The Effects of Vegetation Variation and Water Availability on Rodent Habitat Selection

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INTRODUCTION

Although riparian habitats are relatively limited in the arid Southwest, they contribute substantial biotic diversity and more complex habitat structure than adjacent upland habitats (Szaro 1989, cited in Ellison 1998). Cienegas are marshland communities associated with perennial springs and headwater streams within gently sloping valleys. Today, they are only remnants of those that occurred in the 1800s. Cienegas occur at sites where ground water intersects the surface to form areas slow moving waters, marsh, or swamp bordered by drier areas. In these areas, it is unknown what factors influence the habitat selection of small animals.

Suitable habitat probably is the most important factor influencing the distribution and abundance of small mammals within their geographic ranges (Baker 1968, Vaughan 1972). Many mammalian species have varied ranges of optimal and tolerable conditions that must be met in order for a population to persist and be successful. Habitat preferences for these species probably evolved independent of any current species interactions that, nevertheless, maintain the species' coexistence (Morris 1996).

In this study, I compare the changes in vegetation variation along the Burro Cienega in Southwest New Mexico with rodent occurrence. Diverse rodent communities inhabit the cienega's dry desert grass scrubland, narrow riparian region, and adjacent to the slow, shallow water. They use the vegetation for food, structure for burrows and nests, and cover from predators. The rodents that inhabit these microhabitats are mostly granivores, feeding on a variety of grains, cactus, mesquite, and other types of vegetation. However, carnivorous species occur.

The purpose of this experiment is to observe community interactions between the vegetation, water availability, and rodent response in a desert cienega. In Ellison, percent cover by annual and perennial grasses and shrubs, substrate, and frequency of shrubs, trees, and debris were significant determinants of small mammal distribution within a habitat type (1998). The changes within areas should present changes in microhabitat selection cues between the small mammal community, and I attempt to show patterns in selection cues presented by structure and species composition of the vegetation by comparing rodents captured to the following: percent cover of four vegetation types (grass, forb, woody, and dead wood), the changes in moisture gradients as microhabitats differ from upstream, midstream, and downstream, and distance from a water source. Only species specializing on certain habitat features should be strongly associated with one or more habitat variables. How well the habitat variables predict the local distribution of a species should correspond to the species' degree of habitat specialization with respect to the area sampled (Hallett).

METHODS

Study area – My study was conducted at the Burro Cienega on the Pitchfork Ranch, southeast of Silver City, New Mexico, approximately 17 miles (27.5 km) south down Separ Road off Highway 90. The cienega consists of a slow moving stream bordered by a marshy riparian area whose width diminishes as the water levels reduce as it travels downstream. On either side of the stream occur arid soils with drier vegetation characterized by desert forbs and grasses as well as upland woody vegetation. Given the great diversity of vegetation, I selected three study sites along the stream that differed in vegetation characteristics and amount of water flow. The upstream site had the greatest width riparian zone with adjacent marshy segments, surrounded by arid grasslands. The middle site contained a significantly smaller amount of riparian flora and consisted of a mix of vegetation and woody debris. The downstream site contained a narrow riparian zone surrounded by scattered drought-resistant grasses,

forbs, and woody species within a moderate to steep rocky terrain (Labeled sites C, B, and A, respectively).
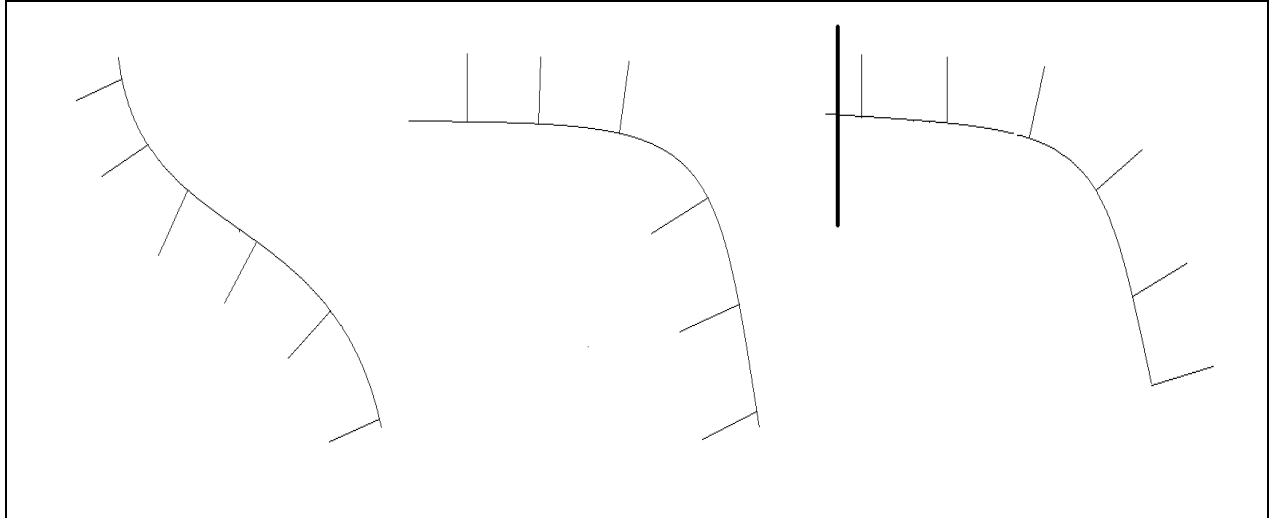

Figure 1: Site A (downstream), Site B (middle section), and Site C (upstream), respectively. Bold black line indicates the end of the property line. Thin lines indicate trap line location along the waterway. Each trap line was 60m in length.

Study Plot Establishment – Each trap line was 60 meters in length and included 12 study plots placed in 5 meter increments. Each of the three study sites contained 6 trap lines and 72 individual study plots. In order to establish sites selected as randomly as possible, each trap line was paced out to be 50 meters from the previous line, which set the standard requirements for each site, as well as allowing each trap line to be relatively unaffected from the other lines. At each study plot, a trap was placed and vegetation data collected. Due to time restrictions, each site was trapped once.

Live Trapping Methodology – Rodents were trapped using live Sherman rodent traps. A trap was placed at each study plot and baited with oatmeal and artificial vanilla flavoring. Trapping was done between September – November, so bedding materials were added. Each trap was oriented with the open door facing the stream so there was no variation between plots that could affect trapping success.

Traps were set in the evening and were left overnight. Rodents and empty traps were collected the following morning.

Habitat Assessment – The vegetation at each study plot was surveyed in order to characterize the plant life in the area. Plants were classified as one of four types: grasses, forbs, woody (which included all shrubs, trees, and succulents), and dead wood. Percent cover was estimated for each vegetation type and for each individual species using the following cover classes: trace (<1%), 1-9%, 10-24% and ≥25%. Vegetation was sampled within a 2 meter radius of each Sherman trap.

To avoid inconsistencies, the following criteria were set that were followed throughout assessment. To differentiate between trace and 1% cover, I considered trace to be represented by the presence of only one example of either a plant type or individual species. A cover class of 1% had to have at least two plants within the designated 2 meter area. A second criterion set for vegetation assessment was a cut off point for the sample area. A decision had to be made whether plants at the border of the 2 meter radius should be included within the sample set. In order to reduce the possibility of discrepancies, if the base or trunk of the plant did not fall within the 2 meters, the plant was not included in the assessment.

Data Analysis – Vegetation data was summarized using detrended correspondence analysis (DCA; Sokal 1998). DCA is an ordination technique that arranges plant community data into a low dimensional space so that similar entities are close together and dissimilar entities are far apart (Gauch 1982, cited in Norris 1999). DCA axes scores and total cover classes of grass, forbs, woody, and dead wood, were compared to rodent capture using a stepwise regression analysis. The number of each rodent species captured as well as the collective sample of granivorous species combined was compared to the physical data. The stepwise analysis compared the abundance of rodents captured to the following independent variables of total grass, forb, woody, and dead wood cover as well as the study

site scores of the first three DCA axes. A two-way Analysis of Variance (ANOVA; Sokal 1998) was also performed on rodent capture for each of the three sites to differentiate whether the different habitats of the upstream, middle, and downstream sections and/or the distance in meters away from the water source had an impact on rodent populations (each rodent species as well as all granivorous species combined). ANOVA compared the mean numbers of rodents captured within each site. It also analyzed the mean capture in comparison to distance from the water source.

RESULTS

The vegetation in 216 individual study plots was surveyed with 126 plant species identified. *Sporobolus giganteus* (grass), *Bouteloua curtipendula* (grass), *Isocoma tennuisecta* (woody*), Salsoa sp (*forb), *Chenopodium sp* (forb), and *Gutierrezia sp (woody),* were the most frequently seen species in the cienega combined (arranged from greatest to least abundance, respectfully). Mean total abundance for each plant cover class type was 35.0% grass, 28.7% forb, 25.6% woody, and 10.7% dead wood (figure 2).

The downstream site (Site A) occurred within moderately steep hillsides with a rocky substrate. Overall vegetation cover declined significantly as the quantity of water decreased. Vegetation composition for Site A differed from the other two sites with a higher ratio of drought tolerant plants to riparian vegetation. *Eriognium wrightii, Aristida* spp*, Bouteloua* spp, and scattered cacti are examples of some commonly occurring species (figure 3). Examples of commonly occurring species within the middle study site (Site B) include *S.giganteus, Xanthisma gracilis, and B. curtipendula* (figure 4). The slope gradient was a combination of gentle terrain to moderate rises. The upper study site (Site C) consisted of a relatively mild slope aspect, the primary vegetation consisting of riparian vegetation near the water and a transition into desert prairie grasslands (figure 5). Typical plant species found at Site C include *S. giganteus, Salsoa* sp*, I. tennuisecta*, and *Chenopodium* sp.

DCA summarized the vegetation data by scoring each species and arranging them into spatial axes. DCA Axis 1 was identified as a moisture gradient, scoring hydrophilic species such as *Baccharis salicifolia, Salix gooddingii*, and *Convolvulus equitans* with high numbers and dry species such as *Plantago patagonia* and *Silene antirrhina* with negative numbers. Patterns in DCA Axis 2 were difficult to interpret, as woody, forbs and grasses found within all moisture gradients were grouped together. High scores within Axis 2 were best interprted as a combination of weedy forbs and shrubs. None of the rodents captured showed any indication of responding to the vegetation gradient in Axis 2. DCA Axis 3 had a general trend of higher scores among woody species such as *Brickellia californica, Celtis reticulata,* and *Berberis haematocarpa.* This axis, however, was not absolute since woody species such as *Ericameria nauseosa* and *B. salicifolia* were given negative scores. Approximately 10.6% of the variance among vegetation was explained by DCA axes, cumulatively (Table 1).

Table 1: The first three DCA axes combined explained 10.6% of the variation in vegetation among all study plots.

Detrended Correspondence Analysis of Vegetation		
Axis	Increment (R^2)	Cumulative (R^2)
1	0.039	0.036
2	0.017	0.056
3	0.05	0.106

Collectively, the three sections of the cienega contained a high diversity of rodent species, due to the trapping of 12 different species out of 52 total captures (Table 2). *Neotoma albigula, Neotoma mexicana, Peromyscus boylii, Peromyscus eremicus*, and *Perimyscus leucopus* were found to show some significant correlation between habitat selection and vegetation variation. A stepwise regression analysis of rodents captured, total vegetation type cover classes, and DCA results showed substantial connections.

Table 2: Total captures for all three sites combined.

Species Name	Total Captured
Dipodomys merriami	1
Baiomys taylori	1
Chaetodipus intermedius	1
Onychomys torridus	2
Neotoma albigula	6
Neotoma mexicana	4
Peromyscus boylii	12
Peromyscus eremicus	3
Peromyscus leucopus	18
Reithrodontomys megalotis	2
Sigmadon fulviventer	1
Sigmadon hispidus	1
Total	**52**

A significant regression model (F=396, df=2,213, p=.026) found two independent variables, grass (β=-.0271, df=1,213, p=.0156) and dead wood (β=-.0167, df=1, 213, p=.0484) that placed significant predictable power explaining numbers of *N. albigula* captured. Both variables possessed negative slopes, which indicates that as grass cover and dead wood cover, respectively, increased, the number of *N. albigula* captured decreased.

The model found that *N. mexicana* responded to the amount of live woody cover (F=4.13, df=1,214, p=.0434). The variable slopes indicate a positive correlation between the amount of woody cover (β=.0157, df=1,214, p=.0434) and the total number of *N. mexicana* captured. Potentially, as woody cover increases the number of *N. mexicana* should potentially increase.

The regression model found that the amount of dead wood influenced capture rates of P. *boylii.* The model (F=4.72, df=1, 214, p=.0308) placed significant value for the independent variable, dead wood (β=.0248, df=1,214, p=0.038), to positively interact with P. boylii.

The model for *P. eremicus* placed significant value for a negative relationship between DCA Axis 1, which organizes the plants into moisture gradients (F=5.45, df=1,214, p=.0205; β=-.0001, df=1,214, p=.0205, model and variable, respectively). This negative slope indicates that *P. eremicus* numbers will increase as the vegetation moisture decreases.

P. leucopus showed substantial connections between forb coverage and microhabitat selections. The model (F=7.58, df=1,214, p=.0064) showed that forb abundance (β=.4947, df=1,214, p=.0064) positively corresponds with the *P. leucopus* captured. Axis 3 in DCA also showed a significant relationship with capture rates of P. leucopus. The regressional analysis model showed that the variable, Axis 3, produced a negative slope with *P. leucopus* (F=7.69, df= 1,214, p=.0061; β=-.0006, df=1,214, p= .0061, model and variable, respectively).

Reithrodontomys megalotis did not demonstrate a significant correlation between those captured and percent cover of any plant type, however, DCA Axis 1 was marginally insignificant (F=3.32, df=1,214, p=0.0698, β=-0.0006, df=1,2124, p=0.0698, model and variable, respectively).

Baiomys taylori, Chaetodipus intermedius, Dipodomys merriami, Sigmadon hispidus, S. fulviventer, and *Onychomys torridus* regression analysis did not show any significant factor in the amount of vegetation cover or plant species composition that is used in habitat selection. The species showed no significant response during data analysis, due to low numbers captured.

Regression analysis of all the granivores combined (excluding *O. torridus*) showed a significant model (F=4.37, df=1,214, p=.0377) in which the independent variable of live woody vegetation (β=.0504, df=1,214, p=.0377) had the most influence within the vegetation structure on cues for microhabitat selection. A correlation between DCA Axis 3 was marginally insignificant (F=3.71, df=1,214, p=0.0554). The slope for Axis 3 (β=-.0006, df=1,214, p=.0554) was negative; as Axis 3 vegetation goes up, overall small mammal abundance potentially decreases.

A two-way ANOVA analysis was conducted on variation of rodents captured and differences in site, as well as distance from water. None of the ANOVA produced significant models (p values ranging from $p=0.1166$ to $p=0.6982$). Although insignificant, general trends were seen. *N. albigula* (mean Site A=0.0556, Site B=0.0, Site C=0.0278) does not show a significant preference for site, however, all captured were within 30 meters of water. *N. mexicana* (mean Site A=0.0417, Site B=0.0139, Site C=0.0) had a general trend of the majority of the species captured were within the downstream, drier site. Also, 75% of *N. mexicana* were found 40 meters or farther away from the stream. *P. boylii* (mean Site A=0.0694, Site B=0.0972, Site C=0.0) showed a general trend for avoiding areas with higher moisture. Over 75% of those captured were also found at least 40 meters away from the water source. *P. leucopus* (mean Site A=0.0694, Site B=0.0972, Site C=0.1528) showed an insignificant trend of those captured at the upstream site. Those captured were found at all distances, therefore no significance was found between *P. leucopus* captured and distance from water.
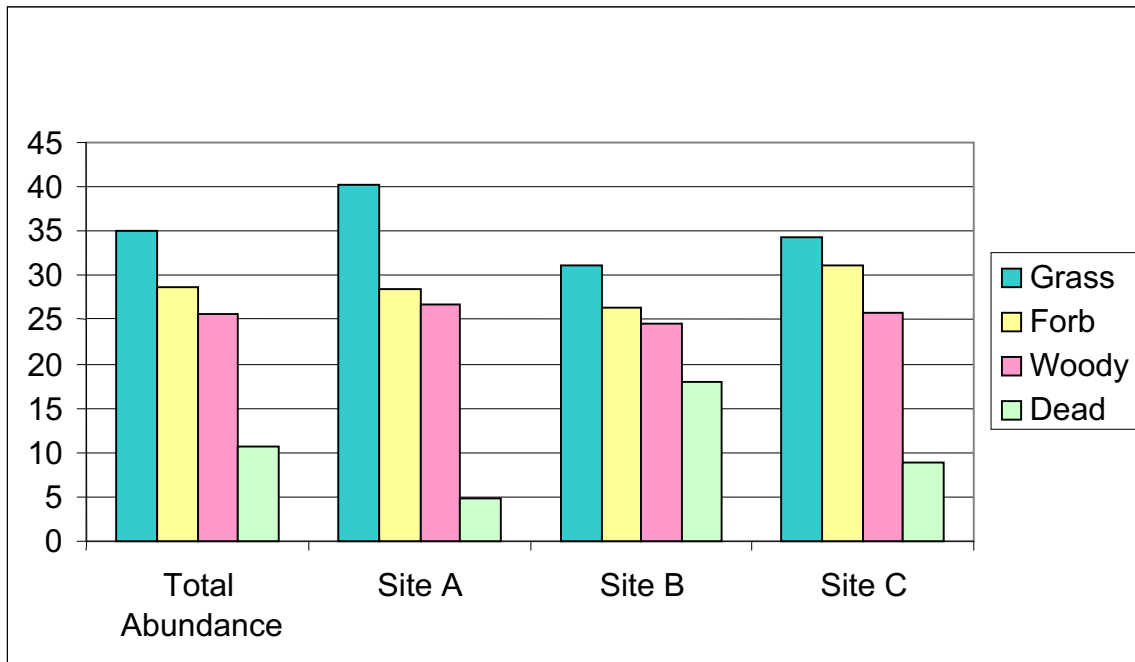
Figure 2: Percent plant cover for each plant type. Overall grass, forb, woody, and dead wood cover for each site and the mean of collective total abundance.
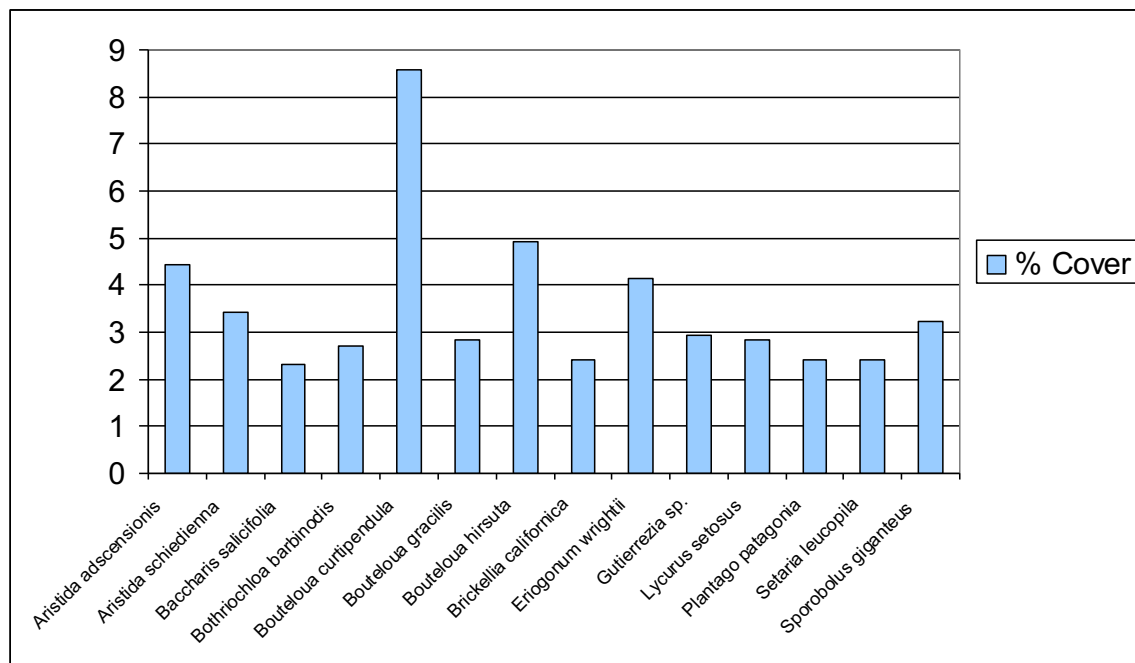

Figure 3: Species that contributed the most cover within Site A. Percent cover calculated from overall cover by vegetation found within Site A.
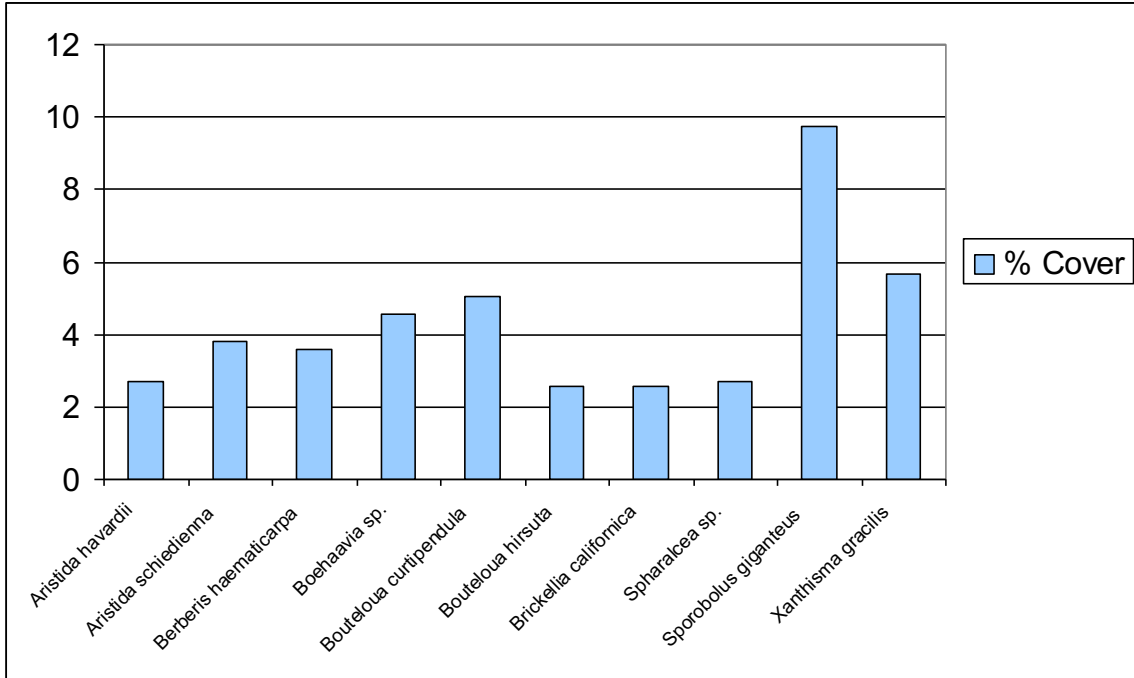
Figure 4: Species that contributed the most cover within Site B. Percent cover calculated from overall cover by vegetation found within Site B.
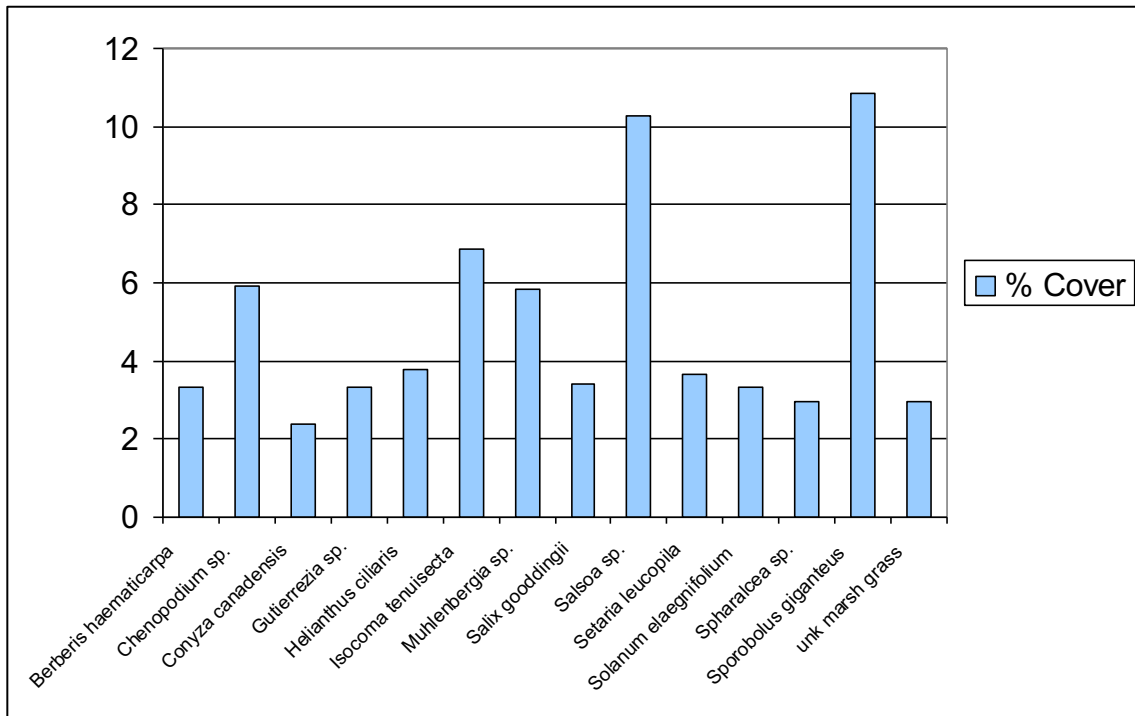

Figure 5: Species that contributed the most cover within Site C. Percent cover calculated from overall cover by vegetation found within Site C.

DISCUSSION

Vegetation Gradients - Vegetation composition differs between the three areas of study along with the variation of moisture gradients. The riparian areas of the cienega include a riparian zone between 3 and 15 meters in width on each side of the waterway, wider riparian occurrences upstream and more restricted sections downstream. Riparian and backwater marshy regions included green marshy streamside grasses, water loving forbs such as *Conyza canadensis, Convolvulus, Medicago*, and *Melilotis* species, and woody species such as *Salix gooddingii*, and *Baccharis salicifolia* characterize these areas. The greater the distance from water, the lower the moisture content. With a reduction in moisture, vegetation would transition from riparian habitat to a combination of desert prairie grasses, forbs, and scattered shrubs and low trees, including succulents, juniper, barberry, and oak. Woody debris was found throughout all habitat types and vegetation zones.

Habitat Selection Cues - *N. albigula* is primarily found in arid regions, and is often, but not obligately, associated with clumps of prickly pear (*Opuntia*; Armstrong, 1972; Stamp, 1979), and according to Macedo, builds dens on moderately rocky slopes, usually using jumping cholla as nest material (1988). The aforementioned describes similar vegetation and composition of the cienega habitat, more so the lower two sites than the upstream site. The mean *N. albigula* captured found the species within Site A and Site C, and absent in Site B. Although slightly contradictory, all areas along the cienega had ample food supply for the species. According to data analysis, *N. albigula* was negatively influenced by grass and dead wood cover. This contradicts what was found by Ellison and Witford, as higher frequencies of trees and shrubs, respectively, provided nest sites as well as leaves and bark that contribute to their diet (1998, 1982). In addition, *N. albigula* was trapped in low numbers in riparian woodland but in higher numbers in desert shrub, during a previous study (Stamp, 1979). Data collected in the cienega contradicts these findings, as all *N. albigula* captured were 30 meters or less from water.

N. mexicana analysis interpreted that the species responded positively to live woody cover. *N. mexicana* possibly uses the live wood as shelter and protection against predation. Those captured were found at distances 40 meters or farther from the stream within Sites A and B, and were absent in Site C. In comparison between the two *Neotoma* species, this can suggest that the species either has weaker ties to water than *N. albigula*, the two species experience competition for resources, and/or rely on different vegetation cues for microhabitat selection. In Sites A and B, the substrate consisted of rocky hillsides and in correlation with Armstrong, the species usually inhabits rocky terrain (1972).

P. boylii habitat selection was positively correlated with dead wood, suggesting that it is important for shelter and security. Similar findings were discovered of P. maniculatus by Doyle (1990). Analysis also showed that the species had a general trend to be found in the lower two sites and at least 40 meters from water. This suggests that the species possibly experiences selection towards drier habitats.

DCA Axis 1 scored plants with high moisture content with high numbers, which adversely affected *P. eremicus*. Analyses provide evidence for *P. eremicus* abundances to be negatively affected by moisture within vegetation, which is supported by species characteristics. *P. eremicus*, the cactus mouse, prefers drier habitats (Reid, 2006). A total of 3 *P. eremicus* were caught, therefore no significant results were found in relation to plant type cover. However, in Ellison, *P. eremicus* occurred in areas with high percentages of perennial grasses and was associated negatively with tree cover, tree frequency, litter cover, and debris piles (1998).

P. leucopus analyses showed positive connections between forb cover and habitat selection. DCA Axis 3 interpretations correlated the presence of thick woody cover with a decline in species abundance. With 18 out of 52 captures, *P. leucopus* had the greatest overall abundance. It was found in

all three sites at all distances from water. This suggests that *P. leucopus* is perhaps a generalist that is able to thrive in a variety of habitats.

Analyses regarding *R. megalotis* did not portray any significant connections with any of the variables tested, likely due to the low numbers caught. It did, however show a tendency towards riparian areas, as it correlated with the marginally insignificant model linking DCA Axis 1 with a negative impact on the species.

The other 6 species caught contained 1 or 2 representatives. These small numbers could not be used to interpret microhabitat preferences, although selection due to vegetation structure and water availability may still occur.

An analysis of all rodents captured, excluding *O. torridus* which is a carnivore, showed a significant correlation to live woody species. Granivorous rodents positively correlated with woody cover, rather than their main food source. The cienega supplies a high abundance of grasses, therefore possibly cover, security, and prospective nesting sites are greater concerns than food availability.

Composition and Percent Cover - Overall analyses show that rodents had a stronger response to the cover classes of each vegetation type, rather than to specific species. The DCA axes had little or weak correlation between those captured and plant composition. This could be caused by the difficulty to interpret the axes. The DCA axes were a cause for confusion, as vegetation was summarized; higher scores occasionally were given to species seen infrequently, while commonly occurring species were given lower scores. Axis 2 and Axis 3 were difficult to interpret as underlining trends were hard to find.

Further Investigation Possibilities - Overall analysis had low R-squared values, in which vegetation structure and water availability explained rodent abundance. Repeat trapping and an increase in sample size would elevate R-squared values, giving a stronger data set for analysis which

could further support my current finding, and/or eliminate or support findings contradictory with similar studies. Other possibilities include sampling consecutive years to reduce variation between overall rodent community size and other influence on population size, as well as returning in the spring, when possible chances in rodent activity may occur.

The correlations toward woody vegetation among rodents could also be examined. Acorn presence was noted, but not well documented and could be a possible food source and connection towards woody plants (McShea, 2000).

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