

Nocturnal Rodents

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Objectives

The monitoring protocol handbook (Petryszyn 1995) states: “to document general trends in nocturnal rodent population size on an annual basis across a representative sample of habitat types present in the monument”.

Introduction

Nocturnal rodents constitute the prey base for many snakes, owls, and carnivorous mammals. All nocturnal rodents, except for the grasshopper mouse, are primary consumers. Whereas heteromyids constitute an important guild of granivores, murids feed primarily on fruit and foliage. Rodents are also responsible for considerable excavation and mixing of soil layers (bioturbation), “predation” on plants and seeds, as well as the dispersal and caching of plant seeds.

Rodents are common in all monument habitats, are easily captured and identified, have small home ranges, have high fecundity, and respond quickly to changes in primary productivity and disturbance (Petryszyn 1995, Petryszyn and Russ 1996, Petterson 1999). Other groups of primary consumers such as invertebrates, iguanid lizards, birds, and larger mammals are either more difficult to monitor, have larger home ranges, migrate, or are less abundant. Rodents provide the most cost-effective indicator for monitoring the primary consumer component of monument ecosystems. Long-term monitoring of nocturnal rodent communities contributes to resource management goals by providing information about status and trends in the condition of monument ecosystems, early warning of abnormal conditions, reference data for comparison with more altered sites, and enhanced understanding of ecological processes.

Two families dominate the nocturnal rodent communities at OPCNM. Pocket mice

(*Chaetodipus* spp. and *Perognathus* spp.) and kangaroo rats (*Dipodomys* spp.) belong to the family Heteromyidae (heteromyids), while the white-throated woodrats (*Neotoma albigula*), Arizona cotton rat (*Sigmodon arizonae*), cactus mouse (*Peromyscus eremicus*), and grasshopper mouse (*Onychomys torridus*), belong to the family Muridae. *Sigmodon arizonae*, a native riparian species relatively new to OPCNM, has been recorded at the Dos Lomitas and Salsola EMP sites, adjacent to Mexican agricultural fields. Botta’s pocket gopher (*Thomomys bottae*) is the lone representative of the family Geomyidae. See Petryszyn and Russ (1996), Hoffmeister (1986), Petterson (1999), Rosen (2000), and references therein, for a thorough review.

As part of the Sensitive Ecosystems Project, Petryszyn and Russ (1996) conducted a baseline study originally titled, *Special Status Mammals of Organ Pipe Cactus National Monument*. They surveyed for nocturnal rodents and other mammals in various habitats throughout the monument and found that murids dominated rocky slopes, while heteromyids dominated bajadas and valley bottoms. They also confirmed the Arizona cotton rat (*Sigmodon arizonae*), on the monument for the first time in December 1988, and recorded Merriam’s mouse (*Peromyscus merriami*) on the monument for the first time since 1894. Current monitoring efforts are guided by the protocol developed for small nocturnal mammals by Petryszyn (1995).

This report provides the following summaries and data reductions:

- Classification of rodent grids by habitat.
- Number of nights of monitoring at each site for each year, 1991-2005.
- List of species and common names for each family.
- Mean annual relative abundance of each

- species at each grid.
- Mean adult body mass for each species.
- Relative abundance of nocturnal rodents monument-wide, 1991-2005.
- Trend analysis for each species 1991-2005.
- Appendix B tables (30), one for each grid, 1997-2005:
 - o Relative abundance of murids at each grid in each year.
 - o Total biomass of murids at each grid in each year.
 - o Relative abundance of heteromyids at each grid in each year.
 - o Total biomass of heteromyids at each grid in each year.
 - o Species richness at each grid in each year.
 - o Diversity (H') at each grid in each year.
 - o Capture success, night 1.
 - o Capture success, night 2.
 - o Recaptures.
- Appendix B graphs (30), one for each grid, 1991-2005:
 - o Relative abundance of each species at each grid in each year.

Methods

Study Sites

Rodents are monitored annually, in summer, on two consecutive nights. There are 30 grids at 16 EMP sites (Figure 10-1); two sites, Bull Pasture and Dripping Springs have 1 grid, the others have 2 grids (Table 10-1). At most study sites, the 2 grids were located in different micro-habitat types (i.e., Armenta Ranch, Alamo, Dos Lomitas, Growler, Middle Bajada, Pozo Nuevo, Salsola, Senita Basin, Quitobaquito, and Valley Floor), whereas at other locales the 2 grids were placed in homologous micro-habitats and could be considered replicates (Aguajita, East Armenta, Lower Colorado Larrea, and Vulture).

Trapping and Processing Techniques

Grid corners are permanently marked with rebar stakes. Each grid consists of 49 traps arranged in

a 7X7 array. Folding Sherman traps, measuring 3x3.5x9in(7.6 x 8.9 x 22.9cm), are used at some rocky sites (Bull Pasture, Alamo), while longer 12in (30.5cm) traps are used in valley and bajada sites where larger species of kangaroo rats may be captured. The traps are placed at 15m intervals, resulting in a 90 x 90m grid. Trap stations on each grid are given permanent alphanumeric designations of A1 - G7 (A1 = southwest grid corner; G7 = northeast grid corner). This designation was useful in tracking species microhabitat selection and species distribution over time. Adding a 15m buffer, which corresponds to the average rodent home range radius, results in an effective sampling area of 1.4ha (3.5a).

Traps were baited with a mixture of rolled oats and sterile bird seed, and opened at dusk for 2 consecutive nights at each site, thereby yielding 98 trap-nights of effort for each grid. Information recorded at time of capture included trap station, species, body mass (g), sex, age, and reproductive condition. From 1991-1996, each new capture (except on the last morning) was marked on the ventral surface with a black permanent ink felt-tip pen. Beginning in 1997, each new capture was marked with a unique combination of color marks to permit individual identification within year. Processing of captures began near dawn on the morning following baiting and finished before the sun had risen high enough to heat the traps appreciably.

In 1997-1999, 7-10 sites were trapped for 4 nights instead of 2 (Table 10-2). In this report, analyses will be limited to results from the first 2 nights of trapping. In 1998, ALAM1, EARM1, LOWE1, and MIDB1 grids were sampled with a 12x12 array with traps spaced at 10 m intervals. The same arrangement was repeated in 1999 except at the ALAM1 grid. The results of trapping with the 12x12 arrangement will be presented in a later report.

Data Analysis

For each grid, an annual abundance index (total

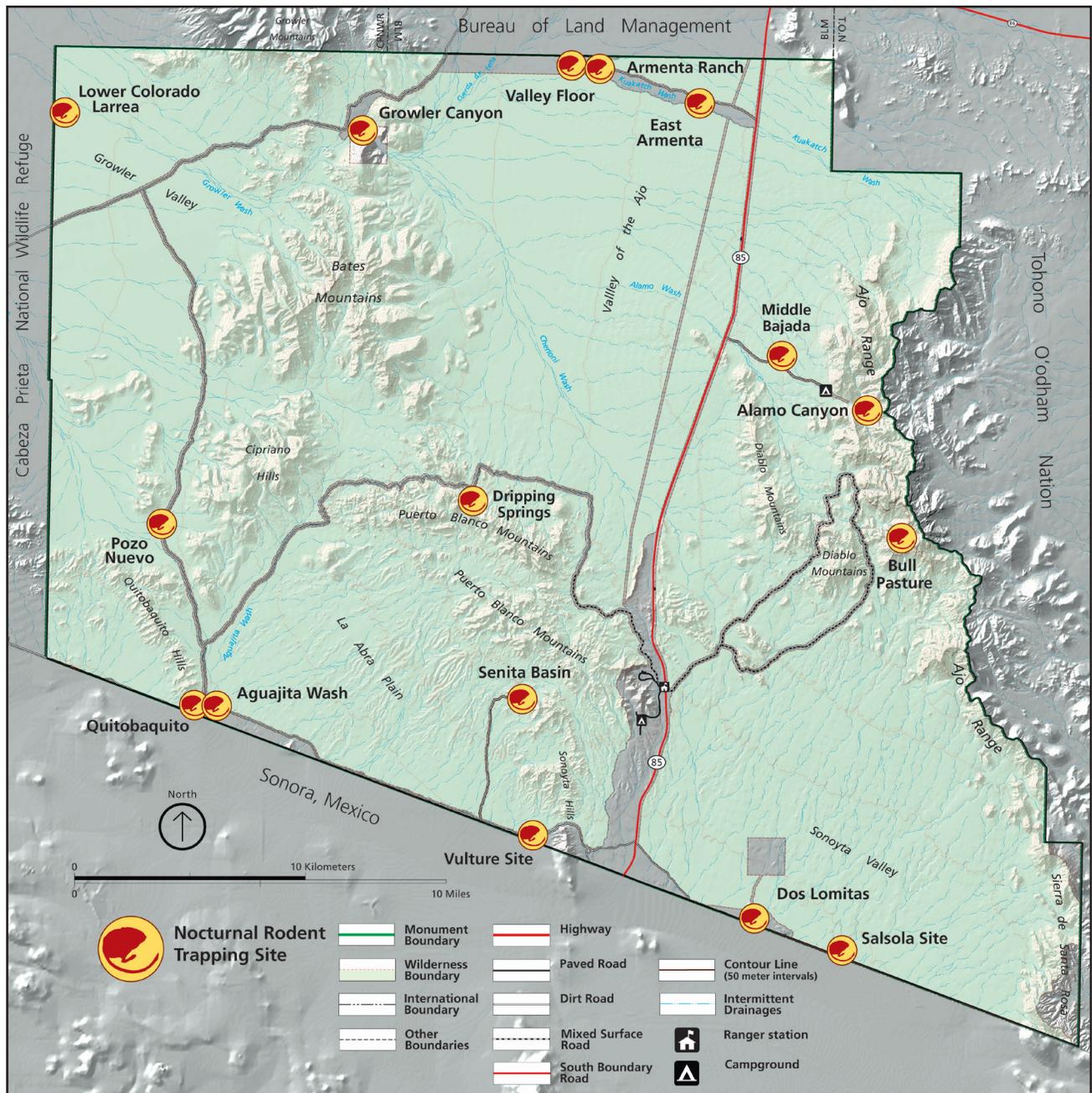


Figure 10-1. Nocturnal rodent trapping sites, Organ Pipe Cactus N.M.

Table 10-1. Classification of rodent grids according to hydrologic regime and soil texture at Organ Pipe Cactus N.M.

Site	Grid	Code	Hydrologic regime	Soil texture
Aguajita Wash	1	AGUA1	xeroriparian	valley floor
Aguajita Wash	2	AGUA2	mixed	valley floor
Alamo Canyon	1	ALAM1	upland	rocky slope
Alamo Canyon	2	ALAM2	xeroriparian	rocky slope
Armenta Ranch	1	ARMR1	mixed	valley floor
Armenta Ranch	2	ARMR2	upland	valley floor
Bull Pasture	1	BULL1	upland	rocky slope
Burn Site	1	BURN1	mixed	valley floor
Burn Site	2	BURN2	upland	valley floor
Dos Lomitas	1	DOLO1	mixed	valley floor
Dos Lomitas	2	DOLO2	mixed	valley floor
Dripping Springs	1	DRIP1	upland	rocky slope
East Armenta	1	EARM1	mixed	valley floor
East Armenta	2	EARM2	mixed	valley floor
Growler Canyon	1	GROW1	xeroriparian	valley floor
Growler Canyon	2	GROW2	xeroriparian	valley floor
Lost Cabin	1	LOST1	mixed	rocky slope
Lost Cabin	2	LOST2	mixed	rocky slope
Lower Colorado Larrea	1	LOWE1	upland	valley floor
Lower Colorado Larrea	2	LOWE2	upland	valley floor
Middle Bajada	1	MIDB1	mixed	bajada
Middle Bajada	2	MIDB2	upland	bajada
Pozo Nuevo	1	POZO1	upland	valley floor
Pozo Nuevo	2	POZO2	upland	valley floor
Quitobaquito	1	QBQT1	mixed	rocky slope
Quitobaquito	2	QBQT2	xeroriparian	bajada
Salsola Site	1	SALS1	mixed	valley floor
Salsola Site	2	SALS2	xeroriparian	valley floor
Senita Basin	1	SENI1	mixed	rocky slope
Senita Basin	2	SENI2	upland	rocky slope
Valley Floor	1	VALL1	upland	valley floor
Valley Floor	2	VALL2	mixed	valley floor
Vulture Site	1	VULT1	mixed	bajada
Vulture Site	2	VULT2	mixed	bajada

Table 10-2. Number of nights of rodent monitoring on each grid for each year at Organ Pipe Cactus N.M. Each site has two grids except for BULL and DRIP which each have one.

Site	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGUA	2	2	2	2	2	2	4	4	4	2	2	2	2	2	2
ALAM	2	2	2	2	2	2	4	4	4	2	2	2	2	2	2
ARMR			2	2	2	2				2	2	2		2	2
BULL					2	2	2	2	2	2	2	2	2	2	2
BURN					2	2									
DOLO	2	2	2	2	2	2	4	4	4	2	2	2	2	2	2
DRIP					2	2	2			2	2	2	2	2	2
EARM	2	2	2	2	2	2	4	4	4	2	2	2	2	2	2
GROW	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2
LOST				2	2	2									
LOWE			2	2	2	2	4	4	4	2	2		2	2	2
MIDB					2	2	4	4	4	2	2	2	2	2	2
POZO	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2
QBQT			2	2	2	2	2	2	2	2	2	2	2	2	2
SALS			2	2	2	2	2	4	4	2	2	2	2	2	2
SENI	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2
VALL					2	2	4	2	2	2	2	2	2	2	2
VULT					2	2	2	2	2	2	2	2	2	2	2

captures) was calculated for each species by counting each individual once and ignoring recaptures. The results are graphed in Appendix 2. Total captures, capture success and recapture rates, and biomass data were summed for each of the two taxonomic groups of rodents, heteromyids and murids; species richness (number of species) and diversity were also calculated and tabulated in Appendix 2. Diversity was calculated using the Shannon function:

$$H' = - \sum (p_i \times \ln(p_i))$$

where p_i is the proportion of the i^{th} species. To use all sites and compare relative abundance, species richness, and diversity among years, each grid was standardized to zero mean and unit standard deviation. Then all grids were averaged for each season and a standard error computed. To provide some insight into possible impacts of adjacent land-use, the sites were divided into interior and border groups: mean and standard error were then computed for each group. Border EMP sites include, from west to east, Quitobaquito, Aguajita Wash, Vulture Site, Burn

Site, Dos Lomitas, and Salsola Site; all other sites are interior (Figure 10-1).

Monument-wide trend analyses were performed on each species as follows. Trends were modeled independently for each species by using a generalized linear mixed model (PROC GLIMMIX; SAS) with a year covariate to estimate trend, and a random quadrat effect and a random year effect. The random year effect captures annual variation that cannot be explained by linear trend alone. The model was specified to have a log link function based on a Poisson distribution with overdispersion. All of the 1991-2005 data were used, except for grids employing the 12x12 arrangement.

Based on a visual scan of the graphs in Appendix 2, single grids were selected for linear regression analyses if individual species or families appeared to show trends. This was only done for Alamo Canyon to provide an example.

Results

In the period 1991-2005, there have been 48 trap mortalities out of 21,647 captures or 0.22%. Overall, mean abundance for each species is

Table 10-3. Rodent species recorded on monitoring plots at Organ Pipe Cactus N.M.

Family	Species	Common name	Code
Heteromyidae	<i>Chaetodipus baileyi</i>	Bailey's pocket mouse	CHBA
Heteromyidae	<i>Chaetodipus intermedius</i>	rock pocket mouse	CHIN
Heteromyidae	<i>Chaetodipus penicillatus</i>	desert pocket mouse	CHPE
Heteromyidae	<i>Perognathus amplus</i>	Arizona pocket mouse	PEAM
Heteromyidae	<i>Perognathus longimembris</i>	little pocket mouse	PELO
Heteromyidae	<i>Dipodomys merriami</i>	Merriam's kangaroo rat	DIME
Heteromyidae	<i>Dipodomys spectabilis</i>	banner-tail kangaroo rat	DISP
Muridae	<i>Neotoma albigula</i>	white-throated woodrat	NEAL
Muridae	<i>Onychomys torridus</i>	grasshopper mouse	ONTO
Muridae	<i>Peromyscus eremicus</i>	cactus mouse	PEER
Muridae	<i>Peromyscus merriami</i>	mesquite mouse	PEME
Muridae	<i>Sigmodon arizonae</i>	Arizona cotton rat	SIAR

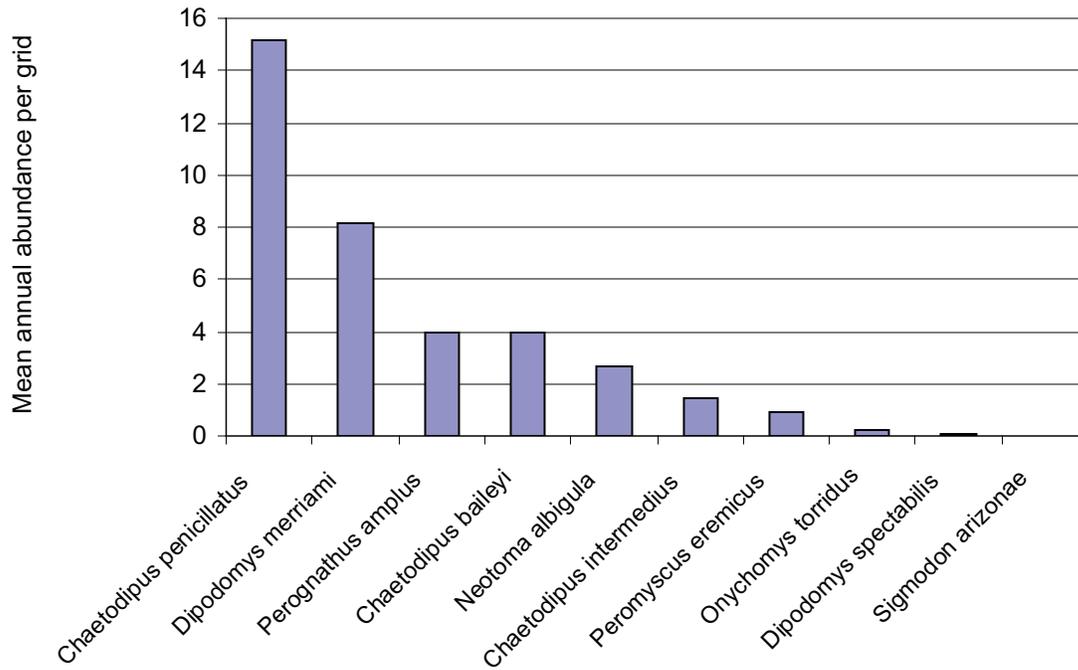


Figure 10-2. Mean abundance, averaged by year and grid, for each nocturnal rodent species on monitoring grids at Organ Pipe Cactus N.M.

Table 10-4. Mean annual abundance of rodent species at each grid at Organ Pipe Cactus N.M. Abundance is total registered over two nights of trapping. See text for definition of site and species codes.

Site code	CHBA	CHIN	CHPE	PEAM	DIME	DISP	NEAL	ONTO	PEER	SIAR	All spp.
AGUA1	0.5	0.1	29.8	3.3	4.5	0.0	2.8	0.5	0.5	0.0	42.0
AGUA2	0.1	0.0	19.4	6.1	9.3	0.0	1.8	0.8	0.0	0.0	37.5
ALAM1	5.4	10.2	7.9	0.0	0.0	0.0	10.1	0.0	5.4	0.0	38.9
ALAM2	11.5	2.1	6.0	0.0	0.0	0.0	7.7	0.0	5.0	0.0	32.4
ARMR1	2.1	0.0	13.5	2.5	11.5	0.1	0.1	0.0	0.0	0.0	29.9
ARMR2	1.4	0.0	12.5	3.6	17.5	0.0	0.1	0.0	0.6	0.0	35.8
BULL1	10.0	3.6	1.5	0.0	0.0	0.0	8.6	0.0	4.4	0.0	28.1
DOLO1	0.2	0.0	15.4	1.3	18.2	0.0	0.4	1.3	0.2	0.6	37.6
DOLO2	0.2	0.1	24.2	1.5	14.0	0.0	0.8	0.3	0.1	0.0	41.2
DRIP1	20.3	6.8	6.8	0.0	0.0	0.0	7.8	0.0	1.8	0.0	43.3
EARM1	0.1	0.0	21.9	9.2	11.9	0.4	3.9	0.0	0.1	0.0	47.5
EARM2	0.1	0.0	13.1	12.1	13.4	0.1	3.6	0.1	0.0	0.0	42.5
GROW1	0.3	0.0	40.5	0.5	10.9	0.0	0.6	0.1	0.0	0.0	52.8
GROW2	1.6	0.0	39.7	0.9	7.4	0.0	1.0	0.1	0.1	0.4	51.2
LOWE1	0.2	0.0	3.7	8.4	17.5	0.0	0.1	0.1	0.0	0.0	30.0
LOWE2	0.1	0.0	2.0	11.5	18.0	0.3	0.0	0.3	0.0	0.0	32.2
MIDB1	18.6	3.8	5.2	2.9	0.3	0.0	1.5	0.0	0.5	0.0	32.8
MIDB2	21.1	0.0	1.0	6.0	4.3	0.0	1.1	0.1	0.0	0.0	33.6
POZO1	0.4	0.7	3.7	5.9	12.5	0.0	0.0	0.1	0.2	0.0	23.5
POZO2	0.2	0.0	6.9	8.6	16.4	0.0	0.1	0.0	0.1	0.0	32.4
QBQT1	1.0	11.4	13.1	0.1	0.1	0.0	12.8	0.0	6.3	0.0	44.8
QBQT2	0.4	0.0	17.5	0.4	4.3	0.0	7.8	0.7	2.8	0.0	33.9
SALS1	0.1	0.0	27.3	2.7	12.5	0.3	0.0	0.7	0.0	0.0	43.5
SALS2	0.6	0.0	42.2	0.6	7.4	0.0	1.1	0.6	0.0	0.1	52.5
SENI1	10.9	1.3	4.7	3.5	3.1	0.0	1.0	0.0	0.0	0.0	24.6
SENI2	9.0	3.8	8.4	1.6	2.3	0.0	1.1	0.0	0.2	0.0	26.4
VALL1	0.1	0.0	3.0	10.8	11.1	0.0	0.0	0.0	0.0	0.0	25.0
VALL2	1.0	0.0	23.2	4.8	7.0	0.0	1.0	0.2	0.0	0.0	37.2
VULT1	0.4	0.0	17.1	6.1	3.5	0.0	1.8	0.0	0.0	0.0	28.9
VULT2	0.7	0.1	23.3	4.1	4.5	0.0	2.2	0.2	0.0	0.0	35.1
Mean	3.95	1.46	15.15	3.96	8.12	0.04	2.69	0.21	0.94	0.03	36.56

Table 10-5. Summary statistics for adult body mass (log transformed) of each nocturnal rodent species on monitoring grids at Organ Pipe Cactus N.M.

	Murids				Heteromyids					
	NEAL	SIAR	ONTO	PEER	DISP	DIME	CHBA	CHPE	CHIN	PEAM
Mean	2.124	1.827	1.338	1.250	1.961	1.562	1.413	1.207	1.111	1.051
Standard Error	0.004	0.046	0.009	0.005	0.023	0.001	0.003	0.001	0.003	0.002
Median	2.146	1.760	1.342	1.255	1.996	1.568	1.415	1.210	1.114	1.041
Mode	2.204	1.716	1.301	1.279	2.004	1.591	1.447	1.230	1.114	1.041
Standard Deviation	0.116	0.195	0.088	0.086	0.110	0.067	0.092	0.093	0.071	0.073
Sample Variance	0.014	0.038	0.008	0.007	0.012	0.005	0.008	0.009	0.005	0.005
Kurtosis	9.916	-1.338	0.722	-0.078	2.979	1.118	0.119	0.081	5.415	0.833
Skewness	-1.708	0.139	-0.448	-0.020	-1.617	-0.725	-0.148	-0.262	1.516	0.037
Range	1.410	0.588	0.450	0.497	0.474	0.533	0.611	0.876	0.599	0.665
Minimum	1.041	1.539	1.079	1.021	1.626	1.238	1.079	0.778	0.903	0.748
Maximum	2.452	2.127	1.529	1.519	2.100	1.771	1.690	1.654	1.502	1.413
Sum	2100.5	32.9	119.1	447.4	47.1	4890.4	1885.3	6741.4	633.5	1654.8
Count	989	18	89	358	24	3131	1334	5587	570	1574

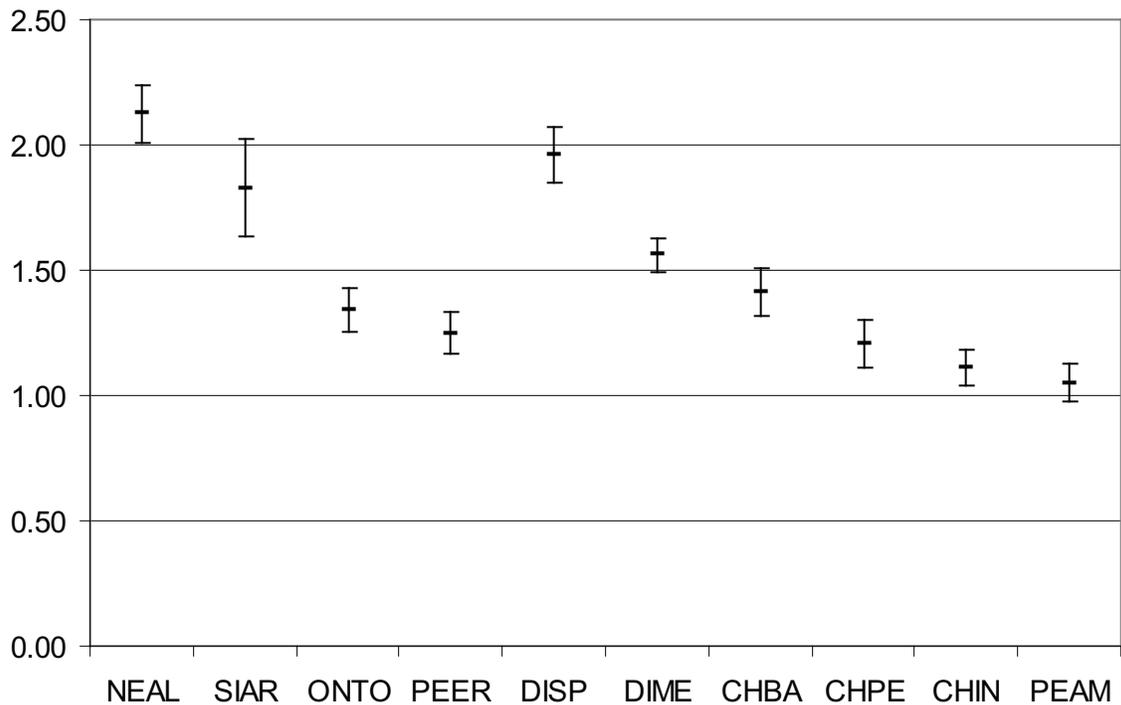


Figure 10-3. Mean and standard deviation of adult body mass (log transformed) for each nocturnal rodent species on monitoring grids at Organ Pipe Cactus N.M.

presented in Figure 10-2. Mean annual abundance for each species at each grid is presented in Table 10-4. *Chaetodipus penicillatus* is the most abundant species with a mean annual abundance ranging from 1.0 captures at MIDB1 to 42.2 captures at SALS2. For all species combined, mean annual abundance among sites ranged from 24.6 at SENI1 to 52.8 at GROW1.

Among years 1997-2004 (Appendix B), the total number of rodents registered in 2 nights of trapping ranged from 2 at VULT2 in 2002 to 76 at EARM2 in 1999. Species richness ranged from 1 species at VULT2 in 2002 to 6 at various sites over the years. Diversity (H') ranged from 0 at VULT2 in 2002 to 1.564 at MIDB1 in 2003.

Eight species, *Chaetodipus baileyi*, *C. intermedius*, *C. penicillatus*, *Perognathus amplus*, *Dipodomys merriami*, *Neotoma albigula*, *Onychomys torridus*, *Peromyscus eremicus*, were captured at one or more sites every year; two species, *Dipodomys spectabilis* and *Sigmodon arizonae* were often not captured at any site in a given year.

Total rodent biomass ranged from 48g at VALL1 in 1998 to 3135g at Dripping Springs in 2004. Overall, the smallest and largest species are *Perognathus amplus* and *Dipodomys spectabilis* among heteromyids, and *Peromyscus eremicus* and

Neotoma albigula among murids (Table 10-5 and Figure 10-3).

Periods of high rodent abundance occurred in 1992-1993, 1999, and 2004 (Figure 10-4). These correspond with the last 3 El Niño events. Despite wide short-term variation in rodent abundance, the 15-year record suggests systematic decline either monument-wide or for the border sites, specifically. The same is true for diversity and species richness (Figures 10-5 and 10-6).

Trend analysis detected significant changes in 2 pocket mouse species, *Chaetodipus baileyi* and *Perognathus amplus* (Table 10-6). Other trends are detectable by linear regression at specific sites. For example, at Alamo Canyon, murids exhibit a significant decline ($R^2=0.71$, $N=14$, $P=0.0001$), while heteromyids increase ($R^2=0.28$, $N=14$, $P=0.0501$).

Discussion

Petryszyn and Russ (1996) classified sites as mountain canyon, small hills, or bajada/valley floor. A better classification to distinguish rodent communities may be to combine rocky sites (mountain canyons, small hills, and bajadas) into one class and divide valley sites into xeroriparian (dominated by washes or floodplains) and upland (i.e., not xeroriparian) classes. In practice, this

Table 10-6. Estimated percent annual change in rodent species at Organ Pipe Cactus N.M., based trend model.

Species	Percent Change	Standard Error	95% Confidence Interval	Significance
<i>Chaetodipus baileyi</i>	10.8	3.8	(3.7 to 18.5)	0.003
<i>Chaetodipus intermedius</i>	9.9	6.2	(-1.6 to 22.7)	0.095
<i>Chaetodipus penicillatus</i>	-1.4	1.8	(-4.9 to 2.2)	0.443
<i>Dipodomys merriami</i>	-0.8	2.4	(-5.3 to 4.0)	0.743
<i>Dipodomys spectabilis</i>	6.5	12.7	(-15.7 to 34.7)	0.597
<i>Neotoma albigula</i>	-2.4	2.8	(-7.8 to 3.3)	0.399
<i>Onychomys torridus</i>	3.4	4.5	(-5.2 to 12.7)	0.450
<i>Perognathus amplus</i>	4.8	1.5	(1.9 to 7.8)	0.001
<i>Peromyscus eremicus</i>	-4.6	3.6	(-11.5 to 2.8)	0.212
<i>Sigmodon arizonae</i>	-25.1	17.7	(-52.9 to 19.1)	0.221

is difficult because many of the grids include a mix of xeroriparian and upland habitat (Table 10-1). Nevertheless, it is apparent that *Chaetodipus baileyi*, *C. intermedius*, *Neotoma albigula*, and *Peromyscus eremicus* prefer rocky sites, *Chaetodipus penicillatus* prefers xeroriparian flats, and *Dipodomys merriami* and *Perognathus amplus* prefer upland flats (Tables 10-1 and 10-4; see also Cockrum and Petryszyn 1986, Petryszyn and Russ 1996). Grids that are mixed (e.g., VALL2) typically have rodent communities that are intermediate between xeroriparian and upland (e.g., compare to GROW1&2 and LOWE1&2).

The low mean abundance of *Neotoma albigula* at Senita Basin compared to other rocky slope sites is perplexing. A closer examination of this site might reveal a scarcity of one or more limiting resources for this species or a high abundance of predators, competitors, or disturbance. The low abundance of another rocky slope species, *Chaetodipus baileyi*, at Quitobaquito poses similar questions.

In Alamo Canyon, there appears to have been a general decline in murids, *Neotoma albigula* and *Peromyscus eremicus*, and increase in heteromyids, *Chaetodipus baileyi*, *C. intermedius*, and *C. penicillatus* (see Appendix B). It was 2 heteromyid species, *C. baileyi* and *Perognathus amplus*, that exhibited a significant increase, based on monument-wide trend analysis. It would be interesting to see if these changes are short-term (several years) or more lasting.

Several long-term studies of rodents have linked population dynamics to climate, biotic interactions, and disturbance. A 13-year study of rodents with extensive field manipulations in the semiarid thornscrub of northern Chile found a pattern of rainfall-induced vegetation and rodent productivity, followed by increased herbivory and predation (Meserve et al. 2003). Long-term studies of rodents in the Chihuahuan Desert near Portal, Arizona, revealed that many, but not all, El Niño events lead to increases in rodent populations (Valone and Brown 1996, Ernest et

al. 2000, Brown and Ernest 2002).

Predators would first exhibit a functional response to higher rodent abundance with a behavioral increase in the rate of predation. The higher intake of prey would lead to an increase in reproductive output among predators, which would further increase predation pressure on rodents. These responses, with their species-specific time lags, may account for the steep decline in rodents at OPCNM from 1992 to 1995 despite high annual rainfall from 1992 to 1994.

There is certainly much more analysis that can be done with the data than has been presented here. Rodent communities differ from each other based on soils, vegetation, and other habitat characteristics. The monument has excellent maps in its GIS data base. Future analyses could partition the data according to habitat categories of interest.

The protocol clearly is able to document general trends in rodents at OPCNM. Perhaps, the data reduction with the greatest management value is that presented in figures 10-4 to 10-6. These figures provide a look at three indicators (relative abundance, diversity, and species richness) of nocturnal rodent communities at OPCNM. All three indicators show some fluctuation but no sustained decline. Therefore, the protocol contributes valuable information about progress toward meeting the goal of preserving a representative portion of the Sonoran Desert ecosystem.

Recommendations

Inventory

There is much variation in geology and vegetation at OPCNM and it would be impossible to monitor rodents in every type of habitat. However, some areas, not presently monitored, may be of interest. Some high elevation areas (more than 1200m) in the Ajo Range have temperate vegetation with oak and juniper in canyons that resembles Madrean woodland or shrub and grass-dominated communities on more gentle

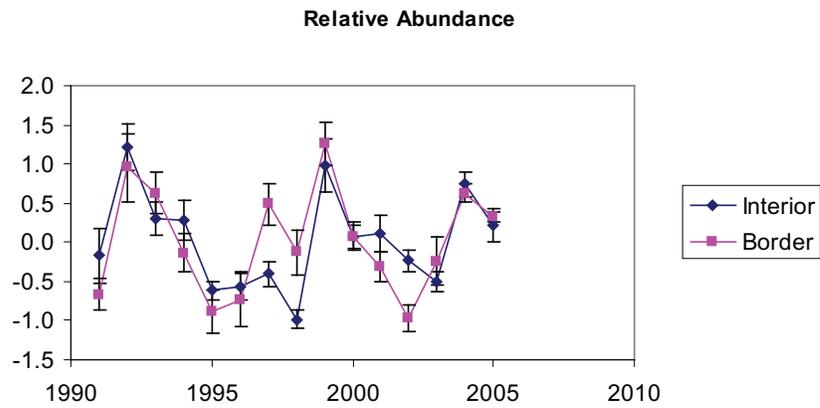


Figure 10-4. Relative abundance of all rodents, standardized for each grid at Organ Pipe Cactus N.M., 1991-2005. Mean and standard error derived from interior and border grids pooled separately for a given season.

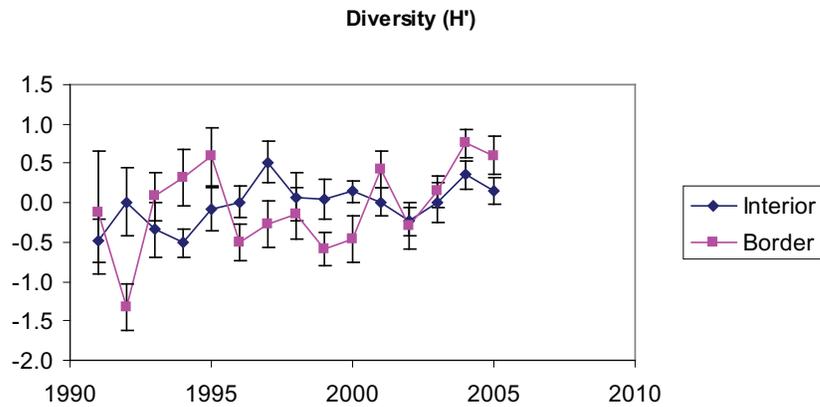


Figure 10-5. Diversity of rodents, standardized for each grid at Organ Pipe Cactus N.M., 1991-2005. Mean and standard error derived from interior and border grids pooled separately for a given season.

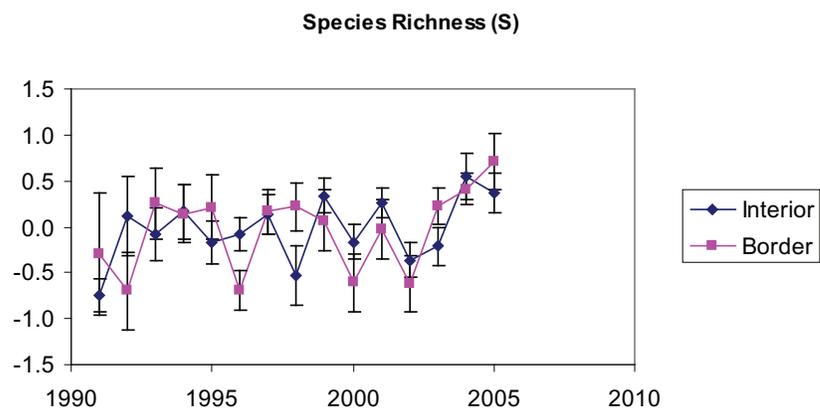


Figure 10-6. Species richness of rodents, standardized for each grid at Organ Pipe Cactus National Monument, 1991-2005. Mean and standard error derived from interior and border grids pooled separately for a given season.

slopes. Some of these areas should be sampled to determine if any species have been overlooked in the monument. Botta's pocket gopher (*Thomomys bottae*) may be common in some of the level basins of the Ajo Range where soil has accumulated. High elevation species may be particularly vulnerable to climate change.

Organ Pipe Cactus N.M. is one of few protected areas and the only NPS unit with intact saltbush (*Atriplex spp.*) communities. Baseline information about these communities, including the rodents, will be valuable for any future restoration effort.

Except for a single lizard transect, no other EMP monitoring has been accomplished on the dark basaltic hills in the western portion of OPCNM. The desert woodrat (*Neotoma lepida*) has been recorded from the Bates Mountains (Hoffmeister 1986) and may be present elsewhere.

Our knowledge of rodent communities in some habitats could be enhanced, if staffing resources are available, by conducting one-time inventories using the standard rodent sampling protocols in the following habitats:

- Temperate communities in the Ajo Range
- Pure saltbush community in the Rio Sonoyta floodplain
- Basalt hills in the western monument

Large Kangaroo Rats

No *Dipodomys deserti* (desert kangaroo rat) have been recorded at EMP sites 1991-2005. This species was not reported either by Warren and Anderson (1987) or Petryszyn and Russ (1996), despite extensive trapping efforts. Museum specimens exist from Quitobaquito, 1 mile east of Quitobaquito, the junction of Puerto Blanco Drive and Pozo Nuevo roads, Bates Well, and the north boundary of OPCNM (Cockrum and Petryszyn 1986, Hoffmeister 1986). The other large kangaroo rat, *D. spectabilis*, is probably more widespread at OPCNM but rarely recorded during monitoring; it has been recorded on 5 grids.

We may be underestimating the relative

abundance and distribution of large kangaroo rats, mainly *D. spectabilis*. This species is rarely recorded in part because its burrows are more widely spaced. To adequately sample large kangaroo rats, we should consider counting their distinctive mounds in a larger plot (e.g., 1 hectare) that includes the regular grid. Sampling large kangaroo rats is recommended because the large species, with their characteristic large burrows, may be more vulnerable to impacts from heavy sources such as off-road vehicles and livestock.

Experimental Restoration

Rodents and lagomorphs (cottontails and jackrabbits) no doubt have a significant impact on the successful establishment of plants. They have been largely responsible for the 100% mortality of young trees and shrubs that appeared in great abundance following major rainfall events in 2003-2005 near Ajo, Arizona (Holm, personal observation). Curtin et al. (2000) conducted experimental removal of rodents in the northern Chihuahuan Desert and determined that rodents inhibit the expansion of vegetation patches. Holmgren and Scheffer (2001) suggested that high rainfall events associated with El Niño episodes provide a unique opportunity to greatly enhance seedling establishment if herbivores are controlled.

In heavily-impacted and barren areas, such as near Armenta Ranch and Dos Lomitas, experimental exclosures could be erected to exclude rodents and lagomorphs and allow the establishment of perennial vegetation. This would facilitate further restoration of the vegetation community and reduce erosion potential. Monitoring climate, vegetation, and small mammals would be key to successful planning, implementation, and determining the effectiveness of such a project.

Woodrats

The white-throated woodrat, also known as packrat (*Neotoma albigula*), ranges throughout the deserts and woodlands of southwestern North America. It is a common inhabitant of rocky areas

and areas where cholla and prickly pear cactus are abundant. Woodrats nest in crevices and under boulders and, in less rocky areas, build an above-ground house (midden) consisting of a pile of sticks and cactus joints at the base of a cactus or shrub. The woodrat diet consists mainly of cactus, but foliage, bark, and seeds (especially mesquite) may also be consumed.

Although woodrats are a natural component of Sonoran Desert ecosystems, they occasionally get noticed for the damage they do to property. Woodrats may chew on electrical wires, construct their nests in inconvenient places, or steal small items to place in their nests. Visitor comments from the 2005-2006 season included complaints about woodrats at the main campground.

A special grid was sampled in 2006 to investigate the campground rodent population. The methods and results will be reported separately. However, preliminary results indicated that woodrat density was the third highest ever recorded in the monument in 437 sampling occasions. Long-term trends in rodent abundance (Figure 10-4) indicate a recent spike in rodent numbers.

A quick look at the campground revealed an abnormally high density of prickly pear cactus. An obvious recommendation for management would be to remove some of the prickly pear cactus. It would also be advisable to remove some of the cholla cactus joints and dry sticks lying on the surface. These actions would reduce the microhabitat sites and materials used for nesting and restore the campground area to a more typical configuration for woodrat habitat on a bajada landscape.

Some interpretive materials here should be helpful in educating visitors about what is going on and satisfying some of their concerns. We can inform visitors about woodrat ecology and population dynamics at OPCNM and we can remind them not to leave containers open and small valuables lying around.

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