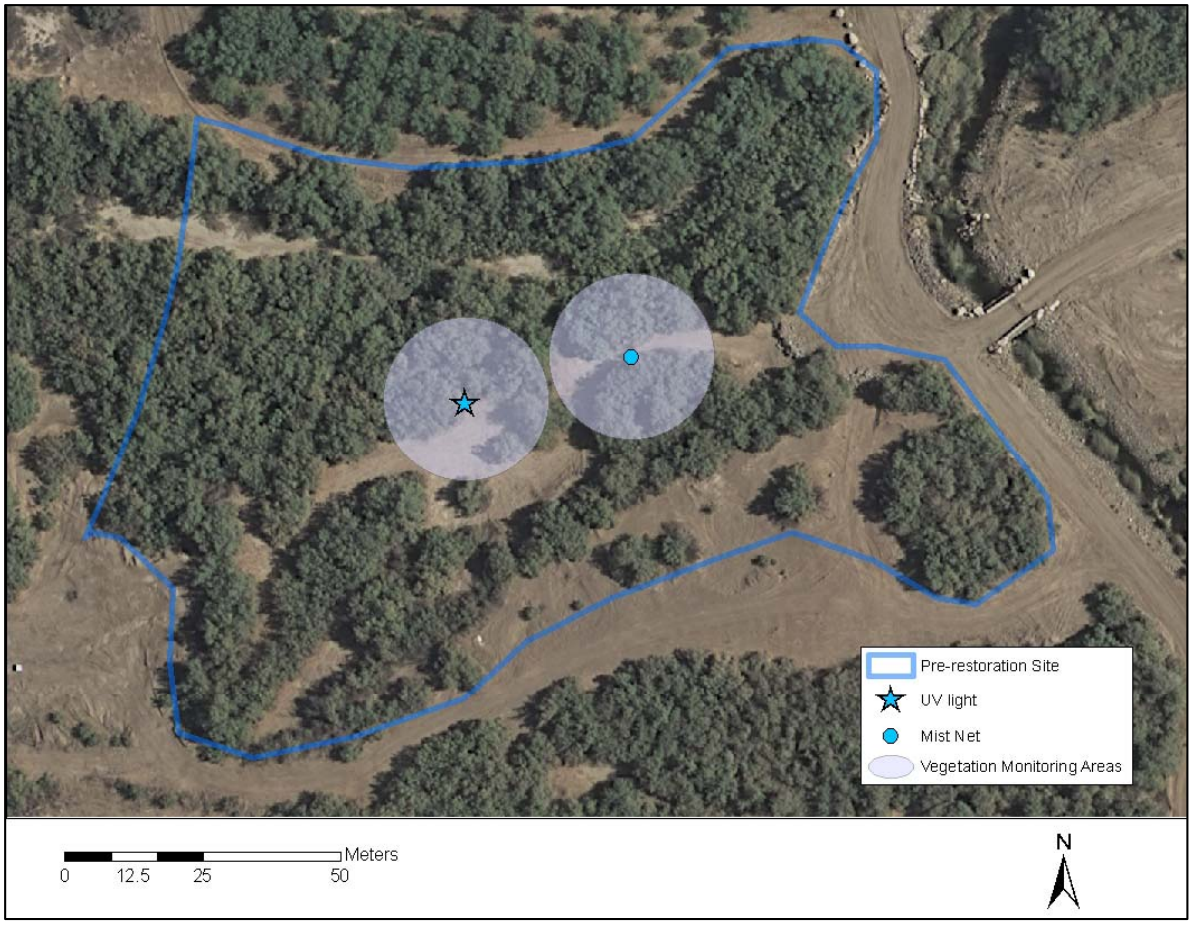
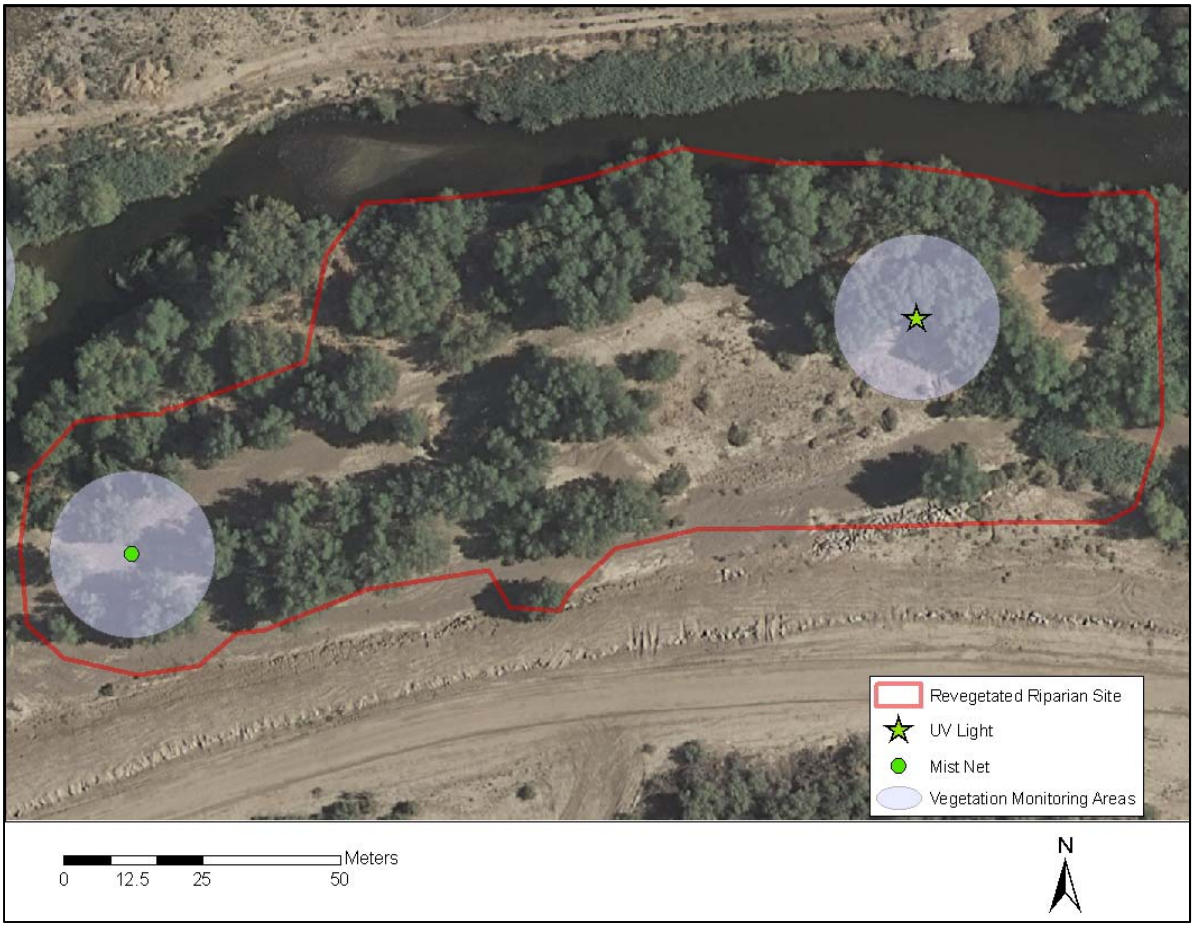
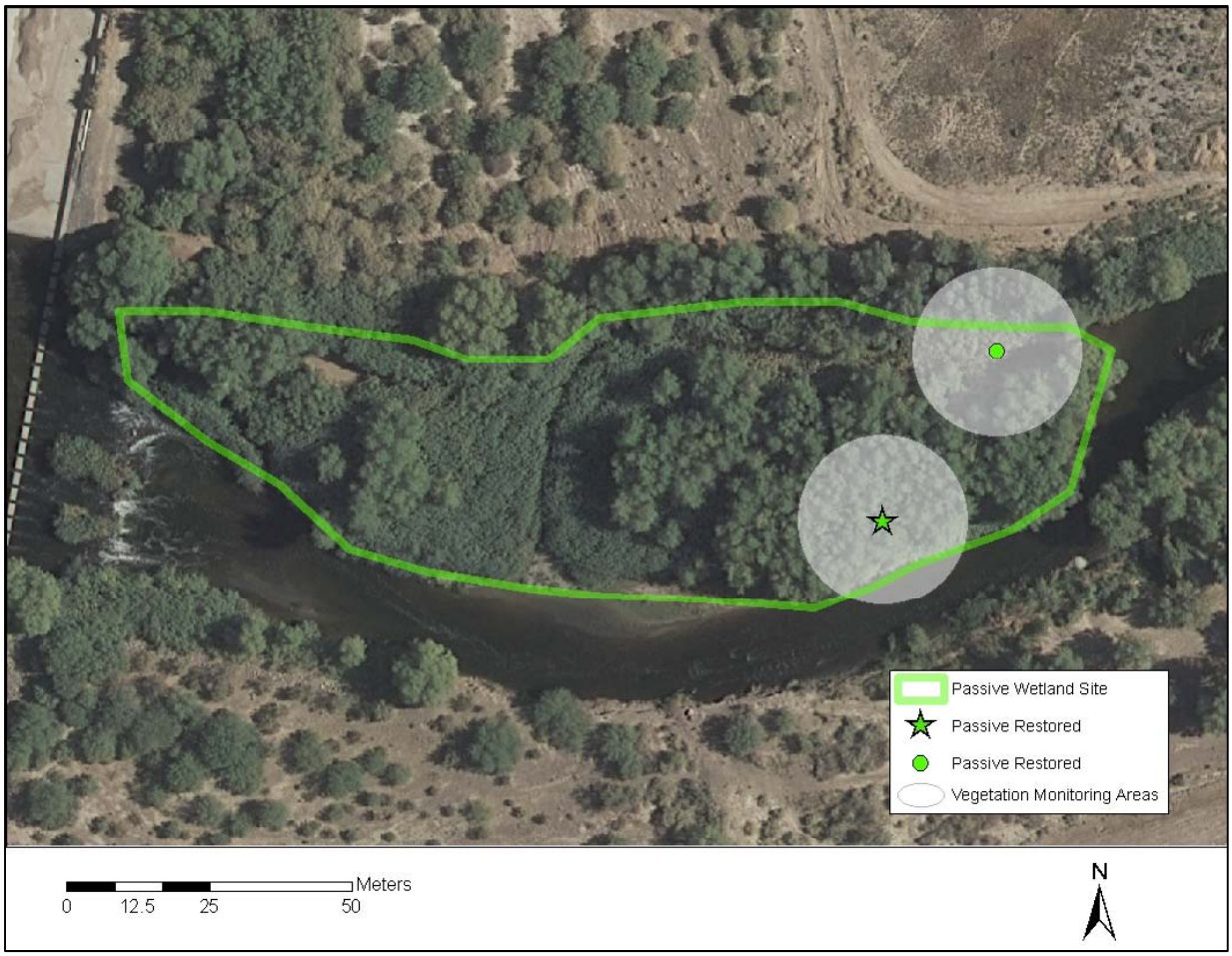
Appendix A
Maps of Study Areas


Nevada
California
Arizona
Lake Mead
Project Location
2009 Clark County Wetlands Park and private property boundary
LAS VEGAS WASH
0
2,500
5,000
10,000
Feet
N


Pabco Road Weir
Bat Foraging Study Sampling Areas
Passive Wetland
Revegetated Riparian
Non-native Tamarisk
2009 Clark County Wetlands Park and private property boundary
0
50
100
200
Meters
N

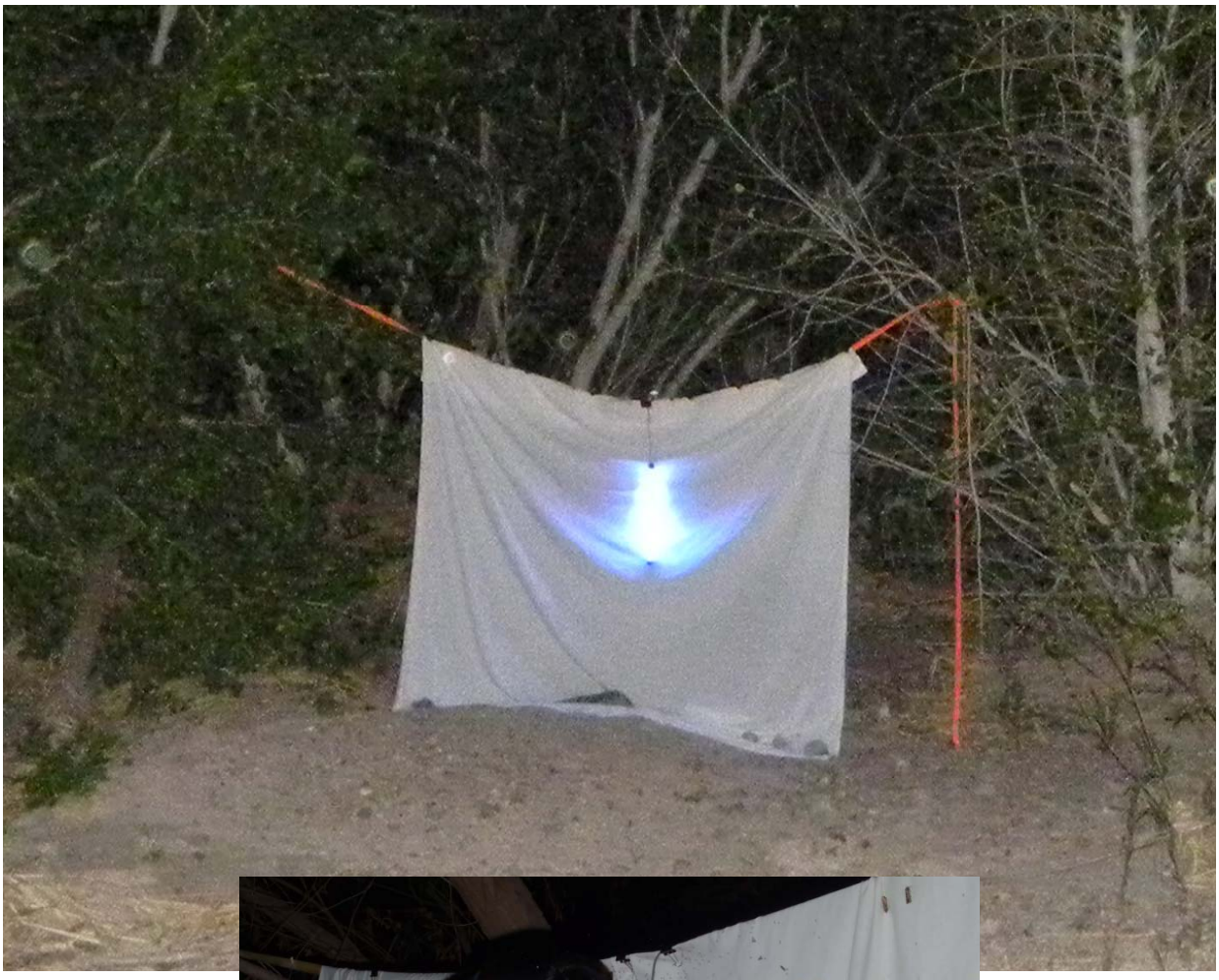

Pre-restoration Site
UV light
Mist Net
Vegetation Monitoring Areas
Meters
0
12.5
25
50
N


Revegetated Riparian Site
UV Light
Mist Net
Vegetation Monitoring Areas
Meters
0
12.5
25
50
N

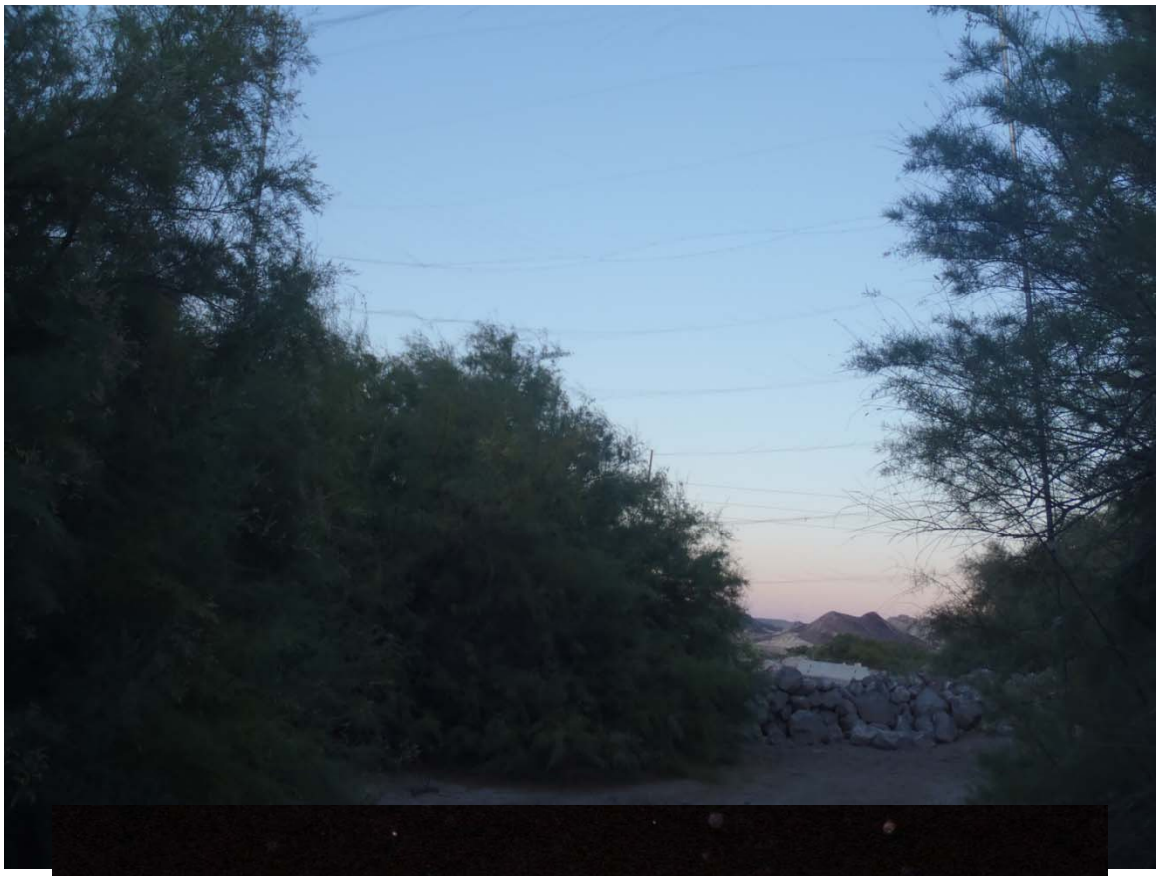

Passive Wetland Site
Passive Restored
Passive Restored
Vegetation Monitoring Areas
Meters
0
12.5
25
50
N

Appendix B
Survey Photos

Insect Capture Sites

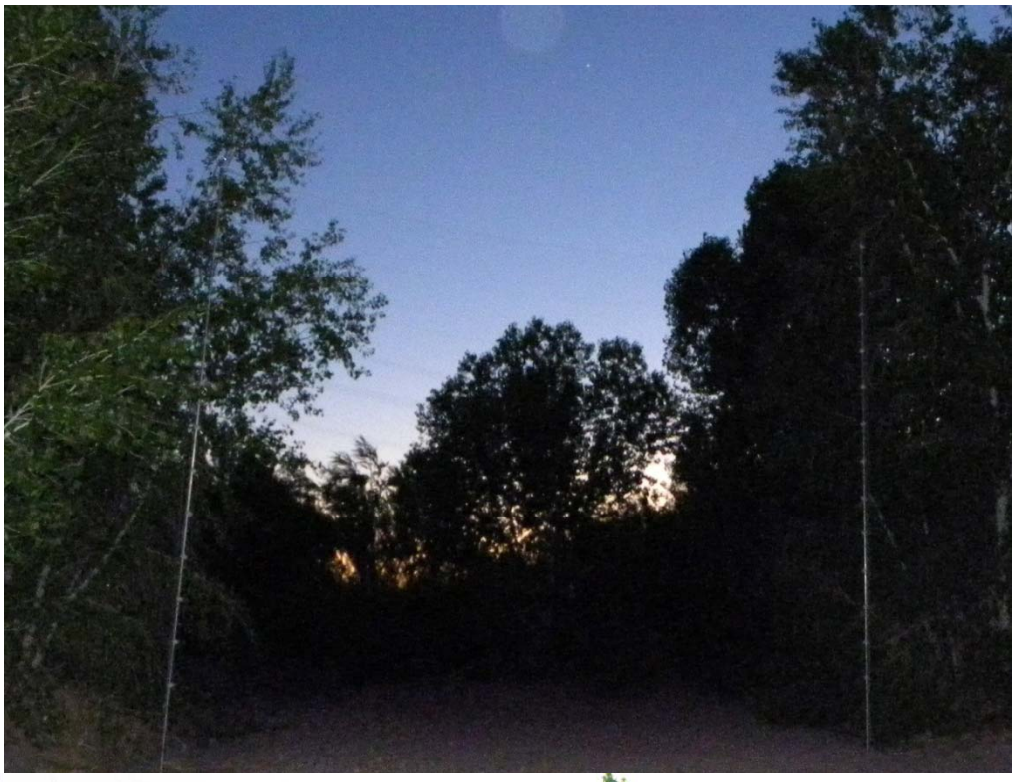


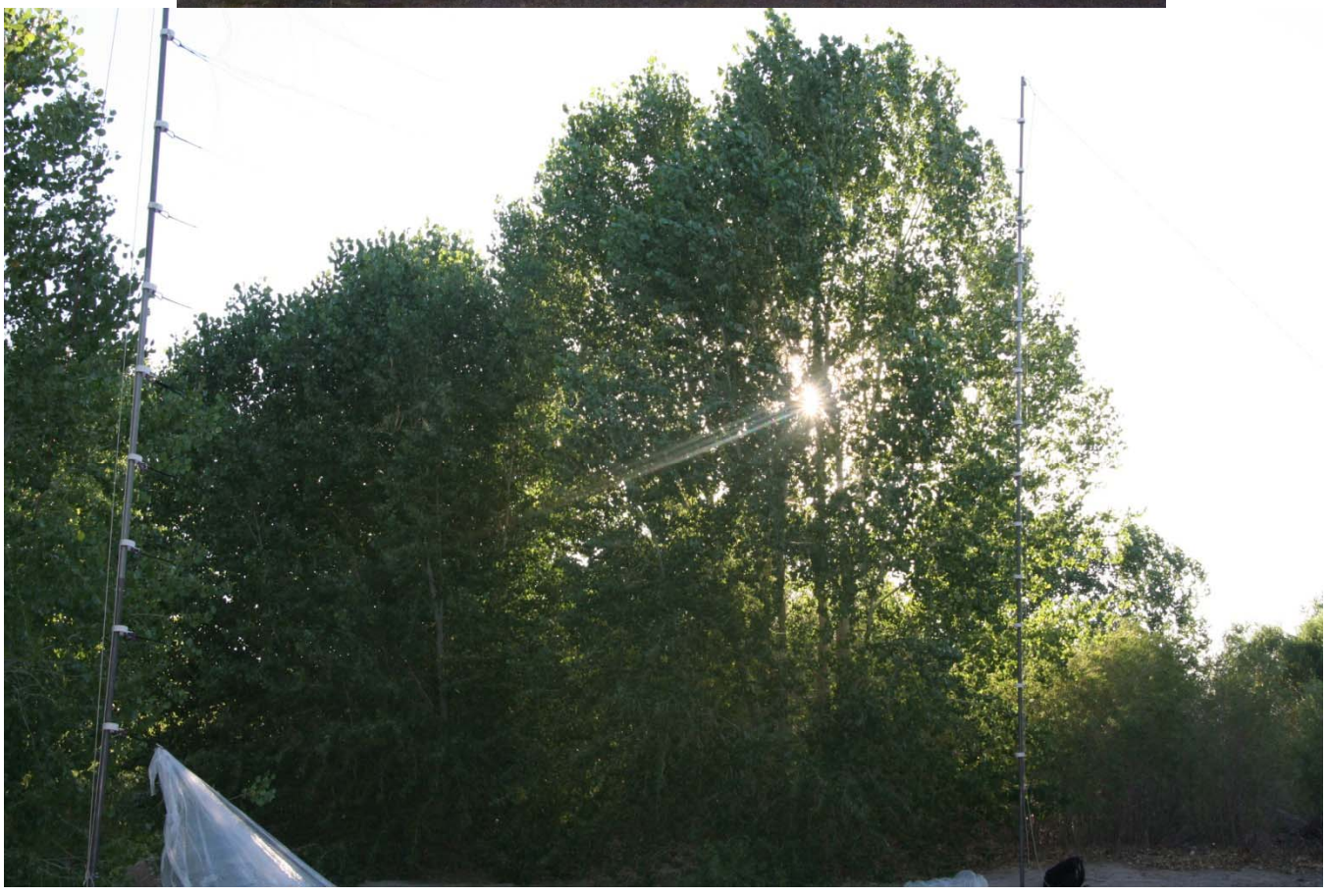
Pre-Restoration Site



Passive Site

Revegetation Site





Acoustic Monitoring Equipment