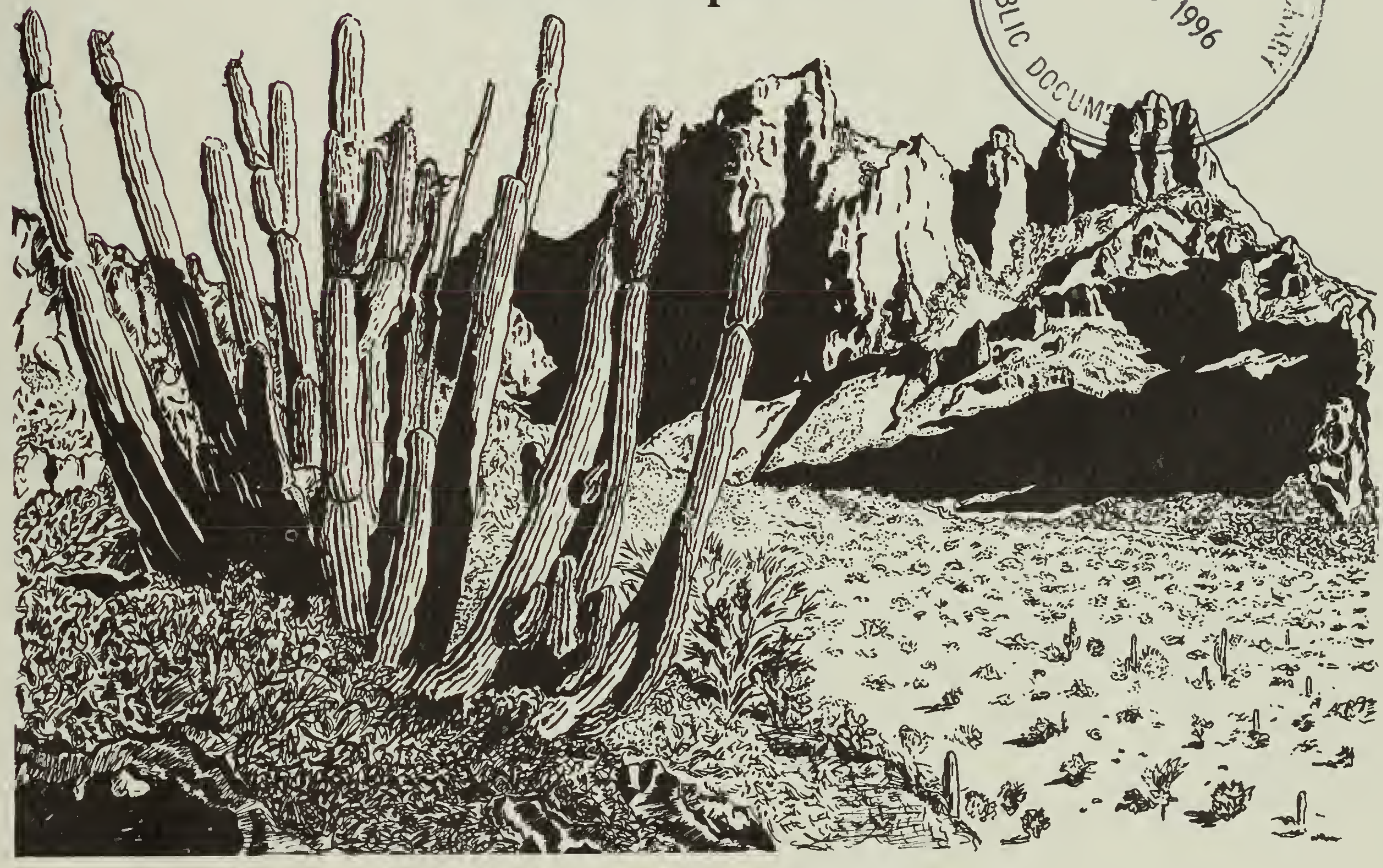
# Nocturnal Rodent Population Densities and Distribution at Organ Pipe Cactus National Monument, Arizona

Yar Petryszyn and Stephen Russ



Technical Report No. 52



United States Department of the Interior
National Biological Service
Cooperative Park Studies Unit
The University of Arizona

and

National Park Service
Organ Pipe Cactus National Monument

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The CPSU/UA provides a multidisciplinary approach to studies in natural and cultural sciences. The unit conducts and coordinates research that is funded by various agencies.

Principal Arizona cooperators include the School of Renewable Natural Resources and the Department of Ecology and Evolutionary Biology of The University of Arizona. The Western Archeological and Conservation Center (NPS) and the School of Renewable Natural Resources (UA) provide administrative assistance. Unit scientists hold faculty or research associate appointments at the university.

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Special thanks go to Jim Barnett for his efforts on our behalf in the field and with administrative needs, for providing some dynamite cookies (courtesy of his wife!), and also for entertaining us with some great stories while camped under the stars at Bull Pasture.

Also, a warm "thank you" to Tom Huels, Glenn McCrea, and others for the many hours spent in proofreading, as well as for their suggestions for improving this manuscript. Their efforts greatly enhanced the legibility of this composition.

# Abstract

Distribution, number, and biomass of nocturnal rodents were determined at Organ Pipe Cactus National Monument through the use of live capture-mark-release techniques. Sixteen sites were sampled throughout the monument. The cricetids (mostly white-throated woodrats [*Neotoma albigula*]and cactus mice[*Peromyscus eremicus*]) dominated the mountainous regions, while the heteromyids (pocket mice[*Chaetodipus* and *Perognathus* spp.] and kangaroo rats [*Dipodomys* spp.]) prevailed in the basins and bajadas. Biomass varied from 127 g/ha (1.8 oz/a.) to 2,625 g/ha (37.5 oz/a.), with a mean of 748 g/ha (10.7 oz/a.). Nocturnal rodent biomass on the monument in 1988 was estimated to be 100,142 kg (109.5 tons), and to consist of 3,000,000 individuals.

## Introduction

To adequately document the effects of a changing habitat or the differences inherent among habitats in a region, a need arises for a monitoring system of relatively stable but responsive populations of common species that would produce information in a relatively short period of time. Among mammals, small rodents meet these criteria well. They (1) are found in most habitats, (2) respond quickly to changes in the primary production of plants, (3) can have several litters in a year, (4) are easily captured, (5) have a relatively small home range, (6) can be captured repeatedly in the same area, and (7) are easily identified.

Several species of rodents are ubiquitous in their occurrence throughout most of the Sonoran Desert, including Organ Pipe Cactus National Monument (ORPI). This allows spatial and temporal comparison among widespread geographic locations within this biome. Effects of climate and habitat changes on segregated populations can be easily recognized, since the requirements for these species remain the same throughout their range.

The 2 dominant families of Sonoran Desert nocturnal rodents are Heteromyidae and Cricetidae. At ORPI, the heteromyids consist of pocket mice (*Chaetodipus* and *Perognathus* spp.) and kangaroo rats (*Dipodomys* spp.) and are the most desert-adapted group. They depend on seeds deposited on and in the soil for nutrients and to metabolically fill much of their water needs. The cricetids, on the other hand, need free water from "greenery" to exist in the desert. At ORPI, the only cricetids found in sufficient numbers to warrant utilization in monitoring are the white-throated woodrat (*Neotoma albigula*) and the cactus mouse (*Peromyscus eremicus*). The southern grasshopper mouse (*Onychomys torridus*) is rarely captured at ORPI.

Members of the squirrel family (Sciuridae) that occur at ORPI are all diurnal. The round-tailed ground squirrel (*Spermophilus tereticaudus*), rock squirrel (*Spermophilus variegatus*), and Harris' antelope squirrel (*Ammospermophilus harrisi*) were observed or captured during this study. These records are dutifully noted within the text. No concerted effort was made to monitor squirrel populations, due to the great likelihood of their deaths from heat stress when the sun causes the metal live traps to become ovenlike.

Members of the pocket gopher family (Geomyidae) were not present in sufficient numbers on any of the sites to warrant attempts to monitor their population. Only Botta's pocket gopher (*Thomomys bottae*) occurs on the monument. These animals are difficult to capture alive and even more difficult to recapture. Traps are generally filled with soil by these burrowing rodents. Burn Site and Salsola Site did show fresh dirt mounds produced by pocket gophers.

Another group of mammals—the hares and rabbits (Order Lagomorpha)—was frequently encountered during this study. Three species, the desert cottontail (*Sylvilagus auduboni*), black-tailed jackrabbit (*Lepus californicus*), and antelope jackrabbit (*Lepus alleni*) occur in the monument. The presence of these species was noted, but they were not monitored, due to the difficulty of live capture and their ability to range over a great distance.

Although areas heavily used by flesh-eaters (Order Carnivora) were noted, no attempt was made to monitor carnivore density or movement. Such documentation would take equipment, personnel, and time beyond the scope and funding of this study. Observations of carnivore activity, via scats (droppings) and tracks, did indicate high use around water sources such as Dripping Springs and heavily vegetated areas like that at the Lost Cabin site.

Several inventories of mammals already exist for the monument or portions thereof (Mearns 1907; Huey 1942; Cockrum 1981; Cockrum and Petryszyn 1986), as well as localized density/biomass data for specific areas within the monument (Quitobaquito Management Area—Petryszyn and Cockrum 1990; Pozo Nuevo—Petryszyn et al., unpubl. data). To our knowledge, this is the first study to gather density/biomass data of nocturnal rodents over wide-ranging habitats throughout ORPI.

The 16 selected sites monitored in this study cover a diverse array of macrohabitats and microhabitats within the monument. Basically, as related to nocturnal rodent populations, they fall into 2 major groups: those dominated by heteromyids and those dominated by cricetid rodents (Fig. 1). The broad valleys and bajada areas are the preferred habitats of pocket mice and kangaroo rats, while the rockier, hilly "canyon" areas contain a higher number of cactus mice and woodrats. Densely vegetated areas such as Quitobaquito and Williams Springs are exceptions to this trend, containing exceedingly high densities of both cactus mice and white-throated woodrats (Petryszyn and Cockrum 1990).

During the course of this study, 2 species of mammals new to the monument were discovered. Merriam's mouse (*Peromyscus merriami*) was trapped at the Dos Lomitas site on 6 December 1988. Although Mearns (1907) captured 1 individual from Quitobaquito Springs in 1894, no other specimen has been captured at ORPI until this study. This mouse, also called the "mesquite mouse" by Hoffmeister (1986), prefers heavily wooded mesquite bosques. Since the time of Mearns, mesquite bosques have diminished in size and number dramatically throughout southern Arizona and northern Sonora, Mexico. Populations of Merriam's mouse have suffered accordingly.

The other mammal discovered new to the monument was the Arizona cotton rat (*Sigmodon arizonae*), captured on the Bull Pasture site in the Ajo Mountains on 3 December 1988. The nearest recorded presence for this animal is the Gila River, 102 km (63 mi) to the north, and Arivaca, 136 km (85 mi) to the east (Hoffmeister 1986). Hall (1981) indicated that the Arizona cotton rat occurs near Caborca, Sonora, in Mexico—a distance of 152 km (94 mi) from Bull Pasture. In all probability this is a small Pleistocene relict population that has been able to persist on grassier areas in the Ajo Mountains.

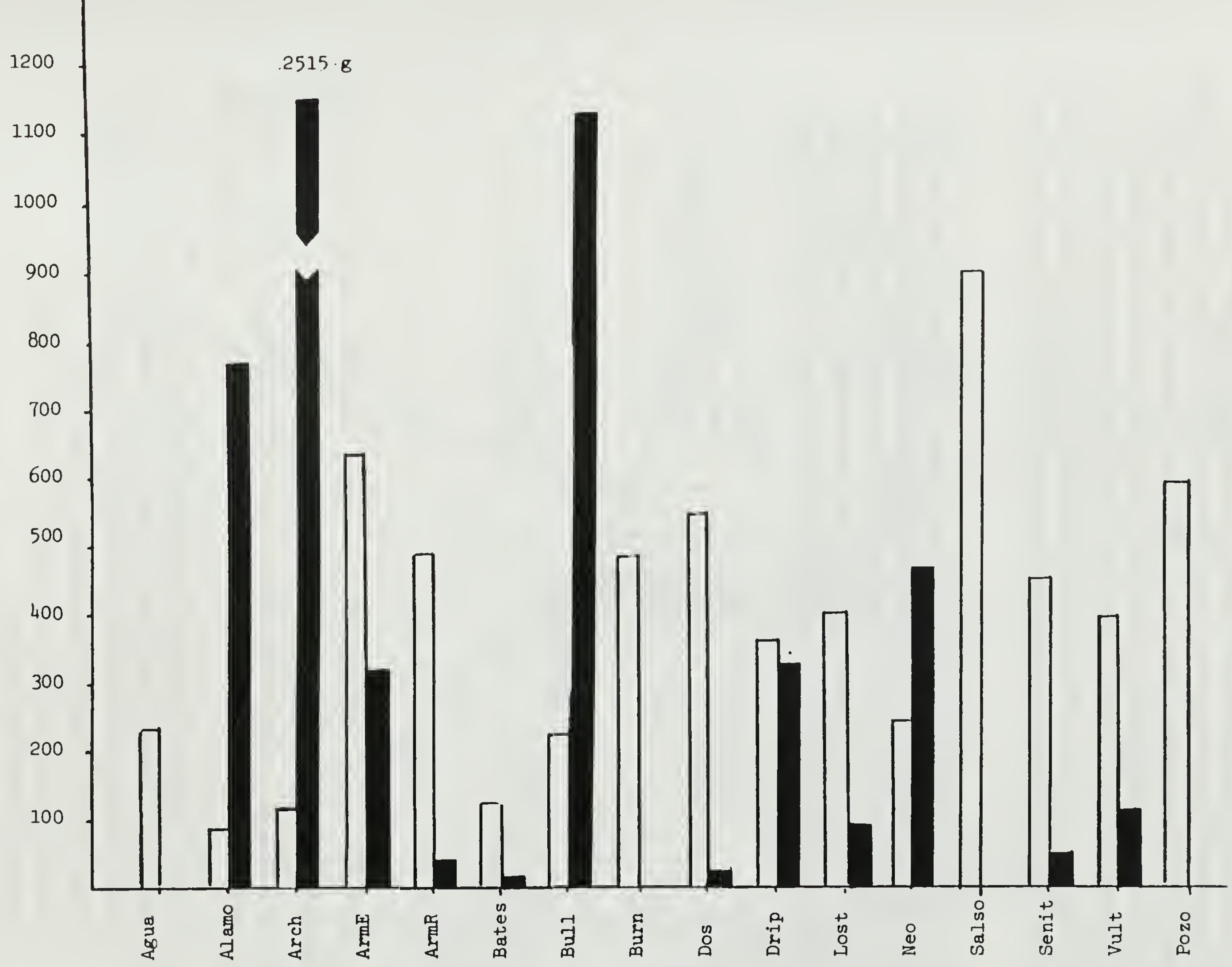



Figure 1. Biomass (g/ha) of heteromyid and cricetid rodents on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. White bars identify heteromyids, while dark bars identify cricetids. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Salso**la Site, **Senit**a Basin, **Vult**ure Site, and **Pozo** Nuevo.

Since the conclusion of this study, 2 additional specimens of the Arizona cotton rat have been captured. In 1991, an individual was captured at the Dos Lomitas site and another at the East Armenta site. These animals may be invading new areas via a refugium centered in the Ajo Mountains, or possibly moving in from the south, due to the development of agriculture in the Sonoita River basin. More information on this unique animal needs to be collected.

Four of the sites were sampled during different seasons. As expected, the winter sampling produced smaller numbers of rodents than were found during warmer months of the year. This is especially true of the heteromyid rodents. Petryszyn (1982), working with the same mammal species as found on the Ecological Monitoring Program (EMP) sites, documented this fact (Fig. 2). The smaller of these rodents routinely pass much of the colder season in an inactive state, rarely being taken above ground. The smallest pocket mice (*Perognathus* spp.) are the first to go underground, while the largest heteromyids, the kangaroo rats, are active throughout the winter.

The locations of the EMP sites monitored in this study are shown in Figure 3. These sites were preselected by ORPI and Cooperative Park Studies Unit (CPSU) personnel before the onset of this study. The Pozo Nuevo site was added at a later date. Data presented in this study for the Pozo Nuevo site were collected in September 1988 as part of another study (Petryszyn et al., unpubl. data). A brief description of each site is given in the Results section of this document.

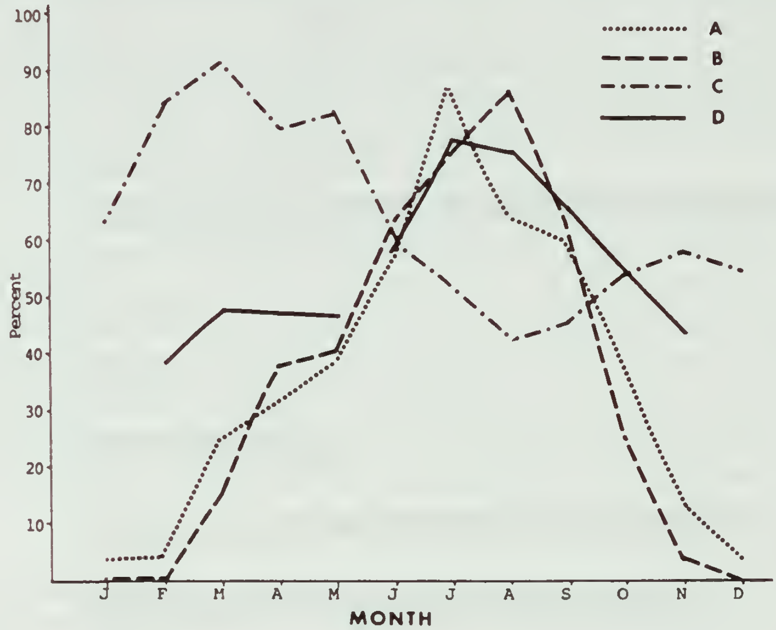
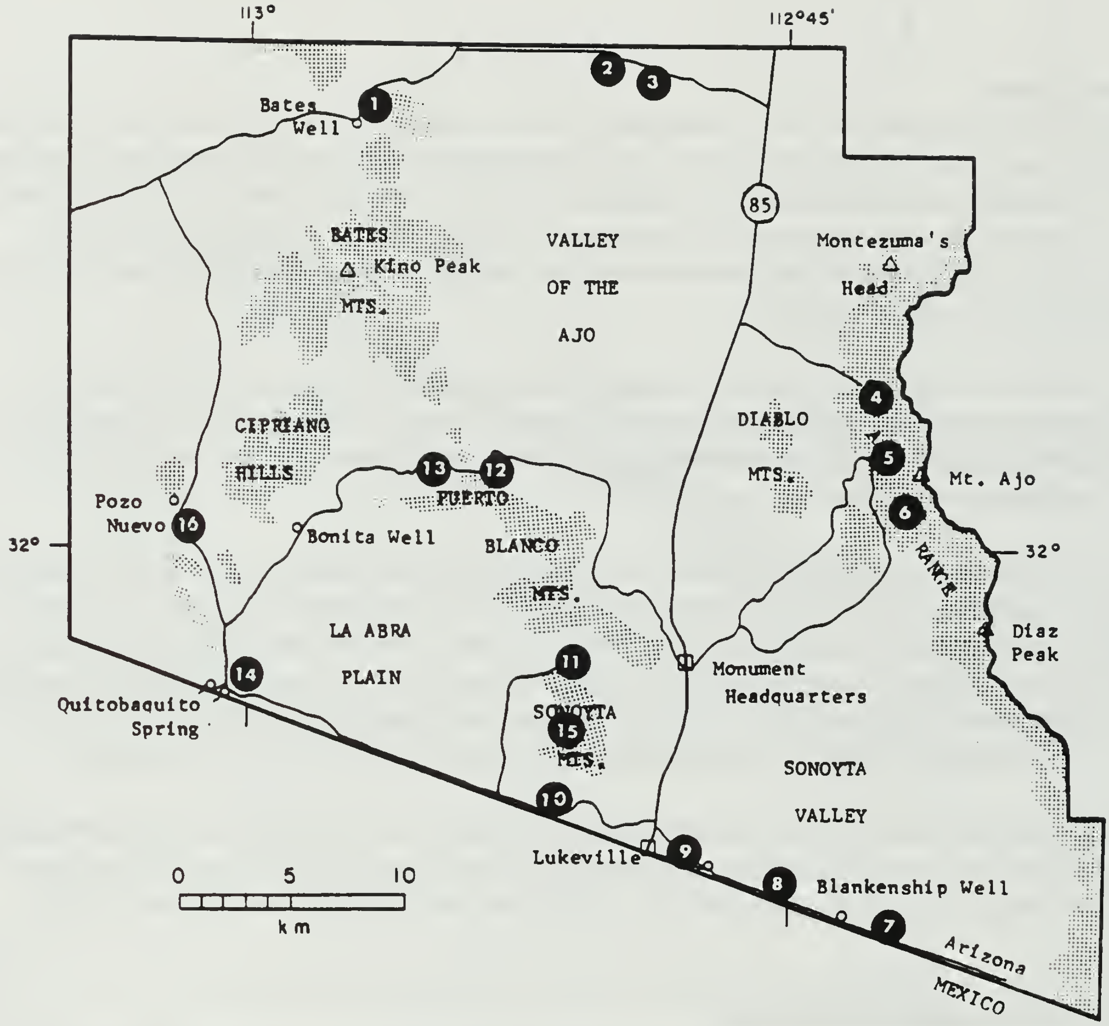



Figure 2. Seasonal activity of heteromyid rodents as an accumulated mean percent over 9 years. Key: A = desert pocket mouse *(Chaetodipus penicillatus)*, B = Arizona pocket mouse (*Perognathus amplus*), C = Merriam's kangaroo rat (*Dipodomys merriami*), D = Bailey's pocket mouse *(Chaetodipus baileyi*).


Petryszyn, Y. 1982. Population dynamics of nocturnal desert rodents: a nine-year study. Ph. D. Dissertation. The University of Arizona, Tucson. 108 p.




❶ Growler Canyon
❷ Armenta Ranch
❸ East Armenta
❹ Alamo Canyon
❺ Arch Canyon
❻ Bull Pasture
❼ Salsola Site
❽ Dos Lomitas
❾ Burn Site
❿ Vulture Site
⓫ Senita Basin
⓬ Dripping Springs
⓭ Neolloydia Site
⓮ Aguajita Wash
⓯ Lost Cabin Mine
⓰ Pozo Nuevo

Figure 3. Location of the initial 16 study sites in the Ecological Monitoring Program at Organ Pipe Cactus National Monument, Arizona.

## Methods

### Trapping Grids

Established at each site were 1 or 2 live-trapping grids consisting of 7 x 7 trap stations placed at 15-m (49-ft) intervals. The corners of each grid were demarcated by tagged rebar driven into the ground. These grids were placed so as to sample as diverse an area as possible on the site. Each of the 49 stations per grid contained 1 "live-capture," folding, Sherman trap baited with dry oatmeal. Traps were baited in late afternoon and checked early the next morning. Each grid was monitored for 2 consecutive nights.

Animals were removed from traps each morning, identified, their reproductive status noted, weighed, marked with toe clips, and released. Traps were closed during the daytime hours due to the lethal effect of heat buildup in the traps to captured animals. Each site was sampled on at least 1, 2-night session during the year.

The 7 x 7, 15-meter interval configuration was chosen for its convenient size. A grid of this size has a rodent sampling area of approximately 1.4 ha (3.5 a.). Two grids of this size in an area would require 98 traps, a number easily processed by 1 person in less than 2 hr. Also, setup and removal of traps during a sampling session is relatively easy for 1 person to accomplish, once the grids are established. In general, this size grid facilitates sampling by minimizing the efforts needed to establish and conduct the monitoring, while maximizing the scientific returns.

Ideally, trapping should be conducted semiannually—once in early spring to record overwintered populations before new young are active above ground, and again in late summer when most rodent populations are at their peak (see Fig. 2). This was not feasible for all the sites in this study.

### Density and Biomass Estimates

In this study, the actual number of individuals captured in a trapping session, the estimated density, and the estimated biomass are given.

Trapping for 2 consecutive nights captures only a portion of the animals that are present in the area, but this portion seems to remain relatively constant (Fig. 4). By utilizing the known rate of captures of previously uncaptured individuals, an estimate of total density can be calculated. Incorporating fieldwork conducted by Petryszyn (1982), an estimate of density is determined by multiplying the number of individuals captured in 2 nights by 1.4. This assumes that in a 2-day trapping period, 72% of the animals are captured.

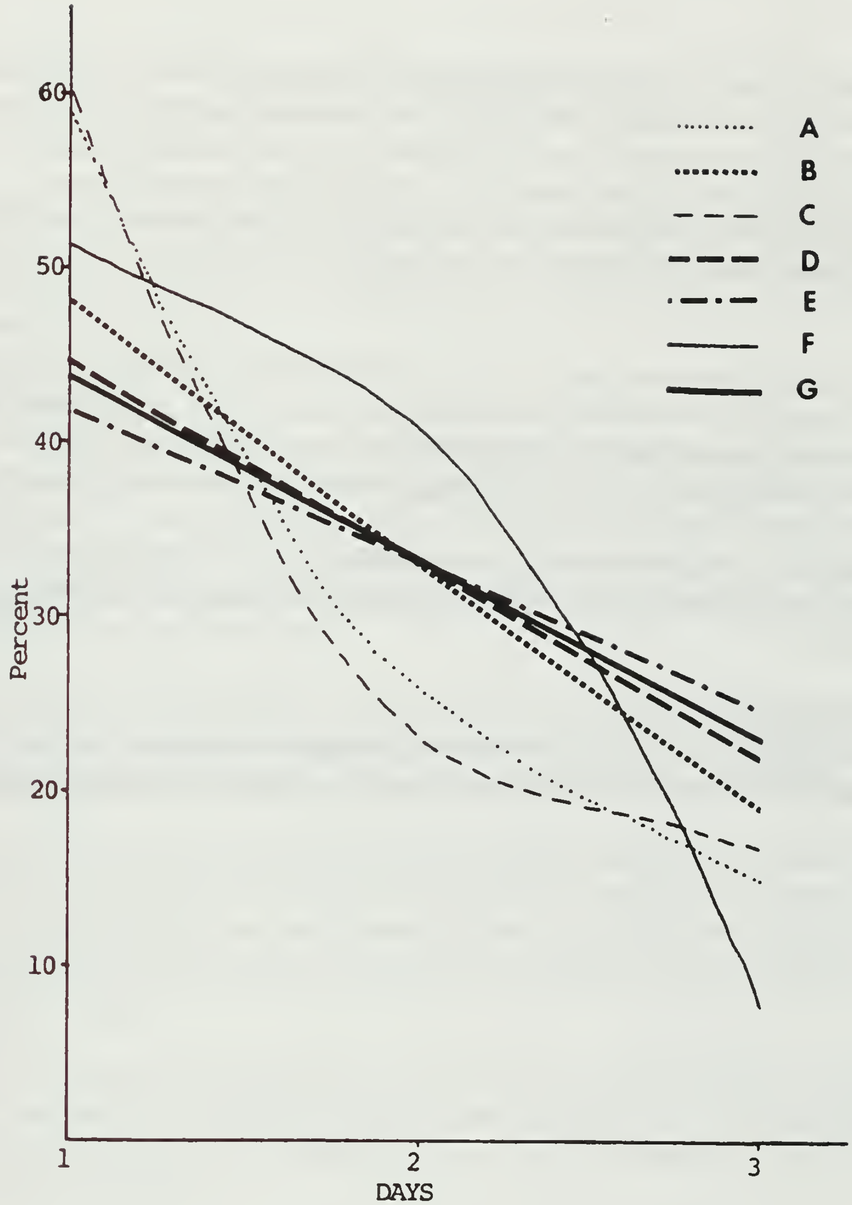



Figure 4. Rate of capture of new individuals for 7 species at the Silverbell Site, Pima County, Arizona. Key: A = rock pocket mouse (*Chaetodipus intermedius*), B = Average for all species, C = Merriam's kangaroo rat (*Dipodomys merriami*), D = desert pocket mouse (*Chaetodipus penicillatus*), E = Arizona pocket mouse (*Perognathus amplus*), F = white-throated woodrat (*Neotoma albigula*), G = Bailey's pocket mouse (*Chaetodipus baileyi*).

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Petryszyn, Y. 1982. Population dynamics of nocturnal desert rodents: a nine-year study. Ph. D. Dissertation. The University of Arizona, Tucson. 108 p.

Biomass is an estimate of the total weight of the animals present per unit area. All biomass figures presented here are determined by multiplying the estimated densities by the mean weight of the species for a specific monitoring session. Biomass can reflect conditions such as abundance of juveniles (less weight per individual) or abundant food supply (heavier individuals), and can be readily used to compare populations of different-sized species (e.g., pocket mice vs kangaroo rats or pocket mice vs woodrats).

### Pitfall Traps

At most sites, 1 or 2 pitfall traps (consisting of 3-lb. coffee cans) were buried with the rim at ground level. Two "running" boards—10 cm (4 in.) high, 1.5 m (59.1 in.) long, and radiating from the pitfall—were utilized to increase sampling area. These pitfalls were in place and continuously operational during the 2-day monitoring periods, then were subsequently removed.

Pitfalls of this design were useful in capturing desert shrews (*Notiosorex crawfordi*) at Quitobaquito (Petryszyn and Cockrum 1990). The Quitobaquito pitfalls were continuously operational for 1.5 mo.

### Large Animal Trapping

At each site a large Havahart trap was set for the possible capture of animals the size of skunk, fox, ringtail and badger. This trap was baited with canned tuna, sardines, bananas, and apples.

## Results

Here, each of the 16 monitoring sites is discussed separately. Only brief descriptions concerning the topography and plant community of each site are given, since more detailed discussions of the characteristics of the sites are presented in other references. Table 1 gives a summary of trapping results for all sites.

### Aguajita Wash

This site is a major drainage in the southwest corner of the monument. It features a shallow, broad, major channel with fine-texture soils bordering on both sides. Dominant plant species include mesquite (*Prosopis velutina*), ironwood (*Olneya tesota*), and foothill paloverde (*Cercidium microphyllum*). Triangle leaf bursage (*Ambrosia deltoidea*) and creosotebush (*Larrea tridentata*) are prevalent throughout. The wash was scoured by a major flood several weeks before the single sampling took place.

Two trapping grids were established on the site. The western grid sampled the riparian community, while the eastern grid sampled a more open area lacking the large number of trees that the west grid contained. Sampling was conducted 23–25 September 1988.

Only 2 species of rodents were captured on this site. The desert pocket mouse (*Chaetodipus penicillatus*) accounted for 92.3% of the total number of individuals captured and was found on both grids (13 individuals on one and 11 on the other). The 2 Merriam's kangaroo rats (*Dipodomys merriami*) were captured only on the more open east grid. Total biomass for the area was 219 g/ha (3.1 oz/a.).

No cricetids were captured, although one would expect at least the white-throated woodrat to have been in the area. Petryszyn and Cockrum (1990) reported that 4 such animals were taken in Aguajita Wash in October 1981. During the current study, the woodrats may have been adversely affected by the recent flood.

Steenbergh and Warren (1977) monitored small rodent populations in the Aguajita Wash area during 1976, as did Petryszyn and Cockrum (1990) did in 1981. A comparison of the results shows that population densities may vary greatly (Table 2). It is worth noting that Steenbergh and Warren found greater numbers of Merriam's kangaroo rats in the Aguajita Wash area (Spring/Higher) during 1976 than were found in 1981 and 1988. The years 1975 and 1976 had very little rainfall, resulting in the disappearance of some vegetation, thus producing more "open" habitats. Lack of vegetative ground cover is conducive to the Merriam kangaroo rat's foraging. Petryszyn et al. (unpubl. data) found the same situation at Pozo Nuevo in several habitats monitored through the 1980s.

Table 1. Nocturnal rodent monitoring results on 16 Ecological Monitoring Program sites at Organ Pipe Cactus National Monument, Arizona. Figures are number of rodents observed per ha, and are listed as totals of all dates sampled per site.

| | | Species | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site | Sample date(s) | CBAI | CINT | CPEN | DMER | NALB | PAMP | PERE | OTHER |
| Aguajita Wash | 23–25 Sep 1988 | | | 12.0 | 1.0 | | | | |
| Alamo Canyon | 1–3 Feb 1988 | 2.0 | | 1.0 | | 4.1 | | 9.5 | |
| Arch Canyon | 8–10 Apr 1988 | 3.0 | 1.0 | | | 19.0 | | 7.0 | |
| Armenta Ranch | 30 Nov–2 Dec 1987<br>20–22 Jun 1988 | 1.0 | | 10.5 | 8.5 | 0.5 | 0.5 | | |
| Bates Well | 3–5 Feb 1988 | | | | 3.5 | | | | 0.5 |
| Bull Pasture | 2–4 Dec 1988 | 9.0 | | | | 6.0 | | 8.0 | 1.0 |
| Burn Site | 18–20 Jun 1988 | | | 2.5 | 12.0 | | 0.5 | | |
| Dos Lomitas | 2–7 Dec 1988 | | | 0.5 | 13.5 | | | | 0.5 |
| Dripping Springs | 2–4 Jun 1988 | 15.0 | | | | 2.0 | | 1.0 | |
| East Armenta | 30 Nov–2 Dec 1987<br>20–22 Jun 1988 | 0.5 | | 16.0 | 8.0 | 2.0 | 5.5 | | |
| Lost Cabin | 21 Dec 1987<br>3–4 Sep 1988 | 0.5 | 7.0 | 17.5 | 0.5 | 1.0 | 1.5 | 0.5 | |
| Neolloydia Site | 2–4 Jun 1988 | 4.0 | 10.0 | 1.5 | | 3.5 | 0.5 | | |
| Pozo Nuevo | 16–18 Sep 1988 | | | 5.3 | 11.3 | | 6.8 | | |
| Salsola Site | 18–20 Jun 1988 | | | 32.0 | 10.0 | | 0.5 | | |
| Senita Basin | 20–23 Dec 1987<br>21–23 Sep 1988 | 3.0 | 5.5 | 11.5 | 3.0 | 0.5 | 0.5 | | |
| Vulture Site | 9–11 Sep 1988 | | | 20.0 | 0.5 | 1.0 | 6.0 | | |
| Total | | 38.0 | 23.5 | 130.3 | 71.8 | 39.6 | 22.3 | 26.0 | 2.0 |
| Mean number | | 2.4 | 1.5 | 8.1 | 4.5 | 2.5 | 1.4 | 1.6 | 0.1 |
| Mean weight (g) | | 24.5 | 11.8 | 15.1 | 37.3 | 134.6 | 10.2 | 18.4 | 46.8 |

CBAI = *Chaetodipus baileyi* (Bailey's pocket mouse)
CINT = *Chaetodipus intermedius* (rock pocket mouse)
CPEN = *Chaetodipus penicillatus* (desert pocket mouse)
DMER = *Dipodomys merriami* (Merriam's kangaroo rat)
NALB = *Neotoma albigula* (white-throated woodrat)
PAMP = *Perognathus amplus* (Arizona pocket mouse)
PERE = *Peromyscus eremicus* (cactus mouse)

Table 2. Species count for live rodent trapping in the Aguajita Wash area in Organ Pipe Cactus National Monument, Arizona, during 1976, 1981, and 1988.

| | February/May 1976[1] | | October 1981[2] | | September 1988[3] | |
|---|---|---|---|---|---|---|
| Species | Spring | Higher | Wash | Flats | West | East |
| Merriam's kangaroo rat (*Dipodomys merriami*) | 20 | 6 | 2 | 13 | 0 | 2 |
| Bailey's pocket mouse (*Chaetodipus baileyi*) | 0 | 0 | 0 | 1 | 0 | 0 |
| Desert pocket mouse (*Chaetodipus penicillatus*) | 4 | 5 | 36 | 12 | 11 | 13 |
| Rock pocket mouse (*Chaetodipus intermedius*) | 0 | 0 | 3 | 9 | 0 | 0 |
| Arizona pocket mouse (*Perognathus amplus*) | 0 | 1 | 0 | 1 | 0 | 0 |
| White-throated woodrat (*Neotoma albigula*) | 0 | 0 | 4 | 1 | 0 | 0 |
| Southern grasshopper mouse (*Onychomys torridus*) | 0 | 1 | 0 | 0 | 0 | 0 |
| Total | 24 | 13 | 45 | 37 | 11 | 15 |
| Total trap nights | 100 | 100 | 240 | 240 | 98 | 98 |

Table is modified from source number 2, below.

[1] Steenbergh, W. F., and P. L. Warren. 1977. Preliminary ecological investigation of natural community status at Organ Pipe Cactus National Monument. Technical Report No. 3, Cooperative Park Studies Unit, The University of Arizona, Tucson. 152 p.

[2] Petryszyn, Y., and E. L. Cockrum. 1990. Mammals of the Quitobaquito management area, Organ Pipe Cactus National Monument, Arizona. Technical Report No. 36, Cooperative Park Studies Unit, The University of Arizona, Tucson. 32 p.

[3] This study.

## Alamo Canyon

This is one of the deep canyons on the western flank of the Ajo Mountains. Slopes are rocky. A relatively flat bench area containing finer soils is also located on the site. Dominant plants include trees and shrubs such as catclaw acacia (*Acacia greggi*), Ajo oak (*Quercus turbinella ajoensis*), and jojoba (*Simmondsia chinensis*) as well as associated plants like ragweed (*Ambrosia ambrosioides* and *Ambrosia cordifolia*), desert hackberry (*Celtis pallida*), and buckwheat brush (*Eriogonum wrighti*).

Two grids were established at this site—one on the less vegetated, west-facing slope and another on a more heavily vegetated bench area located on the western side of the drainage. Trapping was conducted 1–3 February 1988.

Only 2 desert pocket mice and 4 Bailey's pocket mice of the heteromyids were captured on the site, for a biomass total of 76 g/ha (1.1 oz/a.). All were found on the bench area. Of the cricetids, both the cactus mouse (n = 19) and the white-throated woodrat (n = 8) were captured on the site. The cricetid biomass was 761 g/ha (10.9 oz/a.). The abundance of vegetation and nesting sites possibly allows for such a high density of cricetid rodents.

It is probable that the rock pocket mouse (*Chaetodipus intermedius*) also occurs in the area but was inactive during the time of year this site was monitored. Cockrum and Petryszyn (1986) report that 2 rock pocket mice were taken in Alamo Canyon on 26–27 September 1981. It does not seem that they occur in any great numbers in the canyon.

Although the desert shrew has been recorded from Alamo Canyon, none of these animals was captured by the 2 pitfall traps placed on the site. The specimen taken at Alamo Canyon in 1986, as well as the three taken from Quitobaquito in 1983, were from pitfalls that were left in place for several weeks. It may well be that a 2-night set is not in place sufficiently long enough to produce a desert-shrew capture.

## Arch Canyon

This site is a narrow, steep canyon on the west slope of the Ajo Mountains that is very rocky and has poor soils. The bottom of the drainage is dominated by an almost continuous cover of jojoba. Other vegetation is similar to that found at Alamo Canyon.

Only 1 grid was set in the bottom of the drainage due to the narrowness of the canyon. It was monitored 8–10 April 1988 and, as in Alamo canyon, the cricetids dominated the area. Of the cricetid biomass of 2,515 g/ha (35.9 oz/a.), the white-throated woodrat accounted for 94.5%. The density of woodrats (19/ha [7.7/a.]) approached the 50/ha (20.2/a.) found at Quitobaquito (Petryszyn and Cockrum 1990) and is the highest of the 16 sites surveyed in this study.

Of the heteromyids, only rock pocket mice and Bailey's pocket mice were captured. They accounted for a combined biomass of 110 g/ha (1.6 oz/a.). The single pitfall trap placed in the area did not produce any specimens within the 2 nights of sampling.

### Armenta Ranch

This is a heavily impacted area due to overgrazing. Much sheet erosion along with channel cutting occurs in the area. Soils are fine, with large areas devoid of vegetation. Vegetation was dominated by mesquite, creosotebush, and ephemeral species.

Two grids were established, with one on either side of the major eroded channel running through the site. Trapping was conducted 30 November through 2 December 1987, and again during 20–22 June 1988. In the winter of 1987, only 2 species of rodents were captured: Merriam's kangaroo rat and Bailey's pocket mouse. Merriam's kangaroo rat was the most prevalent, accounting for 12 of the 14 animals captured (85.7%).

Four heteromyid species were captured in June. The desert pocket mouse was the most numerous (10.5/ha [4.3/a.]), followed by Merriam's kangaroo rat (8.5/ha [3.4/a.]). The latter accounted for 295 of the 480 g/ha (6.9 oz/a.), or 61.5% of the heteromyid biomass. Arizona pocket mice (*Perognathus amplus*) and Bailey's pocket mice were also found at this time. Only 1 white-throated woodrat was captured on the site, and it proved to be a juvenile.

It was surprising to get such high numbers of rodents (21/ha [8.5/a.]) on this site. Considering the bareness of much of the surface on which the grids were placed and the depauperate nature of the flora, we did not expect to find such a diversity of species and a heteromyid biomass of 480 g/ha (6.9 oz/a.). This compares favorably with the 618 g/ha (8.8 oz/a.) at the East Armenta site, which does not have the "bare ground" look of Armenta Ranch.

### Bates Well

The wash is a major drainage bordered by stands of mesquite. Much of the bench area is secondarily eroded by small washes. The area has been impacted by overgrazing. Heavy stands of mesquite are found bordering the wash, and some ephemeral species occur in the area.

Two trapping grids were established just east of the old corral on the northern side of the wash. Trapping was conducted 3–5 February 1988. Diversity and density were very low. Only Merriam's kangaroo rat (with a biomass of 118 g/ha [1.7 oz/a.]) and southern grasshopper mouse (with a biomass of 9 g/ha [0.1 oz/a.]) were captured. Sampling during warmer months may possibly produce some of the smaller heteromyids, especially the desert pocket mouse.

The area contained much javelina (*Tayassu tajacu*) sign (scats and tracks). No such usage was evident during field trips to this area in the late 1970s and early 1980s. Gray fox (*Urocyon cinereoargenteus*) and coyote (*Canis latrans*) scats were also apparent, and during the night of 4 February the smell of a skunk was prevalent.

### Bull Pasture

This site is located in a small, broad, high basin near the summit of the Ajo Mountains. It is bisected by drainages containing some small tinajas and intermittent springs. This is one of the warmest spots in the monument during the winter. Some prevalent plant species include jojoba, hopbush (*Dodonaea viscosa*), resin weed (*Viguiera deltoidea*), ocotillo (*Fouquieria splendens*), snake weed (*Gutierrezia sarothrae*), and numerous grasses.

Only 1 grid was established at Bull Pasture, due to the difficulty of backpacking large numbers of traps. The grid straddled one of the north-flowing drainages. A good stand of perennial grasses was present in the bottom of the drainage.

Monitoring was conducted 2–4 December 1988. Only Bailey's pocket mouse (n = 9) of the heteromyids was captured, for a biomass of 208 g/ha (3.0 oz/a.) over a total of 98 trap-nights. It is possible that the rock pocket mouse also occurs on the site but that it was too cold for this species to be active. At Bull Pasture during April 1982, Petryszyn captured 1 rock pocket mouse and 1 Bailey's pocket mouse along with 8 white-throated woodrats and 12 cactus mice with 100 trap-nights of effort (Cockrum and Petryszyn 1986).

Six white-throated woodrats and 8 cactus mice were captured during the monitoring period of December 1988, for a biomass of 1,078 g/ha (15.4 oz/a.). This figure falls between the 761 g/ha (10.9 oz/a.) biomass at Alamo Canyon and the 2,515 g/ha (35.9 oz/a.) biomass at Arch Canyon. It becomes apparent that the predominant nocturnal rodents occurring in canyons in the Ajo Mountains are the cricetids—cactus mouse and white-throated woodrat.

Of special note is the capture of an Arizona cotton rat on this site on 3 December 1988, since the nearest known population is 105 km (65.0 mi) to the north. The 68-g (2-oz) female was trapped in the densest green grass at the bottom of the drainage. Subsequent trapping efforts in December 1989 and 1990 were not successful in capturing an additional Arizona cotton rat. It may be that this population (if one is still present) is a relict from the Pleistocene, when vegetation differed in the area.

### Burn Site

This area was accidentally burned in 1984; therefore, vegetation was sparse during this study. A shallow wash lined with a few scraggly mesquites, paloverde, and ironwood bisects the site. Dominant plant species are creosotebush, triangle leaf bursage, and the grass, *Hilaria rigida*. Some saguaros (*Carnegiea gigantea*) and chollas (*Opuntia* spp.) are found on the site. The soil is fine-grained.

Two grids were established on the site. The east grid occupied an area that was minimally affected by the burn. Monitoring took place on 18–20 June 1988. Three heteromyid species were captured. Merriam's kangaroo rat was by far the most common, with 24 animals captured in 2 nights, for a biomass of 433 g/ha (6.2 oz/a.). There was no significant difference in kangaroo rat distribution between the 2 grids. A single Arizona pocket mouse was captured on the east grid and 5 desert pocket mice were captured on the west grid.

Two round-tailed ground squirrels were also captured. Burrow openings of this species were commonly seen throughout the area, and several animals were observed during the day.

It appears the 1984 fire was not very detrimental to the heteromyid or sciurid populations, since their numbers are similar to those in areas not subjected to such burning.

### Dos Lomitas

This is a highly impacted area on the southern boundary of the monument. Overgrazing has left large areas devoid of vegetation. Several deep channel-cuts bisect the area. These are lined by narrow thickets of mesquite and ironwood. Soil is fine-textured. Dominant plants along the washes are mesquite, ironwood, and desert thorn (*Lycium* spp.). Also present is creosotebush, saltbush (*Atriplex* spp.), and ragweed.

Two grids were established on the site. The eastern grid was located just northeast of the permanent enclosure and the western grid in a more vegetated area just northwest of the permanent enclosure. Monitoring was conducted 2–7 December 1988.

Diversity of rodents was low, with only 2 heteromyid and 1 cricetid species present. Of 29 animals captured, Merriam's kangaroo rat accounted for 27, or 93.1%. A lone desert pocket mouse and 1 Merriam's mouse were also captured. The west grid was by far the most productive, with twice as many kangaroo rats captured than were captured on the east grid. Even the mean weight of Merriam's kangaroo rat was less on the east grid than on the west grid—37.7 g vs 39.9 g (1.3 oz vs 1.4 oz). It may be that a summer sampling would also produce some of the smaller heteromyids.

The captured Merriam's mouse is the first from ORPI since one was reported from Quitobaquito by Mearns (1907). Hoffmeister's (1986) name of "mesquite mouse" is appropriate, since these rodents are associated with mesquite bosques. Many trap-nights of effort failed to produce this mouse at Quitobaquito or Williams Spring in recent times (Petryszyn and Cockrum 1990).

### Dripping Springs

This is an area of low hills with a permanent water supply. Rocky, steep slopes are present, and the soil is poorly developed. Common plants are jojoba, ocotillo, brittlebush (*Encelia farinosa*), catclaw acacia, desert thorn, paloverde, and saguaro.

Only 1 grid was established on this site due to the configuration of the terrain. Trapping was conducted 2–4 June 1988. Of the heteromyids, only Bailey's pocket mouse was captured, although in large numbers. With a density of 15/ha (6.0/a.) and a biomass of 349 g/ha (5.0 oz/a.), this was the highest concentration of Bailey's pocket mouse among the 16 sites (see Fig. 11).

One cactus mouse and 2 white-throated woodrats were also captured (total biomass of 322 g/ha [4.6 oz/a.]). A rock squirrel captured on 4 June provided one of the few capture records on file for this species in the monument. Cockrum and Petryszyn (1986) report 4 rock squirrel specimens from Alamo Canyon, held at the Los Angeles County Museum.

Dripping Springs is the only site that has approximately equal biomass of heteromyids and cricetids. All other sites in this study are dominated by one group or the other.

The area contained numerous scats of coyote, kit fox (*Vulpes macrotis*), gray fox, and bobcat (*Felis rufus*). Apparently the area is well used by these predators. A source of permanent water would attract wide-ranging animals such as these.

### East Armenta

Located on a well-drained bajada area, this site has gravelly- to sandy-soils. A good compliment of lower Sonoran vegetation dominated by triangle leaf bursage, creosotebush, paloverde, ironwood, saguaro, and cholla is found on the site.

Two grids with very few apparent differences in vegetation were established on this site. The monitoring results reflect this similarity in that there seems to be no segregation in the species of rodents found on the site. Trapping was conducted from 30 November through 2 December 1987 and again during 20–22 June 1988.

In the winter of 1987, nighttime temperatures dropped below freezing both nights of monitoring. Only Merriam's kangaroo rat was captured (n = 13 and n = 9 for the 2 grids). Most smaller heteromyids were surely inactive above ground at that time.

In June 1988, 4 species of heteromyids were captured, resulting in a total biomass of 618 g/ha (8.8 oz/a.). The desert pocket mouse was the most numerous species (n = 14 and n = 18), followed by Merriam's kangaroo rat (n = 9 and n = 7). This later species accounted for 47.9% of the heteromyid biomass, while the desert pocket mouse (more numerous but smaller) accounted for 40.9%. A single Arizona pocket mouse and 2 Bailey's pocket mice were also captured on the site.

Three white-throated woodrats were captured on the site in June 1988, for a biomass of 307 g/ha (4.4 oz/a.). Active woodrat dens were common throughout the area. No cactus mice were captured.

### Lost Cabin

This site is located on a sandy-, gravelly-soiled drainage between 2 low-lying hills. Although the drainage is not very broad, the floor is relatively flat with very small, bisecting washes. Dominant plants include ironwood, acacia (*Acacia* spp.), saguaro, and creosotebush.

Two grids were established at this site, one on each side of the old road. Monitoring was conducted on 21 December 1987 and again during 3–4 September 1988. Only 1 night of trapping was attempted in December due to the extremely cold nighttime temperatures. As it was, 4 of the 6 heteromyids captured were torpid by morning. The largest of the heteromyids, Bailey's pocket mouse and Merriam's kangaroo rat, were the 2 species captured. The 2 white-throated woodrats also captured did not seem adversely affected by the low temperature.

In September, 5 species of heteromyids were captured, the desert pocket mouse being the most numerous (35 captured). This species accounted for 66.7% of the 385 g/ha (5.5 oz/a.) of heteromyid biomass. Other species also captured were Arizona pocket mouse (n = 3), rock pocket mouse (n = 14), Bailey's pocket mouse (n = 1), and Merriam's kangaroo rat (n = 1).

One cactus mouse and 2 white-throated woodrats were captured, for a cricetid biomass of 142 g/ha (2.0 oz/a.). This figure is not much different than the estimated biomass of cricetids in December 1987 (153 g/ha [2.2 oz/a.]).

The Lost Cabin sampling area also contained much scat of coyote, fox, and bobcat. Although no water was found in the region, the funnelling effect of the topography and the richness of the prey fauna may be factors contributing to the apparent high usage of this area by carnivores.

### Neolloydia Site

This site consists of hilly, gravelly/rocky well-drained habitat containing very poorly developed soil. This is home to the acuña cactus (*Echinomastus erectrocentrus* var. *acunensis*). Other plants common in the area are paloverde, triangle leaf bursage, creosotebush, ocotillo, ironwood, and saguaro.

Two grids were established on this site, one on each side of the road. Monitoring was conducted during 2–4 June 1988. Total heteromyid biomass was estimated to be 236 g/ha (3.4 oz/a.). Four species of heteromyids were captured, with the rock pocket mouse being the most numerous (n = 20) followed by Bailey's pocket mouse (n = 8), desert pocket mouse (n = 30), and Arizona pocket mouse (n = 1). No sample of Merriam's kangaroo rat was captured, which was not unexpected since the substrate is rocky.

Seven white-throated woodrats were captured, for a biomass total of 452 g/ha (6.5 oz/a.). Aside from the 3 canyons in the Ajo Mountains, this was the richest area for cricetid activity among the remaining 13 sites. Only Dripping Springs and East Armenta, of the low-lying sites, approach the number of woodrats found at this site. The number is surprising because the habitat is relatively open. The diversity of denning material may be a factor, although this "richness" was no more apparent than in other areas. With the present concern for acuña cacti, a more in-depth look at the relationship between these plants and woodrats is warranted.

### Pozo Nuevo

Located on a relatively flat bajada area, this site is bisected with small, shallow washes. Soils are sandy to gravelly. The area is dominated by creosotebush and triangle leaf bursage. Drier areas contain white bursage (*Ambrosia dumosa*). The larger washes nearby are lined with mesquite, paloverde, and ironwood, as well as a few acacias.

This area was initially monitored in 1983 and 1984 as a separate project (Petryszyn et al., unpubl. data). It was again monitored in 1987 and 1988. Although the grids established on this site are larger than those on the other sites, the results as given in this study are translated to number and biomass (g) per hectare and are, therefore, comparable. In 1988, the site was sampled on 16–18 September.

Only 3 species of rodents were captured on the 2 grids, all heteromyids. Merriam's kangaroo rat was the most common (11.3/ha [4.6/a.]; biomass of 431 g/ha [6.2 oz/a.]), followed by the Arizona pocket mouse (6.8/ha [2.8/a.]; biomass of 73 g/ha [1.0 oz/a.]) and the desert pocket mouse (5.3/ha [2.1/a.]; biomass of 87 g/ha [1.2 oz/a.]). Total heteromyid biomass was 591 g/ha (8.4 oz/a.). The heteromyid biomass compares favorably to that of other sites situated outside the mountain canyons (Fig. 1).

The desert pocket mouse was more common (n = 10 vs n = 4) on the more vegetated south grid. Similar results were observed at Salsola Site. Petryszyn et al. (unpubl. data) found that the desert pocket mouse preferred (or was possibly forced into) the more vegetated area, while Merriam's kangaroo rat was more prevalent in the open areas at the Pozo Nuevo site. As an area "opens up" due to reduction of plant material, Merriam's kangaroo rat moves in.

### Salsola Site

This is a flat, poorly-drained area with fine-to-gravelly soils, located on the border with Mexico. The area with finer soil is dominated by Russian thistle (*Salsola paulsoni*), careless weed (*Amaranthus palmeri*), and mesquite, while the more gravelly soil is dominated by creosotebush and triangle leaf bursage.

Two grids were established on this site. The eastern grid was placed in the center of the Russian thistle/careless weed habitat, while the western grid was placed in a less dense creosotebush/triangle leaf bursage area. Trapping was conducted 18–20 June 1988.

Salsola Site proved to have the highest density of heteromyid biomass of all sites (888 g/ha [12.7 oz/a.]). Only the East Armenta site approached this amount, with a biomass of 618 g/ha (8.8 oz/a.). For total nocturnal rodent biomass, Salsola Site is only surpassed by Arch Canyon (2,625 g/ha [37.5 oz/a.]), Bull Pasture (1,354 g/ha [19.3 oz/a.]), and East Armenta (925 g/ha [13.2 oz/a.]).

Two species, desert pocket mouse and Merriam's kangaroo rat, comprised the bulk of the animals captured. Only 1 Arizona pocket mouse was captured. Desert pocket mice accounted for 75.3% of the individuals and 56.6% of the biomass, while Merriam's kangaroo rat samples completed these percentages.

Habitat segregation was very much in evidence, with Merriam's kangaroo rat preferring the more open creosotebush-dominated habitat (west grid) and the desert pocket mouse occurring more frequently on the Russian-thistle-dominated east grid (Fig. 5). The heteromyid biomass is similar on the east (974 g/ha [13.9 oz/a.]) and west (799 g/ha [11.4 oz/a.]) grids, but on the Salsola Site east grid, the desert pocket mouse contributed 730 g/ha (10.4 oz/a.), while only contributing 275 g/ha (3.9 oz/a.) on the creosotebush-dominated west grid. Petryszyn et al. (unpubl. data) found similar results on the Pozo Nuevo site. The more dense habitat favored the desert pocket mouse; the more open, Merriam's kangaroo rat.

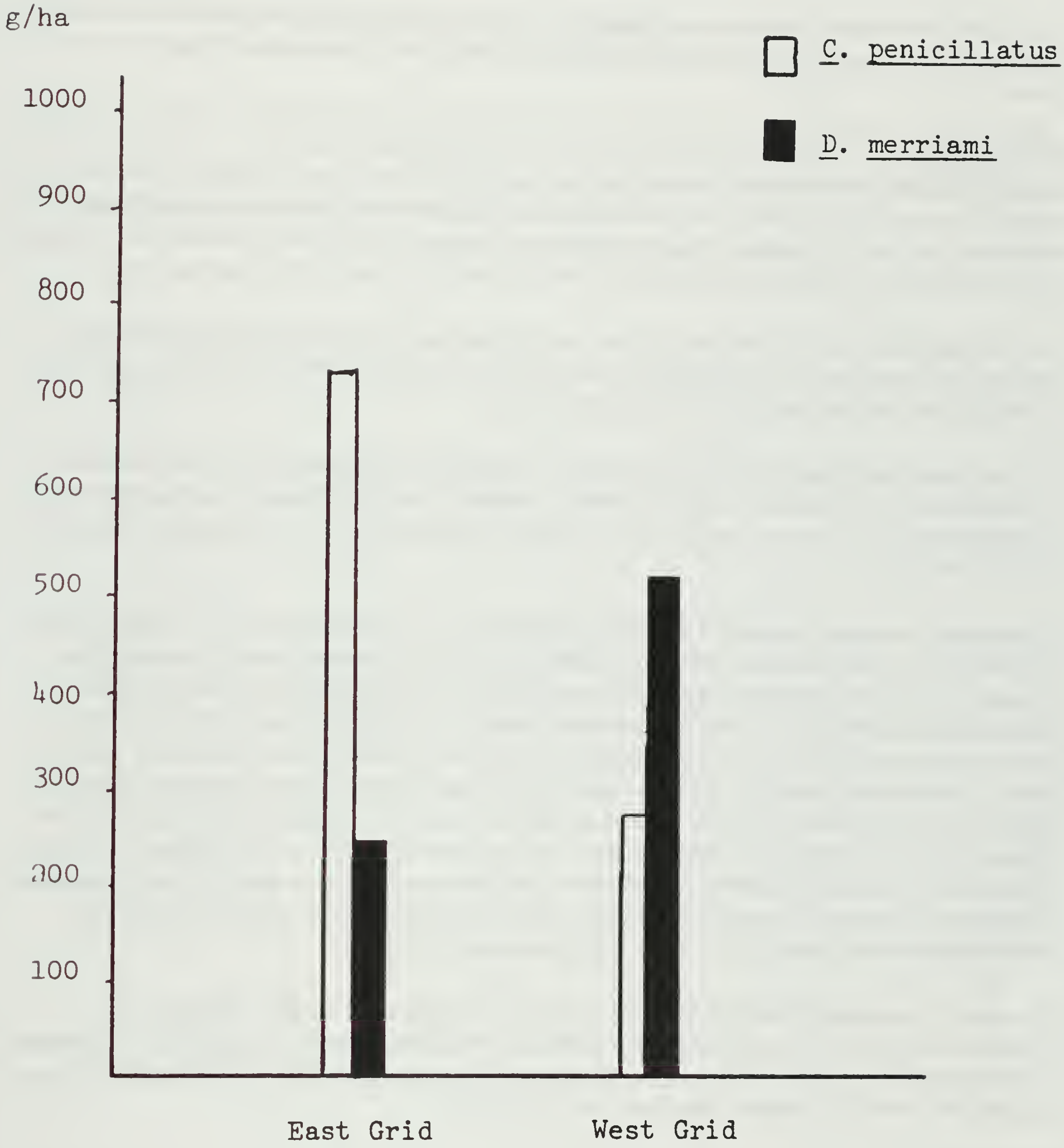


Figure 5. Biomass (g/ha) of 2 species on 2 Ecological Monitoring Program grids at the Salsola Site in Organ Pipe Cactus National Monument, Arizona. White bars identify the species, desert pocket mouse (*Chaetodipus penicillatus*), while dark bars identify Merriam's kangaroo rat (*Dipodomys merriami*).

No cricetids were trapped on the site. Heavy use by javelina travelling through was quite evident. It is possible that they cross this area in travelling to the apple orchards a short distance into Mexico.

### Senita Basin

Senita Basin is an area of low hills with rocky slopes and shallow basins. Soil is gravelly to sandy. This is relatively open habitat containing small washes lined by shrubby trees. Plants common in the area are cholla, saguaro, triangle leaf bursage, creosotebush, ocotillo, organ pipe cactus (*Stenocereus thurberi*), paloverde, brittlebush, and limberbush (*Jatropha cuneata*).

Two trapping grids were established on this site. Monitoring was conducted 20–23 December 1987 and again during 21–23 September 1988. The winter and late summer sampling provided information on seasonal activity of rodents on the site.

The 2 nights of sampling in December produced 13 Merriam's kangaroo rats, 1 cactus mouse, 1 white-throated woodrat, and 1 Harris' antelope squirrel. The lack of smaller heteromyids was not surprising for this time of year. Of the Merriam's kangaroo rats, 7 were captured on one grid and 6 on the other.

In September, captures included 1 Arizona pocket mouse, 11 rock pocket mice, 23 desert pocket mice, 5 Bailey's pocket mice, 6 Merriam's kangaroo rats, and 1 white-throated woodrat. The increase in number of smaller heteromyids, especially in desert pocket mice, was expected. Macrohabitat selection by certain species seems evident. The southern grid, which contains a more rocky, steeper-sloping surface, produced 8 of the rock pocket mouse samples, all 5 of the Bailey's pocket mice, and only 5 of the desert pocket mice. The 3 rock pocket mouse samples captured on the northern grid were located on the far north edge, which is rocky. Likewise, the 5 desert pocket mouse samples taken on the south grid were captured on the northern half, which is more sandy. Essentially, desert pocket mouse, Arizona pocket mouse, and Merriam's kangaroo rat species all preferred the sandier substrate, while rock pocket mouse and Bailey's pocket mouse samples were found on the more rocky portions of the grids.

Biomass for heteromyids totaled 416 g/ha (5.9 oz/a.), compared to 56 g/ha (0.8 oz/a.) for cricetids. Although 1 cactus mouse was captured in December, none were captured in September. The desert pocket mouse was the dominant species in the area, comprising 34.8% of the biomass present, followed by Merriam's kangaroo rat with 23.5%.

### Vulture Site

A grazing-impacted area of typical bajada with shallow washes and coarse, sandy and gravelly soils, Vulture Site is dominated by creosotebush, triangle leaf bursage, and saguaro.

Two grids were established on this site and were monitored 9–11 September 1988. Three species of heteromyids were captured. Desert pocket mouse was the most numerous, with 20/ha (8.1/a.) present, followed by Arizona pocket mouse (6/ha [2.4/a.]). Only 1 Merriam's kangaroo rat was captured. This site shared with the East Armenta site the highest density of Arizona pocket mouse. Also it had the second highest density of desert pocket mouse.

Two white-throated woodrats were captured on the site, for a biomass of 125 g/ha (1.8 oz/a.). In an effort to monitor the ground squirrel population, traps were left open during the day and checked every 3 hr on 10 September. When 2 animals died from heat prostration within a 3-hr period, the traps were immediately closed and no further attempts were made to monitor diurnal rodents.

# Discussion

## Physiognomy of the Sites

The sites fall into 3 general categories that reflect the species and number of nocturnal rodents present: (1) mountain canyons, (2) small hills, and (3) bajadas/valley floors. Each of these has its distinctive geology, drainage, soils, and associated plant and animal communities.

### *Mountain Canyons*

The Alamo, Arch, and Bull Pasture mountain-canyon sites were dominated by the cricetid rodents (Fig. 1) and had some of the highest total biomasses of nocturnal rodents: 837 g/ha (12.0 oz/a.); 2,625 g/ha (37.5 oz/a.); and 1,354 g/ha (19.3 oz/a.), respectively (Table 3). The more dense vegetation found in the bottoms of these canyons apparently provides the moisture, nutrients, and cover needed to sustain a large "standing crop" of cricetid rodents, especially woodrats.

Of the 16 sites monitored in this study, only the 3 mountain canyons in the Ajo Mountains had significant populations of the cricetid cactus mouse—with biomasses of 172 g/ha (2.5 oz/a.) in Alamo Canyon, 135 g/ha (2.0 oz/a.) in Arch Canyon, and 148 g/ha (2.1 oz/a.) in Bull Pasture. In ORPI, only at a few of the densely vegetated spring areas have higher densities of cactus mouse been found. At Quitobaquito Springs, Petryszyn and Cockrum (1990) found the cactus mouse biomass to be 412 g/ha (5.9 oz/a.), or twice that found in the Ajo Mountain canyons during this study. At Williams Spring, 11 cactus mice were captured over 98 trap-nights, which is approximately 40% higher than the 7, 8, and 9.5 mice per 98 trap-nights captured in the canyons.

The Ajo Mountain canyons also produced the highest biomass of white-throated woodrats, with 589 g/ha (8.4 oz/a.) recorded for Alamo Canyon, 2,380 g/ha (34.0 oz/a.) for Arch Canyon, and 930 g/ha (13.3 oz/a.) for Bull Pasture. Of the remaining 13 sites, only at Neolloydia Site did biomass for the white-throated woodrat approach these numbers (452 g/ha [6.5 oz/a.]). The numbers of woodrats in the canyons—over 98 trap-nights: 4 for Alamo Canyon, 19 for Arch Canyon, and 6 for Bull Pasture—compared favorably with the findings at Williams Spring (7.4 over 98 trap-nights). Many more, however, were found at Quitobaquito (7,556 g/ha [107.9 oz/a.]). Of the total nocturnal rodent biomass in the canyons, woodrats accounted for 70.4% at Alamo Canyon, 90.6% at Arch Canyon, and 68.7% at Bull Pasture.

Heteromyids contributed little toward total nocturnal rodent biomass in the mountain canyons: 9% in Alamo Canyon, 4.2% in Arch Canyon, and 15.4% in Bull Pasture. The rocky, steep slopes are not prime habitat for heteromyids. Bailey's pocket mouse was the most common heteromyid in the 3 canyons.

Table 3. Number (n/ha) and biomass (g/ha) of heteromyid and cricetid rodents during 1988 on 16 Ecological Monitoring Program Sites in Organ Pipe Cactus National Monument, Arizona.

| Site | Heteromyids | | Cricetids | | Total |
|---|---|---|---|---|---|
| | n/ha | g/ha | n/ha | g/ha | g/ha |
| Aguajita Wash | 13.0 | 219 | – | – | 219 |
| Alamo Canyon | 3.0 | 76 | 13.6 | 761 | 837 |
| Arch Canyon | 4.0 | 110 | 26.0 | 2,515 | 2,625 |
| Armenta Ranch | 20.5 | 480 | 0.5 | 38 | 518 |
| Bates Well | 3.5 | 118 | 0.5 | 9 | 127 |
| Bull Pasture | 9.0 | 208 | 15.0 | 1,146 | 1,354 |
| Burn Site | 15.0 | 472 | – | – | 472 |
| Dos Lomitas | 14.0 | 537 | 0.5 | 17 | 554 |
| Dripping Springs | 15.0 | 349 | 3.0 | 332 | 671 |
| East Arementa | 30.0 | 618 | 2.0 | 307 | 925 |
| Lost Cabin Mine | 27.0 | 385 | 1.5 | 142 | 527 |
| Neolloydia Site | 16.0 | 236 | 3.5 | 452 | 688 |
| Pozo Nuevo | 23.5 | 591 | – | – | 591 |
| Salsola Site | 42.5 | 888 | – | – | 888 |
| Senita Basin | 23.5 | 416 | 0.5 | 56 | 472 |
| Vulture Site | 26.5 | 369 | 1.0 | 125 | 494 |
| Total | 285.9 | 6,072 | 67.6 | 5,890 | 11,962 |
| Mean | 17.9 | 380 | 4.2 | 368 | 748 |

### *Small Hills*

This grouping, which includes the monitoring sites Dripping Springs, Lost Cabin, Neolloydia Site, and Senita Basin, yielded a mix of heteromyid and cricetid rodents and generally the highest variety of species, reflective of the diversity of habitats on these 4 sites. Nocturnal rodent biomass is modest: 671 g/ha (9.6 oz/a.), 527 g/ha (7.5 oz/a.), 688 g/ha (9.8 oz/a.), and 472 g/ha (6.7 oz/a.), respectively.

The cricetids (primarily woodrats) contribute from 12% of the biomass at Senita Basin to 65.7% at Neolloydia Site. Although few in number, cactus mouse samples were found at Dripping Springs, Lost Cabin, and Senita Basin.

Heteromyids were common in these areas. Each area had its own dominant heteromyid species. At Dripping Springs, Bailey's pocket mouse comprised 100% of the heteromyid biomass, while at Lost Cabin, the desert pocket mouse accounted for 66.9%. At both Neolloydia Site and Senita Basin, 2 heteromyid species shared dominance: rock pocket mouse (50%) and Bailey's pocket mouse (39.1%) at Neolloydia Site, and the desert pocket mouse (39.5%) and Merriam's kangaroo rat (26.6%) at Senita Basin.

Nocturnal rodent diversity was highest at the Lost Cabin and Senita Basin sites (7 species) and lowest at the Dripping Springs site (3 species). Neolloydia Site had 5 species.

### *Bajada/Valley Floor*

The rest of the sites are found on bajadas or the desert floor. Soil is more developed and runoff is slower. These sites include Aguajita Wash, East Armenta, Armenta Ranch, Bates Well, Burn Site, Dos Lomitas, Pozo Nuevo, Salsola Site, and Vulture Site.

With the exceptions of Aguajita Wash and Bates Well, which had very low biomass, and East Armenta and Salsola Site, with very high biomass, these sites had amazingly similar carrying capacities for nocturnal rodents. Biomass for these 5 sites ranges from 591 g/ha (8.4 oz/a.) at Pozo Nuevo to 472 g/ha (6.7 oz/a.) at Burn Site. All 5 sites had been impacted to some degree by overgrazing.

Heteromyid rodents accounted for the bulk of the biomass. Only Vulture Site had a respectable showing of the white-throated woodrat, with a biomass of 125 g/ha (1.8 oz/a.). Even then, woodrats accounted for only 25% of the nocturnal rodent biomass for this site.

The 2 sites with the lowest rodent biomass, Aguajita Wash and Bates Well, are located on the flood plain of major drainages. The flooding that occurred in 1988 may have adversely affected the rodent populations there. Steenbergh and Warren (1977) as well as Cockrum and Petryszyn (1986) reported a much larger rodent population at Aguajita Wash (Table 2). At Bates Well, aside from the mesquites, there were very few understory plants on the floodplain. Lack of plant diversity may have been a contributing factor toward the low rodent density.

The high rodent biomass at East Armenta (925 g/ha [13.2 oz/a.]) and Salsola Site (888 g/ha [12.7 oz/a.]) was unexpected. Of all the bajada/valley-floor sites, East Armenta was probably the least impacted by grazing. The area has a good mix of vegetation, with open creosotebush-dominated areas mixed with tree-lined, shallow washes. The diversity of cacti and ground litter from the mesquites, ironwoods, and paloverdes may explain the relatively high number of white-throated woodrats. Plenty of den sites are available, as well as den building materials. Woodrats contribute 33% (307 g/ha [4.4 oz/a.]) of the rodent biomass for this site, compared to 7.9% or less for Aguajita Wash, Armenta Ranch, Bates Well, Burn Site, Dos Lomitas, and Salsola Site. Of the low-lying sites, only at Vulture Site did woodrats contribute as much to the biomass (34%), but overall woodrat productivity was low (125 g/ha [1.8 oz/a.]).

Salsola Site was an enigma, in that such an impacted area would not be expected to have such a high productivity. Next to East Armenta, this site has the highest nocturnal rodent biomass of the 9 bajada/valley-floor sites. Where a strong diversity of species (5) benefited the productivity of the East Armenta site, no such occurrence was found at Salsola Site. Essentially 2 species, desert pocket mouse and Merriam's kangaroo rat, comprised the biomass of nocturnal rodents. The cover and, apparently, the food resource produced by Russian thistle (*Salsola* spp.) and amaranth (*Amaranthus* spp.) were sufficient to significantly increase the density of rodents. Although Merriam's kangaroo rat preferred the more open creosotebush area (Fig. 5), it may be that the nearby Russian thistle/amaranth thicket provided windblown seeds. Both Russian thistle and amaranth produce tiny seeds that may possibly be moved by strong winds at ground level. Only at Dos Lomitas was there a higher density of Merriam's kangaroo rat.

This site exemplified the macrohabitat selection of these 2 species. The desert pocket mouse was found more prevalently in more dense vegetation, while Merriam's kangaroo rat preferred more open areas (Fig. 5). Similar results were seen at Aguajita Wash, Armenta Ranch, Burn Site, and Pozo Nuevo during this study. Petryszyn et al. (unpubl. data) found desert pocket mice in areas of more dense vegetation at Pozo Nuevo during periods of good rainfall. In years that were drier and when vegetation was more sparse, Merriam's kangaroo rat moved into areas that were formerly dominated by the desert pocket mouse.

### Comparison to Other Populations

Data collected in lower Sonoran and desert grassland areas near Tucson show that populations of both heteromyids and cricetids can fluctuate tremendously on a multiannual scale (Petryszyn 1982 and 1995). The same can be said for the rodent populations at ORPI (Petryszyn et al., unpubl. data). The underlying cause—plant reaction to rainfall quantity and timing—is just as valid at ORPI as it is near Tucson. Coupled with the innate needs of space, food, and shelter (to which each species responds in its own unique way) aggregated populations of rodents of similar species in similar habitats with similar climatic conditions should resemble each other in matters of competition, carrying capacity, and reaction to environmental stimuli. A comparison of the nocturnal rodent populations of this study with that of similar species populations elsewhere seems to give some credence to this thesis.

A study done by Petryszyn (1995) found the heteromyid biomass in 1988 to be 786 g/ha (11.2 oz/a.) for Silverbell Site and 724 g/ha (10.3 oz/a.) for the Santa Rita Experimental Range site. Silverbell Site is a typical lower Sonoran desert bajada area at an elevation of 671 m (2,200 ft), while the Santa Rita site is more of a desert grassland at 914 m (3,000 ft) elevation. The mean heteromyid biomass of 380 g/ha (5.4 oz/a.) for all sites in this study is somewhat less than the mean of 755 g/ha (10.8 oz/a.) found by Petryszyn on his Tucson sites.

It must be emphasized, though, that the overall complexion of Petryszyn's Tucson plots resembles most closely the bajada/valley-floor sites of this study, especially the East Armenta and Armenta Ranch sites. The mean heteromyid biomass of these 9 sites is 477 g/ha (6.8 oz/a.), somewhat less than that found on the Tucson plots, but more than the overall mean for all sites of this study.

If only the East Armenta and Armenta Ranch sites are considered, the difference between heteromyid biomass from the 2 areas is even less. The mean heteromyid biomass of the Armenta sites is 590 g/ha (8.4 oz/a.), which is amazingly close to the 755 g/ha (10.8 oz/a.) of the Tucson sites. The Tucson sites most closely resemble a combination of the East Armenta and Pozo Nuevo sites—rich bajada vegetation with tree-lined washes intermingled with patches of creosotebush. The mean heteromyid biomass for the combined East Armenta and Pozo Nuevo sites is 604 g/ha (8.6 oz/a.)—again, an amazingly close comparison with the Tucson sites.

For cricetids, the comparison of ORPI sites to those of Petryszyn's Tucson sites is not as well defined. The cricetid biomasses (mostly comprised of white-throated woodrats) on the Tucson sites are 1,119 g/ha (16.0 oz/a.) and 1,979 g/ha (28.3 oz/a.), for a mean of 1,599 g/ha (22.8 oz/a.) in 1988. This far exceeds the 368 g/ha (5.3 oz/a.) mean of the 16 ORPI sites and is far removed from the 55 g/ha (0.8 oz/a.) mean of the 9 bajada/valley-floor sites. Actually, it more closely resembles the 1,605 g/ha (22.9 oz/a.) mean of the 3 canyon sites.

Considering the dependence of white-throated woodrats on perennial plants for nutrient and water needs, the 25–35% higher annual rainfall in the Tucson area may be an important factor contributing to the increased levels of woodrats in that area. Perennial plants would respond to increased moisture provided by additional rainfall. The prominence of leafy perennial plants seen along washes and around springs is an obvious manifestation of this principle and demonstrates dependence of many perennial plants on adequate, available moisture. Of Petryszyn's 2 sites, the one with an annual rainfall of 31 cm (12 in.)—compared to 26.7 cm (10.5 in.) on the other site—has the higher cricetid biomass (1,979 g/ha [171 oz/a.] vs 1,119 g/ha [97 oz/a.]). Higher density of white-throated woodrats on the more mesic site seemed to hold true for most years (Petryszyn 1982).

### Seasonal Occurrence of Nocturnal Rodents

Four sites were monitored at 2 different times of the year. The Lost Cabin and Senita Basin sites were monitored in December 1987 and again in September 1988, while the Armenta Ranch and East Armenta sites were monitored in June 1988 and again in December 1988. A comparison of trapping results is shown in Table 4.

Table 4. Comparison of winter/summer nocturnal rodent trapping during 1987 and 1988 on 4 sites in the Ecological Monitoring Program at Organ Pipe Cactus National Monument, Arizona. Figures shown are biomass (g/ha).

| | Winter | | | | Summer | | | |
|---|---|---|---|---|---|---|---|---|
| | December 1988 | | December 1987 | | June 1988 | | September 1988 | |
| Species | Armenta Ranch | East Armenta | Lost Cabin | Senita Basin | Armenta Ranch | East Armenta | Lost Cabin | Senita Basin |
| Bailey's pocket mouse (*Chaetodipus baileyi*) | 27 | | 15 | | 17 | 11 | 10 | 69 |
| Rock pocket mouse (*Chaetodipus intermedius*) | | | | | | | 80 | 65 |
| Desert pocket mouse (*Chaetodipus penicillatus*) | | | | | 163 | 253 | 257 | 164 |
| Merriam's kangaroo rat (*Dipodomys merriami*) | 230 | 391 | 88 | 210 | 295 | 296 | 23 | 111 |
| White-throated woodrat (*Neotoma albigula*) | | | 162 | 56 | 38 | 307 | 132 | 56 |
| Arizona pocket mouse (*Perognathus amplus*) | | | | | 5 | 58 | 15 | 7 |
| Cactus mouse (*Peromyscus eremicus*) | | | 33 | 8 | | | 10 | |



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As expected, the density and diversity of nocturnal rodents are decreased in the winter months on all sites. Petryszyn (1982) showed that the smaller heteromyid species decrease their activity above ground substantially during winter months (Fig. 2).

At the Lost Cabin and Senita Basin sites, 4 and 3 species, respectively, were captured on each site in December. In September, 7 species were captured on the Lost Cabin site and 6 on the Senita Basin site. Missing during the winter were the smaller heteromyid rodents (Arizona pocket mouse, rock pocket mouse, and desert pocket mouse). Winter biomass of nocturnal rodents for each of the 2 sites was 298 g/ha (4.3 oz/a.) and 274 g/ha (3.9 oz/a.), compared to 527 g/ha (7.5 oz/a.) and 472 g/ha (6.7 oz/a.) during the summer. Smaller rodents are probably present, but stay underground during the winter.

The story is much the same for East Armenta and Armenta Ranch. Only 1 species (Merriam's kangaroo rat) was captured during winter monitoring at the East Armenta site, for a biomass of 391 g/ha (5.6 oz/a.). At Armenta Ranch, 2 species (Bailey's pocket mouse and Merriam's kangaroo rat) were captured, for a total biomass of 257 g/ha (3.7 oz/a.).

During summer, the number of species captured at East Armenta increased to 5, with a total biomass of 925 g/ha (13.2 oz/a.), while at the same time, the number of species captured at Armenta Ranch increased by 3, for a biomass total of 518 g/ha (7.4 oz/a.).

## Species Distribution and Densities

### *White-throated Woodrat*

This species was found on 10 of the 16 monitoring sites, ranging in biomass from 38 g/ha (0.5 oz/a.) at the Armenta Ranch site to 2,380 g/ha (34.0 oz/a.) at Arch Canyon (Fig. 6). It was the dominant nocturnal rodent captured on the canyon sites in the Ajo Mountains, averaging 1,300 g/ha (19.0 oz/a.). While white-throated woodrat biomass varied considerably on the small hill sites and the bajada/valley-floor sites, it was consistently high in the canyons of the Ajo Mountains.

Of other sites, East Armenta, Dripping Springs, and Neolloydia Site had the highest biomasses of woodrats—307 g/ha (4.4 oz/a.), 306 g/ha (4.4 oz/a.), and 452 g/ha (6.5 oz/a.), respectively. East Armenta and Dripping Springs provide a diversity of vegetation and denning sites. The relatively high woodrat density at Neolloydia Site, however, was somewhat surprising. This rocky, hilly area of relatively barren soil did not seem conducive for maintaining a high population of woodrats. Considering the importance of this site, and the possibility that woodrats may be preying on acuña cacti (although there was no evidence to this effect), this site should be monitored in the future, and the possible relationship between this cactus and the white-throated woodrat explored.

The 6 sites in which no woodrats were captured are Aguajita Wash, Bates Well, Burn Site, Dos Lomitas, Salsola Site, and Pozo Nuevo. The Aguajita Wash and Bates Well sites were flooded just prior to our sampling. Cockrum and Petryszyn (1986) indicated that the white-throated woodrat species was captured at these locations in the past.

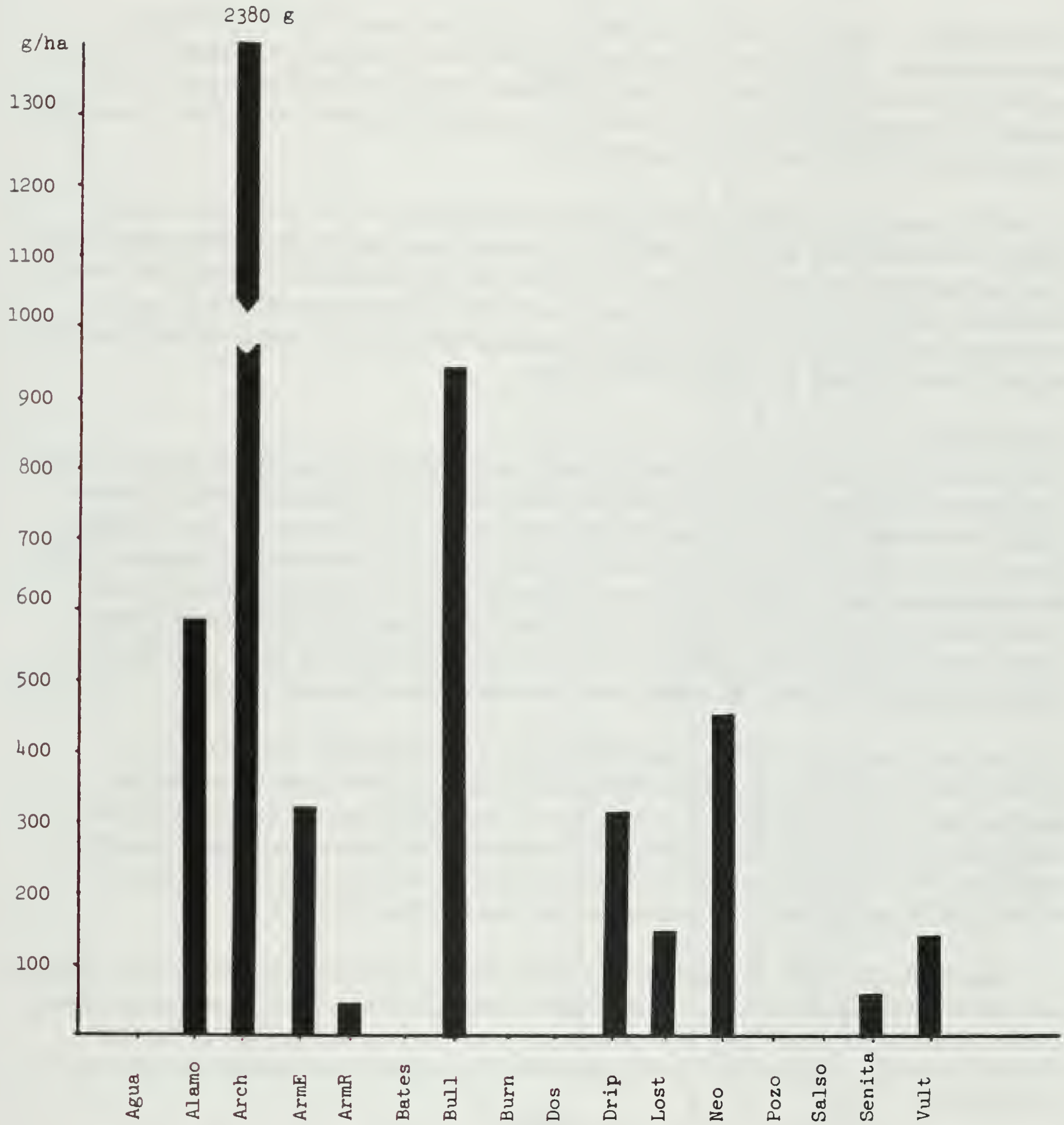


Figure 6. Biomass (g/ha) of the white-throated woodrat (*Neotoma albigula*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Dripping** Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

Burn Site, Dos Lomitas, and Salsola Site were highly impacted sites containing relatively fine-textured soils. Although no woodrats were captured on the grids proper, evidence of their presence in the area was apparent from the few dens observed. The Pozo Nuevo grids were located in creosotebush flats. Another site located on a nearby hill produced a couple of woodrats in September 1988 (Petryszyn et al., unpubl. data).

At ORPI, in general, the canyons in mountainous areas are preferred white-throated woodrat habitat, followed by hilly terrain, and then good, diverse, bajada habitat. The desert valley-floor is the habitat least preferred by woodrats. In addition, very high densities of woodrats are found associated with the heavy vegetation of springs, such as Quitobaquito and Williams Spring (Petryszyn and Cockrum 1990). Overall, white-throated woodrats accounted for 45% of the total nocturnal rodent biomass on the 16 monitoring sites.

### *Cactus Mouse*

This species is the only other cricetid found in any number in the monument and appears to have an affinity for the same habitat as the white-throated woodrat. The highest densities of cactus mouse are found in the canyons of the Ajo Mountains, followed by the low hill sites (Dripping Springs, Lost Cabin, and Senita Basin; see Fig. 7). Cactus mouse biomasses are consistent in the Ajo Mountain canyons—172 g/ha (2.5 oz/a.) in Alamo Canyon, 135 g/ha (1.9 oz/a.) in Arch Canyon, and 148 g/ha (2.1 oz/a.) in Bull Pasture. On 3 of the small-hills sites, the species is present but not abundant—16 g/ha (0.23 oz/a.) in Dripping Springs, 10 g/ha (0.14 oz/a.) in Lost Cabin, and 8 g/ha (0.11 oz/a.) in Senita Basin. None was captured on the other sites.

Petryszyn and Cockrum (1990) reported high biomass and numbers of cactus mice at Quitobaquito (412 g/ha [5.9 oz/a.]) and Williams Spring (11 captured over 98 trap-nights, compared to 9.5 [Alamo Canyon], 7 [Arch Canyon], and 8 [Bull Pasture] captured over 98 trap-nights at the canyon sites). Cockrum and Petryszyn (1986) reported records of occurrence from Bates Well and the eastern end of the Puerto Blanco Mountains, and Steenbergh and Warren (1977) reported taking specimens from the Dos Lomitas enclosure.

It is apparent that, in ORPI, the cactus mouse prefers heavily vegetated areas, either in the deeper canyons of the mountains or around springs, and occasionally occurs in hilly and riparian areas. On the 16 monitoring sites of this study, the cactus mouse contributed only 4% of the total nocturnal rodent biomass, whereas, on the mountain-canyon sites it accounted for 9.5% of the total biomass.

### *Arizona Pocket Mouse*

This smallest of the heteromyids captured during this study was found on 9 monitoring sites (Fig. 8). All but 2 of the sites were on the valley floor. Preferring the finer-grained soils, even on the 2 small-hills sites (Lost Cabin and Senita Basin) on which it occurred, the species was captured on the sandier portions of the grids.


Figure 7. Biomass (g/ha) of the cactus mouse (*Peromyscus eremicus*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

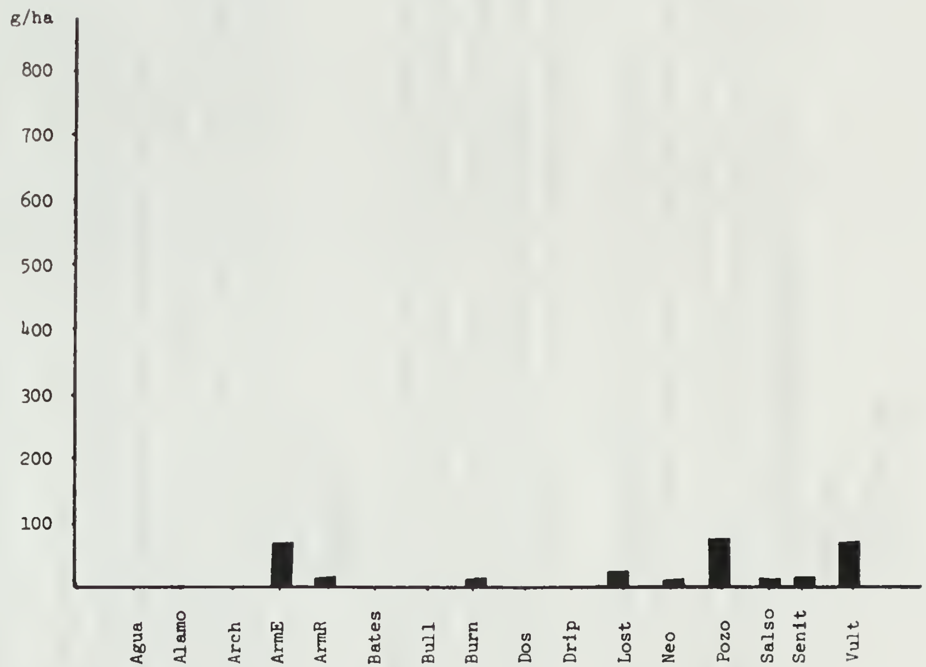


Figure 8. Biomass (g/ha) of the Arizona pocket mouse (*Perognathus amplus*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

Only on the East Armenta, Pozo Nuevo, and Vulture Site grids did this species occur in any number—5.5 g/ha (0.079 oz/a.), 6.8 g/ha (0.097 oz/a.), and 6.0 g/ha (0.086 oz/a.), respectively. Due to its small size, it contributed little to the total heteromyid biomass on these sites—58 g/ha (0.83 oz/a.) at East Armenta, 73 g/ha (1.04 oz/a.) at Pozo Nuevo, and 57 g/ha (0.81 oz/a.) at Vulture Site. Its 1.9% contribution to the total biomass of all sites is even less significant.

It is possible that this rodent may, at times, be much more prevalent in the areas in which it is found. During the high-rainfall year of 1983, Petryszyn et al. (unpubl. data) estimated 22 Arizona pocket mice per ha on the Pozo Nuevo site and, on a site near Tucson, Petryszyn (1982) found it at 425 g/ha (6.1 oz/a.) in 1973 and 632 g/ha (9.0 oz/a.) in 1978. During other years, Petryszyn found that biomass for this species ranged from 12 g/ha (0.2 oz/a.) to 200 g/ha (2.9 oz/a.) on this same site.

### *Rock Pocket Mouse*

This specialized mouse is generally found on rocky slopes, and its occurrence during this study reflects this tendency. The rock pocket mouse was found on only 4 sites: Arch Canyon of the mountain-canyon sites, and Lost Cabin, Neolloydia Site, and Senita Basin of the small-hills sites (Fig. 9). Only on the small-hills sites was this species found in any abundance—80 g/ha (1.1 oz/a.) on Lost Cabin, 118 g/ha (1.7 oz/a.) on Neolloydia Site, and 65 g/ha (0.9 oz/a.) on Senita Basin. The rock pocket mouse contributed only 2.3% toward the total nocturnal rodent biomass of the 16 monitoring sites.

Of the 3 mountain-canyon sites, only Arch Canyon was sampled during a warmer time of the year (April). The rock pocket mouse is known to stay underground during the colder months (Petryszyn 1982). Cockrum and Petryszyn (1986) reported records for this species from both Alamo Canyon and Bull Pasture, as well as from the vicinity of Bates Well, Senita Basin, and Pozo Nuevo. Petryszyn et al. (unpubl. data) found this species in considerable numbers on the rocky slope of a small hill near Pozo Nuevo.

Even though it was monitored during a warm time of year, the Arch Canyon site produced only 1.0 rock pocket mice per ha. Trapping conducted by Petryszyn at Alamo Canyon and Bull Pasture during warmer months never produced many rock pocket mice (Petryszyn et al., unpubl. data).

### *Desert Pocket Mouse*

This species is the counterpart to the rock pocket mouse. Whereas the rock pocket mouse prefers a rocky/gravelly, sloping substrate, the desert pocket mouse prefers the finer-soil substrate. It was found on 12 of the monitoring sites (Fig. 10). Salsola Site had, by far, the largest number of this species (32/ha [13.0/a.]), followed by Vulture Site (20/ha [8.1/a.]), Lost Cabin Mine (18/ha [7.3/a.]), and East Armenta (16/ha [6.5/a.]). Aguajita Wash, Armenta Ranch and Senita Basin monitoring sites also had respectful populations of this mouse—12/ha (4.9/a.), 11/ha (4.4/a.), and 12/ha (4.9/a.), respectively. Alamo Canyon, Burn Site, Dos Lomitas, and Neolloydia Site also harbored this species, though only small numbers were found.

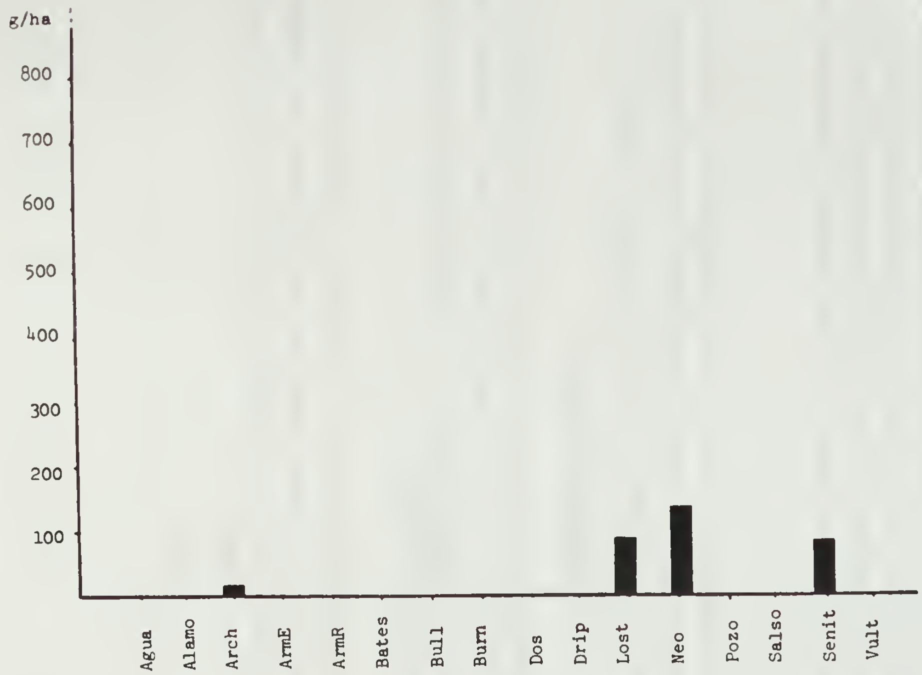


Figure 9. Biomass (g/ha) of the rock pocket mouse (*Chaetodipus intermedius*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

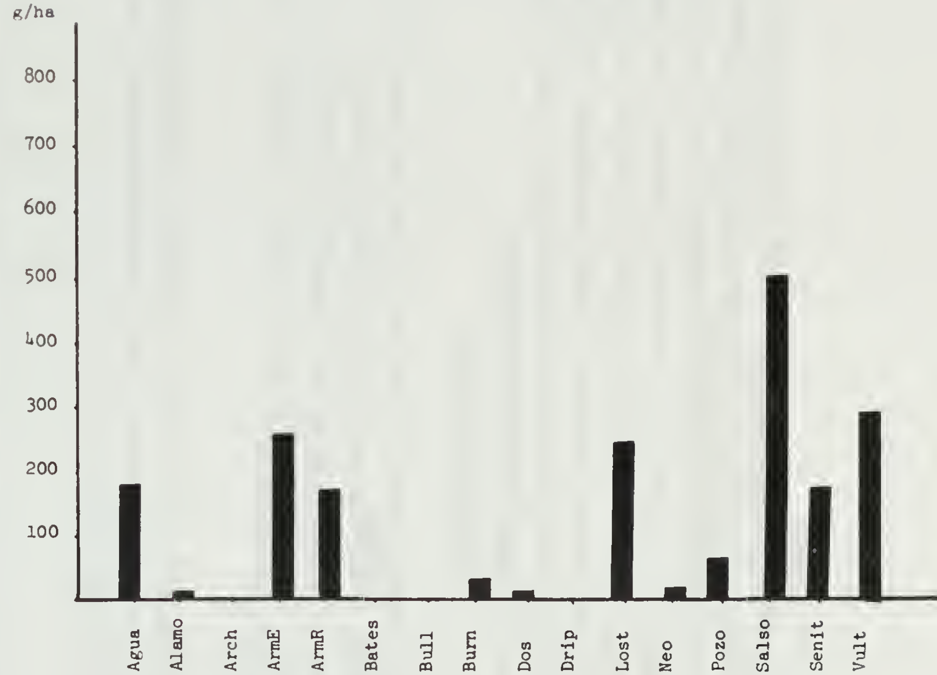


Figure 10. Biomass (g/ha) of the desert pocket mouse (*Chaetodipus penicillatus*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

The unique situation at the Salsola Site monitoring area exemplified its relationship with more "open"-habitat heteromyids, such as the kangaroo rat (Fig. 5). Segregation into more vegetated areas was also noted by Petryszyn et al. (unpubl. data) at Pozo Nuevo during differing periods of rainfall. With 503 g/ha (7.2 oz/a.) at Salsola Site, the desert pocket mouse's biomass is surpassed only by Merriam's kangaroo rat (528 g/ha [7.5 oz/a.]) at the Dos Lomitas site. It shares with this latter species the distinction of being the most common heteromyid on the monument. The desert pocket mouse's contribution of 1,968 g/ha (28.1 oz/a.) to the total biomass of the 16 monitoring sites (or 16.5%) makes it the third most common nocturnal rodent.

### *Bailey's Pocket mouse*

Although found on 9 sites, only at Dripping Springs and Bull Pasture did this species occur in any numbers (Fig. 11). At Dripping Springs, it was the most common nocturnal rodent, contributing 53% of the biomass for that site. Although commonly found on a variety of substrates, it seems to prefer "pebble/rocky" terrain. Of the 9 sites on which it occurred, 7 were of this type (mountain canyons and small hills).

Cockrum and Petryszyn (1986) reported this species from numerous locations throughout ORPI. Very few were captured in finer-soiled areas of the monument. This species accounted for only 15.6% of the heteromyid biomass and even less (7.8%) of the total.

### *Merriam's Kangaroo Rat*

Along with the desert pocket mouse, this species is the most common heteromyid in the monument. Found on all monitoring sites except the 3 mountain-canyon sites and 2 of the small-hills sites, Merriam's kangaroo rat is a resident of finer-soiled, more open habitat (Fig. 12). Even at the Lost Cabin and Senita Basin sites, it was found in the flat, sandier portions of the grids.

The Dos Lomitas site had the highest concentration of this species (14/ha [5.7/a.]), followed by Burn Site (12/ha [4.9/a.]). Both of these sites are fine-soiled, open habitat. Four other sites (Armenta Ranch, East Armenta, Salsola Site, and Pozo Nuevo) demonstrated kangaroo rat densities of over 8/ha (3.2/a.).

The 528 g/ha (7.5 oz/a.) of Merriam's kangaroo rat biomass recorded on the Dos Lomitas site is the highest achieved by any heteromyid during this study. Only the desert pocket mouse biomass on Salsola Site approached this amount (503 g/ha [7.2 oz/a.]). Woodrats on the mountain-canyon sites are the only nocturnal rodents to surpass this figure.

The relationship of Merriam's kangaroo rat to the desert pocket mouse is an interesting one. They share 10 of the monitoring sites and, in most cases, segregate into different macrohabitats (see discussion under Desert Pocket Mouse). This was dramatically illustrated on the monitoring grid at Salsola Site (Fig. 5).

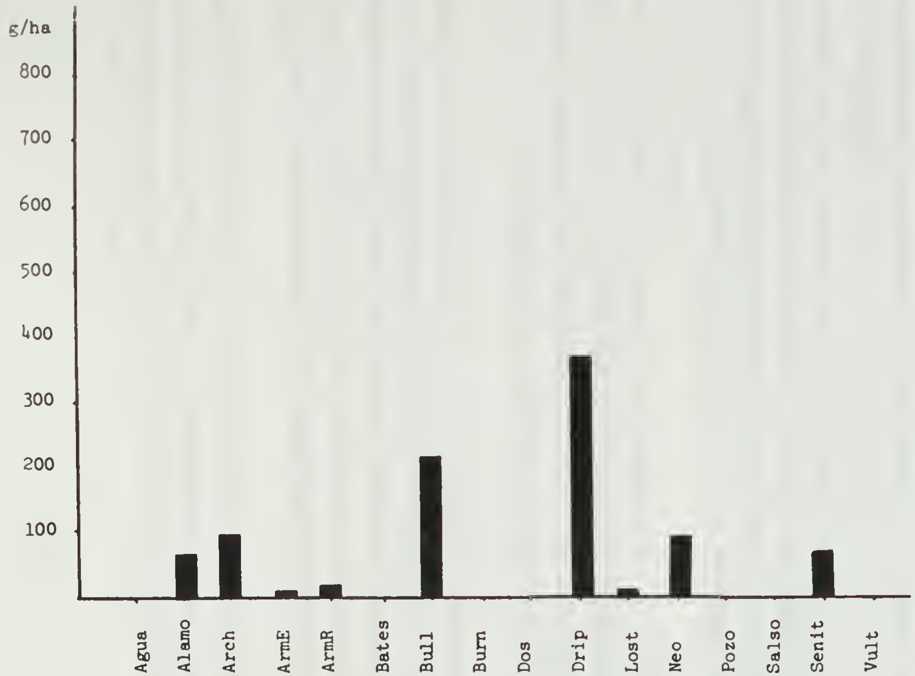


Figure 11. Biomass (g/ha) of Bailey's pocket mouse (*Chaetodipus baileyi*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

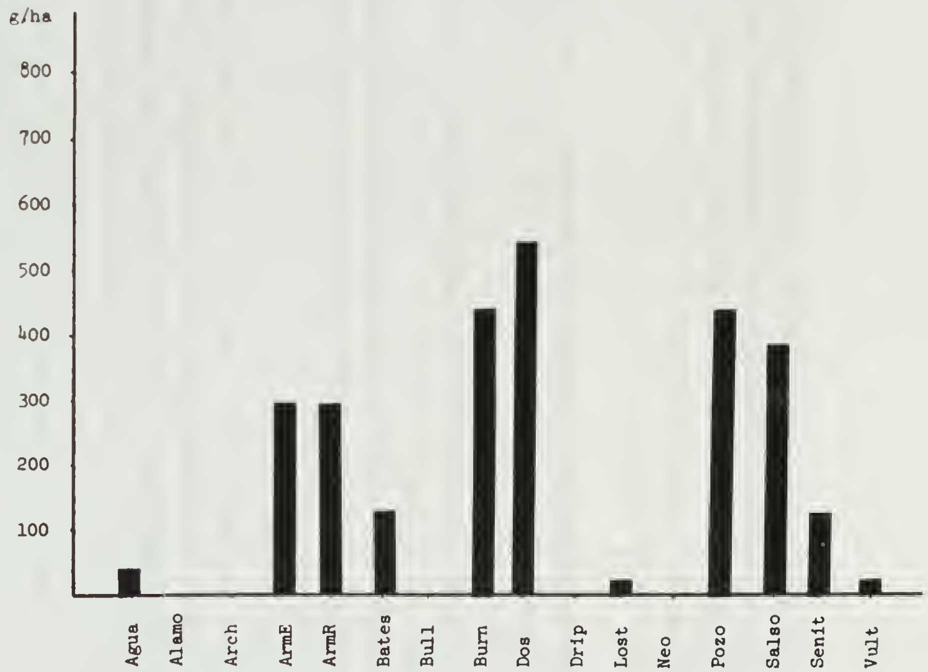


Figure 12. Biomass (g/ha) of Merriam's kangaroo rat (*Dipodomys merriami*) on 16 Ecological Monitoring Program sites in Organ Pipe Cactus National Monument, Arizona. Sites are abbreviated as: **Agua**jita Wash, **Alamo** Canyon, **Arch** Canyon, East **ArmE**nta, **ArmR** = Armenta Ranch, **Bates** Well, **Bull** Pasture, **Burn** Site, **Dos** Lomitas, **Drip**ping Springs, **Lost** Cabin Mine, **Neo**lloydia Site, **Pozo** Nuevo, **Salso**la Site, **Senita** Basin, and **Vult**ure Site.

Merriam's kangaroo rat was the second-most abundant nocturnal rodent (according to total biomass), contributing 21.6% of the total nocturnal rodent biomass. Only the white-throated woodrat contributed more. Of the heteromyids, while only accounting for 24.5% of the total number, it contributed 43.2% of the biomass.

### *Other Nocturnal Rodent Species*

Only 3 other species of nocturnal rodents were captured during this study: southern grasshopper mouse (n = 1), Merriam's mouse (n = 1), and Arizona cotton rat (n = 1).

One southern grasshopper mouse was captured at Bates Well. This species has been found in other locations in the monument (Cockrum and Petryszyn 1986) but was not common or numerous. Primarily a desert-grassland dweller, the southern grasshopper mouse feeds largely on invertebrates. It is possible that it is more numerous during "wet" periods when vegetation and arthropods are plentiful.

At Dos Lomitas, a female Merriam's mouse was captured on 6 December 1988. An inhabitant of dense "bosque" areas (Hoffmeister 1986), it was captured in thick mesquites along a wash. To the authors' knowledge, only 1 other specimen has ever been taken at ORPI, and that was at Quitobaquito Springs in 1894 (Mearns 1907). Several hundred trap-nights of effort in recent times have failed to produce this species in the Quitobaquito area (Petryszyn and Cockrum 1990).

A very unexpected find occurred in the capture of a single Arizona cotton rat at Bull Pasture on 3 December 1988. This 68.0-g (2.4-oz) female was trapped near the bottom of a shallow drainage in heavy grass. No cotton rat has ever before been captured in the monument, and the closest records are 105 km (65 mi) to the north, along the Gila River. Repeated effort at Bull Pasture in December of 1989 and 1990 failed to produce this species. This may be a Pleistocene relict population that was able to persist in the more grassy areas of the Ajo Mountains.

The occurrence of this species at ORPI was so unexpected that Cockrum and Petryszyn (1986) did not even include it on their hypothetical list of possible occurrences in the monument. Since the conclusion of this study, 2 other cotton rats have been captured on the monument, both in 1991. One was captured at Dos Lomitas and another at the East Armenta site.

Two heteromyid species that are known to occur at ORPI but were not captured during this study are the banner-tailed kangaroo rat (*Dipodomys spectabilis*) and the desert kangaroo rat (*Dipodomys deserti*). Neither of these species is plentiful in the monument. Despite several thousand trap-nights of effort throughout the monument, including help from The University of Arizona students, fewer than 10 specimens have been collected (Petryszyn, unpubl. data).

During this study, only at Armenta Ranch was there any sign of either species. Directly to the east of the old buildings are several active mounds of what is probably the desert kangaroo rat. These mounds were outside the established grids, but several traps were set at the mound burrow entrances, to no avail.

### *Diurnal Species*

No attempt was made to monitor diurnal rodents (ground squirrels) or lagomorphs (hares and rabbits). The effort it takes to ensure no casualties occur during the heat of day was beyond the scope of this study. A diurnal trapping period at Vulture Site resulted in the deaths of 2 round-tailed ground squirrels from heat prostration, even though traps were checked periodically.

Despite the fact that traps were closed during the day, some ground squirrels were captured incidentally in the nocturnal trapping periods. Traps were usually baited in late afternoon, and although checked in early morning, a period of daylight elapsed before the last trap was checked and closed. This allowed diurnal rodents access to the traps during the crepuscular portions of the day.

On Burn Site, 2 round-tailed ground squirrels were captured 20 June 1988. They weighed 128.0 g (4.5 oz) and 129.0 g (4.6 oz). This area contained a fairly large population of these rodents. During the day, up to 5 individuals could be seen on 1 grid.

Vulture Site also contained a large population of round-tailed ground squirrels. This and Burn Site suggest excellent areas to conduct population studies on ground squirrels, although traps would require frequent examination.

Several round-tailed ground squirrels were also observed on Salsola Site, although none was captured. While driving between Burn Site and Salsola Site, several areas along the way seemed to have substantial populations of this species. Their preferred habitat was finer-soiled creosotebush flats.

Harris' antelope squirrel was not as frequently encountered as the round-tailed ground squirrel. These animals were observed only on Senita Basin, Bull Pasture, and Vulture Site, although others were seen near the Alamo Canyon and Arch Canyon sites. In each case, it was a single animal that was observed.

A single rock squirrel weighing 283 g (10 oz) was captured at Dripping Springs on 4 June 1988. No other rock squirrel was observed on other sites, although there are records of this species occurring in other parts of the monument (Cockrum and Petryszyn 1986).

Desert cottontails and the 2 jackrabbit species, antelope jackrabbit and black-tailed jackrabbit, were observed during this study. At Armenta Ranch, there appeared to be an unusually large number of antelope jackrabbits present. On 1 occasion, 7 of these animals were seen simultaneously. Droppings and white urine spots from these jackrabbits were prevalent throughout the area. A single antelope jackrabbit was also observed on Salsola Site.

The black-tailed jackrabbit was observed on Burn Site, Salsola Site, Armenta Ranch, and Senita Basin sites. In each case it was a single individual, except at Armenta Ranch, where 2 in close proximity were seen. Tracks of jackrabbits were also seen at Bates Well, East Armenta, Lost Cabin, and Aguajita Wash sites.

Three to 4 desert cottontails were seen on Alamo Canyon and Salsola Site. Tracks of this rabbit were numerous on the Aguajita Wash site. It appeared that this animal preferred the more densely vegetated areas.

### Pitfall Trapping For Desert Shrews

Although pitfall traps set for the desert shrew were used successfully by Petryszyn at Quitobaquito (Petryszyn and Cockrum 1990) and by VanDevender and Olson at Alamo Canyon (pers. comm., 1990), no shrews were captured during this study period, even though pitfalls were set on most sites. The 12 pitfall traps set by Petryszyn at Quitobaquito were in place for almost 6 wk, while the traps set by VanDevender and Olson were in place for several months.

The effort in this study consisted of setting 1 or 2 pitfall traps for 2 nights and then removing them. This appeared to be too little time for a foraging shrew to randomly "bump into" the pitfall array. Also, many of the sites consisted of "open" habitat, which decreased the probability of a shrew encountering a pitfall trap in a 2-night sampling period. For an adequate sampling of desert shrew occurrence, the authors recommend that pitfall traps be in place for a minimum of 2 mo.

### Predatory Mammals

Although a large, Havahart live trap was set at most sites, no predatory mammals were captured, although carnivore scats and tracks were prevalent in many areas. Bait used included sardines, bananas, commercially canned cat food, and canned tuna.

At Bates Well, a strong skunk smell prevailed through the second night of trapping, but the Havahart trap was not triggered and the bait was undisturbed. Numerous tracks and scat of coyote, bobcat, and gray fox were present in the area. In 1982, Petryszyn observed fresh tracks of a mountain lion (*Felis concolor*) and made a plaster cast of them. No mountain lion tracks or scat were in evidence during this study.

The areas that showed the most signs of predatory mammals were the canyons of the Ajo Mountains, the small-hill sites and the heavily vegetated "wash" areas. One of the richest in signs was the area of Dripping Springs. Scats of coyote, gray and kit foxes were numerous throughout the region. The Lost Cabin area was similarly utilized by predators. It would appear that this concentration of predators is due to the water available and a good food base. The large-bodied woodrats are common in these areas, as well as large numbers of rabbits (evident by sight observation and number of droppings). This may be due to better forage available in these areas, resulting in more and bigger prey for predators.

Almost all the sites had some evidence (via droppings and tracks) of predator use. Coyotes and fox (primarily gray but also kit fox) seemed to be almost ubiquitous. During 1 night at Armenta Ranch in December 1988, 4 Sherman live traps were marked on top by deposition of kit fox fecal matter, while another trap was urinated on by a canid predator (presumably a fox). All the fox scats contained mesquite beans.

## Large Herbivores

Only at Bull Pasture and Senita Basin were large herbivores sighted. A female white-tailed deer (*Odocoileus virginianus*) was observed foraging near the weather station at Bull Pasture, and a female mule deer (*Odocoileus hemionus*) was seen on the Senita Basin site. Tracks and droppings of deer were common in some locations, such as Dripping Springs, Senita Basin, and Lost Cabin, probably due to the availability of water. Tracks of mule deer were also encountered at the East Armenta site.

The javelina, or collared peccary, was not sighted during this study, but several sites contained large numbers of tracks and scats. At Salsola Site, several paths were evidently made by the activity of javelinas. Numerous footprints could be seen on the paths. Also, droppings were common in the more heavily vegetated areas. It appeared that the javelinas were making numerous forays across the border into Mexico to forage among the apple orchards there.

The Bates Well area also showed many signs of javelina activity. The thicker stands of mesquite along Growler Wash appeared to be a favorite resting and foraging site. Much rooting around was evidenced, as well as copious amounts of scat. Trails created by the javelinas were also clearly evident.

Tracks and scats of javelinas were also evident on the Armenta Ranch, East Armenta, Senita Basin, Lost Cabin, and Aguajita Wash sites. These animals are probably present in most of the canyons of the Ajo Mountains, but the harder surfaces there are not as likely to show tracks Four javelinas were observed at Bull Pasture by Petryszyn and Barnett on 3 December 1988.

George Ruffner (pers. comm., 1990) reported javelina activity on the Dos Lomitas site, and Petryszyn and Cockrum (1990) reported signs of much activity at Williams Spring. Stephen Russ sighted 3 javelinas in a pass in the Quitobaquito Mountains on 28 April 1989. It appears possible that javelinas are increasing in number in the monument. In the past, very few javelinas were noted in this area (Mearns 1907; Huey 1942; Organ Pipe Cactus National Monument, unpubl. data; Petryszyn, unpubl. data).

## Population Estimates of Nocturnal Rodents

Assuming that the 16 sites sampled in this study are indicative of the whole of ORPI, an estimate of total "standing crop" of nocturnal rodents during 1988 can be made. It would have to be assumed that (1) the 3 mountain-canyon sites (19% of the sites) are typical of the mountainous areas in the monument, (2) the 4 small-hills sites (25% of the sites) adequately represent the actual amount of hilly areas in the monument, and (3) the remaining sites (56%) are indicative of the bajadas and valley-floor. A cursory look at a topographic map of the monument published by Southwest Parks and Monuments Association seems to validate such an assumption.

It must also be considered that the nocturnal rodent biomasses of 7 of the 16 sites are clustered within 15% of 530 g/ha (7.6 oz/a.), while 2 other sites are similar in having 671 g/ha (9.6 oz/a.) and 688 g/ha (9.8 oz/a.). The authors believe that this grouping strengthens the assumption that the 16 sites can be used as indicators to habitat in ORPI as a whole.

The mean heteromyid biomass for the 16 sites is 380 g/ha (5.4 oz/a.). Petryszyn (1982), monitoring 3 sites located on bajadas near Tucson, Arizona, found a 9-yr mean of 1,167 g/ha (16.7 oz/a.) for heteromyids. His population numbers included 2 major population explosions due to exceptional rainfall. If only the years of "normal" rainfall are considered, he found a mean heteromyid biomass of 482 g/ha (6.9 oz/a.)—a value that is very close to the 380 g/ha (5.4 oz/a.) found in this study. In 1988, the same year as this study, Petryszyn (1995) found heteromyid biomasses of 786 g/ha (11.2 oz/a.) and 724 g/ha (10.3 oz/a.) on his 2 sites near Tucson.

Although these figures are higher than the 380 g/ha (5.4 oz/a.) for the monument as a whole, they are reasonably close to the bajada/valley-floor sites' average of 477 g/ha (6.8 oz/a.). It appears that a heteromyid biomass value of 380 g/ha (5.4 oz/a.) for the monument is reasonable. It is quite amazing that the heteromyid biomass from areas 240 km (150 mi) removed are so similar.

Given this 380 g/ha (5.4 oz/a.) value, and projecting it for the 1,338.8 $km^2$ (516.9 $mi^2$) contained in the monument, there was an estimated 50,874 kg (55.6 tons) of heteromyid standing crop (expressed as the total weight of organisms at any one time) in ORPI during 1988. In numbers of individuals, this translates to more than 2.4 million heteromyids on the monument.

The mean cricetid biomass for the 16 sites is 368 g/ha (5.3 oz/a.). This is amazingly close to the 380 g/ha (5.4 oz/a.) for heteromyids. It would appear that ORPI, as a whole, is equally shared by heteromyids and cricetids, although macrohabitat preferences differ.

For the white-throated woodrat, the mean biomass for the 16 sites is 332 g/ha (4.7 oz/a.). Petryszyn (1982) found a 9-year mean for woodrats of 331 g/ha (4.7 oz/a.) on his sites of bajada and desert grasslands. In 1988, on his Tucson area sites, Petryszyn (1995) registered a white-throated woodrat biomass mean of 1,514 g/ha (21.6 oz/a.). A population explosion of this species due to exceptionally high annual rainfall in 1978, 1983, and 1984 occurred in that area through the early and mid 1980s (see also the discussion under Comparison to Other Populations). Regardless, the mean value found in this study is well within the fluctuations found by Petryszyn for this species.

Utilizing the mean cricetid biomass of 368 g/ha (5.3 oz/a.), a standing crop of 49,268 kg (53.9 tons) of cricetid biomass was present in the monument in 1988. Of this, the white-throated woodrat contributed 44,448 kg (48.6 tons), or 90.3%. The estimated number of cricetids in the monument in 1988 is 562,300 individuals.

The mean nocturnal rodent biomass in 1988 on the 16 monitoring sites was 748 g/ha (10.7 oz/a.). The total nocturnal rodent biomass for the monument in 1988 amounted to an estimated 100,142 kg (109.5 tons), consisting of more than 3 million individuals. Of this, the mountain-canyon areas produced 41%, small-hills areas 20%, and the bajada/valley-floor areas 39%.

Cricetids accounted for 92% of the biomass in the mountain-canyon areas, while heteromyids contributed 89% of the biomass in the bajada/valley-floor areas. In the small-hills areas, 59% of the biomass were heteromyids and 41% cricetids.

## Conclusions and Management Recommendations

Although 15 of the sites for this study were so chosen because each was considered unique in some fashion, they seem to represent the general diversity of ORPI. The remaining site (Pozo Nuevo) was chosen because it was so ordinary. Even though a site such as Pozo Nuevo (contributing only 6.25% of the results in this study) is representative of a much larger portion of habitat in the monument, when viewed as an intricate part of the bajada and desert floor as a unit, its values are not so diminished.

When considering nocturnal desert rodents at ORPI, it becomes apparent that some broad generalizations can be made on the strength of the results from this and other studies. The monument can be divided into 3 broad habitat types: mountain canyons, small-hills areas, and bajada/desert floor. Each has its own unique topography and plant composition, as well as unique nocturnal rodent densities and species compositions.

The woodrat overwhelmingly dominates the densely vegetated mountain canyons, a dominance shared with its smaller cousin, the cactus mouse. In the small-hills and bajada/desert-floor areas, cricetid occurrence is much more sporadic and sparse. Only in the heavily "wooded" areas of major springs do cricetids again dominate.

On the other hand, the bajadas and valley floor are less generous to the cricetids, but provide good habitat for the heteromyids. In these "flatlands" one sees a complete reversal in the order of group dominance. Although the cricetids accounted for 92% of the nocturnal rodent biomass on the mountain-canyon sites, they contributed only 11% on the bajada and valley-floor sites. In these areas of more "open" habitat, the heteromyids are in their element and they contribute 89% to the biomass.

The 4 small-hills sites are an interesting mix distinguished by a balance between the cricetids and heteromyids. Taken as a whole, the biomass of this "habitat type" is split—41% cricetids and 59% heteromyids. Considering the integration of hills, drainages, and relatively flat aprons at the bases of hills, this melding of diverse rodent species is not surprising.

Considerable confidence in the results of this study seems warranted. The general "sameness" of nocturnal rodent standing crop in similar sites is startling: the clumping of biomasses of 837 g/ha (12.0 oz/a.), 2,626 g/ha (37.5 oz/a.), and 1,354 g/ha (19.3 oz/a.) for the mountain-canyon sites; 671 g/ha (9.6 oz/a.), 527 g/ha (7.5 oz/a.), 688 g/ha (9.8 oz/a.), and 472 g/ha (6.7 oz/a.) for the small-hills sites; and the less than 15% variation of the total biomass for 5 of the 9 valley-floor sites. Adding to this the facts that 9 of the 16 sites had nocturnal rodent biomasses that fell between 472 g/ha (6.7 oz/a.) and 688 g/ha (9.8 oz/a.), that 2 large wash sites had comparable nocturnal rodent standing crops of 219 g/ha (3.1 oz/a.) and 127 g/ha (1.8 oz/a.), and that the 2 "richest" bajada/valley-floor sites had very similar biomass of 925 g/ha (13.2 oz/a.) and 888 g/ha (12.7 oz/a.), the authors believe this points to the validity of the monitoring techniques in this study. One might expect such similarity of results when monitoring similar species in similar habitats.

The comparison of these data to studies involving the same rodent species in other parts of Arizona shows an uncanny similarity of results for heteromyids in habitats that are very alike—in this case the East Armenta/Pozo Nuevo complex with Petryszyn's Tucson area sites. This may allow long-term comparisons of population fluctuations between areas far removed from each other.

Another possible benefit of this study is the realization that a single monitoring site in a "typical" habitat can provide information that is indicative of species diversity and population fluctuations for a much broader area of similar habitat. This can save time and energy in future field efforts.

The unique assortment of species interacting under the harsh criteria of a desert environment provides us with a grand laboratory for studying the intricacies of survival under a variety of conditions over time.

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