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# A Comparison of population sizes and number of captures for the Desert Woodrat (*Neotoma lepida*) in two microhabitats in the Las Vegas Wash, Nevada

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## Introduction

Nestled in the southeast tract of Clark County, Nevada, the Las Vegas Wash has and continues to play a seminal role in terms of the Las Vegas Valley's growing population trends. The Wash functions as the primary conduit through which millions of gallons of Las Vegas' urban runoff, storm-water runoff, shallow groundwater, and reclaimed water courses each day (LVWCC, 2003). These inputs eventually drain into Lake Mead, which houses the city's main drinking water source. The wetland vegetation that occurs in the Wash naturally filters the pollutants carried in these inputs. Needless to say, managing vegetation in the Wash is paramount to maintaining the area's integrity. Additionally, the Wash provides habitat for myriad species of wildlife, including small mammals. Small mammals occur in many areas of the Wash and serve as important indicators when diagnosing the Wash's ecological stability (Herndon, 2003). Hence, from July 2002 to June 2003, research was conducted to investigate small mammal diversity in the Las Vegas Wash.

Prior to this research, the most recent analysis of small mammal diversity was completed over 30 years ago (LVWCC, 2003). Since then, the Wash has experienced substantial changes in vegetative structure. The Las Vegas Wash Coordination Committee (2003) recently reported that wetland vegetation has decreased from approximately 2000 acres to 200 acres in the last several decades. This decline was attributed to increased water flows associated with increased development of the valley. Moreover, the area has been subjected to the unbridled invasion of non-native species, especially saltcedar (*Tamarix sp.*). Thus, scheduled efforts to restore native plant communities in the wash could potentially affect the various populations of small mammals that reside there (Horn, 2003). The data collected from this research will establish a baseline data set that accurately reflects the existing small mammal assemblage in the wash and will aid

in gauging the effects of the changes in vegetation once restoration work is completed (LVWCC, 2003; Horn, 2003).

While this research was focused on several small mammal species and their utilization of three different microhabitats found in the wash, the present study focuses on one species in particular, the desert woodrat (*Neotoma lepida*) and the microhabitats in which it was observed to be most abundant. These microhabitats comprise the mesquite (*Prosopis sp.*)/quailbush (*Atriplex lentiformis*) and saltcedar (*Tamarix sp.*) microhabitats. Specifically, the objective of this study was to estimate population sizes of *N. lepida* in the aforementioned microhabitats; such an investigation is warranted, given that there are no current records with regards to *N. lepida* populations in the Las Vegas Wash. In addition, this study seeks to determine if *N. lepida* exhibits a preference for specific microhabitat type via comparison of estimated population sizes and number of captures in each respective microhabitat. Lastly, this study investigates what effect, if any, temperature has on estimated population sizes of *N. lepida* in the Wash.

The importance of conducting such a study is that planned removal and eradication of saltcedar in the Las Vegas Wash may generate adverse impacts on the present desert woodrat population inhabiting the area by eliminating necessary habitat. Furthermore, in comparison with other desert rodents, *N. lepida* has not been studied as extensively (Cameron and Rainey, 1972). Only one life history study of *N. lepida* (Stones and Hayward, 1968) is available in the literature. Hence, this study will provide insight into the population ecology of desert woodrats that occur in highly disturbed riparian areas.

## Literature Review

### *Habitat Preference*

Ranging from the lower Sonoran to the Arctic-Alpine, the genus *Neotoma* can be found in all life zones (Cameron and Rainey, 1972). Woodrats are remarkably adaptable, occurring in a kaleidoscope of diverse habitats including, but not limited to, deserts, woodlands, conifer forests, deciduous forests, rocky outcrops, and even humid jungles (Cameron and Rainey, 1972; Nowak, 1999).

The species of woodrat that occurs in the southwest region of the United States, the desert woodrat, is a fine example of the genus' adaptability. *Neotoma lepida* can be found in an assortment of shrub and desert habitats. In the Mojave Desert, habitat preferences of *N. lepida* are predominantly associated with rock outcrops, boulders, cacti, and areas of dense undergrowth (Llewellyn, 1981; Bleich and Schwartz, 1975; Cameron and Rainey, 1972). Thompson's (1981) study of a desert woodrat population at Joshua Tree National Monument, California, noted that the species keenly avoided open areas while engaging in foraging activities by moving between feeding sites using rocks and shrubs as cover. Brown et al. (1972) determined that there is a strong correlation between density of woodrats and density of cacti in jumping cholla (*Opuntia bigelovii*) dominated habitat. Conversely, Llewellyn (1981) found woodrat habitat preference geared towards rocky outcrops as opposed to adjacent shrubby and open areas. In terms of altitude, this species occurs from sea level up to elevations as high as 8,700 feet (Hall, 1946).

Desert woodrats generally occupy home ranges between approximately 0.04 to 0.2 hectares (Bleich and Schwartz, 1975). Their small home ranges, coupled with their preference for dense cover is probably due to their limited mobility; desert woodrats are not fast runners (Vaughan and Schwartz, 1980; Cameron and Rainey, 1972). Mature desert woodrats are rather

sedentary; thus, dispersal into new habitats is unlikely (Smith, 1995). Additionally, Cranford (1977) found that juvenile woodrats establish temporary home ranges in the vicinity of maternal ranges, serving as provisional refuges during an exploratory period prior to dispersal into unoccupied areas. This implies that the distribution of *N. lepida* results from the structure and patchiness of the habitat within which it resides. It is the prevailing notion that habitat preference and selection is largely dependent on adequate cover, suggesting that the capacity of a habitat to support woodrats depends upon the extent to which it can afford them protection from predators (Brown, et al., 1972).

### ***Behavior***

Like other desert-dwelling small mammals, desert woodrats are primarily nocturnal and remain active throughout the year (Nowak, 1999). The use of radio telemetry has shown that *N. lepida* spends approximately 70 percent of the day within the confines of diurnal den sites; additionally, about 21 percent of time was spent at feeding sites and the remaining time traveling or exploring (Thompson, 1981). In addition to *N. lepida*'s routine nocturnal activity, limited diurnal movement was documented by just three diurnal captures in Stones and Hayward's (1968) year-long natural history study. In Bleich and Schwartz' (1972) home range study, no woodrats were captured during daylight hours.

The literature states that *N. lepida* is an uncompromisingly solitary animal and becomes especially hostile when other members of the same species wander into its home range. The unsociable habits of woodrats are well known; the borders of adult ranges are habitually patrolled and scent-marked (Vaughan and Schwartz, 1980; Egoscue, 1957). This observation led Vaughan and Schwartz (1980) to conclude that home range probably equates to territory. While some degree of overlap existed between the home ranges of male and female woodrats, adult

males occupied areas exclusive of other males (Vaughan and Schwartz, 1980). Woodrats exhibited the same animosity in a laboratory setting. When male individuals occupied the same cage, they engaged in incessant fighting. In some instances, the fighting was so vicious that it led to mortality, which resulted from multiple bites to the testes (Egoscue, 1957). This behavior is perhaps an instinctive response to inhibit a competitor's reproductive potential. Female woodrats (especially those not in estrus) were not exempt from aggression by males. Some females were so harassed by males that they probably would have starved to death if they had not been separated (Egoscue, 1957).

Perhaps the most well known characteristic behavior of *N. lepida* is the species' skilled building expertise. The desert woodrat is the architect of the Mojave Desert's small mammals. *Neotoma lepida* constructs shelters (also called "houses" or "middens" in the literature) made up of various materials assembled into elaborate configurations of compartmentalized chambers and entrances (Bonaccorso and Brown, 1972; Cameron and Rainey, 1972). *Neotoma lepida* builds instinctively, even when held in captivity; middens built in controlled settings were observed to have between 3 to 7 entrances, a copious number of interior passageways, and at least two storage rooms where food caches were kept (Bonaccorso and Brown, 1972). Middens found in the wild exhibit even more labyrinthine characteristics. Structures are generally conical in shape (Smith, 1995). Basal diameters and heights of these structures may exceed five feet and four feet, respectively (Stones and Hayward, 1968).

Desert woodrats are notably adaptable in their selection of midden sites and building methods, utilizing available materials, which are dependent upon the habitat in which they occur (Cameron, 1973). They will select areas where building materials are easily accessible. *Neotoma lepida* will use a plethora of materials to build, using practically any object they can

manage to transport (Bonaccorso and Brown, 1972). Building materials may consist of natural objects (i.e. fallen twigs, cactus, scat, owl pellets, rocks) or may be of anthropogenic origin (i.e. jar tops, plastic, cloth, paper, metal) (Cameron and Rainey, 1972; Bonaccorso and Brown, 1972). Even when opting to utilize rocky outcrop crevices as shelter, *N. lepida* will instinctively use these materials to fortify entryways (Llewellyn, 1981).

The importance of middens in relation to desert woodrat survival is paramount. Daily activities revolve around these structures and they play several roles. Middens serve as a protective blockade against the threat of predation, as well as provide a place to rest, store food, and rear offspring (Cameron and Rainey, 1972; Dial, 1988, Bonaccorso and Brown, 1972; Smith, 1995). In addition, middens provide microclimatic temperatures and humidities that permit the occupants to survive the climatic extremes of the desert (Brown et al., 1972).

### ***Diet***

*Neotoma lepida* is regarded as an opportunistic dietary specialist, exploiting a wide variety of food resources (Dial, 1988). Although they occasionally feed on invertebrates, desert woodrats are for the most part herbivorous creatures and are not finicky eaters. Nourishment usually consists of flowers, buds, seeds, berries, leaves, bark, and various species of cacti (Cameron and Rainey, 1972; Stones and Hayward, 1968; Brown, et al., 1972). Creosote bush (*Larrea tridentata*), a plant that is unpalatable to many other species, appears to be an important component of *N. lepida*'s diet; there may have been selective pressure to develop the adaptation of feeding on this toxic plant because creosote bush is dominant over large parts of *N. lepida*'s range (Chess and Chew, 1971). The general feeding pattern involves movement away from the midden or sheltered area (usually within 3 meters), obtaining fodder via clipping, and then

retreating back to the sheltered area or midden for either consumption or storage of the food item (Thompson, 1982).

### ***Reproduction***

In southern parts of *N. lepida*'s range, breeding can apparently take place at any time of the year (Nowak, 1999). Stones and Hayward (1968) reported that the birth of young woodrats commenced in March and continued through May. Schwartz and Bleich (1975) found most breeding to occur between the months of October and April. Vaughan and Schwartz (1980) discovered peak reproductive activity and increased capture rates occurring in December and January. A well-defined breeding season was not evident in a laboratory colony of woodrats. As many as 14 young were produced by a mating pair in a year, an unlikely number in the wild (Egoscue, 1957). Desert woodrat litter sizes typically are between 2 to 3 pups, produced following a gestation period of 30 to 36 days (Egoscue, 1957; Cameron, 1973; Bleich and Schwartz, 1975). After weaning, juveniles will establish temporary home ranges within maternal ranges as a refuge prior to establishing a more permanent home range (Cranford, 1977).

### ***Physiology***

Despite the fact that desert woodrats are highly adapted to arid desert environments, unlike their heteromyid counterparts (i.e. *Dipodomys merriami*) that occupy the same habitats, they are unable to rely on metabolic water alone (Cameron and Rainey, 1972; Brown et al., 1972), as they lack the ability to concentrate urine (Vaughan and Schwartz, 1980; Smith and Charnov, 2001; Stallone, 1979). *Neotoma lepida* meets its daily water requirements through dietary utilization of fresh succulent vegetation, preferably cacti (Cameron and Rainey, 1972; Smith and Charnov, 2001; Stallone, 1979; Vaughan and Schwartz, 1980; Brown et al., 1972).

In juxtaposition with *N. lepida*'s inability to rely exclusively on metabolic water, is the species' sensitivity to environmental temperature (Smith and Charnov, 2001; Cameron and Rainey, 1972; Brown et al., 1972). It has been shown experimentally that the desert woodrat is not able to withstand the high diurnal temperatures characteristic of the Mojave Desert (Cameron and Rainey, 1972). The empirically derived upper critical temperature for *N. lepida* is approximately 42° C, which is fairly low for a desert animal (Smith and Charnov, 2001). As ambient air temperatures move toward the upper lethal temperature, *N. lepida* cannot afford to expend any water; their low threshold of 42° C is, for the most part, attributable to their aforementioned inability to concentrate urine (Smith and Charnov, 2001; Vaughan and Schwartz, 1980; Stallone, 1979; Cameron and Rainey, 1972). *Neotoma lepida* also lacks any other specialized physiological adaptations to deal with heat stress; they have no specialized, water conserving nasal passages and are not able to estivate (Smith and Charnov, 2001). The only defense *N. lepida* has against extreme diurnal temperatures is to spend as much time possible in insulated retreats (Vaughan and Schwartz, 1980). Greater vapor pressure within midden chambers leads to reduced evaporative water loss and thus enhances the species' survival during those times of the year when ambient air temperatures are near the upper lethal temperature (Cameron and Rainey, 1972).

### **Hypotheses**

We tested the null hypothesis that there was no significant difference in *N. lepida* population sizes in the Las Vegas Wash's saltcedar and mesquite/quailbush microhabitats. Based on unpublished observations, it is expected that population sizes of *N. lepida* will be greater in the saltcedar microhabitat than in the mesquite/quailbush microhabitat. This is counter to current scientific thinking concerning the invasive saltcedar. Saltcedar possesses a number of

undesirable attributes: 1) uses more water than comparable native plant communities; 2) dries up springs, wetlands, and riparian areas by lowering surface water tables; and 3) increases soil salinity, thereby rendering it inhospitable to native plants (Carpenter, 1998). Saltcedar creates thick monocultures, exhibits little diversity in height or composition, and is generally thought to provide less suitable habitat for wildlife than native vegetation (LVWCC, 2003). However, while conducting the small mammal diversity study, a variety of species were captured in the saltcedar microhabitat. This observation represents a gap in the literature, as the use of saltcedar by small mammals is not documented. Also, Herndon (2004) concluded that *N. lepida* appears to be greatly dependent upon the foliage litter generated by saltcedar.

Additionally, we hypothesized that population sizes of *N. lepida* will be dependent on ambient air temperature. It is expected that population sizes of *N. lepida* will be highest when ambient air temperatures are at its coolest in the Wash. *Neotoma lepida*'s inability to physiologically withstand high temperatures is well documented (Cameron and Rainey, 1972), but it is suspected, purely through speculation, that increased population size during the winter months may be in part a result of reproduction. Though *N. lepida* can breed all year (Nowak, 1999), Vaughan and Schwartz' (1980) study indicated peak reproductive activity of one population occurring in December and January. If the Wash's desert woodrat population follows a similar pattern, increased foraging time will likely increase the probability of capture, thereby resulting in higher population estimates.

## **Methods**

### ***Field Collection***

Data collection utilizing mark-recapture techniques commenced in July 2002 and ended in June 2003. The study area was comprised of two sites situated north of the Las Vegas Wash

(Figure 1). These included the creosote, mesquite/qaillbush, and saltcedar microhabitats.

Transects were established in both areas for each respective microhabitat. Creosote-dominated



**Figure 1: Aerial map of study area and transect sites near the Las Vegas Wash, Nevada.**  
 \*Aerial photograph provided by the Las Vegas Wash Coordination Committee (2002)

microhabitats were omitted from the analyses owing to the absence of *N. lepida* therein.

Although creosote bush, as discussed earlier, is an important dietary component for many desert woodrat populations, the absence of and distance away from adequate cover made the creosote bush microhabitats less than ideal for desert woodrat inhabitation.

Fifty Sherman live traps (8cm x 8cm x 30 cm) were laid out on each of four transects, spaced approximately 1.0 to 1.5 meters apart from each other, and marked with flags. Trapping was conducted at night. Discounting the creosote transects, 60 nights of trapping (5 nights per month for 12 months) resulted in a total of 12,000 trap nights.

Trapping periods were initiated on the third Wednesday and ended on the following Sunday of each month. On each successive day prior to sundown, all traps were set and baited with a mixture of oats and birdseed. Traps were then cleaned of any remaining bait during subsequent non-trapping periods to discourage opportunistic scavengers from disturbing trap arrays (Gerstenberger et al., 2004); traps were left closed during the day. After each five-day trapping period, traps were removed until the next scheduled trapping month.

Upon capture, animals were placed into a large plastic bag to facilitate easy handling for data collection (Gerstenberger et al., 2004). Morphological measurements including length of tail, body, hind-foot, and ear were measured using a ruler and weight was recorded using a 100 g  $\pm$  1 g hand held Pesola scale. Morphological data were not used in this study but were utilized in other follow-up investigations subsequent to the small mammal survey. New captures were tagged with self-piercing ear tags and identification numbers were recorded. If the animal was a recapture, tag numbers were recorded and tag loss was noted. Live captures were released at the point of capture. Animals that were found dead in the traps were brought back to the UNLV toxicology laboratory for tissue analysis. These procedures were repeated for each trapping period during the twelve-month mark-recapture survey.

### ***Population Estimation***

Estimated population sizes for *N. lepida* in each respective transect were calculated using program CAPTURE (Otis et al., 1978), which is incorporated into program MARK (White and Burnham, 2000). Owing to varied capture histories and small sample sizes, program CAPTURE by design, chose the appropriate model for estimation. In program MARK's capture-recapture models for closed populations, *N. lepida* populations were assumed to remain constant (i.e. closed to birth, immigration, death, and emigration) throughout each trapping period;

additionally it was assumed that marks were not lost or overlooked and that capture probabilities were appropriately modeled (Williams, et al., 2002). Probability of capture and 95% confidence intervals (CI) were calculated. When the minimum number known alive (MNKA) (Cross and Waser, 2000) was either 1 or 0, the MNKA was the estimated population size. In these instances, probability of capture and 95% CI were not calculated.

### ***Microhabitat Preference Comparison***

Population size estimates in each microhabitat were compared statistically via contingency tables (i.e. chi-square analysis) in program SPSS. Numerous cell values with expected counts less than 5 compromised the validity of the chi-square approximation; hence, contingency analyses were calculated with the log-likelihood ratio (G) (Zar, 1999).

### ***Temperature***

Ambient air temperature data for this study was not collected in the field. Instead, ambient air temperatures for each trapping period throughout the survey were obtained from two sources. These include archival weather station data made available by the Regional Flood Control District (2005) and ambient air temperature data recorded by Horn (2003). Using the Regional Flood Control District's data, mean daily ambient air temperatures for three different time slots (20:00, 0:00, 4:00) were calculated. From these numbers, mean trapping week ambient air temperatures were calculated for each month. However, ambient air temperature data for July 2002 and August 2002 were not available in the database and Horn's (2003) measurements were utilized to estimate ambient air temperatures for unavailable months. This was achieved via linear regression in program EXCEL. In ascending order, mean monthly ambient air temperatures were then categorized into quartiles.

For each transect, monthly population sizes were combined in correspondence to appropriate ambient air temperature quartile. Subsequently, chi-square tests were performed for all transects in accordance with procedures outlined by Zar (1999). *P*-values were obtained using program MINITAB.

## **Results**

### ***Population Estimation***

Best-fit models for population estimation for every month in each respective transect were selected by program CAPTURE. In months when the MNKA was either 0 or 1, models were not used for estimation and the MNKA was the estimated population size. Selected models, monthly estimated population sizes, and 95% confidence intervals for each respective transect are given in Table 1.

### ***Microhabitat Preference Comparison***

Log-likelihood ratio tests (G) computed for each microhabitat type indicates no significant differences in capture histories (Table 2).

### ***Temperature***

Ambient air temperature throughout the trapping year ranged from a low of 5.3° C in December 2002 to a high of 31.3° C in August 2002. Quartile mean monthly ambient air temperatures are given in Table 3. As shown in Table 4, combined *N. lepida* population sizes for each microhabitat type corresponding to respective ambient air temperature quartiles are largest in quartile 4 (27.7°-31.3° C). Chi-square tests ( $\chi^2$ ) calculated for each microhabitat type indicates significant differences in *N. lepida* population size dependence on ambient air temperature for the saltcedar microhabitats and no significant differences for the mesquite/quailbush microhabitats (Table 5).

**Table 1: Summary population estimates for *Neotoma lepida* in four arrays (two areas X two habitats) near the Las Vegas Wash, NV.**

Month	Microhabitat <sup>a</sup>	Model <sup>b</sup>	N-hat	C.I. <sup>c</sup>
July 2002	SC-1	M(o)	9	[7,28]
	M/Q-1	MNKA	0	
	SC-2	MNKA	1	
	M/Q-2	MNKA	0	
August 2002	SC-1	M(o)	7	[7,7]
	M/Q-1	MNKA	0	
	SC-2	MNKA	0	
	M/Q-2	MNKA	1	
September 2002	SC-1	M(o)	6	[6,6]
	M/Q-1	MNKA	1	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
October 2002	SC-1	M(o)	4	[4,4]
	M/Q-1	MNKA	0	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
November 2002	SC-1	M(o)	2	[2,2]
	M/Q-1	MNKA	0	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
December 2002	SC-1	M(h)	7	[5,17]
	M/Q-1	MNKA	1	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
January 2003	SC-1	MNKA	1	
	M/Q-1	MNKA	0	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
February 2003	SC-1	M(o)	2	[2,2]
	M/Q-1	MNKA	0	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
March 2003	SC-1	M(o)	5	[5,14]
	M/Q-1	MNKA	0	
	SC-2	MNKA	0	
	M/Q-2	MNKA	0	
April 2003	SC-1	M(o)	6	[6,13]
	M/Q-1	MNKA	1	
	SC-2	MNKA	1	
	M/Q-2	MNKA	0	
May 2003	SC-1	M(th)	18	[15,30]
	M/Q-1	M(o)	3	[3,3]
	SC-2	M(o)	3	[3,3]
	M/Q-2	MNKA	0	
June 2003	SC-1	M(o)	10	[10,10]
	M/Q-1	MNKA	1	
	SC-2	M(o)	5	[5,14]
	M/Q-2	MNKA	1	

a: SC = Saltcedar and M/Q = Mesquite/Quailbush; 1 and 2 designate array

b: M(o) = Constant Capture Probability; M(h) = Heterogeneity among Individuals; M(th) = Temporal Variation and Individual Heterogeneity; MNKA = Minimum Number Known Alive

c: Confidence intervals cannot be calculated for MNKA estimates

**Table 2: Summary log-likelihood ratio (G) values and associated *p*-values comparing respective transects near the Las Vegas Wash, NV.**

	Microhabitat <sup>a</sup>	G	<i>p</i> -value
July 2002 – June 2003	SC-1 vs. M/Q-1	13.542	0.337
	SC-1 vs. M/Q-2	5.924	0.878
	SC-1 vs. SC-2	13.507	0.262
	SC-2 vs. M/Q-1	6.538	0.257
	SC-2 vs. M/Q-2	5.407	0.248
	M/Q-1 vs. M/Q-2	6.762	0.239

a: SC = Saltcedar and M/Q = Mesquite/Quailbush; 1 and 2 designate array

**Table 3: Quartile ambient air temperatures for the Las Vegas Wash, NV.**

Quartile 1	Temperature (° C)
December 2002	5.3
January 2003	10.9
February 2003	13.7
Quartile 2	
November 2002	14.6
March 2003	14.9
April 2003	17.6
Quartile 3	
October 2002	19.3
September 2002	26.8
July 2002	27.2
Quartile 4	
June 2003	27.7
May 2003	30.1
August 2002	31.3

**Table 4: Summary combined population sizes corresponding to appropriate ambient air temperature quartiles.**

Microhabitat <sup>a</sup>	Ambient Air Temperature Quartiles (° C)			
	5.3°-13.7°	14.6°-17.6°	19.3°-27.2°	27.7°-31.3°
SC-1	10	13	19	35
M/Q-1	1	1	1	4
SC-2	0	1	1	8
M/Q-2	0	0	0	2

a: SC = Saltcedar and M/Q = Mesquite/Quailbush; 1 and 2 designate array

**Table 5: Summary chi-square ( $\chi^2$ ) values and associated  $p$ -values testing population size dependence on ambient air temperature.**

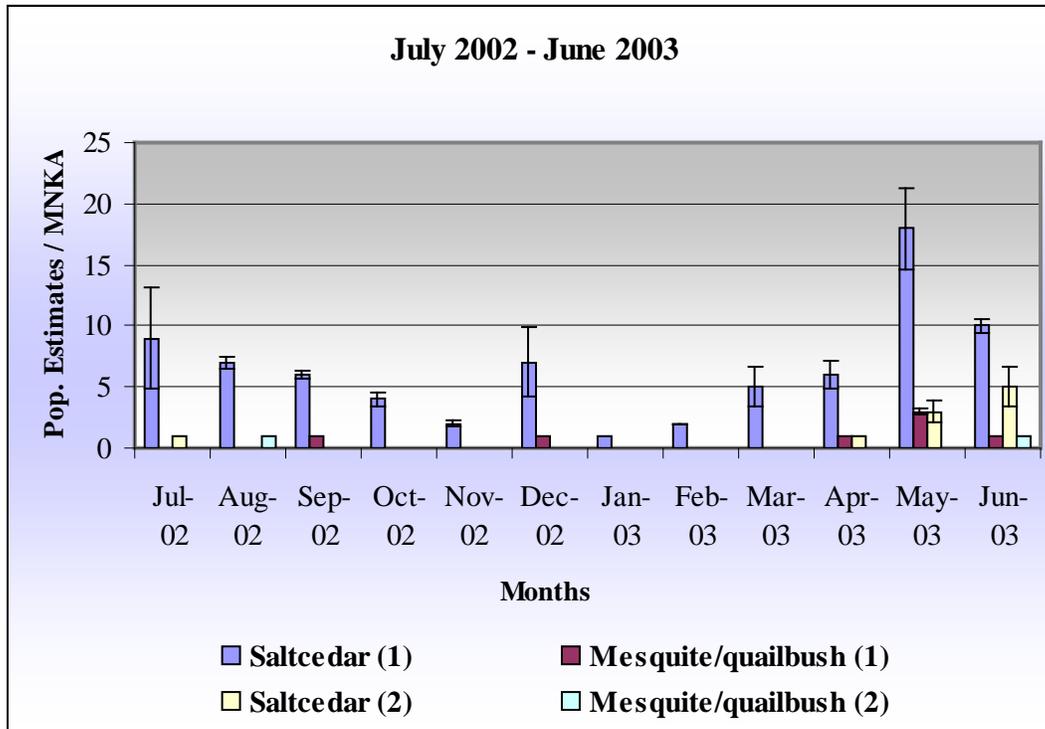
	Microhabitat <sup>a</sup>	$\chi^2$	$p$ -value
July 2002- June 2003	SC-1	19.363	0.0002
	M/Q-1	3.856	0.2774
	SC-2	16.400	0.0009
	M/Q-2	6.000	0.1116

a: SC = Saltcedar and M/Q = Mesquite/Quailbush; 1 and 2 designate array

## Discussion

Log-likelihood ratio tests (G) comparing *N. lepida* population estimates in all four transects failed to reject the null hypothesis of no difference in capture histories between the two microhabitats, which does not indicate preference for a specific microhabitat type. However, the large number of zero cell counts (i.e. no captures or low population estimates) presented a challenge to the G-test's suitability in providing a useful approximation for the data, owing to a lack of discriminatory power.

The inconclusive G-test results do not necessarily suggest that the Wash's desert woodrat population does not exhibit preference for a specific microhabitat type. Validating our first hypothesis, population estimates and MNKA for *N. lepida* throughout the year clearly indicates that the Wash's saltcedar microhabitats support a larger number of the species than the mesquite/quailbush microhabitat. Looking at the resultant population estimates and MNKA graphically, it is apparent that the Wash's desert woodrats prefer residence in the saltcedar microhabitat (Figure 2). More notably, the saltcedar transect in area 1 repeatedly exhibited the highest monthly number of captures, which accounts for its considerably larger monthly population estimates over the other transects.



**Figure 2: Monthly population estimates for *Neotoma lepida* in four arrays near the Las Vegas Wash, NV.**

There may be several reasons to which the higher estimated population sizes for *N. lepida* in the saltcedar microhabitats can be attributed. The consistency of captured individuals in area 1's saltcedar transect is probably a result of its dense cover. While the monotypic stand of saltcedar that occurs in this particular transect impedes native plant growth, it facilitates the existence of *N. lepida* by allowing unconstrained mobility through decreased risk of predation. The mesquite/quailbush microhabitats' vegetative cover was deficient in comparison, which explains the low numbers of *N. lepida* in these areas. Furthermore, the sheer amount of leaf litter readily available in the saltcedar microhabitat provides an overabundance of material for midden construction.

In contrast, the dense cover of the saltcedar microhabitat presents unfavorable conditions for Merriam's kangaroo rat (*Dipodomys merriami*) inhabitation, providing marginal habitat

requirements, at best, for the species (Horn, 2003). Additionally, only one kangaroo rat was captured in the saltcedar microhabitat in Horn's (2003) analysis of the species. The success of *D. merriami*'s competitive ability is well documented and their preference for more unobstructed, open habitats (Nowak, 1999) eliminates the negative competitive effects that would otherwise thwart *N. lepida* population sizes in the Wash's saltcedar microhabitats.

Again, owing to numerous zero cell counts, chi-square ( $\chi^2$ ) testing for dependence of desert woodrat population size on ambient air temperature in the mesquite/quailbush transects lacked the discriminatory power to assess whether or not dependency does, in fact, exist in this microhabitat. This problem also applied to the saltcedar transect in area 2. Opportunely, this issue was not problematic for chi-square testing in area 1's saltcedar transect, which significantly indicated dependence of *N. lepida* population size on ambient air temperature (Table 5). As shown in Table 4, resultant population estimates and MNKA clearly denote an increase in population size occurring in the warmer months of the trapping year (27.7°-31.3° C), thereby invalidating our hypothesis that population sizes would be largest during periods when ambient air temperatures were at its coolest in the Wash.

We can speculate several reasons as to why population sizes for the desert woodrat were largest during the warmer months. Although we did not study reproductive aspects of *N. lepida* in the Wash, the increase in population size may have coincided with final weaning of juveniles and their attempts at establishing temporary home ranges within the vicinity of their maternal ranges (Cranford, 1977). In accordance with the weaning of juveniles, provisional range overlap may elucidate the considerable increase in captures as well. Moreover, the warmer months are subsequent to Las Vegas' growing season, equating to an increase in foraging time owing to an increase in available food resources. The low numbers documented during the coolest months

(5.3°-13.7° C) may be attributed to the fact that *N. lepida* caches its food (Thompson, 1982). In lieu of this behavioral characteristic, desert woodrats may not have spent as much time foraging in our study area, relying instead on stored rations for sustenance.

### **Recommendations**

Despite the desert woodrat's well-documented adaptability and resilience following anthropogenic modification of resource availability (McMurry, et al., 1992), the species needs to be considered throughout ongoing restoration efforts in the Wash, specifically with regards to the removal and eradication of saltcedar (Herndon, 2004). This study has shown that *N. lepida* thrives in dense stands of this highly invasive, troublesome species and puts into question claims that it does not provide suitable habitat for wildlife. It is recommended that control measures be implemented during periods that do not coincide with peak reproductive activity, so it is imperative that research be conducted to determine when breeding is most likely to occur. This will ensure that litters are given the opportunity to reach maturity prior to the removal of saltcedar, thereby increasing their chances at survival. Additionally, it is recommended that the methods utilized in this study be repeated subsequent to the removal of saltcedar and again once desired vegetation has established to monitor *N. lepida*'s adaptability and survivorship.

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