Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Modeling Microhabitat and Survival Estimates of Sigmodon arizonae plenus along the Lower Colorado River 2010 Report

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Lower Colorado River Multi-Species Conservation Program

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Abstract

Sigmodon arizonae habitat use and survival estimates were quantified using a mark-recapture technique. Sigmodon were captured, marked, and recaptured at 3 sites where there are known populations along the lower Colorado River. Permanent trapping grids were used to model microhabitat structural characteristics at capture locations. Individual recapture histories were used to model survival and recapture probability over three trapping occasions spanning 1.5 years. *Sigmodon arizonae* have moderately high survival (0.3) on an accretion bench near Palo Verde Ecological Reserve and lower survival at the other 2 sites. The habitat models identified 2 important structural measurements, vertical density at 10-20 cm and 90-100 cm, which can be used to predict the probability of capturing *Sigmodon arizonae*. *Chlorocantha* is a native plant that may provide habitat structural components identified by the habitat models. The habitat model will be useful in adaptive management of habitat, for determining habitat credit, and possibly for determining habitat of the ecologically similar *S. hispidus eremicus*. Future research plans are also discussed.

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. Recent genetic analyses conducted by the Bureau of Reclamation (Reclamation) in cooperation with University of Nevada Las Vegas (UNLV) have shown that *S. a. plenus* is genetically unique and displays some level of population structuring. The same study identified several localities where *S. a. plenus* are locally abundant and noted an apparent absence of this species in intervening localities. The presence localities coincide in general with previously documented geographic areas from a recent 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 *Sigmodon* are generally attributed (Cameron and Spencer 1981). The life history strategy of *Sigmodon* is well adapted to quickly changing habitat (e.g. high reproductive output; Cameron and Spencer 1981 and citations within). Prior to damming 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 *S. arizonae*, that were capable of quickly re-colonizing disturbed areas.

Studies documenting the habitat use of cotton rats have generally focused on *Sigmodon hispidus*. While these studies may provide some data on general characteristics of the habitat utilized by *S. arizonae* they are not appropriate for meeting MSCP objectives of creating species specific habitat along the LCR. General descriptions of habitat where *S. a. plenus* 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 MSCP stipulates that 125 acres of the 512 acres of marsh being created for Yuma Clapper Rail will also be designed for *S. a plenus*. Preliminary surveys conducted during 2008 and 2009 suggest that marsh habitat designed for Yuma Clapper Rail may not satisfy habitat requirements for *S. a. plenus.* Currently much of the habitat along the LCR in which *Sigmodon* 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 presence of cotton rats. For example, two sites selected for this study are at the Cibola Nature trails (Cibola) restoration site and on an accretion bench near the Palo Verde Ecological Reserve (PVER) restoration site. The Cibola site was planted with cottonwood, mesquite, and baccaris, although Johnsongrass (*Sorghum halepense*), an invasive grass species, has established a thick ground cover which *S. a. plenus* appear to be using. The bench near PVER is dominated by *Paspalum dilatatum*, another non-native, and maybe more indicative of the physical characteristics of cotton rat habitat that occurred along the LCR prior to anthropogenic change. Pintail Slough contains a diversity of vegetation including much thinner Johnsongrass compared to Cibola and various other grasses and forbs. The density of grassy vegetation, particularly within 1 meter above ground, at these sites are likely an important habitat characteristic determining the abundance of *S. a. plenus,* similar to what has been documented for *S. hispidus* in the Great Plains (Goertz, 1964; Kaufman and Fleharty, 1974).

The main goal of this research is to model habitat use to provide a practical method to quantify habitat restoration attempts and estimate survival and population size of these populations being monitored. To achieve this end, we quantify habitat characteristics and estimate, through mark-recapture, the survival of *S. arizonae* at three distinct localities along the lower Colorado River where vegetation structure and composition appear qualitatively different. *Sigmodon* species are known to exhibit extreme population cycles making population demographic analyses and even presence absence surveys ineffective over short (1-3 years) sampling periods. An additional goal of this study is to use the data to conduct simulations aimed at determining the appropriate sampling effort for this species that will accurately estimate the population parameters of interest. This will give an indication of the minimum number of trap nights, sampling frequency, and duration necessary to meet the monitoring goals of the MSCP.

Study Areas

Sigmodon were lived trapped using Sherman traps at three localities where they are known to maintain populations along the lower Colorado River: Cibola Unit #1 Nature Trail in Cibola National Wildlife Refuge (NWR) near Cibola, AZ; an accretion bench near Palo Verde Ecological Reserve in the river channel north of Blythe CA; Pintail Slough in Havasu NWR near Needles, AZ.

Methods

Permanent trapping stations were established at each site. Stations were set up at approximately 10 meter intervals with 15 stations per transect. At two sites, PVER and Cibola, four transects established, while 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 sub-meter GPS 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 1 meter of the pin flag. Traps were run for 3-4 nights at each locality twice a year, once in the fall (late November/ early December) and once in the spring (Apil-May). 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 *Sigmodon arizonae*, 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 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. We assumed *Sigmodon* were directly interacting with vegetation 1 m or less vertically and so our methods only record vegetation up to 1 m from the ground. Vertical vegetation density will be measured using a modified version of the vegetation profile board protocol outlined in Nudds (1977). Our protocol involves using a 10cm 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 and an observer 1 meter 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 is repeated from west of the board looking east so there are two estimates for vertical density for each plot. Horizontal vegetation density was measured by laying a meter PCV 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%, 9 = >95%. Average litter depth was calculated from 4 measurements, one taken at each corner of the 1m square.

Mark Recapture

Program MARK version 6.0 was used to model population parameters of interest. We used a Cormack-Jolly-Seber recapture only model to estimate survival and recapture rates. As of the end of FY10 we had only 2 occasions; however, we included a 3rd occasion, which was collected in FY11 (November-December 2010), in our analyses. Time was scaled to 6 months, the approximate time between sampling occasions.

We developed several a priori hypotheses that we wanted to compare in the Mark analyses. These include the effects of group, sex, and site on the survival estimates of *Sigmodon*. We used Akaike Information Criterion for small sample sizes (qAIC) to compare competing models. We used weighted model averaging to estimate the mean and unconditional standard error of survival and recapture.

We described growth rates between seasons using summary statistics. Because of few recaptures between seasons, the data were pooled among sites.

Vegetation

Logistic regression was used to model trap success of *Sigmodon* as a function of habitat. A variety of exploratory analyses were conducted to examine the data prior to running the final analysis. Forward and backward stepwise addition where used to examine the effects of the different sequence of variable addition on the model. We also treated trap success as a binomial (*Sigmodon* captured/not captured at a station) or a polynomial (0, 1, >1 *Sigmodon* captures at a station). Because species composition different between sites, cover classes were grouped into several categories in an attempt to describe the structural and life history characteristics of different types of plants. These categories are grass, forb, shrub, and tree. Prior to running the logistic regression, a MANOVA was used to test for differences in vegetation structure between the sites and seasons.

Results

To date (January 2011) trapping has been conducted three times at each site. A total of 40 individuals from Pintail, 101 individuals from Cibola Unit#1, and 97 individuals from Palo Verde Ecological Reserve were captured, PIT tagged, and released for use in the mark-recapture analysis. The average weight at initial capture for an individual was similar among sites (Table 1). Sixteen individuals that were marked in Fall 09 were recaptured in Spring 10. Three individuals were recorded during Spring 10 and Fall 10; two of which were initially captured in Fall 09 the other was first captured in Spring 10. From these data we estimated an average growth rate of 60g (stdev =36.1, range 8-124g) between Fall 09 and Spring 10, while the growth rate was -3.7g (stdev = 14.8, range = -20-9g) between Spring 10 and Fall 10.

Mark Recapture

Results of the mark-recapture analyses are shown in Table 2. The best model included site as an effect on survival. Recapture rate did not differ between sites. The next best model was the simplest model (i.e. no effects). Time was not found to have an appreciable effect on survival or recapture. The estimated individual survival probability was highest for PVER (0.369 ± 0.11) and considerably lower for Cibola (0.088 ± 0.05) and Pintail (0.076 ± 0.07). Recapture probability across all sites was 0.556 ± 0.04.

Table 1. The average, standard deviation, and range of weight at the time of initial capture of an individual, at each site.

Site	Average weight (g)	Standard Deviation (g)	Range (g)
Cibola Unit #1	124.5	35.5	52-218
Pintail Slough	111.8	49.7	22-234
Palo Verde Ecological Reserve	102.4	38.5	20-227

Table 2. Hypotheses and results of the mark-recapture analysis in program MARK.

Model	QAICc	Delta QAICc	AICc Weights	Model Likelihood	Num. Par	QDeviance	-2log(L)
Phi(site)P(.)	328.7131	0	0.87196	1	4	147.2536	625.2007
Phi(.)P(.)	333.7214	5.0083	0.07128	0.0817	2	156.3301	642.9
Phi(sex)P(.)	335.6826	6.9695	0.02674	0.0307	3	156.2621	642.7674
Phi(site)P(site)	336.5686	7.8555	0.01717	0.0197	8	146.8526	624.4188
Phi(.)P(site)	337.1872	8.4741	0.0126	0.0145	4	155.7277	641.7253
Phi(site*time)P(site*time)	441.5188	112.8057	0	0	65	113.6424	559.6589
Phi(sex*site*time)P(sex*site*time)	647.9397	319.2266	0	0	131	90.8029	515.1218

Vegetation

The MANOVA showed a significant difference between site and season (Site F=150.3, d.f = 1, 334, P<0.001; Season F=100.65, d.f.=1,334, P<0.001). Post hoc analyses revealed that the amount of bare ground, shrub and forb cover, and average litter depth differed between sites, while the amount of grass cover differed among sites and seasons. The vertical density at 20-30 cm also differed between sites.

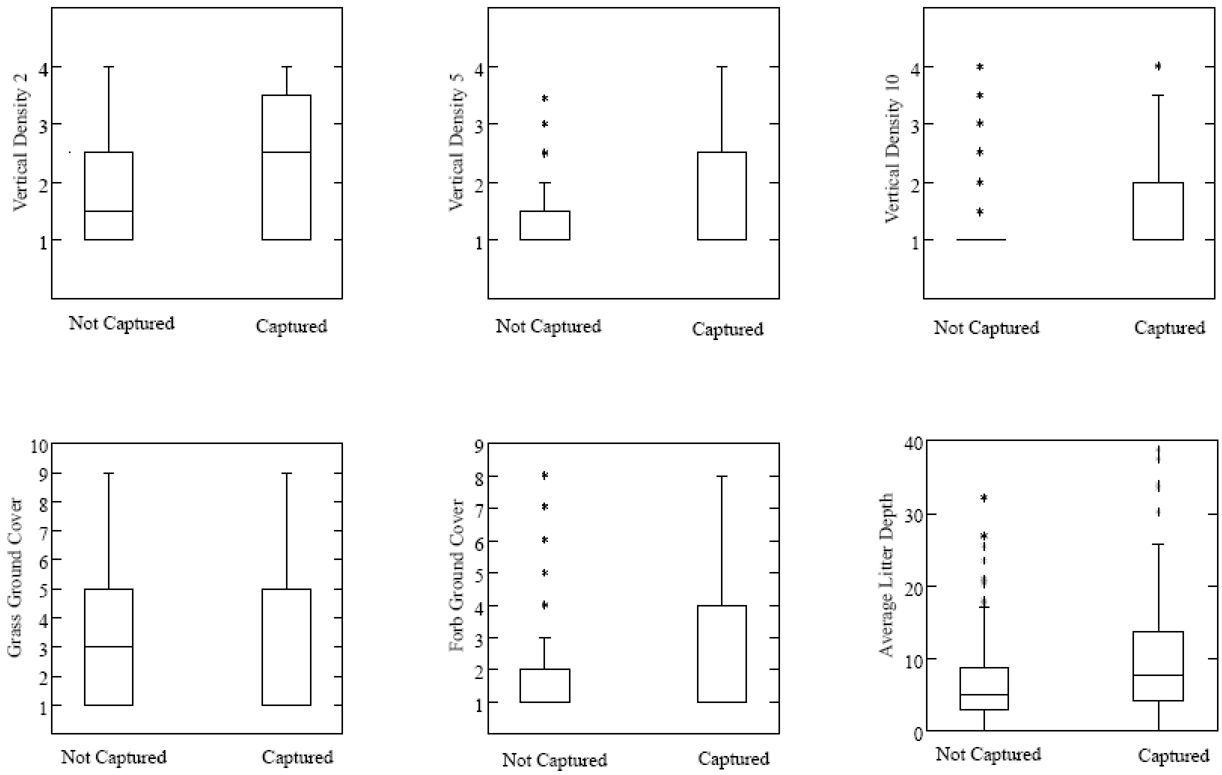
Both the forward and backward addition models were significantly better than the constants only model (Table 3). The forward addition model identified 9 variables that were deemed important while the backward addition model contained 6 variables. Both models identified the vertical density at 10-20 cm (VD2) and 90-100 cm (VD10), as well as, average litter depth as important variables in predicting the capture of *Sigmodon*. Other variables identified by either of the two models were vertical density at 40-50cm (VD5) and cover classes of forb, shrub, litter, and grass.

Summary data for the variables deemed important in estimating the probability of capturing *Sigmodon* are shown in Fig 1. In general, there is a greater vertical density of vegetation between 10-20cm and 90-100cm at microhabitat stations where *Sigmodon* were captured. In addition, there was on average higher ground cover of forbs and lower cover class for grass. The average litter depth tended to be greater at capture sites, as well.

Table 3. Parameters included in the logistic regression analysis of vegetation at capture sites.

Model	Parameters included in model
Backward addition	VD2 VD5 VD10 GRASS FORB LITTER AVELITTER SITE SEASON
Forward addition	VD2 VD10 FORB AVELITTER SITE SEASON

Figure 1. Select microhabitat variables that were identified as important in explaining the capture probability of *Sigmodon arizonae plenus* are compared at trap stations where the species was captured and not captured. Y-axis scale denotes categorical values for all variables except Average Litter Depth which is in centimeters. See text for further explanation of how variables where categorized.



Discussion

This is a preliminary dataset with preliminary results. Caution should used when interpreting the finding of this study. Data collection is estimated to be completed in May 2012 with a final analysis and report later that year.

Survival Estimates

The 3-4 day mark-recapture methodology appears to provide reasonable estimates of demographic parameters; however, to address more complex scenarios, more data will need to be collected. One methodology under consideration is conducting 4 occasions of 2 days each at Cibola and PVER where the populations are large and large numbers of captures can be obtained in a short amount of time. This would result in the same amount of effort and cost but allow twice the number of occasions. One reasoning for this would be because of the low number of recaptures between 6-month intervals. In this study, 19 of the 228 total individuals marked were captured in a later season. The between season recapture rate was especially low between Spring10 and Fall10.

In this study, individual survival was determined to range between 0.07-0.3 over 6 months. This is the first known estimate for *S. arizonae* so no comparisons to previous research can be made. *Sigmodon hispidus*, a closely related species to *S. arizonae*, exhibit 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. Results of the demographic analysis may benefit from sampling less intensely but more often to obtain better mark-recapture data. This methodology is not currently being considered for Pintail Slough because the low trap success requires several days of trapping to capture any *Sigmodon*. More frequent sampling would provide more data on growth rates as well.

Future research in this area will address the following questions:

What is the most appropriate sampling frequency to estimate demographic parameters (primarily survival) of Sigmodon populations at restoration sites?

This should address the number of nights per occasion and number of occasions per year to sufficiently determine *Sigmodon* presence at a site.

What is an appropriate amount of survival to meet MSCP goals?

Currently there is low but consistent survival at Pintail Slough. If survival is low but birth rate is high, a population can be sustained. At present, the survival at Pintail Slough appears to be sufficient to maintain the population with a high amount of turnover. It is unknown if the individuals between sampling occasions are born at the site or are immigrating from a different source.

Implications for Habitat Restoration

Differences between sites were primarily attributable to the differences in species and types of herbaceous cover available at each site. Cibola is dominated by Johnsongrass, the PVER bench is primarily a forb, *Pulicaria*, and Pintail Slough is partially Johnsongrass but also is heavily dominated by *Chlorocantha*, a shrub. The differences in cover types but not vertical density measurements underscores the results of other studies on *Sigmodon* which found that *Sigmodon hispidus* selects for shrubs at least 1 meter high and high herbaceous cover but does not select for any specific vegetation type (Browne et al. 1999). It appears the structural characteristics of the habitat are more important in predicting the probability of capturing a *Sigmodon* than the specific vegetation type that is present. It is important to remember that these two things are not completely independent; a particular species or vegetation type will create a specific vertical density. There are several species of plants that can provide the necessary structure. This allows greater flexibility in designing habitat for this species.

Of particular interest to restoration design is the shrub *Chlorocantha.* This shrub provides the structural components that *Sigmodon arizonae* are using on the lower Colorado River. It appears to be low maintenance, drought tolerant, and creates a thick cover that excludes other vegetation. At full height, it is just over 1 meter tall and would probably require little to no management to maintain appropriate habitat for *Sigmodon*. It is also native and may be a useful species to incorporate in restoration sites that will be irrigated infrequently or in areas that receive less water. The plant may also prove useful for filling in clearings in restoration sites where trees did not grow and there is open canopy. Two sites, one at either end of the lower Colorado River, have this species; Pintail Slough has a large patch of *Chlorocantha* running through it and it has also been identified at the Pratt restoration site near Betty's Kitchen north of Yuma. It is believed that in both cases the species has naturally colonized the sites. For continuity with Pintail Slough, the Beal Lake site at Havasu National Wildlife Reserve could utilize this species if conditions are appropriate and it fits with restoration plans.

The logistic regression models indicate several variables that can be used for determining habitat credit and adaptively managing a restoration area for *Sigmodon arizonae*. The simplest methodology would be to scale the number of variable to 2 or 3 easily obtained measurements. At the moment, it appears that vertical density measures at 10-20 cm and 90-100cm would provide a quick and simple measurement that may allow Reclamation to reasonable determine the probability of capturing a *Sigmodon*. Taking points at predetermined intervals across an area would allow a user to generate GIS surfaces with high and low probability interpolated between points. This would highlight areas that are suitable, as well as highlight areas that may need management. Taking the measurements through time would allow Reclamation to determine how long a particular habitat would remain as high probability of capturing a *Sigmodon*. Future directions include, using the model generated here to predict next year's data to test how well the model performs on an independent data set. Many of these ideas will be incorporated into next year's report as a proof of concept.

The results of this research might be able to be applied to the ecologically similar *Sigmodon hispidus eremicus* on the river. *Sigmodon hispidus* has not been found at any site in large numbers making a full-scale habitat assessment difficult. This species has only been documented in areas dominated by *Phragmites* (common reed) mixed with other vegetation (see F3 year-end report for more detail). *Phragmites* creates a dense herbaceous cover at 20-30 cm and 90-100 cm superficially satisfying the model requirements reported for *S. arizonae*. More research should be conducted to determine the applicability of this model to *S. h. eremicus* habitat management.

Other questions that will be addressed include:

How many points are necessary to robustly determine whether the area is appropriate for Sigmodon or if habitat management needs to occur?

This should focus on how many points and at what distance apart a field technician should measure habitat variables in a given area.

How much habitat is appropriate at a specific site to meet the goals of our program?

This will focus on the size and connectivity of patches of habitat to determine the minimum acreage necessary to support a population. It will also be focused on individual use of a network of patchy habitats.

Literature Cited

Andersen, D. 1994. Demographics of small mammals using anthropogenic desert riparian habitat in Arizona. Journal of Wildlife Management 58:445-454.

Andersen, D. and M. Nelson 1999. Rodent use of anthropogenic and 'natural' desert riparian habitat, lower Colorado River, Arizona. Regulated Rivers: Research and Management 15:377-393.

Blood, B.R. 1990. Taxonomy and distribution of Sigmodon in California. Bulletin of Southern California Academy of Sciences 89:86-93.

Browne et al. 1999. Effects of landscape spatial structure on movement patterns of the hispid cotton rat (*Sigmodon hispidus).* Landscape Ecology 14:53-65.

Cameron, G.N. 1977. Experimental species removal: Demographic responses by *Sigmodon hispidus* and *Reithrodontomys fulvescens*. Journal of Mammalogy 58:488-506.

Cameron, G.N. and S.R. Spencer. 1981. *Sigmodon hispidus. Mammalian* Species 158:1-9.

Geortz, J.W. 1964. Influence of habitat quality upon density of cotton rat populations. Ecological Monographs 34:359-381.

Kaufman, D.W. and E. D. Fleharty. 1974. Habitat selection by nine species of rodents in north-central Kansas. The Southwestern Naturalist 18:443-451.

Nudds, T. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5:113-117.

Peterson, M. 1973. Interactions between the cotton rats, *Sigmodon fulviventer* and *S. hispidus*. American Midland Naturalist 90:319-333.

Sikes, R.S., W.L. Gannon, and the Animal Care and Use Committee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 92(1):235-253.