

Population Trends and Habitat Associations of Rodents in Southern Texas

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ABSTRACT.—Population trends for seven genera of rodents were monitored by snap-trap capture rates on a study area (700 km²) in Webb County, Texas, during winter from 1976 to 1986. Population irruptions occurred in 1982 (46-fold) and 1986 (13-fold) for *Sigmodon*, and in 1982 (17-fold) for *Reithrodontomys*. Annual variability in abundance was positively correlated between the following pairs of genera: *Sigmodon-Reithrodontomys*, *Peromyscus-Onychomys*, *Onychomys-Reithrodontomys*, and *Dipodomys-Chaetodipus*. Annual abundance of *Sigmodon* in winter was positively correlated with rainfall in the prior growing season. Analysis of the distribution of the composite rodent community among five vegetative habitats revealed greater abundance of rodents in the most dense and diverse shrub community (high-density shrub/mixed-grass habitat).

INTRODUCTION

Population fluctuations of desert rodents are associated with variations in precipitation which influence plant growth and seed production (Whitford, 1976; Brown and Zeng, 1989; Brown and Heske, 1990). Coexisting species with different life histories may exhibit contrasting patterns of fluctuation in the same environment (Brown and Heske, 1990).

The population dynamics (Whitford, 1976; Brown and Zeng, 1989) and community structure (Brown, 1989; Brown and Heske, 1990) of rodents in the Chihuahuan Desert of North America have been investigated extensively. However, rodent populations in the semiarid Tamaulipan Biotic Province of southern Texas and northeastern Mexico (Blair, 1952; Jahrsdoerfer and Leslie, 1988) have received limited attention. Brown and Heske (1990) stressed the importance of long-term studies in providing insights about the community dynamics of small mammals. Here I present data for trends in population abundance of seven genera of rodents in the Tamaulipan brushland of southern Texas for 11 y (1976–1986). I examine the effects of environmental factors and interspecific interactions on rodent population dynamics by analyses for relationships between variations in annual rodent abundance and rainfall and for covariation among taxa.

Rodent habitat use, and their competitive interactions for resources, has also been well-studied in the Chihuahuan Desert (Hallett, 1982; Brown, 1989; Rogovin *et al.*, 1991). In this study, I examine habitat use by the rodent community in southern Texas by analysis of rodent abundance in five vegetative habitats during a 4-y period (1981–1984), and assess intraspecific competition for habitats by analyses of rodent body mass.

METHODS

The study area of approximately 700 km² was located 5–40 km NE of Laredo, Webb County, Texas. The climate of the region is semiarid; annual rainfall at Laredo averages 51 cm (Windberg *et al.*, 1985) but is erratic among and within years (Norwine, 1978; Jahrsdoerfer and Leslie, 1988). Topography is level to rolling; drainages flow into the Rio Grande River (Windberg *et al.*, 1985). Soils are generally shallow and vary from fine sandy loam to clay.

Vegetation on the study area was typical of the Rio Grande Plains of southern Texas

(Gould, 1975; Archer *et al.*, 1988). The original vegetative community was a grassland-savannah climax, but present communities are dominated by dense stands of shrubs (Archer *et al.*, 1988). Extensive brush control by landowners results in varying stages of secondary plant succession (Jahrsdoerfer and Leslie, 1988). The study area was privately owned rangeland used for grazing by cattle.

In conjunction with other studies (Windberg and Mitchell, 1990; Windberg, 1995), four 24-km routes along unimproved roads were used for sampling rodent abundance in winter. The relative abundances of seven genera were estimated by capture rates in snap-trap surveys conducted from mid-January to early March, 1976–1986. Trap-transects ($n = 100$) were spaced 1 km apart along each of the four routes. Ten M-4 Victor rat traps with expanded treadles (5 by 5 cm), baited with a mixture of peanut butter and rolled oats, were spaced 10 m apart on each transect. The transects were operated for 4 consecutive days and effective trap-days ranged from 2782 to 3309/y. Indices of relative abundance of rodents were computed from total captures per unit of trap effort, and incorporated a correction for occupied and inoperable traps (Caughley, 1977). The sex and body mass of each rodent captured was recorded.

The seven taxa of heteromyid and murid rodents captured in this study were: hispid pocket mouse (*Chaetodipus hispidus*), Ord's kangaroo rat (*Dipodomys ordii*), fulvous harvest mouse (*Reithrodontomys fulvescens*), white-footed mouse (*Peromyscus leucopus*), northern grasshopper mouse (*Onychomys leucogaster*), hispid cotton rat (*Sigmodon hispidus*), and southern plains woodrat (*Neotoma micropus*). Because rodents were only identified to genus for this analysis, a few of the less common species of *Peromyscus* (*P. eremicus*, *P. maniculatus*, *P. pectoralis*), which may occur in the region (Davis and Schmidly, 1994), were probably incorporated into the generic category with the predominant species (*P. leucopus*).

Vegetation was sampled at each rodent trap site in June 1982. The point-centered quarter method was used to estimate species composition and density of shrubs (Cottam and Curtis, 1956), *i.e.*, four plants were sampled in ordinal compass bearings at each trap site ($n = 1000$ points). The height of each shrub sampled, excluding seedlings (<0.3 m), was recorded. Vegetative habitat types were subjectively classed as low-, medium-, and high-density shrub communities based on visual perspective at time of sampling, and were subsequently defined by analysis as <1500 and >4000 shrubs/ha for low- and high-density communities, respectively. The dominant ($>50\%$) grass cover within a 3-m radius of each trap site was rated as either curlymesquite (*Hilaria belangeri*) or mixed species of native grasses. Common curlymesquite is a perennial shortgrass which grows in clay soils and forms sod via stolons. The mixed-grass category included a variety of mid-sized and tall perennial grasses, such as *Cenchrus*, *Setaria*, *Bouteloua*, *Panicum*, *Chloris* and *Sporobolus*.

The vegetative data were analyzed to characterize habitat types based on: (1) shrub density; (2) composition of shrub species; (3) shrub height and (4) dominant herbaceous ground cover. Five vegetative habitats were defined: (1) low density of shrubs—pricklypear (*Opuntia engelmanni*) and curlymesquite; (2) low density of shrubs—mixed shrubs and curlymesquite; (3) medium density of shrubs and mixed-grass; (4) high density of shrubs and curlymesquite and (5) high density of shrubs and mixed-grass.

For analysis of rodent abundance in relation to vegetative habitats, data for the 2 winters preceding (1981–1982) and following (1983–1984) the year of vegetative sampling were combined. I assumed that vegetative measurements centered in the 4-y period were representative of habitats during those years because changes due to plant growth were minor.

To assess effects of the availability of food and cover on yearly fluctuations in rodent populations, cumulative rainfall during the prior growing season (March–October) was used as a relative measure of annual forage production (Whitford, 1976). Rainfall data from two

stations at Laredo, Texas (NOAA, 1975–1985; IBWC, 1975–1985) were averaged for this analysis. Rainfall was abundant in April–May 1982 (19.6 cm), which assured that the permanent herbaceous cover was evident at time of vegetative sampling. To assess potential intraspecific competition for food in the five vegetative habitats, as measured by differences in body condition, body masses of rodents were compared among habitats for those genera with sufficient data.

Annual variability in abundance of rodents was analyzed for each genus by the coefficient of variability (CV) and between genera, and in relation to rainfall, by linear correlation. Shrub densities for vegetative habitats, along with shrub height, were compared with 1-factor analysis of variance (ANOVA) and Duncan's Multiple-Range Test. Species composition of vegetative habitats was analyzed by chi-square tests of pairwise contingency tables. For rodent associations with habitats during 1981–1984, the number of trap-days and estimates of rodent abundance were compared with 1-factor ANOVA. Relative abundances of the seven genera of rodents in the five vegetative habitats were analyzed with contingency tables. Mean body masses of rodents were compared among habitats with 1-factor ANOVA. Statistical significance was inferred at $P < 0.05$.

RESULTS

Population trends.—During 1976–1986, I captured 4129 *Peromyscus*, 1280 *Onychomys*, 657 *Sigmodon*, 630 *Neotoma*, 458 *Reithrodontomys*, 247 *Dipodomys* and 192 *Chaetodipus*. Five northern pygmy mice (*Baiomys taylori*) were also captured but excluded from this analysis. The percentage of total rodents captured ($n = 7593$) declined over the 4 days of sampling from 29% to 27%, 24% and 20%.

Relative abundance of total rodents varied 3-fold during the 11-y study with greatest abundance in 1978 and 1979 (32.9 and 33.5 rodents/100-trap-days) and lowest in 1984 and 1985 (10.9 and 11.1 rodents/100-trap-days) (Fig. 1). Annual variability in abundance was greatest for *Sigmodon* (CV = 128%) and least for *Peromyscus* (CV = 35%), compared with the other genera (CV = 47–82%) (Fig. 1). Annual variability was statistically significant ($t \geq 2.5$, 9 df, $P \leq 0.04$) and positively correlated between *Peromyscus-Onychomys* ($r = 0.66$), *Onychomys-Reithrodontomys* ($r = 0.79$), *Sigmodon-Reithrodontomys* ($r = 0.69$) and *Dipodomys-Chaetodipus* ($r = 0.64$) (Table 1).

Annual variability in abundance of *Sigmodon* was positively correlated ($r = 0.72$, $t = 3.1$, 9 df, $P = 0.01$) with total rainfall during the preceding growing season (March–October). Variability in abundance of *Reithrodontomys* with rainfall was not statistically significant ($r = 0.55$, $t = 2.0$, 9 df, $P = 0.08$). The *Sigmodon* population irrupted 46-fold in 1982 and 13-fold in 1986 from abundance in the previous year, which were winters preceded by abundant rainfall (85.3 and 77.5 cm) in the growing seasons (Fig. 1). The *Reithrodontomys* population irrupted 17-fold from 1981 to 1982. There were no significant relationships ($r = 0.07$ – 0.39 , $t' \leq 1.3$, 9 df, $P \geq 0.21$) between abundance of the other genera, nor total rodents, and rainfall in the prior year. However, abundance of the five murids (*Peromyscus*, *Onychomys*, *Sigmodon*, *Neotoma*, *Reithrodontomys*) was relatively low during the low-rainfall years of 1983–1985 (Fig. 1).

To assess potential interspecific competition associated with variations in availability of food and ground cover, I analyzed for relationships between the annual percent composition of each genus among the rodent community and rainfall in the preceding growing season. The significant relationships were (1) a positive correlation ($r = 0.73$, $t = 3.2$, 9 df, $P = 0.01$) between percent composition of *Sigmodon* (1–29%) and rainfall and (2) a negative relationship ($r = -0.63$, $t = 2.4$, 9 df, $P = 0.04$) for *Dipodomys* (2–7%).

Habitat associations.—Five types of vegetative habitats were distinguished based on shrub

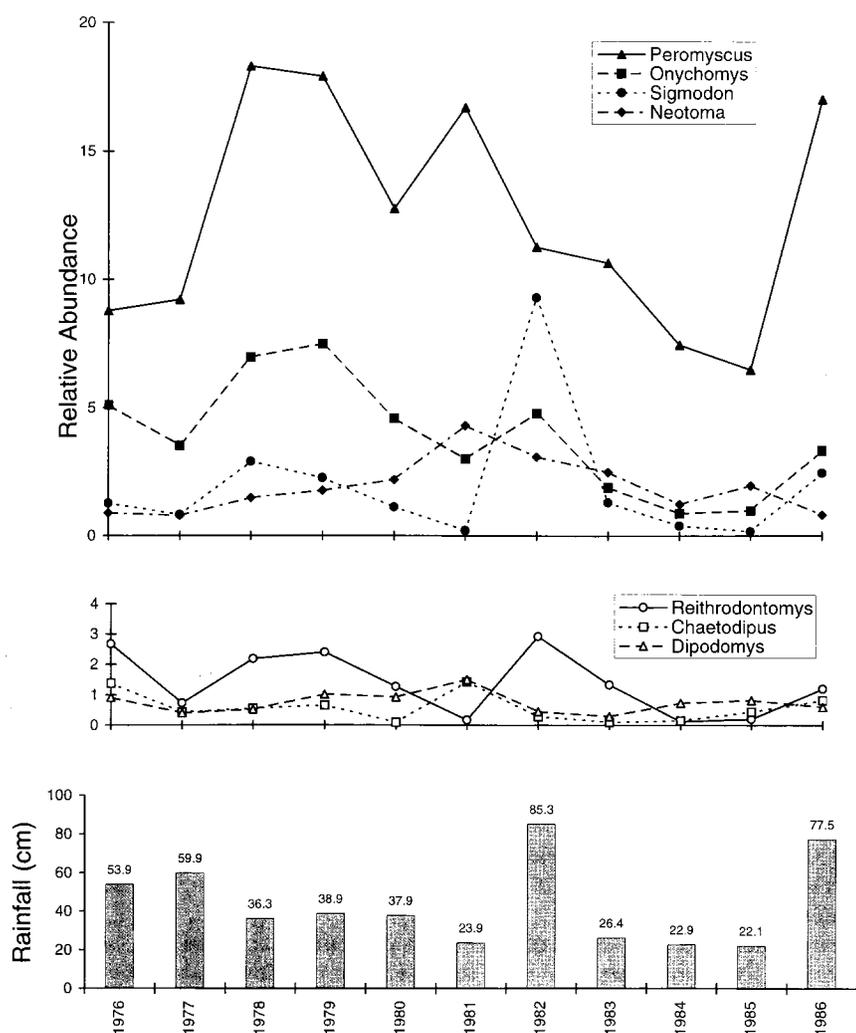


FIG. 1.—Annual relative abundance (n/100-trap-days) of seven genera of rodents in winter, and rainfall in preceding growing season (March–October), 1976–1986

density and the dominant herbaceous ground cover, along with the composition and height of shrub species (Table 2). Both low-density habitats had significantly lower ($P < 0.05$) shrub densities (<1500 shrubs/ha) and a relatively homogeneous ground cover of curlymesquite. Compared with the low-density shrub/curlymesquite habitat, the low-density pricklypear/curlymesquite habitat had a significantly greater ($X^2 = 96.1$, 1 df, $P < 0.001$) percentage (74%) of pricklypear, a low species richness ($n = 6$ vs. 14), and shorter ($F_{1,142} = 9.2$, $P < 0.01$) mesquite (*Prosopis glandulosa*) (Table 2). The high-density shrub habitats were distinguished from the medium-density shrub habitat by the higher ($P < 0.05$) shrub densities (>4000 shrubs/ha), and by a greater ($X^2 = 33.2$, 1 df, $P < 0.001$) occurrence of blackbrush (*Acacia rigidula*) which was also significantly ($F_{2,353} = 12.8$, $P < 0.001$) taller.

TABLE 1.—Correlation coefficients (r) for annual variations in relative abundance between genera of rodents, 1976–1986^a

| Genera | <i>Onychomys</i> | <i>Sigmodon</i> | <i>Neotoma</i> | <i>Reithrodontomys</i> | <i>Dipodomys</i> | <i>Chaetodipus</i> |
|------------------------|------------------|-----------------|----------------|------------------------|------------------|--------------------|
| <i>Peromyscus</i> | 0.66 | 0.17 | 0.21 | 0.30 | 0.27 | 0.32 |
| <i>Onychomys</i> | | 0.39 | -0.10 | 0.79 | 0.08 | 0.23 |
| <i>Sigmodon</i> | | | 0.20 | 0.69 | -0.38 | -0.19 |
| <i>Neotoma</i> | | | | -0.12 | 0.46 | 0.13 |
| <i>Reithrodontomys</i> | | | | | -0.25 | 0.09 |
| <i>Dipodomys</i> | | | | | | 0.64 |

^a Significant coefficients ($P \leq 0.04$) in boldface

The high-density shrub/mixed-grass habitat had a greater ($X^2 = 46.9$, 1 df, $P < 0.001$) species richness of shrubs ($n = 24$) than the high-density shrub/curlymesquite habitat ($n = 10$).

The number of trap-days in the five vegetative habitats did not differ significantly ($F_{3,24} = 0.1$, $P > 0.90$) among the 4 yr (1981–1984) included in this analysis. Likewise, there were no significant differences ($F_{3,24} = 2.5$, $P = 0.09$) in relative abundance of the seven genera of rodents in the habitat types among the 4 yr. Hence, captures of rodents ($n = 1972$) during the 4 yr were combined for analysis of relative abundance of each genus in the five habitats.

Relative abundance ($n/100$ -trap-days) of total rodents differed significantly ($X^2 = 52.8$, 4 df, $P < 0.001$) among the five vegetative habitats, with greatest ($X^2 = 4.5$, 1 df, $P = 0.04$)

TABLE 2.—Characteristics of five vegetative habitats

| Variables | Low density of shrubs (<1500 /ha) | | | High density of shrubs (>4000 /ha) | |
|--|---|--------------------------------------|--|--|-------------|
| | Pricklypear and curlymesquite | Mixed shrubs and curlymesquite | Medium density of shrubs and mixed grass | Curlymesquite | Mixed grass |
| % of rodent trapsites | 7 | 25 | 24 | 5 | 39 |
| No. species of shrubs | 6 | 14 | 23 | 10 | 24 |
| \bar{x} shrub density (plants/ha) ^a | 1322 (74) | 1480 (52) | 2128 (92) | 4272 (417) | 5879 (197) |
| % species composition: | | | | | |
| Pricklypear | 74 | 35 | 23 | 33 | 17 |
| Mesquite | 11 | 34 | 19 | 13 | 11 |
| Blackbrush | 0 | 3 | 12 | 33 | 21 |
| Other shrub species ^b | 15 | 28 | 46 | 21 | 51 |
| n (samples/habitat) | 197 | 765 | 727 | 147 | 1164 |
| \bar{x} shrub height (m) ^a | | | | | |
| Pricklypear | 0.5 (0.01) | 0.6 (0.02) | 0.7 (0.02) | 0.7 (0.04) | 0.8 (0.03) |
| Mesquite | 0.7 (0.09) | 1.1 (0.04) | 1.1 (0.06) | 1.1 (0.12) | 1.8 (0.08) |
| Blackbrush | | 1.2 (0.10) | 1.1 (0.06) | 1.5 (0.12) | 1.6 (0.04) |

^a SE of mean shown in parentheses

^b Included: tasajillo (*O. leptocaulis*) ($\leq 14\%$); lotebush (*Condalia obtusifolia*) ($\leq 11\%$); guayacan (*Porteria angustifolia*) ($\leq 8\%$); amargosa (*Castela texana*) ($\leq 6\%$); guajillo (*A. berlandieri*) ($\leq 7\%$); whitebrush (*Aloysia lycioides*) ($\leq 6\%$); granjeno (*Celtis pallida*) ($\leq 2\%$); 14 other species ($\leq 11\%$)

TABLE 3.—Relative abundance (n/100-trap-days) of rodents (n = 1972) in five vegetative habitats, 1981–1984

| Genera | Low density of shrubs (<1500/ha) | | | High density of shrubs (>4000/ha) | |
|------------------------|-------------------------------------|--------------------------------------|--|--------------------------------------|-------------|
| | Pricklypear and curlymesquite | Mixed shrubs and curlymesquite | Medium density of shrubs and mixed grass | Curlymesquite | Mixed grass |
| <i>Peromyscus</i> | 1.5 | 4.1 | 13.1 | 10.3 | 19.4 |
| <i>Onychomys</i> | 0.2 | 0.7 | 2.5 | 1.7 | 4.5 |
| <i>Sigmodon</i> | 0 | 1.4 | 2.5 | 1.8 | 4.5 |
| <i>Neotoma</i> | 0 | 0.8 | 2.2 | 2.0 | 6.2 |
| <i>Reithrodontomys</i> | 0.3 | 0.6 | 1.8 | 0 | 1.8 |
| <i>Dipodomys</i> | 0 | 0.3 | 1.3 | 0 | 0.9 |
| <i>Chaetodipus</i> | 0.2 | 0.2 | 0.3 | 0.4 | 0.3 |
| Total | 2.2 | 8.2 | 23.7 | 16.2 | 37.6 |

abundance in the high-density shrub/mixed-grass habitat and relatively low ($X^2 = 3.7$, 1 df, $P = 0.06$) abundance in the low-density pricklypear/curlymesquite habitat (Table 3). The distribution of *Peromyscus* differed significantly ($X^2 = 23.4$, 4 df, $P < 0.001$) among habitats with lower ($X^2 = 5.2-7.0$, 1 df, $P \leq 0.02$) abundance in the low-density pricklypear/curlymesquite and shrub/curlymesquite habitats. Occurrence of *Neotoma* also differed significantly ($X^2 = 10.4$, 4 df, $P = 0.03$) among habitats with greatest ($X^2 = 9.0$, 1 df, $P < 0.01$) abundance in the high-density shrub/mixed-grass habitat. Relative abundance of the other five genera did not differ significantly ($X^2 \leq 6.1$, 4 df, $P \geq 0.21$) among habitats (Table 3). Also, there were no significant differences ($X^2 \leq 2.3$, 1 df, $P \geq 0.14$) in the proportionate distribution of any of the seven genera within the five habitats.

There were no differences in mean body mass among the five habitats for either *Peromyscus* males ($F_{4,677} = 1.1$, $P = 0.37$) or females ($F_{4,389} = 0.6$, $P = 0.66$). Excluding the low-density pricklypear/curlymesquite and high-density shrub/curlymesquite habitats because of insufficient samples ($n < 5$), there were no differences in mean body mass among habitats for either: (1) *Onychomys* males ($F_{3,109} = 2.0$, $P = 0.13$) or females ($F_{2,102} = 1.6$, $P = 0.22$); (2) *Sigmodon* males ($F_{3,82} = 0.2$, $P > 0.75$) or females ($F_{3,131} = 1.6$, $P = 0.20$); or (3) *Neotoma* males ($F_{3,124} = 0.7$, $P = 0.56$) or females ($F_{2,149} = 0.6$, $P = 0.59$).

DISCUSSION

The rodent community on this study area included two granivores (*Dipodomys* and *Chaetodipus*), a herbivore (*Sigmodon*), an insectivore (*Onychomys*), and three omnivores (*Neotoma*, *Peromyscus*, *Reithrodontomys*) (Davis and Schmidly, 1994). Most granivores typically occupy open habitats, whereas the other species generally favor habitats with a protective canopy (Davis and Schmidly, 1994). *Peromyscus*, which was the numerically dominant taxon in the rodent community, is a habitat generalist (Adler and Wilson, 1987).

In the shrub communities on the study area, the greatest abundance of rodents occurred in the vegetative habitat of greatest density and diversity (high-density shrubs and mixed-grass). The availability of food and cover for rodents was likely greater in the more dense and diverse habitat. However, direct associations between abundance of rodents and the five types of vegetative habitats were not readily discernible for the individual genera. The only notable relationships were a greater abundance of *Neotoma* in the high-density shrub

and mixed-grass habitat and lower abundances of *Peromyscus* in the two low-density vegetative habitats. Box (1959) reported that densities of *Neotoma* dens were positively related to percent overhead-cover in four plant communities in southern Texas.

The granivores (*Dipodomys* and *Chaetodipus*) were evenly distributed in low abundance among all vegetative habitats in this study. There was no evidence of either interspecific or intraspecific competition among the taxa of rodents for food and cover as the proportionate composition of the seven genera did not differ among the five vegetative habitats. Also, there were no detectable differences in body mass of rodents among habitats for the genera analyzed.

High mortality rates are characteristic of the taxa in this rodent community and usually lead to complete population turnover annually (Spencer and Cameron, 1982, Lackey *et al.*, 1985; Brown and Zeng, 1989). Hence, my estimates of rodent abundance in winter generally reflect population recruitment for each year, which may have been affected by environmental conditions during the preceding year. Although total rainfall in the Tamaulipan Biotic Province averages substantially more than in the southwestern desert biomes of North America, extreme variability in rainfall patterns in this semiarid region (Norwine, 1978) strongly influences seasonal and annual forage growth.

Populations of the herbivorous *Sigmodon* responded to rainfall during the prior growing season. This direct relationship was apparently attributable to an immediate effect of annual rainfall on the availability of herbaceous forage. Both *Sigmodon* and *Reithrodontomys* (an omnivore) populations irrupted during a year of high rainfall (1982), and their variation in annual abundance was positively correlated. Both genera have exceptionally high reproductive capabilities which allow rapid responses to increased resources (Whitford, 1976), and they use similar habitats on the coastal prairie of Texas (Kincaid *et al.*, 1983). Sharp declines of both populations following their irruptions in 1982 were likely due to poor forage production during 3 yr of low rainfall. In addition, I observed a notable influx of raptors on the study area in 1983, which may have resulted in increased rodent mortality due to predation.

Populations of the two granivores (*Dipodomys* and *Chaetodipus*) also fluctuated in concert annually. A trend for a greater proportion of *Dipodomys* in the rodent community during lower rainfall years suggested that granivores were affected less by periods of drought than other taxa of rodents. A direct relationship in annual fluctuations of *Peromyscus* and *Onychomys* populations had no detectable association with rainfall. Raun (1966) suggested that heavy rainfall may cause substantial mortality of *Neotoma* due to flooding of their burrows. I found no relationship between abundance of *Neotoma* in winter and rainfall in the preceding growing season, but the population decline of *Neotoma* in 1986 (when most other rodents increased) may have been influenced by the high rainfall.

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