Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Habitat and Population Demographics of the Colorado River Cotton Rat (*Sigmodon arizonae plenus*) Along the Lower Colorado River

2009–2013 Final Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

May 2016

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Prepared by:

Sean Neiswenter

School of Life Sciences, University of Nevada, Las Vegas

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

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ACRONYMS AND ABBREVIATIONS

AIC_c	small sample version of Akaike's information criterion
CI	confidence interval
Cibola Nature Trail	Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail
cm	centimeter(s)
CMR	capture-mark-recapture
d.f.	degrees of freedom
g	gram(s)
ID	identification
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
MANOVA	multivariate analysis of variance
Pintail	Pintail Slough
PIT	passive integrated transponder
PVER	Palo Verde Ecological Reserve
Reclamation	Bureau of Reclamation

Symbols

ΔAI_C	difference in Akaike's information criterion
>	greater than
%	percent

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ABSTRACT

Colorado River cotton rat *(Sigmodon arizonae plenus)* habitat and population demographics were quantified using a capture-mark-recapture technique along the lower Colorado River. Permanent trapping grids were established at three sites with Colorado River cotton rats present. Habitat was quantified horizontally and vertically within 1 cubic meter surrounding every trap station four times across 2 years. Individual recapture histories were used to model the survival, capture probability, and population size of Colorado River cotton rats over five trapping occasions spanning 4 years. Program Mark was used to model population demographic parameters using the Robust model. Survival parameters for all of the sites were not statistically different from each other; however, the best model among the ones examined had separate survival parameters for each site. The accretion bench near the Palo Verde Ecological Reserve (PVER) in the river channel north of Blythe, California, on average, had a higher survival estimate, and the Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail (Cibola Nature Trail) near Cibola, Arizona, and Pintail Slough (Pintail) in the Havasu National Wildlife Refuge, Arizona, near Needles, California, had lower survival estimates. Population sizes (as estimated by capture-mark-recapture methods) were highly variable within and among the three sites. The PVER population initially increased then decreased in size. The Cibola Nature Trail population began large and decreased overtime. At the beginning of the study, 20 individuals occupied the Pintail site. No Colorado River cotton rats were captured at Pintail during the last occasion. There are differences in vegetation structure among the three sites but not between trap stations where Colorado River cotton rats were captured versus stations where they were not captured. Site differences in vegetation composition and cover were documented. Although no statistical differences in microhabitat use were revealed, there was a general trend toward higher and greater vertical cover at successful trap stations. In general, the PVER had the highest vertical cover estimates, followed by the Cibola Nature Trail and Pintail. Reasonable estimates for demographic data were not possible for most occasions due to a steady drop in trap success throughout the study. The limitations of these data are discussed, along with their utility in developing a monitoring strategy.

INTRODUCTION

Understanding the interplay between population demographics and habitat use is central to conservation biology. The particular habitat utilized by an individual provides food, protection, and even access to mates, ultimately affecting the fitness of an individual. At the population level, the distribution of habitat determines the distribution of a species and how populations of that species interact and persist through time. For example, highly stable habitat can provide a reliable resource that maintains a consistent population of organisms through time.

The Colorado River cotton rat (*Sigmodon arizonae plenus*) is a disjunct subspecies of Arizona cotton rat that is only known from the lower Colorado River (LCR) north of the Palo Verde Mountains. Genetic analyses conducted during a recent study by the Bureau of Reclamation (Reclamation) in cooperation with University of Nevada, Las Vegas, have shown that the Colorado River cotton rat is genetically unique and displays some level of population structuring (Neiswenter 2010). Several localities where Colorado River cotton rats are locally abundant were identified through the same study, and an apparent absence of this species in intervening localities was noted. The presence localities coincide, in general, with previously documented geographic areas from a survey of the species (Blood 1990), although in several areas where they have been reported previously (Anderson 1994; Anderson and Nelson 1999), they were not detected after repeated attempts by Reclamation biologists. These results underscore the patchy distribution and ephemeral nature of the preferred habitat with which cotton rats are generally attributed (Cameron and Spencer 1981). The life history strategy of cotton rats is well adapted to quickly changing habitat (e.g., high reproductive output) (Cameron and Spencer 1981 and citations within). Prior to construction of dams along the LCR and subsequent disruption of flood regimes, catastrophic flood events that periodically restructured the LCR habitat probably created an environment that favored species, such as cotton rats, which were capable of quickly re-colonizing disturbed areas.

Studies documenting the habitat use of cotton rats have generally focused on hispid cotton rats (*Sigmodon hispidus*). While these studies may provide some data on general characteristics of the habitat utilized by Colorado River cotton rats, they are not appropriate for meeting Lower Colorado River Multi-Species Conservation Program (LCR MSCP) objectives of creating species-specific habitat along the LCR. General descriptions of habitat where the Colorado River cotton rat was trapped along the LCR are available (Anderson 1994; Anderson and Nelson 1999) but fall short of quantifying the habitat structure and microhabitat characteristics that are being used by this species. Furthermore, the LCR MSCP stipulates that 125 acres of the 512 acres of marsh being created for the Yuma clapper rail (*Rallus longirostris yumanensis*) will also be designed for the Colorado River cotton rat. Preliminary surveys conducted during 2008 and 2009 suggest that marsh habitat designed for the Yuma clapper rail may not

satisfy the habitat requirements for the Colorado River cotton rat. Currently, much of the habitat along the LCR in which Colorado River cotton rats have been detected is composed of non-native vegetation, although the structure of the vegetation may be a more important aspect than species composition in determining the presence of cotton rats, as seen at the sites selected for this study – the Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail (Cibola Nature Trail) near Cibola, Arizona; on an accretion bench near the Palo Verde Ecological Reserve (PVER) in the river channel north of Blythe, California; and Pintail Slough (Pintail) in the Havasu National Wildlife Refuge, Arizona, near Needles, California. The Cibola Nature Trail was planted with Fremont cottonwood (*Populus fremontii*) and honey mesquite (*Prosopis glandulosa*), with some areas where volunteer *Baccharis* spp. have become established, although Johnsongrass (*Sorghum halepense*), an invasive grass species, has established a thick ground cover that Colorado River cotton rats appear to be using. The accretion bench near the PVER is dominated by dallisgrass (*Paspalum dilatatum)* and Spanish false fleabane (*Pulicaria paldosa*), two other non-native species, and may be more indicative of the physical characteristics of cotton rat habitat that occurred along the LCR prior to anthropogenic change. Pintail contains a diversity of vegetation, including much thinner Johnsongrass compared to the Cibola Nature Trail and various other grasses and forbs. The density of grassy vegetation, particularly within 1 meter (m) above ground at these sites, is likely an important habitat characteristic that determines the abundance of Colorado River cotton rats, similar to what has been documented for hispid cotton rats in the Great Plains (Goertz 1964; Kaufman and Fleharty 1974).

The main goal of this research is to gain an understanding of the population demographics and habitat associations of the Colorado River cotton rat to aid in developing a monitoring plan. The specific tasks were to:

1. Estimate population demographics of the Colorado River cotton rat using mark-recapture methods at localities where they are known to occur along the LCR

2. Quantify microhabitat characteristics at Colorado River cotton rat localities for use in restoration efforts

To begin, practical methods for describing and modeling habitat use by Colorado River cotton rats were applied, and the survival and abundance of populations at three distinct localities along the lower Colorado River were estimated. The vegetation and demographic estimates were compared to determine if there were differences among the sites. Finally, recommendations were made on how to proceed with developing a monitoring protocol for Colorado River cotton rats and on how the information may be used for Yuma hispid cotton rat monitoring as well.

STUDY AREAS

Colorado River cotton rats were lived trapped using Sherman traps at three localities where they are known to maintain populations along the LCR: the Cibola Nature Trail, an accretion bench near the PVER, and Pintail.

METHODS

Permanent trapping stations were established at each site. Stations were set up at approximately 10-m intervals with 15 stations per transect. At two sites, the PVER and the Cibola Nature Trail, four transects were established, and at Pintail, because trap success was considerably lower, five transects were used to increase the number of captures per night. Coordinates for each station were recorded with a submeter Global Positioning System unit and marked with a pin flag displaying a letter and number combination that identified each transect and station. Two Sherman live traps were set at each station within 0.5 m of each pin flag. Traps were run for 3–4 nights at each locality twice a year, once in fall (late November/ early December) and once in spring (April – May). The traps were baited with a mix of oats, peanut butter, and vanilla, opened approximately 1 hour prior to sunset, and retrieved approximately 1 hour after sunrise. On cold nights, cotton was also provided in each trap. Upon first capture of an individual Colorado River cotton rat, weight and sex were recorded, an ear clip was taken for future genetic analysis, and the individual was uniquely identified by subdermally implanting a passive integrated transponder (PIT) tag near the nape of the neck. Upon recapture, the individual was scanned for the unique ID, and its weight was recorded if the previous capture for that individual was from a different season. Therefore, an individual's weight was only taken once per trapping season to estimate long-term growth and not daily fluctuations. All protocols were in compliance with the guidelines set forth by the American Society of Mammalogists (Sikes et al. 2011).

Vegetation structure and composition was quantified at each permanent trapping station during each trapping session. The choice of scale can have profound effects on the interpretation of what habitat characteristics are important to an organism (Mayor et al. 2009). The vegetation structure at each trap station was quantified within a 1-m square centered on the pin flag and included all vegetation up to 1 m from the ground. This scale was chosen for several reasons:

- The interest in whether Colorado River cotton rats were using specific areas within the broader site in which they occur. It was assumed that Colorado River cotton rats were directly interacting with the habitat in the immediate vicinity of the trap in which it was caught; therefore, the microhabitat that the trapped individual was actively using was quantified.

- Cotton rats are known to build and maintain aboveground runways that they use during activity, lending some credibility to the assumption that the components of a habitat that are most important to a Colorado River cotton rat are those that the individual directly interacts with.

- Personal observations and other research on the closely related hispid cotton rat suggest habitat selection occurs at about 1–2 m (Bowne et al. 1999).

Vertical vegetation cover was measured using a modified version of the vegetation profile board protocol outlined in Nudds (1977). The protocol involves using a 10-centimeter (cm) wide board that is 1 m high and marked at 10-cm intervals. The board is held upright at the center of the trapping station (along the pin flag), and an observer 0.5 m to the north looking south at the board categorizes the percentage of each square decimeter section that is covered by vegetation using a single digit representing quartiles (e.g., 1 is 0–25%, 2 is 26–50%, etc.). The process was repeated from west of the board looking east, and the 2 values were averaged for each of the 10 vertical cover measures per plot. The first cover category included 0% cover due to the lack of cover above 50 cm (i.e., differentiating 0% cover would have resulted in highly skewed distributions). This likely resulted in overestimates of cover for the upper strata. Horizontal vegetation cover was measured by laying a 1-m polyvinyl chloride square on the ground with the plot pin flag in the center. Plant species, dead organic material (litter), bare ground, and their respective approximate proportions were recorded using the following cover classes: 1 = 0–1%, 2 = 1–2%, 3 = 2–5 %, 4 = 5–10%, 5 = 10–25%, 6 = 25–50%, 7 = 50–75%, 8 = 75–95%, and 9 = > 95%. The average litter depth was calculated from four measurements, one taken at each corner of the 1-m square. Bare ground was measured using the same criteria. During the first two sampling occasions, all values were scored by two observers independently, and discrepancies were resolved prior to recording the final values to ensure consistency in data collection among the individuals collecting the data. The total proportions for each station were checked to ensure they would equal 100%.

Each site was dominated by two to three species, and as noted previously, the dominant species differed between sites. All other plant species present at each site made up a very small proportion of the total vegetation, and in general, these species were small annuals that added very little to the overall structure of the habitat that we were seeking to characterize. Therefore, after the initial species identification, it was decided to consolidate species into life forms: grass, herb, bush, and tree. The general life form categories increased efficiency in collecting vegetation data and reduced the amount of rare event data included in analyses but still resulted in large numbers of null values for each site because the sites were generally dominated by only one life form. Therefore, for statistical

analyses, only the 10 vertical cover measures and percent vegetation cover (100-Bare ground percent cover) were considered as methods of quantifying the vegetation structure.

Capture-Mark-Recapture

Capture-mark-recapture (CMR) was conducted over six primary occasions: fall 2009, spring 2010, fall 2010, spring 2011, fall 2011, and fall 2013. Program MARK version 7.1 was used to simultaneously estimate survival, capture probability, and population size using the Robust model, which assumes closed populations within primary sampling occasions but allows temporary immigration and emigration between occasions. Due to logistical issues, several sites were not sampled on every occasion, and there was uneven sampling periods between some occasions. The Robust model does not handle missing data, so the data file was reduced to only occasions for which there were data from every site, which further increased the unevenness of primary occasions. During spring 2011, the PVER was not sampled, and only 3 trap-nights (secondary occasions) were conducted during spring and fall 2010. Therefore, the final analysis had five primary occasions, with four, three, three, four, and four secondary occasions, respectively. Furthermore, the Robust analysis employed in Program MARK does not properly correct movement parameters when sampling is uneven; therefore, we set $\gamma' = 1$ and $\gamma'' = 0$ (i.e., no movement). This was considered appropriate because we were primarily interested in estimating survival and population size, which are properly corrected for uneven time between sampling. Time was scaled to 6 months, the approximate time between most of the occasions.

Several *a priori* hypotheses were developed so they could be compared in the Program MARK analyses. These included the effects of site and season on the survival estimates of Colorado River cotton rats. The small sample version of Akaike's information criterion (AIC_c) was used, and ΔAI_C values > 2 were considered as less support for a model when comparing competing models following guidelines in Burnham and Anderson 2002. Weighted model averaging of all the models with AIC weight > 0 was used to estimate the mean, unconditional standard error, and 95% confidence intervals (CIs) of survival, capture probability, and population size.

Growth rates between seasons were described using summary statistics of weight. Weight was only collected from fall 2009 to fall 2010 and then again in fall 2013. Because of few recaptures among successive occasions, the data were pooled for all three sites.

Vegetation

Habitat was analyzed at two levels: (1) the entire site and (2) specific trap locations that Colorado River cotton rats used within a site. The overall habitat at each site is described by first reporting plant species lists for each site. Vertical cover and overall vegetation cover were used to test if there were differences among sites and microhabitat use that may correlate with survival and population size estimates. Microhabitat (hereafter referred to as use) was defined as at least one Colorado River cotton rat captured at a particular trap station during a given trapping occasion. For all statistical analyses, the midpoint of each of the categorical variables was used.

A multivariate analysis of variance (MANOVA) in IBM SPSS Statistics version 21 (IBM Corporation) was used to statistically test for differences in the vertical cover of vegetation among sites and between used and unused areas during each trapping occasion. The habitat structure of each site was quantified by calculating summary statistics for the vertical cover and vegetation cover for all of the trapping locations. Prior to running the MANOVA, the dependent variables were examined for highly correlated strata. Vertical covers 3, 5, 6, 7, 9, and 10 were removed because these variables were highly correlated with the other vertical cover measures (Spearman coefficient > 0.75). Homogeneity of variances was tested using Levene's test. Separate tests were conducted for each season by comparing vegetation among sites and used versus unused trap stations (p for all statistical comparisons was set at 0.05), which eliminated the need to use a repeated measures model to account for autocorrelated errors and control for among-season effects. Additionally, whether a trap station was used or unused could change between seasons, making repeated measures difficult to implement to test that effect.

We were interested in whether vegetation structure could be used to predict the specific areas of a site that are being used by Colorado River cotton rats. Microhabitat use was modeled using a logistic regression in IBM SPSS Statistics version 21 (IBM Corporation). Logistic regression has many potential benefits over other methods (such as MANOVA) for quantifying habitat use (Cross and Peterson 2001). If a predictive model could be developed, it would be very informative for adaptive management of restoration efforts. The probability of cotton rat use was modeled with vertical covers 1, 2, 4, 8, and vegetation cover (same variables used in the MANOVA) was assigned as the predictor variable. The model was built using a training dataset composed of the data from the first vegetation sampling, spring 2010, and compared all combinations of the predictor variables using the change in log likelihood scores. To test the predictive ability of the model, cotton rat use data during the three other seasons, fall 2010, spring 2011, and fall 2011, were classified based on the habitat variables collected during those seasons with a probability threshold of 0.5.

Results

Vegetation

Vegetation sampling occurred four times during 2010 and 2011. During fall 2010, only 21 of 39 stations were unavailable at the PVER bench because the river flooded a portion of the site. During spring 2010, only 45 trap stations were used at the Cibola Nature Trail, and during spring 2011, the PVER was not sampled – both due to logistical constraints. A fourth transect was added to the Cibola Nature Trail after spring 2010 by increasing the number of field workers. No data were collected from two trap stations at the Cibola Nature Trail in fall 2010 due to dense vegetation that made it difficult to find all of the stations.

The species list for all plants found at the three sites is presented in attachment 3. Native status and life form are also provided for reference. Each site had different dominant plant species and life forms that dominated; therefore, plant species and life forms were not included in statistical analyses due to the large amount of null measurements within a given site.

At the site level, the PVER and the Cibola Nature Trail had higher average vertical cover close to the ground when compared to Pintail. During spring 2010 and spring 2011, vertical cover within the first 20 cm of the ground (VC1 and VC2) was significantly higher at the PVER and the Cibola Nature Trail. Vertical cover was also significantly higher, 30–40 cm above ground, at both of those sites in spring 2010 but only at the PVER spring 2011. A similar, though non-significant trend of increased vegetation cover at or very near ground level was observed at the PVER and the Cibola Nature Trail. The results of the MANOVA are presented in table 1. The sites differed in vegetation structure during spring 2010, fall 2010, and fall 2011. During spring 2011, only two sites were sampled, the Cibola Nature Trail and Pintail, and the total number of Colorado River cotton rats captured was unusually low (N = 12) compared with other seasons (attachments 1a–b). The average vertical cover measurements for each site up to 1 m are summarized on figure 1, and descriptive statistics are reported in attachments 2a–d. The results of the MANOVA show there was a statistical difference between vegetation structure at used and unused stations during spring 2010 (table 1 and attachments 1a–c). There was a tendency toward higher vegetation density, in particular within the first 50 cm, at trap stations where a Colorado River cotton rat was captured compared to unused trap stations during every season (figure 2 and attachments 1a–c).

The binomial logistic regression resulted in a model that was a significantly better fit than the intercept only model (Hosmer and Lemeshow test, χ^2 =2.866, degrees of freedom (d.f.) = 6, p = 0.825). The best model based on our selection criteria included vertical covers 2 and 8 as predictor variables (log likelihood = 224.328). The predictive ability of the model was overall fairly low but consistent between the training and test data (table 2). The overall accuracy of the model was 63.9%.

Table 1.—MANOVA results comparing vegetation structure among three sites and between used and unused trap stations during four sampling occasions

(Use is defined as at least one Colorado River cotton rat being captured at that trap station during a season. Pillai's trace F statistic is reported. Significant differences are shown in bold when alpha < 0.05.)

Season	Effect	F	d.f.	Error d.f.	Significance
Spring 2010	**Use**	**2.964**	**5**	**170**	**0.014**
	Site	**3.338**	**10**	**342**	**< 0.001**
	Use X Site	0.408	10	342	0.942
Fall 2010	Use	1.306	5	162	0.264
	Site	**2.699**	**10**	**326**	**0.003**
	Use X Site	1.428	10	326	0.166
Spring 2011	Use	1.821	5	127	0.113
	Site	0.741	5	127	0.594
	Use X Site	0.643	5	127	0.667
Fall 2011	Use	1.904	5	185	0.090
	Site	**4.071**	**10**	**372**	**< 0.001**
	Use X Site	1.3341	10	372	0.207

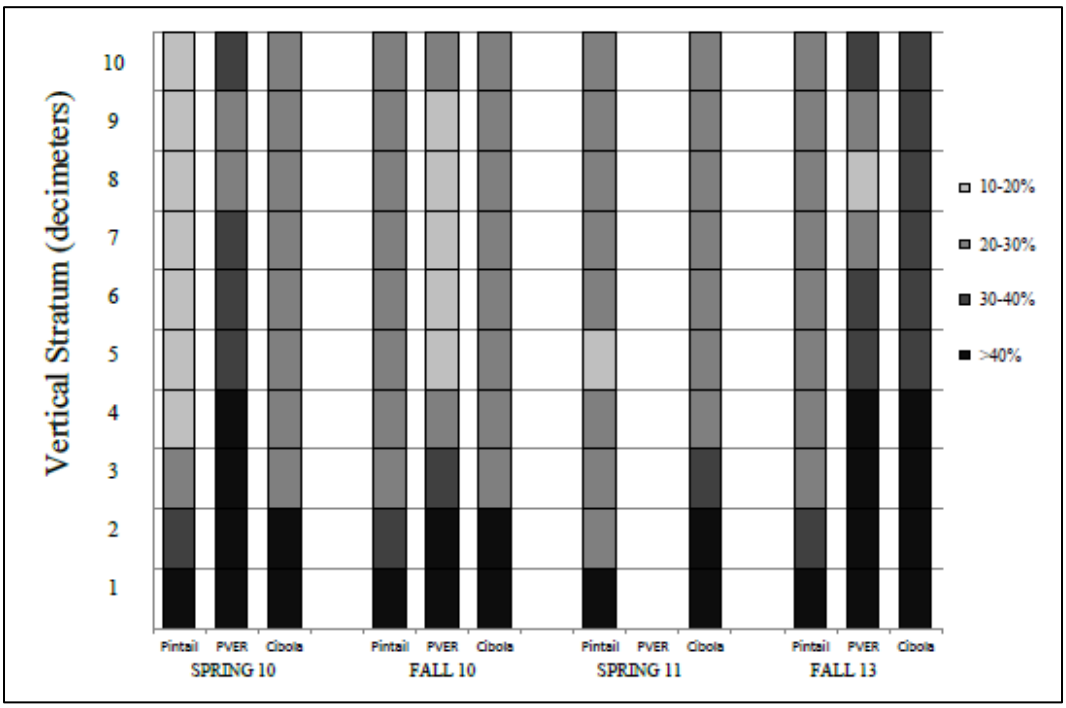

Figure 1.—Mean vertical cover scores for each decimeter at three sites during four sampling occasions.

Darker shading represents higher average density values at that decimeter for the overall site.

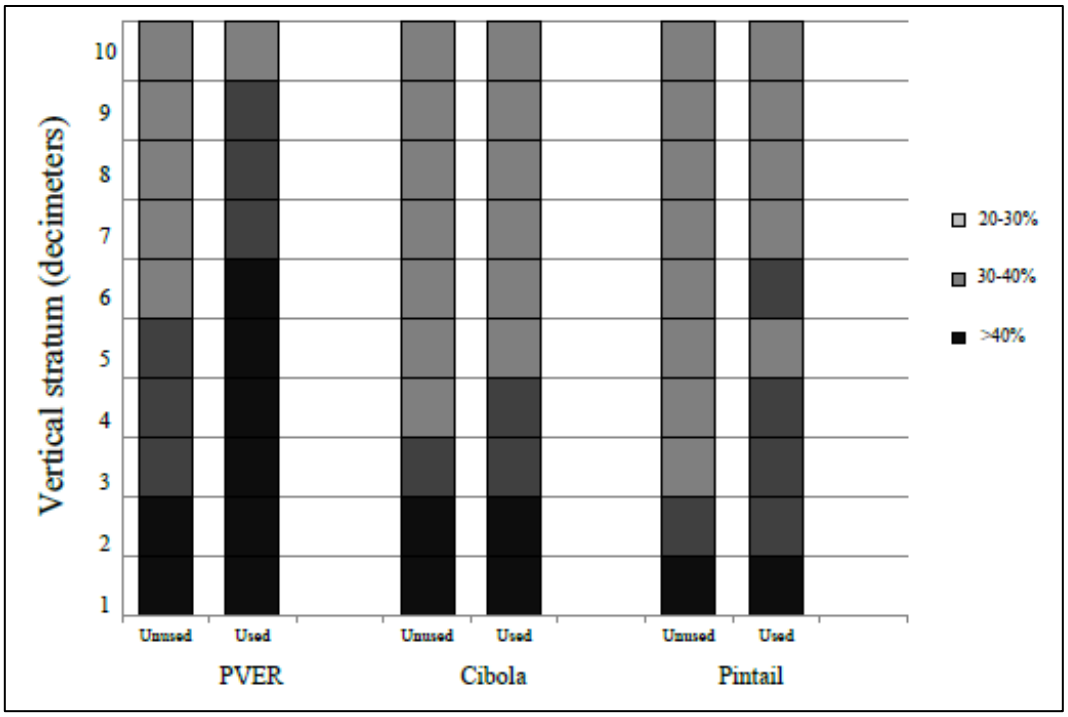

Figure 2.—Mean vertical cover of trapping stations where Colorado River cotton rats were captured (used) compared to stations where they were not captured (unused) at three sites over all four sampling intervals.
(Darker shading represents higher average density values. Values were pooled across seasons.

Table 2.—Classification results of the binomial logistic regression for the training dataset, spring 2010, and the test datasets, fall 2010, spring 2011, and fall 2011
(See text for more information.)

Predicted						
	Training data			Test data		
Observed	Not used	Used	Percent correct	Not used	Used	Percent correct
Not used	76	19	80.0	257	126	67.1
Used	42	43	50.6	55	64	53.8
Overall percentage			66.1			63.9

The sensitivity of the model (correctly predicting a cotton rat capture) was relatively low at 53.8%. The specificity (correctly predicting no use by cotton rats) was slightly higher at 67.1% of the test data.

Capture-Mark-Recapture

The numbers of cotton rats marked at the three sites during each primary sampling occasion (first trapping night of a single trapping session) are reported in table 3. Fall typically had higher numbers of captured individuals than spring. Over the course of the study, there was a general decline in the number of captures at each site.

Table 3.—Number of individual Colorado River cotton rats marked (N) at each site per sampling occasion

Site	Season	Year	N
PVER	Fall	2009	29
	Spring	2010	20
	Fall	2010	65
	Spring	2011	Not sampled
	Fall	2011	52
	Fall	2013	16
Cibola Nature Trail	Fall	2009	42
	Spring	2010	23
	Fall	2010	38
	Spring	2011	10
	Fall	2011	9
	Fall	2013	4
Pintail	Fall	2009	21
	Spring	2010	14
	Fall	2010	7
	Spring	2011	2
	Fall	2011	5
	Fall	2013	0

All Robust models with AIC_c weights > 0 are given in table 4. Preliminary analyses were run to evaluate the effect of varying the parameters that were not of primary interested to estimate: capture probability (*p*) and recapture probability (*c*). Estimates for most of the parameters were not possible if capture and recapture probabilities were modeled independently, so it was assumed there was no effect of marks or trap experience and set *c* equal to *p* (capture probability = recapture probability). Models in which *c* and *p* were held constant and allowed to vary over time, over sites, and over both time and sites were evaluated.

Table 4.—Model results from Program MARK
(The Robust design was used to model CMR data. Only models with > 0 AIC_c weight are shown. S = survival; capture probability varied over sites and time for all models.)

Model	AIC_c	Delta AIC_c	AIC_c weights	Model likelihood	Number of parameters
S(Site x Time)	17.8206	0.0000	0.62468	1.000	44
S(Site)	19.4658	1.6452	0.27441	0.4393	35
S(.)	21.5777	3.7571	0.09546	0.1528	33
S(Time)	27.3021	9.4815	0.00545	0.0087	36

The best-fit models allowed *c* and *p* to vary over sites and time. The best-fit models showed time and site or just site-dependent survival, although estimates for these parameters were unavailable for Pintail and the Cibola Nature Trail during many occasions. In general, the PVER had the highest average survival probability, while the Cibola Nature Trail and Pintail had relatively lower survival, although when the 95% CIs of these estimates are considered, there is effectively no difference in survival estimates at the three sites (table 5).

Population sizes were highly variable within and among the three sites, although the Robust model showed there was a general trend toward declining population size over the 4 years of the study. The population at the PVER, which was the only one that showed statistical significance using 95% CI, increased in fall 2010 and then declined back to what it was at the beginning of the study. The Cibola Nature Trail initially had the largest population of Colorado River cotton rats among the three sites but, by fall 2013, had declined to a relatively small population. The population at Pintail was also relatively high but then declined to the point that no cotton rats were captured during the last sampling (table 6).

The average weight at initial capture for an individual Colorado River cotton rat was similar among sites (table 7). Sixteen individuals that were marked in fall 2009 were recaptured in spring 2010. Three individuals were recorded during spring 2010 and fall 2010 – two of which were initially captured in fall 2009, and the other was first captured in spring 2010. From these data, an average growth rate of 60 grams (g) was estimated (standard deviation = 36.1; range 8–124 g) between fall 2009 and spring 2010, while the growth rate was -3.7 g (standard deviation = 14.8; range = -20–9 g) between spring and fall 2010.

Table 5.—Model-averaged parameter estimates from Program MARK
(Survival estimates are the probability of survival between the corresponding primary occasions scaled to 6 months.)

Parameter	Estimate	Standard error	95% CI	
Survival parameter (S) Pintail 1	0.108	0.090	0.019	0.430
Survival parameter (S) Pintail 2	0.132	0.098	0.028	0.449
Survival parameter (S) Pintail 3	N/A			
Survival parameter (S) Pintail 4	N/A			
Survival parameter (S) Cibola Nature Trail 1	0.116	0.052	0.046	0.262
Survival parameter (S) Cibola Nature Trail 2	N/A			
Survival parameter (S) Cibola Nature Trail 3	N/A			
Survival parameter (S) Cibola Nature Trail 4	N/A			
Survival parameter (S) PVER 1	0.307	0.109	0.140	0.547
Survival parameter (S) PVER 2	0.295	0.123	0.116	0.571
Survival parameter (S) PVER 3	0.161	0.074	0.062	0.358
Survival parameter (S) PVER 4	N/A			
Capture probability (p) session 1 Pintail	0.472	0.064	0.351	0.596
Capture probability (p) session 1 Cibola Nature Trail	0.261	0.045	0.183	0.359
Capture probability (p) session 1 PVER	0.538	0.053	0.434	0.639
Capture probability (p) session 2 Pintail	0.440	0.105	0.255	0.644
Capture probability (p) session 2 Cibola Nature Trail	0.788	0.050	0.673	0.870
Capture probability (p) session 2 PVER	0.475	0.087	0.313	0.642
Capture probability (p) session 3 Pintail	0.279	0.148	0.084	0.621
Capture probability (p) session 3 Cibola Nature Trail	0.492	0.059	0.378	0.607
Capture probability (p) session 3 PVER	0.480	0.045	0.394	0.568
Capture probability (p) session 4 Pintail				
Capture probability (p) session 4 Cibola Nature Trail				
Capture probability (p) session 4 PVER	0.587	0.037	0.513	0.657
Capture probability (p) session 5 Pintail				
Capture probability (p) session 5 Cibola Nature Trail	0.437	0.124	0.225	0.676
Capture probability (p) session 5 PVER	0.433	0.075	0.296	0.581

Table 6.—Population size estimates (N) for each site and occasion estimated by Program MARK

(For occasions during which no estimate was possible due to insufficient data, a minimum population size is reported based on the number of individuals marked during that occasion, and no 95% CI is provided. Numbers denoted with a superscript letter are based on the number of marked individuals released during that occasion.)

Site	Occasion	N	95% CI
Pintail	Fall 2009	22	19–26
	Spring 2010	16	11–21
	Fall 2010	10	7[a]–19
	Fall 2011	9	2[a]–19
	Fall 2013	No captures	N/A
Cibola Nature Trail	Fall 2009	59	43–75
	Spring 2010	23[a]	N/A
	Fall 2010	43	38[a]–50
	Fall 2011	9[a]	N/A
	Fall 2013	4[a]	N/A
PVER	Fall 2009	29	29[a]–31
	Spring 2010	20 [a]	20[a]–23
	Fall 2010	75	66–84
	Fall 2011	54	51–57
	Fall 2013	17	17[a]–21

Table 7.—The average, standard deviation, and range of weight at the time of initial capture of an individual Colorado River cotton rat at each site

Site	Average weight (g)	Standard deviation (g)	Range (g)
Cibola Nature Trail	124.5	35.5	52–218
Pintail	111.8	49.7	22–234
PVER	102.4	38.5	20–227

DISCUSSION

Vegetation

The first goal of this research was to define the physical structure of the habitat utilized by the Colorado River cotton rat at two scales. The importance of studying habitat selection at multiple scales has been understood since at least Johnson (1980) outlined his four orders of selection. Scale is a vibrant area of research, and the utility of understanding resource use at multiple levels is underscored by the variety of ecological and evolutionary research that continues to focus on scale (e.g., see review by Mayor et al. 2009). The necessity of habitat modeling at different scales in habitat conservation research is also apparent (e.g., Doherty et al. 2010); however, there is little consensus in the literature regarding the appropriate scale to conduct studies or even the use of terms – variation that is perhaps due to the inherent variability among species (Mayor et al. 2009). Two levels of study were chosen because of the utility to the goals of the LCR MSCP, logistics, and previous research.

Foraging microhabitat was not able to be distinguished from what was available within each of the sites for all but spring 2010. In this study, foraging microhabitat was examined by assuming that when an individual was trapped at a location, it was actively foraging at that location. This further assumes a cubic meter (the area measured in the vegetation analysis) is approximately the extent of which an individual cotton rat was selecting for while foraging. The inability to distinguish habitat differences at this scale may be due to several issues, including data collection methodology, small sample size, characteristics of the species, and available habitat.

The sampling strategy employed in this study had many limitations that likely contributed to the inability to differentiate use and non-use microhabitat. First, the measurements of vertical cover may have been too coarse to detect subtle differences in use by Colorado River cotton rats, if there were differences. The methodology was chosen for its ease in use and the limited expertise and training necessary to implement the data collection; however, the simplicity comes at the cost of limited resolution. Additionally, the categorical nature of the data collection and differences in observers (or observer bias) throughout the study may have introduced additional errors. Zero percent was included within the 1–25% vertical cover category, which likely introduces bias in the estimates since 0% was progressively more common near the top of the meter board. The relatively short time period of sampling, the low numbers of captures, and the short distances between successive trap stations are also possible issues with the sampling design that could have impacted the ability to detect subtle microhabitat differences in use. At most, only 3–4 trap nights were sampled each occasion to determine if a station was used, so it is likely that some areas that may have been used by Colorado River cotton rats during the season were classified as unused

simply because of the limited sampling effort or low trap success (which may be due to sampling effort, population size, or both). More sensitive measurements of vertical cover may provide evidence of differences within the site; however, it does not appear as though that level of detail would be necessary or worth the effort given the focus of the LCR MSCP.

For the large area that would need to be monitored along the LCR, the site-level analysis appears to be a more appropriate scale to sample with respect to the LCR MSCP program objectives and amount of effort necessary. A site was defined as the area of habitat that includes some or all of a local population (deme) of Colorado River cotton rats. This addresses the habitat at a broad scale because a site is a patch of habitat that encompasses multiple individuals that are born, reproduce, and die within the site. The site is not necessarily selected by an individual (i.e., no immigration), and the presence of an individual at the site is assumed to be the result of successful reproduction within it. The choice of scale for the site appears to fit the previous assumption during the timeframe of the study that no immigration or emigration of tagged individuals from one site was observed outside of that site during this study. Given the population dynamics and other natural history characteristics of cotton rat species, the size of the trapping grid and the definition of a site is probably not valid over longer time periods or in areas with habitat patches that are closer together, both of which would increase the likelihood of movement among similar-sized sites.

The three sites examined in this study differed in terms of vegetation composition and structure, and for at least part of the study, Colorado River cotton rat population size. The Cibola Nature Trail is dominated by Johnsongrass, the PVER accretion bench is primarily a shrub-like forb, *Pulicaria,* and Pintail Slough was partially Johnsongrass at the beginning of the study but is heavily dominated by *Chlorocantha,* a shrub. Colorado River cotton rats were captured in both the Johnsongrass and the *Chlorocantha*, but the Johnsongrass had diminished throughout the 4 years of the study. Prior to this study, no quantitative analysis of habitat for Colorado River cotton rats has been conducted; however, the ecologically similar hispid cotton rat selects for shrubs at least 1 m high and high herbaceous cover but does not select for any specific vegetation type (Bowne et al. 1999). In the present study, Colorado River cotton rats were found to occupy sites with different species and life forms of dominant vegetation, with the PVER primarily driving any observed differences in vertical cover among sites (attachments 1a–c). It appears that multiple vegetation types can create the structural characteristics of habitat that will be used by Colorado River cotton rats.

Of particular interest to restoration efforts is the shrub *Chlorocantha.* This shrub provides vertical cover up to 1 m within the range of what Colorado River cotton rats are using along the LCR. At Pintail, a strip of *Chlorocantha* runs perpendicular through the center of the trapping grid. Cotton rats were usually captured in the very dense patch of *Chlorocantha*. The shrub appears to be low

maintenance and drought tolerant, and it creates a thick cover that excludes other vegetation. At full height, it is just over 1 m tall and would probably require little management to maintain appropriate habitat for cotton rats. It is also native (unlike *Pulicaria* or *Sorguhm*) and may be a useful species to incorporate in restoration sites that will be irrigated infrequently or in areas that receive less water. It was suggested, when used, that *Chlorocantha* be incorporated into a broader mosaic with native grasses instead of monocultures to avoid negative or unanticipated consequences of having a single plant species dominate an area such as reduced biodiversity or loss of a minor but essential resource necessary for cotton rat survival. The plant may also prove useful for filling clearings where trees did not grow and there is open canopy. Two sites, one at either end of the LCR, have *Chlorocantha*; Pintail has a large patch running through it, and the shrub has also been identified at the Pratt Restoration Demonstration Area near Betty's Kitchen north of Yuma, Arizona. It is believed that in both cases *Chlorocantha* has naturally colonized the sites.

Capture-Mark-Recapture

The CMR methodology used does not appear to provide sufficient data to robustly estimate the population size and survival of Colorado River cotton rats, with the exception of dense populations when recaptures rates were highest. There were low numbers of recaptures between 6-month intervals (e.g., 19 of the 228 total individuals marked were captured in a later season during the first year of trapping when capture rates were still fairly high). Better demographic estimates may be obtained from sampling less intensively (fewer secondary occasions) but more often (increased primary occasions). It is known that some species of cotton rats exhibit trap bias (Cameron and Spencer 1981) and may also exhibit differences in recapture probability. Capture and recapture probability could not be estimated independently as a result of insufficient sample sizes and the large number of parameters in that type of model (> 90 parameters). The Robust analysis employed here does not properly correct emigration and immigration parameters when sampling is uneven. The time period between occasions is not consistent in this study because some seasons were not sampled; therefore, the immigration and emigration parameters were not estimated. Even sampling would allow the movement parameters to be built into the model, if that were of interest. More recaptures could be obtained by reducing the time interval between occasions, perhaps down to every 2–3 months.

In this study, average survival was estimated between 0.10–0.31 for 6 months. This is the first known estimate for Colorado River cotton rats, so no comparisons to previous research can be made. The hispid cotton rat, a closely related species to the Colorado River cotton rat, exhibits a low expectation of further life (mean duration of residence for all individuals), estimated at 2 weeks for a site in Durango, Mexico (Peterson 1973) and 2 months in southern Texas (Cameron

1977). These estimates are slightly different than the survival estimates reported in this study; therefore, they are not directly comparable, but they all suggest a fairly high turnover rate for a population. Hispid cotton rats and, presumably, Colorado River cotton rats, have an incredible reproductive output (Cameron and Spencer 1981) that likely offsets (or possibly is necessary because of) the low survival probability estimated in this study.

It was not determined if vegetation cover affects the survival probability or the population size of Colorado River cotton rats due to the inability of the models to reliably estimate the demographic parameters. The population at the PVER had the highest average survival estimate, and the population size at that site may be on average higher than the other sites at least during the beginning of the study; however, it is important to note that none of the survival estimates were statistically different due to wide CIs, and caution should be used when inferring anything from such a small dataset. Hispid cotton rats and Colorado River cotton rats are both known to exhibit large population cycles (Cameron and Spencer 1981; Blood 1990; Gwinn et al. 2011). It appears, at least superficially, that during the 4 years this study was conducted, much of the high and low points of a single cycle at each site were captured, but continued monitoring is necessary to confirm this observation. Two of the sites (Pintail and The Cibola Nature Trail) consistently had too few captures or recaptures over the last two occasions to provide sufficient data for either the CMR or the vegetation use analyses. These populations may have entered the low point of a cycle, making studies that rely on large numbers of captures and recaptures difficult to implement. To improve these estimates, a massive sampling effort would be necessary. If we look at this another way and ask how many trap-nights are necessary to confirm presence when cotton rats are known to be present at a site, even when population size and/or trap success was fairly low, the probability of detecting cotton rats was 100% after 2 nights of trapping during any season of this study. The results of this analysis infer that a minimum trapping effort of 2 nights could be used in future protocols to document presence.

Given the cursory objective of obtaining preliminary data on the demographics of Colorado River cotton rats, we were also interested in better understanding the level of effort required to implement an informative long-term monitoring survey of the species. At this point, we several issues have been identified with the methodology examined and logistics necessary to correct some of the deficiencies of the methods used to make some logical recommendations. First, many of the above-mentioned limitations to the current design will likely not be able to be resolved; for example, increasing sampling frequency to every 2 months is probably not worth the increased cost or time that would go into collecting the data. Furthermore, limitations inherent to the species also present issues that are out of the investigator's hands, such as population crashes that preclude adequate data sampling irrespective of design. It seems the most prudent course of action at this point would be to turn the focus of the remaining resources from the first two objectives of this work (the habitat and population demographics reported

here) to the third goal of establishing a monitoring plan for cotton rats along the LCR that incorporates the information obtained regarding the logistics of monitoring cotton rats and the feasibility of collecting the necessary data to meet the goals of the LCR MSCP.

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ATTACHMENT 1A

Descriptive Statistics of Vertical Cover (VC1–VC10) and Vegetation Cover (Vegetation) for the Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail Comparing Used and Unused Trap Stations

Attachment 1a.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover (vegetation) for the Cibola Nature Trail comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC1	Spring 2010	Unused	61.719	29.7450	16
		Used	68.534	22.8105	29
		Total	66.111	25.3697	45
	Fall 2010	Unused	50.962	27.3686	26
		Used	68.750	25.0000	32
		Total	60.776	27.3509	58
	Spring 2011	Unused	60.784	23.5876	51
		Used	62.500	28.6411	9
		Total	61.042	24.1477	60
	Fall 2011	Unused	59.722	24.2416	54
		Used	79.167	15.1383	6
		Total	61.667	24.1230	60
	All seasons	Unused	58.759	25.2307	147
		Used	68.750	23.8485	76
		Total	62.164	25.1661	223
VC2	Spring 2010	Unused	35.156	23.3714	16
		Used	48.707	28.0196	29
		Total	43.889	26.9972	45
	Fall 2010	Unused	29.808	20.9395	26
		Used	50.000	25.9885	32
		Total	40.948	25.7341	58
	Spring 2011	Unused	40.196	23.4938	51
		Used	48.611	28.2597	9
		Total	41.458	24.1916	60
	Fall 2011	Unused	47.222	27.4363	54
		Used	68.750	18.9572	6
		Total	49.375	27.3692	60
	All seasons	Unused	40.391	25.1735	147
		Used	50.822	26.6408	76
		Total	43.946	26.0977	223

Attachment 1a.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover (vegetation) for the Cibola Nature Trail comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC3	Spring 2010	Unused	21.094	17.5112	16
		Used	31.034	22.8105	29
		Total	27.500	21.4198	45
	Fall 2010	Unused	24.038	18.3450	26
		Used	33.984	20.8766	32
		Total	29.526	20.2368	58
	Spring 2011	Unused	32.353	20.3372	51
		Used	41.667	31.2500	9
		Total	33.750	22.2300	60
	Fall 2011	Unused	41.898	26.3947	54
		Used	62.500	22.3607	6
		Total	43.958	26.5905	60
	All seasons	Unused	33.163	23.3007	147
		Used	36.020	24.1495	76
		Total	34.137	23.5780	223
VC4	Spring 2010	Unused	20.313	17.6039	16
		Used	27.155	21.1471	29
		Total	24.722	20.0300	45
	Fall 2010	Unused	22.596	17.6845	26
		Used	27.344	20.4381	32
		Total	25.216	19.2359	58
	Spring 2011	Unused	26.716	18.2036	51
		Used	37.500	27.9508	9
		Total	28.333	20.0459	60
	Fall 2011	Unused	39.120	25.9315	54
		Used	50.000	17.6777	6
		Total	40.208	25.3254	60
	All seasons	Unused	29.847	22.3055	147
		Used	30.263	22.1042	76
		Total	29.989	22.1882	223

Attachment 1a.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover (vegetation) for the Cibola Nature Trail comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC5	Spring 2010	Unused	18.750	11.1803	16
		Used	23.276	15.2084	29
		Total	21.667	13.9500	45
	Fall 2010	Unused	20.673	16.9345	26
		Used	25.391	20.4497	32
		Total	23.276	18.9425	58
	Spring 2011	Unused	23.529	16.5165	51
		Used	36.111	26.1041	9
		Total	25.417	18.5500	60
	Fall 2011	Unused	36.574	24.0199	54
		Used	43.750	18.9572	6
		Total	37.292	23.5256	60
	All seasons	Unused	27.296	20.4310	147
		Used	27.303	19.8652	76
		Total	27.298	20.1951	223
VC6	Spring 2010	Unused	17.188	8.9849	16
		Used	22.845	17.0572	29
		Total	20.833	14.8381	45
	Fall 2010	Unused	22.596	17.3274	26
		Used	24.609	20.6947	32
		Total	23.707	19.1213	58
	Spring 2011	Unused	24.020	16.3637	51
		Used	36.111	25.3448	9
		Total	25.833	18.2477	60
	Fall 2011	Unused	35.648	24.9300	54
		Used	39.583	22.9356	6
		Total	36.042	24.5825	60
	All seasons	Unused	27.296	20.5354	147
		Used	26.480	20.5109	76
		Total	27.018	20.4845	223

Attachment 1a.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover (vegetation) for the Cibola Nature Trail comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC7	Spring 2010	Unused	17.969	7.8644	16
		Used	24.138	19.1712	29
		Total	21.944	16.2447	45
	Fall 2010	Unused	23.077	21.1224	26
		Used	23.828	20.1705	32
		Total	23.491	20.4228	58
	Spring 2011	Unused	23.284	14.7943	51
		Used	25.000	19.7642	9
		Total	23.542	15.4542	60
	Fall 2011	Unused	36.806	25.3997	54
		Used	39.583	21.5300	6
		Total	37.083	24.8903	60
	All seasons	Unused	27.636	21.0609	147
		Used	25.329	19.8928	76
		Total	26.850	20.6544	223
VC8	Spring 2010	Unused	16.406	9.9150	16
		Used	25.431	20.9918	29
		Total	22.222	18.2488	45
	Fall 2010	Unused	24.038	21.7724	26
		Used	21.875	14.5497	32
		Total	22.845	18.0061	58
	Spring 2011	Unused	22.059	14.7029	51
		Used	27.778	19.5434	9
		Total	22.917	15.4671	60
	Fall 2011	Unused	35.185	24.2911	54
		Used	41.667	18.8193	6
		Total	35.833	23.7468	60
	All seasons	Unused	26.616	20.6525	147
		Used	25.493	18.5338	76
		Total	26.233	19.9208	223

Attachment 1a.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover (vegetation) for the Cibola Nature Trail comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC9	Spring 2010	Unused	15.625	9.6825	16
		Used	24.569	21.2560	29
		Total	21.389	18.3909	45
	Fall 2010	Unused	23.558	22.1718	26
		Used	21.875	14.1990	32
		Total	22.629	18.0546	58
	Spring 2011	Unused	22.059	15.1221	51
		Used	31.944	26.5982	9
		Total	23.542	17.3894	60
	Fall 2011	Unused	34.259	23.9380	54
		Used	35.417	22.9356	6
		Total	34.375	23.6528	60
	All seasons	Unused	26.105	20.5825	147
		Used	25.164	19.5249	76
		Total	25.785	20.1892	223
VC10	Spring 2010	Unused	15.625	9.6825	16
		Used	27.155	22.4277	29
		Total	23.056	19.5757	45
	Fall 2010	Unused	23.077	20.8244	26
		Used	21.484	14.9712	32
		Total	22.198	17.6844	58
	Spring 2011	Unused	22.549	17.5035	51
		Used	27.778	21.4492	9
		Total	23.333	18.0434	60
	Fall 2011	Unused	34.491	23.5343	54
		Used	37.500	34.4601	6
		Total	34.792	24.4745	60
	All seasons	Unused	26.276	20.8311	147
		Used	25.658	20.7057	76
		Total	26.065	20.7439	223

Attachment 1a.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover (vegetation) for the Cibola Nature Trail comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
Vegetation	Spring 2010	Unused	96.0938	10.08170	16
		Used	98.0517	7.57032	29
		Total	97.3556	8.48637	45
	Fall 2010	Unused	98.8462	3.69261	26
		Used	99.3750	3.09266	32
		Total	99.1379	3.35449	58
	Spring 2011	Unused	97.8529	7.44936	51
		Used	97.9444	3.29246	9
		Total	97.8667	6.96411	60
	Fall 2011	Unused	99.6019	1.21849	54
		Used	100.0000	0.00000	6
		Total	99.6417	1.16113	60
	All seasons	Unused	98.4796	5.79409	147
		Used	98.7500	5.20224	76
		Total	98.5717	5.58910	223

ATTACHMENT 1B

Descriptive Statistics of Vertical Cover (VC1–VC10) and Vegetation Cover for Pintail Slough Comparing Used and Unused Trap Stations

Attachment 1b.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for Pintail Slough comparing used and unused trap stations (Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC1	Spring 2010	Unused	49.554	25.4465	56
		Used	53.289	31.1365	19
		Total	50.500	26.8284	75
	Fall 2010	Unused	53.333	25.6139	60
		Used	57.500	26.6425	15
		Total	54.167	25.6942	75
	Spring 2011	Unused	48.116	26.8153	73
		Used	50.000	0.0000	2
		Total	48.167	26.4522	75
	Fall 2011	Unused	49.653	26.0326	72
		Used	41.667	31.4576	3
		Total	49.333	26.0662	75
	All seasons	Unused	50.048	25.9553	261
		Used	53.846	28.1201	39
		Total	50.542	26.2286	300
VC2	Spring 2010	Unused	28.125	17.5567	56
		Used	40.789	30.0006	19
		Total	31.333	21.8809	75
	Fall 2010	Unused	31.667	20.6446	60
		Used	37.500	28.3473	15
		Total	32.833	22.3014	75
	Spring 2011	Unused	29.110	21.6561	73
		Used	37.500	0.0000	2
		Total	29.333	21.4048	75
	Fall 2011	Unused	34.896	24.5503	72
		Used	29.167	28.8675	3
		Total	34.667	24.5374	75
	All seasons	Unused	31.082	21.5282	261
		Used	38.462	27.8602	39
		Total	32.042	22.5352	300

Attachment 1b.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for Pintail Slough comparing used and unused trap stations (Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC3	Spring 2010	Unused	17.634	8.8474	56
		Used	31.579	26.4734	19
		Total	21.167	16.3075	75
	Fall 2010	Unused	23.750	18.0776	60
		Used	30.000	27.0581	15
		Total	25.000	20.1347	75
	Spring 2011	Unused	21.747	16.6702	73
		Used	56.250	8.8388	2
		Total	22.667	17.4000	75
	Fall 2011	Unused	27.778	21.4179	72
		Used	37.500	33.0719	3
		Total	28.167	21.7570	75
	All seasons	Unused	22.989	17.4938	261
		Used	32.692	26.3790	39
		Total	24.250	19.1112	300
VC4	Spring 2010	Unused	15.625	7.6314	56
		Used	29.605	25.0730	19
		Total	19.167	15.2863	75
	Fall 2010	Unused	21.458	15.4542	60
		Used	27.500	25.9636	15
		Total	22.667	17.9965	75
	Spring 2011	Unused	20.548	15.9167	73
		Used	50.000	0.0000	2
		Total	21.333	16.4108	75
	Fall 2011	Unused	26.389	22.6497	72
		Used	41.667	31.4576	3
		Total	27.000	22.9791	75
	All seasons	Unused	21.312	17.0598	261
		Used	30.769	25.1388	39
		Total	22.542	18.5348	300

Attachment 1b.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for Pintail Slough comparing used and unused trap stations (Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC5	Spring 2010	Unused	15.402	6.3025	56
		Used	27.632	22.2747	19
		Total	18.500	13.3748	75
	Fall 2010	Unused	21.250	16.1593	60
		Used	27.500	24.1831	15
		Total	22.500	18.0324	75
	Spring 2011	Unused	19.349	14.4399	73
		Used	37.500	35.3553	2
		Total	19.833	15.1141	75
	Fall 2011	Unused	26.042	22.9580	72
		Used	45.833	31.4576	3
		Total	26.833	23.4028	75
	All seasons	Unused	20.785	16.8479	261
		Used	29.487	23.7322	39
		Total	21.917	18.0831	300
VC6	Spring 2010	Unused	14.955	5.5492	56
		Used	27.632	21.4812	19
		Total	18.167	12.8816	75
	Fall 2010	Unused	21.875	17.4705	60
		Used	30.000	26.2202	15
		Total	23.500	19.5990	75
	Spring 2011	Unused	21.233	15.9596	73
		Used	31.250	26.5165	2
		Total	21.500	16.1235	75
	Fall 2011	Unused	26.736	24.2226	72
		Used	50.000	33.0719	3
		Total	27.667	24.7703	75
	All seasons	Unused	21.552	17.9833	261
		Used	30.449	24.1287	39
		Total	22.708	19.0838	300

Attachment 1b.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for Pintail Slough comparing used and unused trap stations (Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC7	Spring 2010	Unused	15.179	7.4293	56
		Used	25.658	18.8533	19
		Total	17.833	12.1875	75
	Fall 2010	Unused	21.250	18.3105	60
		Used	26.667	23.0811	15
		Total	22.333	19.3096	75
	Spring 2011	Unused	21.575	16.8300	73
		Used	43.750	26.5165	2
		Total	22.167	17.2635	75
	Fall 2011	Unused	26.910	23.7041	72
		Used	58.333	40.1819	3
		Total	28.167	24.9233	75
	All seasons	Unused	21.600	18.3398	261
		Used	29.487	23.5583	39
		Total	22.625	19.2373	300
VC8	Spring 2010	Unused	14.955	7.3158	56
		Used	22.368	15.3540	19
		Total	16.833	10.3758	75
	Fall 2010	Unused	20.208	16.6105	60
		Used	28.333	23.3694	15
		Total	21.833	18.2759	75
	Spring 2011	Unused	21.918	16.7680	73
		Used	37.500	17.6777	2
		Total	22.333	16.8576	75
	Fall 2011	Unused	27.083	23.1727	72
		Used	62.500	33.0719	3
		Total	28.500	24.3635	75
	All seasons	Unused	21.456	17.7966	261
		Used	28.526	22.2036	39
		Total	22.375	18.5401	300

Attachment 1b.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for Pintail Slough comparing used and unused trap stations (Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC9	Spring 2010	Unused	13.839	4.5718	56
		Used	23.026	14.5912	19
		Total	16.167	9.1380	75
	Fall 2010	Unused	21.042	19.5949	60
		Used	29.167	24.3975	15
		Total	22.667	20.7231	75
	Spring 2011	Unused	23.288	18.5540	73
		Used	37.500	17.6777	2
		Total	23.667	18.5602	75
	Fall 2011	Unused	25.521	22.0472	72
		Used	54.167	38.1881	3
		Total	26.667	23.1889	75
	All seasons	Unused	21.360	18.3756	261
		Used	28.526	21.8301	39
		Total	22.292	18.9740	300
VC10	Spring 2010	Unused	15.402	9.5320	56
		Used	23.026	15.1744	19
		Total	17.333	11.6054	75
	Fall 2010	Unused	21.250	18.3105	60
		Used	30.833	27.4946	15
		Total	23.167	20.6210	75
	Spring 2011	Unused	23.288	19.1298	73
		Used	31.250	8.8388	2
		Total	23.500	18.9416	75
	Fall 2011	Unused	26.215	22.4157	72
		Used	54.167	38.1881	3
		Total	27.333	23.4929	75
	All seasons	Unused	21.935	18.6746	261
		Used	28.846	23.1475	39
		Total	22.833	19.4106	300

Attachment 1b.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for Pintail Slough comparing used and unused trap stations (Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
Vegetation	Spring 2010	Unused	93.1696	17.38162	56
		Used	94.2105	11.93887	19
		Total	93.4333	16.10677	75
	Fall 2010	Unused	96.6167	9.04104	60
		Used	98.6667	2.04124	15
		Total	97.0267	8.16340	75
	Spring 2011	Unused	96.6370	7.36841	73
		Used	98.0000	2.12132	2
		Total	96.6733	7.27570	75
	Fall 2011	Unused	93.2014	14.08492	72
		Used	97.3333	4.19325	3
		Total	93.3667	13.83770	75
	All seasons	Unused	94.9406	12.43535	261
		Used	96.3590	8.64425	39
		Total	95.1250	12.00802	300

ATTACHMENT 1C

Descriptive Statistics of Vertical Cover (VC1–VC10) and Vegetation Cover for the Accretion Bench Near the Palo Verde Ecological Reserve Comparing Used and Unused Trap Stations

Attachment 1c.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for the accretion bench near the PVER comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC1	Spring 2010	Unused	67.391	23.4579	23
		Used	69.257	23.8621	37
		Total	68.542	23.5256	60
	Fall 2010	Unused	60.000	24.7382	25
		Used	52.679	20.3211	14
		Total	57.372	23.2474	39
	Fall 2011	Unused	65.341	22.4708	22
		Used	71.053	19.7333	38
		Total	68.958	20.7757	60
	All seasons	Unused	64.107	23.4985	70
		Used	67.416	22.3462	89
		Total	65.959	22.8468	159
VC2	Spring 2010	Unused	46.739	29.9662	23
		Used	57.095	29.9798	37
		Total	53.125	30.1501	60
	Fall 2010	Unused	42.000	27.6887	25
		Used	43.750	23.8938	14
		Total	42.628	26.0815	39
	Fall 2011	Unused	52.273	23.0283	22
		Used	63.158	22.1228	38
		Total	59.167	22.8836	60
	All seasons	Unused	46.786	27.0605	70
		Used	57.584	26.4909	89
		Total	52.830	27.1950	159

Attachment 1c.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for the accretion bench near the PVER comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC3	Spring 2010	Unused	35.326	24.9010	23
		Used	46.959	27.5450	37
		Total	42.500	26.9573	60
	Fall 2010	Unused	31.500	24.2384	25
		Used	38.393	19.2805	14
		Total	33.974	22.5709	39
	Fall 2011	Unused	47.159	24.9797	22
		Used	61.513	22.7690	38
		Total	56.250	24.4104	60
	All seasons	Unused	37.679	25.2248	70
		Used	51.826	25.7384	89
		Total	45.597	26.3908	159
VC4	Spring 2010	Unused	33.696	23.9658	23
		Used	45.946	26.8506	37
		Total	41.250	26.2707	60
	Fall 2010	Unused	26.500	20.5142	25
		Used	29.464	15.1967	14
		Total	27.564	18.6245	39
	Fall 2011	Unused	45.455	24.2585	22
		Used	60.526	22.9803	38
		Total	55.000	24.3779	60
	All seasons	Unused	34.821	23.8782	70
		Used	49.579	25.9376	89
		Total	43.082	26.0328	159

Attachment 1c.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for the accretion bench near the PVER comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC5	Spring 2010	Unused	31.522	22.8848	23
		Used	44.932	26.2631	37
		Total	39.792	25.6785	60
	Fall 2010	Unused	22.000	18.1430	25
		Used	21.429	15.0548	14
		Total	21.795	16.8970	39
	Fall 2011	Unused	39.773	22.0377	22
		Used	54.605	23.8628	38
		Total	49.167	24.1230	60
	All seasons	Unused	30.714	21.9813	70
		Used	45.365	26.1376	89
		Total	38.915	25.3918	159
VC6	Spring 2010	Unused	32.065	24.0814	23
		Used	42.568	27.5535	37
		Total	38.542	26.5705	60
	Fall 2010	Unused	20.500	17.2603	25
		Used	18.750	10.6856	14
		Total	19.872	15.0978	39
	Fall 2011	Unused	35.795	21.2326	22
		Used	50.658	23.2400	38
		Total	45.208	23.4805	60
	All seasons	Unused	29.107	21.6738	70
		Used	42.275	25.9415	89
		Total	36.478	24.9592	159

Attachment 1c.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for the accretion bench near the PVER comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC7	Spring 2010	Unused	27.174	19.8188	23
		Used	39.527	26.4368	37
		Total	34.792	24.6900	60
	Fall 2010	Unused	18.500	14.0312	25
		Used	16.071	5.8601	14
		Total	17.628	11.7253	39
	Fall 2011	Unused	30.114	19.5405	22
		Used	47.697	23.5841	38
		Total	41.250	23.6164	60
	All seasons	Unused	25.000	18.3070	70
		Used	39.326	25.3211	89
		Total	33.019	23.5448	159
VC8	Spring 2010	Unused	25.000	16.8550	23
		Used	36.149	25.9847	37
		Total	31.875	23.4052	60
	Fall 2010	Unused	17.000	11.3422	25
		Used	13.393	3.3408	14
		Total	15.705	9.3883	39
	Fall 2011	Unused	26.705	20.8793	22
		Used	41.776	26.0386	38
		Total	36.250	25.1794	60
	All seasons	Unused	22.679	16.9308	70
		Used	34.972	25.6437	89
		Total	29.560	22.9982	159

Attachment 1c.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for the accretion bench near the PVER comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
VC9	Spring 2010	Unused	22.283	14.5757	23
		Used	32.770	25.0609	37
		Total	28.750	22.1106	60
	Fall 2010	Unused	14.000	5.4962	25
		Used	13.393	3.3408	14
		Total	13.782	4.7942	39
	Fall 2011	Unused	24.432	18.6913	22
		Used	34.211	26.4262	38
		Total	30.625	24.1843	60
	All seasons	Unused	20.000	14.3393	70
		Used	30.337	24.6342	89
		Total	25.786	21.3139	159
VC10	Spring 2010	Unused	21.739	15.6386	23
		Used	31.419	24.9342	37
		Total	27.708	22.2052	60
	Fall 2010	Unused	14.000	5.4962	25
		Used	13.393	3.3408	14
		Total	13.782	4.7942	39
	Fall 2011	Unused	25.568	18.6913	22
		Used	29.934	22.6122	38
		Total	28.333	21.2015	60
	All seasons	Unused	20.179	14.7891	70
		Used	27.949	22.6151	89
		Total	24.528	19.8833	159

Attachment 1c.—Descriptive statistics of vertical cover (VC1–VC10) and vegetation cover for the accretion bench near the PVER comparing used and unused trap stations
(Use refers to a station that had at least one Colorado River cotton rat captured within a single season. All means are expressed as percent. See the main text for more information regarding measurements.)

Vegetation measurement	Season	Use	Mean	Standard deviation	N
Vegetation	Spring 2010	Unused	96.2174	8.37180	23
		Used	94.1892	12.13830	37
		Total	94.9667	10.81778	60
	Fall 2010	Unused	99.3000	1.72603	25
		Used	98.2143	2.70835	14
		Total	98.9103	2.16087	39
	Fall 2011	Unused	95.7500	8.55062	22
		Used	90.5263	14.81232	38
		Total	92.4417	13.04071	60
	All seasons	Unused	97.1714	6.94434	70
		Used	93.2584	12.69263	89
		Total	94.9811	10.70444	159

ATTACHMENT 2A

Estimated Marginal Mean of Overall Vertical Cover Measures and Vegetation Cover for the Three Sites During Spring 2010

Attachment 2a.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the three sites during spring 2010
(VC = vertical cover, PVER = Palo Verde Ecological Reserve, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance [MANOVA] was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$]).

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC1	PVER[A]	68.542	3.280	62.069	75.014
	Cibola Nature Trail[A]	66.111	3.787	58.637	73.585
	Pintail[B]	50.500	2.933	44.711	56.289
VC2	PVER[A]	53.125	3.377	46.460	59.790
	Cibola Nature Trail[A]	43.889	3.900	36.193	51.585
	Pintail[B]	31.333	3.021	25.372	37.295
VC3	PVER	42.500	2.791	36.992	48.008
	Cibola Nature Trail	27.500	3.223	21.139	33.861
	Pintail	21.167	2.497	16.240	26.094
VC4	PVER[A]	41.250	2.669	35.982	46.518
	Cibola Nature Trail[B]	24.722	3.082	18.640	30.805
	Pintail[B]	19.167	2.387	14.455	23.878
VC5	PVER	39.792	2.391	35.074	44.510
	Cibola Nature Trail	21.667	2.761	16.219	27.115
	Pintail	18.500	2.138	14.280	22.720
VC6	PVER	38.542	2.448	33.711	43.372
	Cibola Nature Trail	20.833	2.826	15.256	26.411
	Pintail	18.167	2.189	13.846	22.487
VC7	PVER	34.792	2.348	30.157	39.426
	Cibola Nature Trail	21.944	2.712	16.593	27.296
	Pintail	17.833	2.100	13.688	21.979
VC8	PVER[A]	31.875	2.274	27.386	36.364
	Cibola Nature Trail[B]	22.222	2.626	17.039	27.405
	Pintail[B]	16.833	2.034	12.819	20.848
VC9	PVER	28.750	2.168	24.472	33.028
	Cibola Nature Trail	21.389	2.503	16.449	26.329
	Pintail	16.167	1.939	12.340	19.993

Attachment 2a.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the three sites during spring 2010
(VC = vertical cover, PVER = Palo Verde Ecological Reserve, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance [MANOVA] was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$]).

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC10	PVER	27.708	2.295	23.180	32.237
	Cibola Nature Trail	23.056	2.650	17.827	28.285
	Pintail	17.333	2.052	13.283	21.384
Vegetation	PVER	94.967	1.660	91.690	98.243
	Cibola Nature Trail	97.356	1.917	93.572	101.139
	Pintail	93.433	1.485	90.503	96.364

ATTACHMENT 2B

Estimated Marginal Mean of Overall Vertical Cover Measures and Vegetation Cover for the Three Sites During Fall 2010

Attachment 2b.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the three sites during fall 2010
(VC = vertical cover, PVER = Palo Verde Ecological Reserve, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance [MANOVA] was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$]).

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC1	PVER	57.372	4.123	49.233	65.511
	Cibola Nature Trail	60.776	3.381	54.102	67.450
	Pintail	54.167	2.973	48.298	60.036
VC2	PVER	42.628	3.903	34.923	50.333
	Cibola Nature Trail	40.948	3.200	34.630	47.266
	Pintail	32.833	2.814	27.277	38.389
VC3	PVER	33.974	3.321	27.418	40.531
	Cibola Nature Trail	29.526	2.723	24.150	34.902
	Pintail	25.000	2.395	20.272	29.728
VC4	PVER	27.564	2.973	21.696	33.432
	Cibola Nature Trail	25.216	2.438	20.404	30.027
	Pintail	22.667	2.144	18.435	26.898
VC5	PVER	21.795	2.898	16.073	27.516
	Cibola Nature Trail	23.276	2.377	18.584	27.968
	Pintail	22.500	2.090	18.374	26.626
VC6	PVER	19.872	2.965	14.019	25.724
	Cibola Nature Trail	23.707	2.431	18.908	28.506
	Pintail	23.500	2.138	19.280	27.720
VC7	PVER	17.628	2.930	11.844	23.413
	Cibola Nature Trail	23.491	2.403	18.748	28.235
	Pintail	22.333	2.113	18.162	26.505
VC8	PVER[A]	15.705	2.657	10.459	20.951
	Cibola Nature Trail[B]	22.845	2.179	18.543	27.147
	Pintail[B]	21.833	1.916	18.050	25.616
VC9	PVER	13.782	2.788	8.278	19.286
	Cibola Nature Trail	22.629	2.286	18.116	27.143
	Pintail	22.667	2.010	18.698	26.636

Attachment 2b.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the three sites during fall 2010
(VC = vertical cover, PVER = Palo Verde Ecological Reserve, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance [MANOVA] was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$]).

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC10	PVER	13.782	2.759	8.336	19.228
	Cibola Nature Trail	22.198	2.262	17.732	26.664
	Pintail	23.167	1.989	19.239	27.094
Vegetation	PVER	98.910	.934	97.066	100.754
	Cibola Nature Trail	99.138	.766	97.626	100.650
	Pintail	97.027	.674	95.697	98.356

ATTACHMENT 2C

Estimated Marginal Mean of Overall Vertical Cover Measures and Vegetation Cover for the Two Sites Sampled During Spring 2011

Attachment 2c.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the two sites sampled during spring 2011 (VC = vertical cover, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance (MANOVA) was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$.])

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC1	Cibola Nature Trail	61.042	3.286	54.541	67.542
	Pintail	48.167	2.939	42.353	53.981
VC2	Cibola Nature Trail	41.458	2.928	35.666	47.251
	Pintail	29.333	2.619	24.153	34.514
VC3	Cibola Nature Trail	33.750	2.542	28.722	38.778
	Pintail	22.667	2.274	18.170	27.164
VC4	Cibola Nature Trail	28.333	2.338	23.708	32.959
	Pintail	21.333	2.092	17.196	25.470
VC5	Cibola Nature Trail	25.417	2.159	21.146	29.688
	Pintail	19.833	1.931	16.013	23.653
VC6	Cibola Nature Trail	25.833	2.207	21.467	30.199
	Pintail	21.500	1.974	17.595	25.405
VC7	Cibola Nature Trail	23.542	2.128	19.332	27.751
	Pintail	22.167	1.904	18.401	25.932
VC8	Cibola Nature Trail	22.917	2.099	18.766	27.068
	Pintail	22.333	1.877	18.621	26.046
VC9	Cibola Nature Trail	23.542	2.330	18.932	28.151
	Pintail	23.667	2.084	19.544	27.789
VC10	Cibola Nature Trail	23.333	2.395	18.597	28.070
	Pintail	23.500	2.142	19.264	27.736
Vegetation	Cibola Nature Trail	97.867	.922	96.044	99.690
	Pintail	96.673	.824	95.043	98.304

ATTACHMENT 2D

Estimated Marginal Mean of Overall Vertical Cover Measures and Vegetation Cover for the Three Sites During Fall 2011

Attachment 2d.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the three sites during fall 2011
(VC = vertical cover, PVER = Palo Verde Ecological Reserve, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance [MANOVA] was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$]).

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC1	PVER[A]	68.958	3.091	62.861	75.055
	Cibola Nature Trail[A]	61.667	3.091	55.570	67.764
	Pintail[B]	49.333	2.765	43.880	54.787
VC2	PVER[A]	59.167	3.223	52.810	65.523
	Cibola Nature Trail[A]	49.375	3.223	43.019	55.731
	Pintail[B]	34.667	2.882	28.981	40.352
VC3	PVER	56.250	3.117	50.103	62.397
	Cibola Nature Trail	43.958	3.117	37.811	50.106
	Pintail	28.167	2.788	22.668	33.665
VC4	PVER[A]	55.000	3.118	48.851	61.149
	Cibola Nature Trail[B]	40.208	3.118	34.059	46.358
	Pintail[B]	27.000	2.789	21.500	32.500
VC5	PVER	49.167	3.055	43.141	55.192
	Cibola Nature Trail	37.292	3.055	31.266	43.317
	Pintail	26.833	2.732	21.444	32.223
VC6	PVER	45.208	3.140	39.015	51.402
	Cibola Nature Trail	36.042	3.140	29.848	42.235
	Pintail	27.667	2.809	22.127	33.206
VC7	PVER	41.250	3.165	35.007	47.493
	Cibola Nature Trail	37.083	3.165	30.840	43.327
	Pintail	28.167	2.831	22.582	33.751

Attachment 2d.—Estimated marginal mean of overall vertical cover measures and vegetation cover for the three sites during fall 2011
(VC = vertical cover, PVER = Palo Verde Ecological Reserve, Cibola Nature Trail = Cibola National Wildlife Refuge Unit #1 Conservation Area Nature Trail, and Pintail = Pintail Slough. A multivariate analysis of variance [MANOVA] was run on vegetation layers VC1, VC2, VC4, and VC8. Different superscript letters denote statistical differences among sites based on simple contrasts for the variables included in the MANOVA [$p < 0.05$]).

Vegetation measurement	Site	Mean	Standard error	95% confidence interval	
				Lower bound	Upper bound
VC8	PVER[A]	36.250	3.154	30.029	42.471
	Cibola Nature Trail[A]	35.833	3.154	29.612	42.054
	Pintail[A]	28.500	2.821	22.936	34.064
VC9	PVER	30.625	3.052	24.605	36.645
	Cibola Nature Trail	34.375	3.052	28.355	40.395
	Pintail	26.667	2.730	21.282	32.051
VC10	PVER	28.333	2.986	22.444	34.223
	Cibola Nature Trail	34.792	2.986	28.902	40.681
	Pintail	27.333	2.671	22.066	32.601
Vegetation	PVER[A]	92.442	1.452	89.578	95.305
	Cibola Nature Trail[B]	99.642	1.452	96.778	102.505
	Pintail[A, B]	93.367	1.299	90.805	95.928

ATTACHMENT 3

Species List of All Plants Identified at the Three Sampled Sites

Attachment 3.—Species list of all plants identified at the three sampled sites

Species	Nativity	Life history growth category
Arundo donax	Non-native	Perennial
Avena fatua	Non-native	Annual
Baccharis sarothroides	Native	Shrub
Chloracantha spinosa	Native	Shrub
Conyza bonariensis	Non-native	Annual
Cynodon dactylon	Non-native	Perennial
Gaura coccinea	Native	Perennial
Hydrocotyle verticillata	Native	Perennial
Lactuca serriola	Non-native	Annual
Leptochloa uninervia	Native	Annual
Lolium perenne	Non-native	Perennial
Lythrum californicum	Native	Perennial
Malva parviflora	Non-native	Annual
Melilotus indica	Non-native	Annual
Paspalum dilitatum	Non-native	Perennial
Pluchea sericea	Native	Shrub
Polypogon interruptus	Native	Perennial
Polypogon monospeliensis	Native	Perennial
Populus fremontii	Native	Tree
Prosopis glandulosa	Native	Tree
Prosopis pubescens	Native	Tree
Pulicaria paludosa	Non-native	Perennial
Salix exigua	Native	Tree
Scirpus pungens	Native	Perennial
Sorghum halepensis	Non-native	Perennial
Typha sp.	Native	Perennial