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Abstract

In this study, we describe seasonal dietary composition for 15 species of rodents collected in all major habitats on the Sevilleta National Wildlife Refuge (Socorro County) in central New Mexico. A comprehensive literature review of food habits for these species from throughout their distribution also is provided. We collected rodents in the field during winter, spring and late summer in 1998 from six communities: riparian cottonwood forest; piñon-juniper woodland; juniper-oak savanna; mesquite savanna; short-grass steppe; and Chihuahuan Desert scrubland. Rodents included *Spermophilus spilosoma* (Spotted Ground Squirrel), *Perognathus flavescens* (Plains Pocket Mouse), *Perognathus flavus* (Silky Pocket Mouse), *Dipodomys merriami* (Merriam's Kangaroo Rat), *Dipodomys ordii* (Ord's Kangaroo Rat), *Dipodomys spectabilis* (Banner-tailed Kangaroo Rat), *Reithrodontomys megalotis* (Western Harvest Mouse), *Peromyscus boylii* (Brush Mouse), *Peromyscus eremicus* (Cactus Mouse), *Peromyscus leucopus* (White-footed Mouse), *Peromyscus truei* (Piñon Mouse), *Onychomys arenicola* (Mearn's Grasshopper Mouse), *Onychomys leucogaster* (Northern Grasshopper Mouse), *Neotoma albigula/leucodon* (White-throated Woodrats), and *Neotoma micropus* (Southern Plains Woodrat). We collected stomach contents of all species, and cheek-pouch contents of heteromyids, and quantified them in the laboratory. We determined seasonal diets in each habitat by calculating mean percentage volumes of seeds, arthropods and green vegetation (plant leaves and stems) for each species of rodent. Seeds consumed by each rodent were identified to genus, and often species, and quantified by frequency counts. Comparisons of diets between and among species of rodents, seasons, and ecosystems were also examined. We provide an appendix of all plant taxa documented.

INTRODUCTION

In recent decades, ecologists have demonstrated the importance of rodents influencing the structure and functioning of arid and semi-arid ecosystems of the American Southwest. Most rodents are omnivorous, consuming large quantities of green vegetation, fruits, seeds, and animal prey (generally arthropods). While sometimes opportunistic in their selection of food items, rodents frequently display food preferences that typically lead to a disproportionately high consumption of preferred prey species (e.g., Reichman 1975; Soholt 1973; Best et al. 1993; but see Stamp and Ohmart (1978) for an alternative view). Field studies and manipulative experiments show that rodents, through their foraging behavior and diet selectivity, alter both plant and arthropod composition and abundance (Flake 1973; Brown et al. 1979; Inouye et al. 1980; Brown and Ojeda 1987; Parmenter and MacMahon 1988a, 1988b; Samson et al. 1992).

In view of documented impacts of rodents on southwestern ecosystems, considerable research efforts have been directed toward understanding foraging behaviors of rodents. Much of this research has focused on foraging behavior and prey selection (usually seed types) in terms of energy budgets (Reichman 1977; Stamp and Ohmart 1978; Parmenter et al. 1984; Kelrick et al. 1986; Jenkins and Ascanio 1993), seed spatial distributions and clumping (Reichman and Oberstein 1977; Bowers 1982; Harris 1984; Price and Reichman 1987), microhabitat use (Brown and Lieberman 1973; Stamp and Ohmart 1978; McCloskey 1980; Bowers 1982; Price and Waser 1985; Reichman and Price 1993), and competition (Davidson et al. 1980; Mitchell et al. 1990). While these studies are important to our understanding of foraging behaviors and ecology of rodents, many of the experiments utilized artificial mixtures of seeds containing non-native species, creating unavoidable shortcomings that inhibit, to an unknown degree, application of specific results to natural assemblages of rodents, plants, and arthropods.

Surprisingly, a relatively small number of studies have actually examined and quantified diets of wild rodents through analyses of stomach contents, cheek pouches, or fecal pellets. Many of these studies have generally focused on a single or small number of species of rodents

(Flake 1973; Reichman 1975; Meserve 1976; Smartt 1978; Best et al. 1993), on a single ecosystem (Best and Hoditschek 1982; Harris 1986; Dial 1988), or in a single season (Alcoze and Zimmerman 1973; Vaughan 1974).

Our main goal in this study was to survey diets of common murid, heteromyid and sciurid rodents inhabiting major communities of the Sevilleta National Wildlife Refuge (NWR) in central New Mexico. The Sevilleta NWR is the primary research site for the Sevilleta Long Term Ecological Research Program (LTER), and while considerable long-term research is being conducted on rodent communities, population dynamics, and rodent-plant interactions, detailed site-specific information on diets of rodents is lacking. Therefore, we addressed the following objectives: (1) determine diets of common species of rodents on the Sevilleta NWR; (2) quantify relative proportions of vegetation, seeds, and arthropods in the diet of each species of rodent; (3) compare diets of rodents over different seasons (spring, late summer, and winter); and (4) analyze differences in diets of rodents among different communities found on the Sevilleta NWR, in terms of both (a) total prey consumption—all species of rodents combined, and (b) within individual species of rodents that inhabit more than one community.

In addition to reporting on the specific diets of rodents at the Sevilleta NWR, we also conducted an extensive literature review and compiled a detailed summary of diet for each species of rodent based on these publications. We provided these data because we wanted to compare our results with those from other studies of the same species conducted in the western United States and because many of the primary data sets are located in reports, out-of-press books, and unpublished M.S. theses and Ph.D. dissertations that are difficult to acquire. Our efforts will provide a comprehensive review of all available data on food habits of our species of rodents in a single document.

STUDY SITES

The study was conducted on the Sevilleta National Wildlife Refuge (NWR), Socorro County, New Mexico (Fig. 1). The Sevilleta NWR encompasses nearly 100,000 ha, including two mountain ranges (Los Pinos Mountains and Sierra Ladrones) with the Rio Grande valley in between. The refuge straddles transition zones between the Chihuahuan Desert, the Great Plains short–grass steppe, the Colorado Plateau shrub–steppe, and the Mogollon mixed-conifer woodlands. Formerly a Spanish Land Grant and cattle ranch, the Sevilleta NWR was established in 1974. All livestock were removed from the refuge during 1974–76 and in 1988 it became a Long Term Ecological Research (LTER) Network site. Since that time, the refuge has been managed by the U.S. Fish and Wildlife Service for conservation, research, and environmental education.

Six dominant habitats were selected for study (Figs. 1, 2), each representing a point along a temperature/moisture gradient from forest to desert. These habitats included (1) cottonwood riparian forest along the Rio Grande, (2) piñon-juniper woodland, (3) juniper-oak savanna, (4) mesquite savanna, (5) short-grass steppe, and (6) Chihuahuan Desert scrubland. All sites are characterized by an arid to semi-arid climate regime, with approximately 60% of annual precipitation falling during July–September. We conducted this study during the El Niño year of 1998. Regional precipitation during the 1997–98 winter–spring was approximately 20% above average, but summer precipitation in 1998 was approximately 15% below average (Sevilleta LTER meteorological data: http://sev.lternet.edu/).

Cottonwood Riparian Forest

The Rio Grande flows through the middle of the Sevilleta NWR and is lined with gallery cottonwood forests. Our study site was located on the west bank of the river, near the NM State Highway 60 bridge east of Bernardo, NM (latitude 34°25'0"N, longitude 106°48'0"W, elevation 1,441 m). The site consisted of flat, forested terrain that supported a mature riparian forest habitat ("bosque") with a thick litter layer of leaves and woody debris (Fig. 2, A). Vegetation was dominated by Rio Grande valley cottonwood (*Populus deltoides wislizeni*), salt cedar (*Tamarix ramosissima*), and Russian olive (*Elaeagnus angustifolia*), Virgin's bower (*Clematis ligusticifolia*), spiny aster (*Chloracantha spinosa*) and several species of dropseed (*Sporobolus* spp.). Soils were sandy near the riverbanks, and were classified as Typic Ustifluvents (Johnson 1988). Mean annual precipitation is 207 mm, with a mean daily minimum temperature of –8.1° C in January and a mean daily maximum temperature of 34.7° C in July (Sevilleta LTER meteorological data: http://sev.lternet.edu/).

Piñon–Juniper Woodland

Piñon-juniper woodlands dominate higher elevations of the Los Pinos Mountains on the Sevilleta NWR (Fig. 2, B). Our study site was located in Montoso Canyon and the upper part of the Goat Draw watershed (latitude 34°21'50"N, longitude 106°32'13"W, elevation 1920 m). Piñon pine (*Pinus edulis*), one-seed juniper (*Juniperus monosperma*) and shrub live oak (*Quercus turbinella*) dominated the overstory. Dominant shrubs and succulents included squawberry (*Rhus trilobata*), mountain mahogany (*Cerocarpus montanus*), banana yucca (*Yucca baccata*), and bear grass (*Nolina microcarpa*). Milkvetch (*Astragalus missouriensis*) and Fendlers bladderpod (*Physaria fendleri*) were the

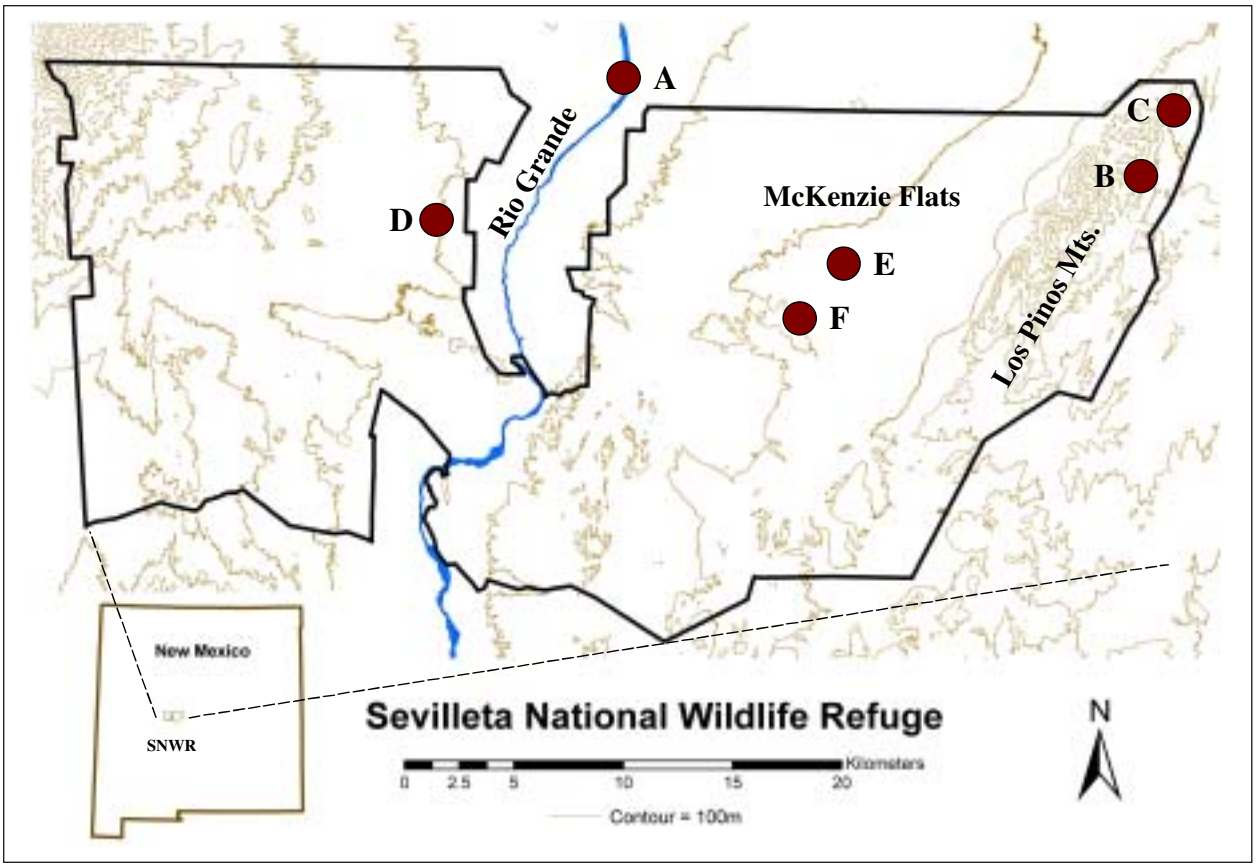

Figure 1. Locations of study sites on the Sevilleta National Wildlife Refuge, Socorro County, New Mexico. Lettered dots indicate collection sites and correspond to photographs in Fig. 2: (A) cottonwood riparian forest; (B) piñon-juniper woodland; (C) juniper oak savanna; (D) mesquite savanna; (E) short-grass steppe; (F) Chihuahuan Desert scrubland.

dominant forbs. Blue grama (*Bouteloua gracilis*) and hairy grama (*B. hirsuta*) were the dominant grasses. Soils were a combination of the Deama and Puerticito Rock series, with slopes from 3–60%, and composed of loamy-skeletal, carbonatic, mesic Lithic Calciustolls to mixed, mesic Lithic Ustollic Haplargids (Johnson 1988). Mean annual precipitation is 373 mm, with a mean daily minimum temperature of –2.8° C in January, and a mean daily maximum of 30.5° C in July (Sevilleta LTER meteorological data: http://sev.lternet.edu/).

Juniper–Oak Savanna

Savannas with juniper and oak trees dominate the lower elevations of the Los Pinos Mountains. Our study site was located in the lower part of the Goat Draw watershed (latitude 34°24'03"N, longitude 106°31'19"W, elevation 1770 m). The valley is characterized by rolling hills (Fig. 2, C), having predominantly east- and west-facing aspects with slopes of 1–30%. One–seed juniper and shrub live oak were the dominant trees, while Apache plume (*Fallugia paradoxa*) and walking stick cholla (*Opuntia imbricata*) were the dominant shrub and cactus, and Nuttall's locoweed (*Astragalus nuttallianus*), Fendler bladderpod, blue grama and dropseeds (*Sporobolus* spp.) were the dominant forbs and grasses. Soils were classified as the Sedillo-Clovis association, composed of fine loamy/loamy skeletal, mixed, mesic Ustollic Haplargids (Johnson 1988). Mean annual precipitation is 319 mm, with a mean daily minimum temperature of –3.2° C in January and a mean daily maximum of 31.1° C in July (Sevilleta LTER meteorological data: http://sev.lternet.edu/).

Mesquite Savanna

Savannas dominated by mesquite are found at mid to low elevations near the University of New Mexico's Sevilleta Research Field Station. Our study site was located adjacent to the Sevilleta Research Field Station and is characterized by gently rolling, east-facing hills separated by arroyos (latitude 34°21'11"N, longitude 106°52'55"W, elevation 1480 m; Fig. 2, D). The site was dominated by honey mesquite (*Prosopis glandulosa*), with widely dispersed one-seed juniper and creosotebush (*Larrea tridentata*). Other shrubs, such as Apache plume,

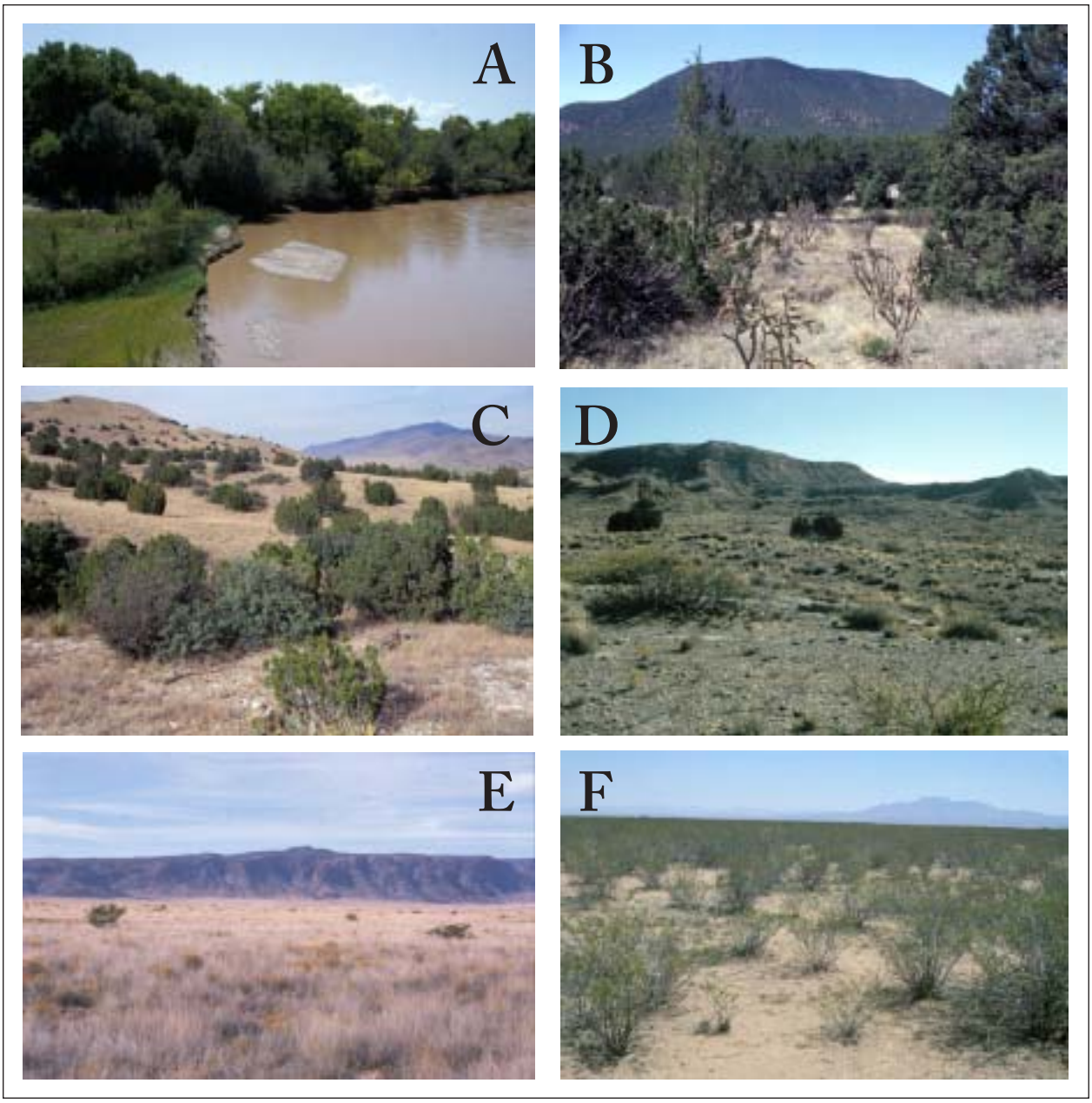

Figure 2. Photographs of study sites on the Sevilleta National Wildlife Refuge, Socorro County, New Mexico. (A) cottonwood riparian forest; (B) piñon-juniper woodland; (C) juniper-oak savanna; (D) mesquite savanna; (E) short-grass steppe; (F) Chihuahuan Desert scrubland.

fourwing saltbush (*Atriplex canescens*), and indigo bush (*Psorothamnus scoparius*) were abundant. Forbs were dominated by globemallow (*Sphaeralcea fendleri*), white ragweed (*Hymenopappus filifolius*), and bladderpod, and grasses dominated by Indian ricegrass (*Achnatherum* [*Oryzopsis*] *hymenoides*) and dropseed (*Sporobolus* spp.). The soil was classified as the Blupoint–Caliza complex, consisting of sandy skeletal, mixed, thermic Typic Torripsamments/Calciorthids (Johnson 1988). Mean annual precipitation is 237 mm, with a mean daily minimum temperature of –4.5° C in January and a mean daily maximum of 34.2° C in July.

Short–Grass Steppe

Short–grass steppe dominates the plains west of the Los Pinos Mountains on the Sevilleta NWR. Our study site was located on a flat, grassy plain, known locally as McKenzie Flats (latitude 34°21'07"N, longitude

106°41'20"W, elevation 1606 m; Fig 2, E). The site was dominated by a variety of grasses, including blue grama, black grama (*Bouteloua eriopoda*), purple three-awn (*Aristida purpurea*), fluff grass (*Dasyochloa pulchellum*) and several dropseeds (*Sporobolus flexuosus*, *S. contractus*, and *S. cryptandrus*). Common forbs included Indian rushpea (*Hoffmannseggia glauca*), globemallow, bladderpod, and several species of spurge (*Chamaesyce* spp.). Scattered shrubs included fourwing saltbush and snakeweed (*Gutierrezia sarothrae*). In areas, soapweed yucca (*Yucca glauca*) was locally abundant. Soils were classified as Berino-Dona Ana association, consisting of fine-loamy, mixed, thermic Typic Haplargids (Johnson 1988). Mean annual precipitation is 244 mm, with a mean daily minimum temperature of –7.3° C in January and a mean daily maximum of 33.2° C in July (Sevilleta LTER meteorological data: http://sev.lternet.edu/).

Chihuahuan Desert Scrubland

Scrubland typical of the Chihuahuan Desert creosote community dominates lower elevations and southern areas of the Sevilleta NWR both east and west of the Rio Grande. Our study site was located at the southern end of McKenzie Flats, where the grassland changed to desert scrubland (Fig 2, F). The study area included both flat terrain of McKenzie Flats and the slopes and bottom of a broad canyon, known locally as Palo Duro Canyon (latitude 34°19'41"N, longitude 106°42'22"W, elevation 1630 m). The site was dominated by creosotebush, with scattered prickly pear cacti (*Opuntia phaeacantha*, *O. macrocentra* [*violacea*]), club cholla (*O. clavata*), and soapweed yucca. The mostly bare soil supported occasional forbs, including stickseed (*Lappula occidentalis*), hiddenflower (*Cryptantha crassisepala*), dwarf skyrocket (*Ipomopsis pumila*), and tansy mustard (*Descurania obtusa*). Grasses, while rare, included black grama, dropseed, and fluff grass. Soils were classified as the Turney Series, consisting of fine-loamy, mixed, thermic Typic Calciorthids (Johnson 1988). Mean annual precipitation is 240 mm, and mean monthly temperatures range from –4.7° C in January to 32.9° C in July (Sevilleta LTER meteorological data: http://sev.lternet.edu/).

METHODS

Field Sampling

We collected rodent specimens during three sampling periods in 1998: winter (27 January– 3 February), late spring (27 May–28 June), and late summer (31 August–18 September). We sampled all habitats in each period with a line of 120 Victor® snap traps set at 60 trap stations with one large rat-trap and one small mouse-trap at each station. We set trap stations ~25 m apart and baited traps with a mixture of rolled oats and peanut butter. We set traps in the evening, and checked them early each morning. Each sampling period continued until at least 15 individuals of the most abundant rodent species were caught depending on both habitat type and time of year.

Diet Analyses

At the Sevilleta Research Field Station laboratory, we identified rodents to species, and dissected them to remove the gastro-intestinal tract. Stomach contents were removed and placed in labeled vials with 70% ethanol. We also removed contents of cheek pouches from heteromyid rodents and stored them in dry labeled vials. For each specimen we recorded species, sex, reproductive condition, age, mass, and body measurements (lengths of total body, tail, right hind foot, and ear). All individuals were prepared as vouchers and archived in the Museum of Southwestern Biology, Division of Mammals, at the University of New Mexico and assigned New Mexico Kryovoucher (NK) numbers (series: NK42399–NK42500, NK45238–NK45500, and NK47501–NK47773). Field protocols and animal collection procedures were in accordance with the permit obtained by the Museum of Southwestern Biology from the New Mexico Department of Game and Fish (Permit #1509).

Our methods of diet analysis in this study followed those of DeBlase and Martin (1981). Contents of each stomach were placed in a petri dish and thoroughly mixed to loosen material and to give all constituents a uniform distribution. We examined contents under a binocular dissecting scope at 20x magnification to identify material. All layers of the material were examined to ensure none was overlooked.

For each stomach sample, an ocular estimate to the nearest 10% was made of the relative quantities (volumes) of seed material, plant material, and arthropod material. We acknowledge that these 10% categories are coarse, but attempted to ensure consistency of estimates through-out the study by having the senior author perform all volume estimates. Estimated percentages for the above categories were based on the identifiable parts present, including those from fruits and seed coats, arthropod exoskeletons, and foliar plant materials.

While plant leaves and minute insect parts were difficult to identify to species, seeds were more conducive to detailed identifications. We identified seeds by comparing seed coat fragments to a seed reference collection compiled from the Museum of Southwestern Biology Herbarium. Identification of seeds was enhanced by macerating samples of known reference seed materials to simulate their appearance in stomach samples. Seeds from each stomach were identified and recorded as present/absent because mastication by rodents made it impossible to consistently quantify numbers of each

species of seed consumed. Lastly, for heteromyid rodents, we identified contents of cheek pouches and counted numbers of each species of seed present. This permitted us to compare species of seed from stomach and cheek pouches for these rodents, as well as differences in seed harvesting between and among rodent species.

Data Analysis

Diets of each species of rodent were determined from the list of prey species (plants and arthropods) observed in samples from stomachs and cheek pouches. We derived mean prey quantity (percentage volume) specific to each species for each diet category (vegetation, seed, arthropod) by averaging data from all individuals collected in each habitat during each season. We cate-gorized data for species of seeds eaten into the following groups: tree, shrub, grass, and forb. Relative abundance of each category of seed in each species of rodent was given by calculating percentages for each category based on counts of occurrence (frequency). For example, in a sample of 23 *Peromyscus boylii* from winter in piñon-juniper habitat, 20 consumed juniper berries and 17 consumed acorns. This totals 37 "counts" of seeds from trees, and when divided by the number of total "counts" of all seeds from all types of plants ingested by the 23 mice (in this case, 51 total "counts" of various seed species), seeds in the tree category accounted for 72% (37/51).

To examine variation in prey consumed by the entire rodent community (all species pooled) between seasons and habitats, non-parametric Kruskal–Wallis one–way ANOVA tests were performed. Data were initially checked for normality using the D'Agostino test and several transformation options (Zar 1974), but persistent lack of normality in some samples prevented use of parametric testing. We first tested the null hypothesis that prey consumption (by percentage volume) did not differ significantly between habitat types within each season. We then tested the null hypothesis that prey use did not differ significantly by season in each habitat.

Species Accounts of Diet Composition

During this study, we collected 625 rodents representing 15 species from a total of 11,258 trap nights for analysis of stomach contents (Table 1). Differences in sample sizes among species led to varying levels of dietary resolution. Species with large sample sizes yielded more detailed diet information. Nonetheless, from our results for diets of specific species, we describe diets for all species collected during our study and have cautiously interpreted those results from particular species, sites, or seasons that were based on small sample sizes. Taxonomy of rodent species follows Wilson and Reeder (1993) and Frey (2004), with order of presentation following Wilson and Ruff (1999), wherein families and genera are presented phylogenetically and species are presented alphabetically within genera. Nomenclature of arthropods follows Poole and Gentili's (1996-1997) *Nomina Insecta Nearctica*. Taxonomy of plants follows U.S. Department of Agriculture's Kartez nomenclature (as of 2006: http://plants.usda.gov) as it is an online resource regularly updated. However, for flora of New Mexico we also recommend the Working Index of New Mexico Vascular Plant Names compiled by Kelly Allred (as of 2006: http://spectre.nmsu.edu/dept/academic.html?i=1742) as an accurate cross–reference. Many of the primary sources of literature we reference are books, monographs, reports, and journal articles from the 19th and early 20th Centuries that refer to plant taxa whose nomenclature has changed markedly over the years. In this report, we provide current nomenclature for each plant species, and note the original botanical species name [in brackets] as it was found in its respective publication. A listing of current and original names of plant species (as found in the cited literature sources) is provided in Appendix 1.

FAMILY SCIURIDAE

***Spermophilus spilosoma* Bennett 1833**
Spotted Ground Squirrel

The spotted ground squirrel is the only sciurid we collected in this study, although two chipmunks (*Neotamias quadrivittatus*, *N. dorsalis*), the rock squirrel (*S. variegatus*), the Texas antelope squirrel (*Ammospermophilus interpres*), and Gunnison's prairie dog (*Cynomys gunnisoni*) also occur at low densities within the Sevilleta NWR (Friggens 2003). Predictably for *S. spilosoma*, we only collected specimens in spring and late summer sampling because this species is known to hibernate in winter. Specimens of *S. spilosoma* were collected in short–grass steppe (n=4), mesquite savanna (n=4), and Chihuahuan Desert scrubland (n=1; Table 1). Our small sample size of this species (n=9) limits our ability to accurately describe the diet.

In the diet of *S. spilosoma*, prey types by volume were roughly equal in the mean proportions of seeds (29%), plants (39%), and arthropods (32%) consumed. Green plants were discovered most often in the diet during spring (62% by volume) compared to summer (20% by volume), while arthropods remained a consistent component (29% in spring, 35% in summer). Seeds were a relatively minor component of diet in spring (9% by volume), but increased in frequency in summer (45% by volume). In short-grass steppe, seeds in the diet consisted entirely of forbs, including *Astragalus* sp., *Cryptantha crassisepala*, *Lappula occidentalis*, *Physaria* sp., *Oenothera albicaulis*, *Plantago patagonica*, and an unidentified Asteraceae. In mesquite savanna, seeds consumed included honey mesquite (*Prosopis glandulosa*), Indian rice

TABLE 1. List of rodents sampled on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent sample sizes by sampling period within habitat (Wi=winter; Sp=spring; Su=summer).

	Cottonwood riparian forest			Piñon-juniper woodland			Juniper-oak savanna			Mesquite savanna			Short-grass steppe			Chihuahuan Desert scrubland			Seasonal totals			Total
Sampling period	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	
Trap nights	120	240	120	300	600	960	248	240	600	390	1080	1320	480	1200	840	480	1080	960	2018	4440	4800	11258
Sciuridae																						
Spermophilus spilosoma Spotted ground squirrel	—	—	—	—	—	—	—	—	—	—	1	3	—	3	1	—	—	1	—	4	5	9
Heteromyidae																						
Perognathus flavescens Plains pocket mouse	—	—	—	—	—	—	—	—	—	—	4	8	—	—	—	—	—	—	—	4	8	12
Perognathus flavus Silky pocket mouse	—	—	—	—	—	—	—	—	5	1	—	3	—	5	3	—	15	1	1	20	12	33
Dipodomys merriami Merriam's kangaroo rat	—	—	—	—	—	—	—	2	—	18	9	3	—	—	—	1	4	2	19	15	5	39
Dipodomys ordii Ord's kangaroo rat	—	—	—	—	—	—	—	—	—	3	2	6	10	5	6	—	—	1	13	7	13	33
Dipodomys spectabilis Banner-tailed kangaroo rat	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	—	3	—	3

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[TABLE 1, continued.] List of rodents sampled on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent sample sizes by sampling period within habitat (Wi=winter; Sp=spring; Su=summer).

	Cottonwood riparian forest			Piñon-juniper woodland			Juniper-oak savanna			Mesquite savanna			Short-grass steppe			Chihuahuan Desert scrubland			Seasonal totals			Total
Sampling period	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	Wi	Sp	Su	
Trap nights	120	240	120	300	600	960	248	240	600	390	1080	1320	480	1200	840	480	1080	960	2018	4440	4800	11258
Muridae																						
Reithrodontomys megalotis Western harvest mouse	—	—	—	1	1	—	13	1	—	4	—	—	—	—	—	1	—	—	19	2	—	21
Peromyscus boylii Brush mouse	—	—	—	23	16	5	—	—	—	—	—	—	—	—	—	—	—	—	23	16	5	44
Peromyscus eremicus Cactus mouse	—	—	—	—	—	—	—	—	—	1	—	2	—	—	—	1	—	—	2	—	2	4
Peromyscus leucopus White-footed mouse	22	23	25	1	1	—	39	13	18	1	4	3	—	1	1	4	2	2	67	44	49	160
Peromyscus truei Pinon mouse	—	—	—	17	25	15	15	24	6	2	5	3	—	1	—	—	1	1	34	56	25	115
Onychomys arenicola Mearn's grasshopper mouse	—	—	—	2	—	—	8	1	8	1	—	1	11	4	5	5	2	7	27	7	21	55
Onychomys leucogaster Northern grasshopper mouse	—	—	—	—	—	—	—	—	—	5	6	2	—	—	—	—	—	—	5	6	2	13
Neotoma albigula White-throated woodrat	—	—	—	2	7	2	4	3	17	9	16	12	—	6	—	—	—	—	15	32	31	78
Neotoma micropus Southern plains woodrat	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	4	1	—	5	1	6
Total number of individuals	22	23	25	46	50	22	79	45	54	45	47	46	21	26	16	12	30	16	225	221	179	625
Total number of species	1	1	1	6	5	3	5	7	5	10	8	11	2	8	5	5	7	8	11	14	13	15

grass (*Achnatherum hymenoides*), and a variety of forbs (*Astragalus* sp., *Dalea* sp., *Helianthus* sp. *Hoffmanseggia glauca*, *Physaria* sp., *Linum* sp., *Machaeranthera canescens*, and an unidentified Asteraceae). The single specimen collected in Chihuahuan Desert scrubland consumed seeds of *Opuntia* sp., *Muhlenbergia* sp., and *Sphaeralcea* sp. Overall, seeds of forbs made up 83% of seeds observed in the diet, with grasses, shrubs, and trees represented by small proportions (9%, 4%, and 4%, respectively).

The generalist nature of *S. spilosoma* has been noted in previous studies. In New Mexico and Texas, Bailey (1905, 1931) recorded a wide variety of green vegetation, seeds, and arthropods (grasshoppers and beetles) in their diet, and he noted that these squirrels were "fond of fresh meat" (Bailey 1931, p. 111). Green vegetation in the diet of *S. spilosoma* included primarily forbs, shrub, and cactus seeds, including sand burr (*Tribulus terrestris* [*tribuloides*]) sunflower (*Helianthus* sp.), four-wing saltbush (*Atriplex canescens*), mesquite (*Prosopis glandulosa*) and wild gourd (presumably *Cucurbita foetidissima*).

In southern New Mexico, Wood (1969) examined 291 stomachs of *S. spilosoma* collected from six vegetation assemblages (black grama grassland, creosotebush scrubland, mesquite scrubland, chamiza-mesquite scrubland, tobosa grassland, and an area dominated by annual forbs). Animal material made up 58% of the diet by volume, composed of unidentified insects (23%), caterpillars (18%), termites (9%), ants (2%), rodents (5%), and lizards (1%). Green vegetation contributed 38%, of which *Ephedra* sp. and flowering blooms of succulents were major components, while seeds accounted for only 5% of the volume of diet (Wood 1969).

In southeastern New Mexico, Best et al. (1993) discovered arthropod materials in stomachs of 64 of 70 individuals (91%), with arthropods comprising 38% of all items consumed. Vegetation (leaf and fiber material) was observed in 54% of individuals, making up 48% of items consumed. Best et al. (1993) reported finding seeds and leaves of 25 taxa of plants in the diet of *S. spilosoma*. The most common plants included various grasses (Poaceae), *Croton* sp., and *Prosopis glandulosa*. Other species in descending order of abundance included *Sphaeralcea* sp., *Oenothera* sp., *Triplasis purpurea*, *Quercus havardii*, *Chamaesyce* [*Euphorbia*] sp., *Ephedra* sp., *Helianthus petiolaris*, *Descurania pinnata*, *Phacelia crenulata* [*corrugata*], *Astragalus* sp., *Linum aristatum*, *Yucca campestris*, *Palafoxia sphacelata*, *Sporobolus cryptandrus*, *Mentzelia* sp., *Boerhaavia intermedia*, and 6 unidentified species.

In central New Mexico, Sumrell (1949) conducted direct observations on feeding behavior and examined stomach contents of 51 *S. spilosoma*. The following plants were found in the diet in descending order of abundance: *Salsola tragus* [*pestifer*], *Tribulus terrestris*, *Achnatherum* [*Oryzopsis*] *hymenoides*, *Cucurbita foetidissima*, *Thelesperma megapotamicum*, *Eriogonum* sp., *Sporobolus contractus*, *Echinocactus papyracanthus*, *Mentzelia pumila*, *Dimorphocarpa* [*Dithyrea*] *wislizeni*, *Baileya multiradiata*, *Caesalpinia* [*Hoffmanseggia*] *drepanocarpa*, *Solanum elaeagnifolium*, and *Munroa squarroso*. Arthropods, while not a large proportion of the total volume, were discovered in most stomachs examined and one stomach contained remains of a lizard.

In western Oklahoma, McCulloch (1959) observed that arthropods constituted the major component in the stomachs of 24 *S. spilosoma* and ranged from 25% to 82% by volume over three summers (1956–58). Green vegetation, consisting of leaves primarily of forbs, ranged from 5–66% by volume, while seeds contributed 3–70% of the volume. Seeds from the following species were observed: *Sporobolus cryptandrus*, *Nuttallanthus* [*Linaria*] *canadensis*, *Silene antirrhina*, and *Lepidium densiflorum* (McCulloch 1959).

In northeastern Colorado, Streubel (1975) and Streubel and Fitzgerald (1978) reported that in spring, *S. spilosoma* fed upon seeds of *Solanum rostratum*, *Mentzelia nuda* [*nudastricta*], and *Croton texensis*, as well as green shoots and seeds of grasses, particularly *Vulpia* [*Festuca*] *octoflora*. Grasshoppers were an important dietary component in mid- and late-summer. Vertebrates also were eaten by *S. spilosoma*, as Streubel (1975) observed these squirrels feeding upon Ord's kangaroo rat (*Dipodomys ordii*), lesser earless lizards (*Holbrookia maculata*), and six-lined racerunners (*Aspidoscelis* [*Cnemidophorus*] *sexlineatus*).

FAMILY HETEROMYIDAE

For Heteromyid rodent species, stomach contents and cheek pouch contents were analyzed. This was useful because not only could cheek pouch contents be quantified by counting seeds, but also it was possible to compare prey species found in cheek pouches with those found in stomach contents.

Perognathus flavescens Merriam 1889
Plains Pocket Mouse

During this study, the plains pocket mouse was collected only from mesquite savanna habitat during spring and summer (Table 1). While our small sample (n=12) limited a detailed analysis of diet, results indicated that seeds of forbs and grasses comprised the majority of the diet (Tables 2, 3). Arthropods occurred relatively rarely, and green vegetation was not observed at all. During the spring, seeds from Indian rice grass (*Achnatherum hymenoides*) were commonly discovered in the diet (Table 2), whereas summer forbs dominated samples from late summer. Seeds and fruits from shrubs

TABLE 2. List of items discovered in the diet of the plains pocket mouse (*Perognathus flavescens*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season; values for cheek pouch contents represent total numbers of seeds. No specimens were collected during winter.

Items	Stomach contents		Cheek pouch contents	
	Spring (n=4)	Summer (n=8)	Spring (n=4)	Summer (n=5)
Arthropods	0	12	0	0
Vegetation	0	0	0	0
Seeds	100	100	178	55
Grasses:				
Achnatherum hymenoides	100	—	116	—
Aristida sp.	25	—	—	—
Poaceae, unidentified species	—	12	—	—
Sporobolus sp.	—	12	—	—
Forbs:				
Chamaesyce sp.	25	—	—	—
Eriogonum sp.	—	38	—	45
Fabaceae, unidentified species	—	—	1	—
Hymenopappus filifolius	50	75	61	—
Lappula occidentalis	—	—	—	10

and trees were not observed in the diet, but this was likely an artifact of our small sample size.

Unlike other heteromyid analyses in this study, cheek pouch samples of *P. flavescens* reflected stomach contents reasonably well (Table 2), at least in terms of the numerically dominant species. While only 3 of the 9 plant species were discovered in contents of both stomachs and cheek pouches, these 3 species were numerically the most abundant species in both cases and ranked in the same order of abundance in stomachs and cheek pouches (Table 2).

Previous studies of *P. flavescens* also indicated a highly granivorous diet, supplemented with arthropods on many occasions (Monk and Jones 1996). In Texas and New Mexico (Bailey 1905, 1931), *P. flavescens* (= *P. apache*) collected mainly seeds from *Dalea* sp., *Helianthus* sp., *Croton texensis*, and *Lolium perenne*. Individuals captured in agricultural fields growing millet, had cheek pouches filled with millet seeds (*Panicum miliaceum* [*millefolium*]).

In the canyon country of southeastern Utah, Armstrong (1982) examined the stomach contents and cheek pouches of 7 *P. flavescens* and found remarkably similar dietary proportions to our individuals from the Sevilleta NWR. The diet in the Utah population based on stomach contents was 81% seeds, 9% insects, 8% stems and leaves, and 1 % fungus (compare to Table 3), while cheek pouch contents revealed seeds of 7 species, dominated by *Achnatherum* [*Oryzopsis*] *hymenoides* (compare to Table 2). Other species represented in his cheek pouch seed list included *Malacothrix* sp., *Astragalus* sp., *Lupinus* sp., *Helianthus* sp., *Agropyron* sp., and *Vulpia* [*Festuca*] sp. Armstrong (1982) reported that the fraction of arthropods in the data set was nearly all due to a single individual *P. flavenscens*, and that the stomach was approximately half full of insect parts; similarly, in our sample at the Sevilleta NWR, arthropods in the data set are due to a single individual's consumption of insects (Table 2).

Populations of *P. flavescens* in northeastern Colorado were found to have collected a large variety of seeds from forbs and grasses (Mohamed 1989). The study was based on contents of cheek pouches and the species of plants included spiderwort (*Tradescantia occidentalis)*, Indian ricegrass (*Achnatherum* [*Oryzopsis*] *hymenoides*), needlegrass (*Hesperostipa* [*Stipa*] *comata*), lupine (*Lupinus pusillus*), scurfpea (*Psoralidium* [*Psoralia*] sp.), three-awn grass (*Aristida purpurea* [var. *longiseta*]), stoneseed (*Lithospermum* sp.), bindweed (*Convolvulus arvensis*), milkvetch (*Astragalus missouriensis* and *Astragalus* sp.), and *Cryptantha fendleri* (Mohamed 1989).

In the Nebraska sand hills, Lemen and Freeman (1985) conducted a rodent-tracking experiment on

TABLE 3. Summary of prey types of the plains pocket mouse (*Perognathus flavescens*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Mesquite savanna	Spring	4	100	0	0	0	0	63	37
	Summer	8	87	0	13	0	0	18	82
Total means (%)		12	91	0	9	0	0	33	67

P. flavescens using ultraviolet-fluorescing powders to determine movements, locations of burrows, and types of forage. They observed that *P. flavescens* routinely climbed up stalks of sedges (*Carex* sp.) to harvest fruiting heads.

In an agricultural region of the Great Plains of Kansas, Reed and Choate (1986) analyzed contents of both stomachs (n=33) and cheek pouches (n=18), along with one underground cache of seeds of *P. flavescens*. They found that seeds were the most common item found in stomachs, and only 3 stomachs contained parts of insects (identified as ants [Hymenoptera: Formicidae]). Corn (*Zea mays* [*maes*]) made up 48.7% of the dry mass of contents in cheek pouches, with other species contributing mass as follows: an unidentified species of the Polygonaceae (13.1%), *Setaria* sp. (12.3%), *Lithospermum* sp. (6.3%), *Paspalum* sp. (4.6%), *Ambrosia* sp. (3.0%), and 10 other species comprising the remainder (*Lycopus* sp., *Croton texensis*, *Cenchrus spinifex* [*pauciflorus*], *Carex* sp., *Panicum* sp., *Hesperostipa* [*Stipa*] sp., *Digitaria* sp., *Vulpia* [*Festuca*] sp., and two unidentified species). In addition, some cheek pouches contained leaves and stems of plants, and parts of ant bodies (Hymenoptera: Formicidae). The cache consisted of *Croton texensis* (67.3%), *Lithospermum incisum* (26.2%), and nine other species (total of 6.5%) (Reed and Choate 1986).

In the grasslands of Minnesota, Hibbard and Beer (1960) examined contents of cheek pouches (n=21) and excavated caches of seeds (n=8) of *P. flavescens*. They found a large variety of seeds including, in order of abundance, wild buckwheat (*Polygonum convolvulus*), foxtail (*Pennisetum* [*Setaria*] *glauca* and *Setaria viridis*), sedge (*Carex* sp.), spiderwort (*Tradescantia* sp.), puccoon (*Listhospermum* sp.), sweetclover (*Melilotus* sp.), switchgrass (*Panicum* sp.), ragweed (*Ambrosia* sp.), knotweed (*Polygonum ariculare*), vetch (*Vicia* sp.), and sandbur (*Cenchrus* sp.).

In piñon-juniper habitat in Colorado, Haufler and Nagy (1984) analyzed the summer (July-August) diet of *P. flavescens* using fecal analysis. They discovered that arthropods comprised 59.5% of the diet in summer, with a variety of plants (seeds and vegetation) in the following proportions: *Juniperus osteosperma* (16.8%), *Phlox* sp. (5.1%), unidentified seeds (3.5%), *Quercus* sp. (3.2%), *Pinus edulis* (3.2%), *Bromus tectorum* (2.9%), and moss (1.6%). Of arthropods consumed, Lepidoptera were most common (30.0%), followed by Hymenoptera (14.0%), Coleoptera (11.2%), Orthoptera (2.4%), and unidentified insects (11.5%). The unusually high proportion of arthropods in the diet was explained by two potential factors: (1) fecal analysis tends to over-represent items that resist digestion (such as arthropod exoskeletons), implying that a high proportion of arthropods is an artefact of the method, and/or (2) the year of study (1977) was exceptionally dry, and production of seeds was very low, perhaps forcing *P. flavescens* to consume more arthropods than usual (Haufler and Nagy 1984). In either case, the study revealed that *P. flavescens* was very capable of consuming a wide range of arthropods.

***Perognathus flavus* Baird 1855**
Silky Pocket Mouse

The silky pocket mouse was widespread on the Sevilleta NWR and was collected during all seasons and in all habitats with grass/shrub components (Table 1). The diet of *P. flavus* proved to be primarily seeds from a wide variety of forbs, grasses and shrubs (100% frequency, and 93% of total volume of diet). Arthropods and vegetation were discovered only rarely (Tables 4, 5). Seeds constituted 67% of volume of diet in winter, and increased to 90% in spring and 100% in summer (Table 5). Within the seed category, seeds of forbs from at least 17 taxa constituted 78% of seeds consumed, followed by seeds of grass (4 species, 16% of total seeds consumed) and cacti (1 species, 6% of total consumed; Tables 4, 5). Arthropods were found in the diet only in spring, and comprised only 6% of total diet volume; vegetation was extremely rare, occurring in only one individual (Tables 4, 5).

Contents of cheek pouches analyzed contributed six

TABLE 4. List of items discovered in the diet of the silky pocket mouse (*Perognathus flavus*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season; values for cheek pouch contents represent total numbers of seeds.

Items	Stomach contents			Cheek pouch contents		
	Winter (n=1)	Spring (n=20)	Summer (n=12)	Winter (n=0)	Spring (n=18)	Summer (n=10)
Arthropods	0	25	0	-	0	0
Vegetation	100	0	0	-	0	0
Seeds	100	100	100	-	1,287	183
Trees:						
Juniperus monosperma	—	—	—	—	—	1
Quercus turbinella	—	—	—	—	—	3
Shrubs/cacti:						
Larrea tridentata	—	—	—	—	3	3
Opuntia sp.	—	—	42	—	—	4
Grasses:						
Aristida sp.	—	20	—	—	3	—
Bouteloua gracilis	—	—	—	—	—	2
Dasyochloa pulchellum	—	—	17	—	—	—
Muhlenbergia sp.	—	5	—	—	—	—
Sporobolus sp.	100	5	33	—	—	—
Forbs:						
Allium macropetalum	—	—	—	—	15	—
Asteraceae, unidentified species	—	20	—	—	—	—
Astragalus missouriensis	—	—	8	—	—	—
Astragalus nuttallianus	—	—	—	—	65	76
Astragalus sp.	—	10	17	—	—	10
Brassicaceae, unidentified species	100	—	—	—	—	—
Chamaesyce sp.	—	—	17	—	20	1
Cryptantha crassisepala	—	5	8	—	74	—
Descurania obtusum	—	10	—	—	24	—
Eriogonum sp.	—	5	—	—	—	—
Fabaceae, unidentified species	—	—	—	—	2	—
Hoffmanseggia glauca	—	25	—	—	1	—
Hymenopappus filifolius	—	5	—	—	—	—
Ipomopsis pumila	—	35	—	—	657	—
Lappula occidentalis	—	50	17	—	205	60
Linum sp.	—	—	—	—	125	—
Melampodium leucanthum	—	10	—	—	—	—
Oenothera albicaulis	—	25	—	—	70	—
Phacelia integrifolia	—	5	—	—	13	—
Plantago patagonica	—	5	8	—	—	—
Portulaca sp.	—	—	—	—	—	2
Townsendia annua	—	—	—	—	10	15
Verbena wrightii	—	—	8	—	—	6

TABLE 5. Summary of prey types of the silky pocket mouse (*Perognathus flavus*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Juniper-oak savanna	Summer	5	100	0	0	0	22	22	56
Mesquite savanna	Winter	1	67	33	0	0	0	50	50
	Summer	3	100	0	0	0	0	33	67
Short-grass steppe	Spring	5	91	0	9	0	0	10	90
	Summer	3	100	0	0	0	17	0	83
Chihuahuan Desert scrubland	Spring	15	89	0	11	0	0	10	90
	Summer	1	100	0	0	0	33	67	0
Total means (%)		33	93	1	6	0	6	16	78

species of forbs to the potential diet, along with one species each of grass and shrub, and two species of trees (Table 4). On average, the cheek pouches of *P. flavus* contained 72 seeds/individual in spring, and 18 seeds/individual in summer (Table 4). As observed with comparative results from *D. merriami* and *D. ordii* (see below), contents of cheek pouches did not represent actual components of the diet consumed since arthropods and vegetation were not present (only seeds were observed; Table 4). In addition, only 12 of 32 species of seeds (38%) were common in both stomach contents and cheek pouch contents (Table 4).

The small body mass of *P. flavus* (8-11 g) is indicative of a preference for smaller seeds, as some authors have observed a correlation between body size and seed size (e.g., Brown and Lieberman [1973], Brown [1975], Mares and Williams [1977]; however, see Lemen [1978], Smigel and Rosenzweig [1974], Stamp and Ohmart [1978], McCloskey [1980] and Price [1983] for alternative views). The only example of preference for small seeds observed in our study was in mesquite savanna habitat, where *Sporobolus* grass seeds were consumed; otherwise, seeds were generally large in size. Contents of cheek pouches included creosotebush seeds (*Larrea tridentata*), juniper berries (*Juniperus monosperma*), and acorns (*Quercus turbinella*) that are large but easy to manipulate. The most notable example of large seeds was the presence of *Opuntia* cactus seeds in both stomachs and cheek pouches. Cactus seeds possess extremely hard and thick seed coats but were still found macerated within stomachs. Even seeds of grasses found were large, such as *Aristida* sp. As noted for *D. merriami* (see below), contents of cheek pouches of *P. flavus* showed varying degrees of seed "preparation" where seed coats, husks, and spines had been removed prior to seed storage in pouches.

Previous studies on *P. flavus* food habits, though few in number and sparse in detail, also indicate a predominantly granivorous diet. Bailey's (1905, 1931) accounts from Texas and New Mexico indicated a nearly completely granivorous habit, consisting of seeds from sunflowers (*Helianthus* sp.), *Croton* sp., *Juniperus* sp. and various "small grass and weed seeds" (Bailey 1931, p. 275); no mention of arthropods or green vegetation was made, although in captivity, *P. flavus* readily accepted green leaves, cactus pulp and lettuce. Blakely (1936) noted that nests and burrows of *P. flavus* in Albuquerque, New Mexico, contained large numbers of Russian thistle seeds (*Salsola kali*). In Arizona, *P. flavus* cheek pouches also contained seeds of *Croton pottsii* [*corymbulosus*] and *C. texensis* (Hoffmeister and Goodpaster 1954). Best and Skupski (1994) summarized additional diet information from studies in Mexico, noting one report from Dalquest (1953) that *P. flavus* cheek pouches contained seeds of springtime desert plants, and a second report from Baker (1954) that *P. flavus* frequented harvester ant (*Pogonomyrmex* spp.) mounds, presumably attracted to seeds collected by ants.

The most comprehensive study of *P. flavus* diet was conducted by Forbes (1962) in five locations throughout New Mexico. He examined contents of stomachs and cheek pouches from 171 *P. flavus*, with 159 collected in

summer and 12 in winter. Diet consisted almost entirely of seeds, representing species in the following genera (listed in order of decreasing abundance): *Salsola*, *Chenopodium*, *Vulpia* [*Festuca*], *Cryptantha*, *Amaranthus*, *Opuntia*, *Achnatherum* [*Oryzopsis*], *Sphaeralcea*, an unidentified fruit, an unidentified grass, and *Cucurbita* (Forbes 1962). Cheek pouches from three individuals contained small insects (Homoptera: Cicadellidae), and 26 contained miscellaneous vegetation (leaves, flowers and parts of stems); 18 cheek pouches had sand or soil (Forbes 1962).

Comparing these findings with ours from the Sevilleta NWR, it is clear that while diet of *P. flavus* is dominated by seeds from forbs, it also includes seeds of grasses, cacti, shrubs, and trees. Arthropods are a small component of the diet, as is green vegetation. In spite of small body size, *P. flavus* appears capable of consuming relatively large seeds and fruits, including juniper berries and acorns.

Dipodomys merriami **Mearns 1890**
Merriam's Kangaroo Rat

In our study, Merriam's kangaroo rats were collected in three of six habitats, including mesquite savanna (n=30), Chihuahuan Desert scrubland (n=7), and juniper-oak savanna (n=2); long-term studies of rodent populations conducted by Sevilleta LTER researchers have indicated that *D. merriami* is often the dominant rodent in scrubland habitats on the Sevilleta NWR (Friggens 2003).

Dipodomys merriami was found to be largely granivorous, with seeds occurring in the diet with frequencies >90% (Table 6) and comprising 73% of diet volume; 20% of diet by volume was arthropods (Table 7). Seeds were consistently present in samples from contents of both stomachs (93-100% of all samples) and cheek pouches (79% of all samples). Seeds were harvested by *D. merriami* from 37 taxa of plants, including 23 forbs, 7 grasses, 5 shrubs, 1 cactus, and 1 tree (Table 6). Averaged across all habitats and seasons, grasses comprised 51% of seeds found in stomachs followed by seeds of forbs (45%) and shrubs (4%). Green vegetation was observed only in stomach contents, not in cheek pouches (Table 6), and made up only 7% of diet by volume (Table 7). Similarly, arthropods also were found only in stomach contents, but were generally more common than green vegetation in the diet during all seasons (Tables 6, 7); arthropods were observed in the diet most frequently during spring (25% by volume) and summer (30%), and only rarely in winter (12%). Conversely, seeds made up 83% of the diet volume in winter, and dropped in relative abundance during spring (65%) and summer (64%) seasons (Table 7).

Dominant grasses in the diet included genera often associated with disturbed soils (*Aristida*, *Dasyochloa*, and *Achnatherum* [especially in spring]; see Table 6). Due to the apparent importance of *Achnatherum hymenoides* seeds in the spring diet of *D. merriami*, some additional details from our analyses are warranted. In mesquite savanna habitat, over 300 seeds of *A. hymenoides* were found in cheek pouches of 9 individuals during spring, totaling many more grass seeds than from any other category of seeds. Although most of these *D. merriami* individuals had also consumed *A. hymenoides* seeds, we suspect from contents of cheek pouches that they may have consumed more of these seeds than was evident. The relatively large (millet-sized), spherical *A. hymenoides* seeds consist of white endosperm, a dark brown brittle seed coat, and numerous silver hair filaments covering the seed coat. While some *D. merriami* individuals stored whole seeds, seed coat and hairs intact inside their cheek pouches, other individuals had removed hairs, and still others had removed both hairs and seed coat before storage in pouches. It is unknown whether such variation in seed preparation depends on the individual or on other factors such as time of night, food patch size, or food availability. In stomach contents, presence of *A. hymenoides* seeds was usually evidenced by fragments of the dark seed coat, because the white endosperm in stomachs was featureless following mastication. The possibility exists, therefore, that if seeds all had their seed coats removed before consumption, none would be recognized in a stomach sample at all. For other rodent species lacking cheek pouches, this could make recognition and identification of certain seeds very difficult, and some species of seeds may have been overlooked altogether.

Interestingly, when comparing complete data from cheek pouches with data from stomachs for *D. merriami*, counts of all cheek pouch seeds (when grouped into grass/forb/shrub/tree categories) matched counts of occurrence of seeds within stomachs. Of all seeds found in cheek pouches, 49% were grass seeds, 45% were forb seeds, 6% were shrub seeds, and virtually none were tree seeds except a small number from *Prosopis glandulosa* (Table 6). These plant type values were very similar to those from stomachs for seeds of grasses (51%), forbs (45%), and shrubs (4%) (Table 7). However, at the plant species level, differences between cheek pouches and stomach contents were apparent, with 15 of 37 plant species (41%) present only in cheek pouches, and 10 of 37 plant species (27%) present exclusively in stomachs. Only 12 of 37 plant species (32%) were recorded from both cheek pouches and stomachs in *D. merriami* (Table 6).

Diet of *D. merriami* has been examined in detail by many researchers throughout the 20th century, particularly as a result of extensive ecological studies on structure and functioning of desert rodent communities mediated

TABLE 6. List of items discovered in the diet of Merriam's kangaroo rat (*Dipodomys merriami*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season; values for cheek pouch contents represent total numbers of seeds.

Items	Stomach contents			Cheek pouch contents		
	Winter (n=19)	Spring (n=15)	Summer (n=5)	Winter (n=12)	Spring (n=14)	Summer (n=5)
Arthropods	36	67	40	0	0	0
Vegetation	11	33	20	0	0	0
Seeds	95	93	100	135	507	159
Trees:						
Prosopis glandulosa	—	—	—	1	—	2
Shrubs/cacti:						
Atriplex canescens	5	7	—	—	—	—
Ephedra sp.	—	—	—	—	—	8
Fallugia paradoxa	—	20	—	—	—	—
Larrea tridentata	—	—	—	7	—	2
Opuntia sp.	—	—	—	—	—	8
Psorothamnus scoparius	—	—	—	24	—	—
Grasses:						
Achnatherum hymenoides	—	53	—	—	302	—
Aristida sp.	47	47	—	3	23	—
Bouteloua sp.	5	—	—	—	—	—
Dasyochloa pulchellum	58	—	40	47	—	—
Panicum capillare	—	—	—	8	—	—
Sporobolus flexuosus	—	—	—	10	—	—
Sporobolus sp.	21	—	20	—	—	—
Forbs:						
Asteraceae, unidentified species	16	33	20	—	—	—
Astragalus sp.	20	—	—	—	—	—
Bahia sp.	10	—	—	1	—	—
Bahia pedata	—	—	20	—	—	—
Brassicaceae, unidentified species	5	13	—	—	—	1
Chamaesyce sp.	—	—	20	—	—	20
Cryptantha crassisepala	—	—	—	—	10	—
Dalea nana	—	—	—	—	20	—
*Dale*a sp.	5	—	20	—	—	16
Fabaceae, unidentified species	16	13	—	5	10	—
Helianthus sp.	—	—	—	—	—	100
Hymenopappus filifolius	5	27	20	—	103	—
Ipomopsis pumila	—	7	—	—	5	—
Lappula occidentalis	—	13	—	—	25	—
Linum sp.	—	—	—	1	—	—
Machaeranthera spinulosis	—	7	—	—	—	—
Oenothera albicaulis	—	7	—	—	—	—
Phacelia integrifolia	—	—	—	—	9	—
Physaria fendleri	—	—	—	2	—	—
Stephanomeria tenuifolia	—	—	—	—	—	2
Thelesperma megapotamicum	—	—	—	1	—	—
Townsendia annua	—	7	20	—	—	—
Vicia sp.	—	7	—	25	—	—

TABLE 7. Summary of prey types of the Merriam's kangaroo rat (*Dipodomys merriami*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Juniper-oak savanna	Spring	2	72	14	14	0	0	0	100
Mesquite savanna	Winter	18	82	5	13	0	3	67	30
	Spring	9	74	7	19	0	12	38	50
	Summer	3	62	0	38	0	0	17	83
Chihuahuan Desert shrubland	Winter	1	100	0	0	0	0	100	0
	Spring	4	40	15	45	0	0	37	63
	Summer	2	66	17	17	0	0	67	33
Total means (%)		39	73	7	20	0	4	51	45

by availability of food resources (see review by Reichman and Price 1993). As a result, the list of food items and quantities collected and consumed by *D. merriami* (along with that of *D. ordii* [see below]) constitutes one of the most well known rodent diets in North America today. In addition, various aspects of the nutritional requirements of *D. merriami* have been studied relating to their natural history, including energy requirements (Chew and Chew 1970, Kenagy 1973, Soholt 1973, Reichman 1977, Morton et al. 1980, Parmenter et al. 1984), efficiency of digestive assimilation (Soholt 1973), acquisition of water from food types (Schmidt-Nielsen and Schmidt-Nielsen 1951, Schmidt-Nielsen 1964), water balance requirements (MacMillen and Christopher 1975, Schmidt-Nielsen 1975, Morton and MacMillen 1982, Vander Wall 1993, Sipos et al. 2002), and linkage between dietary green herbaceous vegetation and reproductive activity (Beatley 1969, Van De Graaff and Balda 1973, Reichman and Van De Graaff 1975, Soholt 1977).

Early accounts of the diet of *D. merriami* established the granivorous nature of this species, although details were generally lacking. In Texas and New Mexico, Bailey (1905, 1931) reported that, based on contents of cheek pouches, *D. merriami* specialized on seeds as its primary food source, with green vegetation being a minor constituent (though not found in stomachs); no mention of arthropods in the diet was made in these early accounts. Seeds found in cheek pouches of specimens collected in New Mexico during November-December, 1892, and August-October, 1908, included mesquite beans (*Prosopis glandulosa*), creosote bush (*Larrea tridentata*), purslane (*Portulaca* sp.), ocotillo (*Fouquieria splendens*), and blue grama (*Bouteloua gracilis* [*oligostachya*]), along with "many other seeds…that could not be identified and some fragments of grass and other material that may have been intended for nest building rather than for food" (Bailey 1931, p. 265).

In southern New Mexico and southern Arizona, Monson and Kessler (1940) attempted to examine stomach contents of *D. merriami*, but found that "it masticates its food so thoroughly that stomach analyses failed to contribute any material knowledge… Frequently stomach contents were partially greenish in color, indicating that this rodent turns to fresh green annual grasses or weeds for part of its diet" (Monson and Kessler 1940, p. 41). An analysis of *D. merriami* cheek pouches, while often containing trap bait, revealed seeds of *Vulpia* [*Festuca*] *octoflora*, *Bouteloua aristidoides* and *B. barbata*, *Larrea tridentata*, *Plantago patagonica* [*ignota*], and *Lotus* spp.; arthropods were not mentioned from either stomachs or cheek pouches (Monson and Kessler 1940). Excavation of seven dens of *D. merriami* revealed stored caches of seeds composed of *Vulpia* [*Festuca*] *octoflora* and *Gutierrezia* sp. (Monson and Kessler 1940).

Dunham (1968) provided additional cheek pouch analyses from 62 *D. merriami* specimens collected from numerous locations in New Mexico in 1961–63 and 1966–67. Dunham (1968) identified seeds from 16 species of plants, including *Agropyron* sp., *Eriogonum* sp., *Atriplex* sp., *Astragalus* sp., *Bouteloua* sp., *Cenchrus* sp., *Chenopodium* sp., *Croton* sp., *Cryptantha* sp., *Descurainia* sp., *Muhlenbergia* sp., *Oenothera* sp., *Opuntia* sp., *Prosopis glandulosa* [*juliflora*], *Salsola kali*, and *Tribulus terrestris*. Seeds of *S. kali* were most common (36%),

collected in greatest abundance in winter along with *Muhlenbergia* seeds; summer collections of seeds were dominated by *P. glandulosa*, *Opuntia* sp., and *Cryptantha* sp. (Dunham 1968).

Early diet assessments of *D. merriami* in Nevada also relied on contents of cheek pouches recovered from a relatively few animals. Burt (1934) reported that cheek pouches included seeds, seed pods, and leaves from *Vulpia* [*Festuca*] *octoflora*, *Lepidium* sp., *Chenopodium* sp., an unidentified mustard (Brassicaceae), *Astragalus* sp., *Penstemon* sp., and *Prosopis* sp. In summarizing other early reports from Nevada, Hall (1995 [originally published in 1946]) described contents of cheek pouches from 2 individuals of *D. merriami* collected in 1928 as containing seeds of *Malacothrix torreyi* and *Cleomella brevipes*, and another specimen collected in 1933 as having seeds and leaves of *Cryptantha circumcissa*. As with other reports from that period of time, there was no mention of arthropods, although Hall (1995, p. 406), based on personal experiences, stated "I have noted a half dozen or so [kangaroo] rats, the pouches of which were well filled with pupae of insects." Hall (1995) did not identify the species of *Dipodomys* to which he was referring in this quote, and thus it may refer to one or more Nevada species within the genus (i.e., *D. panamintinus*, *D. ordii*, *D. microps*, *D. merriami*, or *D. deserti*).

In the Guadalupe Mountains of west Texas, O'Connell (1979) examined both stomach contents (n=276) and cheek pouch contents (n=192) of *D. merriami* collected from various habitats during monthly sampling in 1974-75. Based on stomach content analyses, the annual *D. merriami* diet was composed of 63.6% seeds (24.1% forbs, 23.0% shrubs, 12.0% succulents, and only 4.5% grasses), 23.5% insects, and 12.9% green vegetation. Seasonal differences in diet composition were apparent, with seeds most important in late summer and autumn (~80% of total diet), insects peaking in winter (~30% of total diet), and green vegetation maximizing in late spring (~18% of total diet). O'Connell (1979) recorded seeds from 31 plant genera in stomach contents of *D. merriami*, of which 14 contributed >1% of the total: *Larrea* (14.2%), *Chamaesyce* [*Euphorbia*] (10.2%), *Lepidium* (4.6%), *Prosopis* (4.2%), *Dasylirion* (4.1%), *Opuntia* (4.0%), *Yucca* (3.7%), *Bouteloua* (3.1%), *Atriplex* (2.4%), *Dyssodia* (2.2%), *Flourensia* (1.7%), *Pectis* (1.5%), *Gutierrezia* (1.5%), and *Sporobolus* (1.4%).

O'Connell (1979) also compared stomach contents results to those from cheek pouches, and found considerable differences. Seeds comprised 99.2% of cheek pouch contents (compared to 63.6% in stomachs), and only a single insect was observed (compared to 23.5% insects in the total diet). Seed species composition was generally similar in stomachs and cheek pouches, but proportions were substantially different, with, for example, *Larrea* being over-represented in cheek pouches, but *Lepidium* being under-represented in cheek pouches relative to the stomach contents (O'Connell 1979). In addition, O'Connell (1979) noted large differences in diets of *D. merriami* collected from different habitats, due to obvious differences in availability of different seed species.

In a diet study using only cheek pouch contents of *D. merriami* in southern New Mexico, Gaby (1972) examined 96 individuals having food items in their cheek pouches, and recorded seeds of 23 plant taxa; no vegetative materials or arthropods were observed. Gaby (1972) calculated an "importance value" for each seed taxon, based upon its frequency of occurrence, numbers of seeds present, and seed mass. In decreasing order of importance values (given in parenthesis), these seed taxa were: *Chenopodium* sp. (51.56), *Larrea tridentata* (31.19), *Aristida adscensionis* (12.32), *Dasyochloa* [*Tridens*] *pulchella* (3.30), *Bouteloua* spp. (0.66), *Boerhaavia* spp. (0.32), *Pectis papposa* (0.28), *Amaranthus* sp. (0.27), *Prosopis glandulosa* [*juliflora*] (0.04), *Baileya multiradiata* (0.03), unknown seed #II (0.03), *Acacia constricta* (0.01), *Bahia absinthifolia* (0.01), *Salsola kali* (0.01), and seven taxa with values <0.01 (*Senna* [*Cassia*] *bauhinioides*, *Ziziphus obtusifolia* [*Condalia lycioides*], *Gutierrezia sarothrae*, *Krameria erecta* [*parvifolia*], *Rhus microphylla*, *Zinnia acerosa* [*pumila*], and unknown seed #I). Gaby (1972) reported no substantial differences in cheek pouch composition or importance values during different seasons, and suggested that the potential seed bank available to his study populations was relatively constant during his study period (1967-70). As stomach contents were not included in this study, and examination of cheek pouch contents did not yield any vegetation nor arthropods, the definitive composition and potential seasonal changes in the *D. merriami* diet on Gaby's (1972) study site could not be determined.

In their classic study of desert community energetics in the Chihuahuan Desert of southeastern Arizona, Chew and Chew (1970) estimated that *D. merriami* on their study sites consumed 82% seeds, 14% green vegetation from forbs and small shrubs, 2% green vegetation from large shrubs (browse), and 2% arthropods. Chew and Chew (1970) conducted a limited inspection of cheek pouch contents of 15 *D. merriami*, and found seeds of *Larrea tridentata*, *Chamaesyce* [*Euphorbia*] *albomarginata*, *Bahia absinthifolia*, *Dasyochloa* [*Tridens*] *pulchella*, and *Opuntia phaeacantha*, along with presence of a single insect (a froghopper [Homoptera: Cercopidae]). Chew and Chew (1970) also reported observing a *D. merriami* feeding on unripe pods of *Hoffmanseggia glauca* [*densiflora*].

In a more recent experimental study in the same region of southeastern Arizona, Kerley et al. (1997) partially attributed observed clipping of grass tillers in Chihuahuan Desert grasslands to *D. merriami* (along with *D. ordii*, which also was present at study sites; however, in laboratory studies, *D. merriami* tended to clip more grass tillers than *D. ordii* [Sipos et al. 2002]). Kerley et al. (1997) assessed grass tiller-clipping frequencies in plots from which *Dipodomys* spp. were excluded and compared them to "open" plots with *Dipodomys* spp. present. Results showed that when *Dipodomys* spp. were absent, tussock-forming grasses experienced clipping frequencies of only 0.25%, whereas when *Dipodomys* spp. were present, 58.25% of grass tussocks suffered tiller clipping. These grass species included (in order of decreasing clipping intensity) *Digitaria californica*, *Bothriochloa barbinodis*, *Sporobolus airoides*, *Aristida ternipes*, *Setaria leucopila*, *Sporobolus flexuosus*, *Sporobolus cryptandrus*, *Aristida purpurea*, *Eragrostis lehmanniana*, *Bouteloua curtipendula*, *Pleuraphis* [*Hilaria*] *mutica*, and *Bouteloua eriopoda* (Kerley et al. 1997). Presumably some were consumed as food, although a portion may have been collected for nest building purposes.

In the Sonoran Desert of southern Arizona, Reichman (1975) analyzed stomach contents and cheek pouch contents of 1,054 *D. merriami* over a 2-yr period (1970-72). Based on analyses of stomach contents (expressed as relative frequency of occurrence), Riechman (1975) found that seeds comprised an average of 78.4% of the diet, with arthropods contributing 15.5%, and green vegetation contributing 6.1%. Considerable variability in these proportions occurred between the two years of study, with green vegetation increasing from 1.1% of the diet in 1970-71 to 9.3% in 1971-72; seed use declined by 8.6% over this same time period, while arthropods remained nearly constant (15.3% vs. 15.7% in the two years, respectively). Over the 2-yr study, forb seeds made up 76% of the dietary seed component, followed by shrubs/trees (16%) and grasses (7%). Of 41 plant taxa found in stomach contents, the 12 taxa that comprised >1% of the diet were as follows: *Pectocarya platycarpa* (20.8%), *Plantago ovata* [*insularis*] (15.4%), *Erodium cicutarium* (9.4%), *Chamaesyce* [*Euphorbia*] spp. (9.3%), *Larrea tridentata* [*divaricata*] (9.0%), *Opuntia* spp. (2.6%), *Panicum* sp. (2.6%), *Acacia constricta* (1.5%), *Lotus* sp. (1.4%), *Vulpia* [*Festuca*] *octoflora* (1.3%), *Dasyochloa* [*Tridens*] *pulchella* (1.3%), and *Physaria* [*Lesquerella*] *gordoni* (1.2%).

In comparing his results of stomach analyses to cheek pouch contents, Reichman (1975, p. 743) concluded that cheek pouch contents "are poor indicators of how much the rodents ingest and when they ingest it." Using a similarity index to compare potential diet (cheek pouch contents) to actual diet (stomach contents), Reichman (1975) calculated a relatively low value of 0.412 (a value of 1.00 would have indicated complete concordance between cheek pouches and stomach contents), due to large disparities in seed species compositions. Along with a near absence of arthropods and green vegetation in cheek pouches, indications were that these latter items were consumed by *D. merriami* during foraging periods rather than collected in cheek pouches for later caching and use (Reichman 1975). This same pattern of differences between stomach contents and cheek pouch contents was observed in our Sevilleta NWR samples (Table 6).

In a study relating available plant resources to cheek pouch contents of *D. merriami* in five plant communities of southern Arizona, Stamp and Ohmart (1978) examined seeds collected by 265 individuals over all four seasons. They found that forb seeds were collected most during June through February, while grass seeds were most common during March through May. Dominance by forb versus grass seeds in cheek pouches varied by habitat type, with forb seeds comprising 46–73% and grass seeds comprising 25–52% in desert shrub, creosotebush and mesquite shrub communities, while in a mesquite woodland community, grass seeds made up 83% of cheek pouch contents and forb seeds only contributed 17%; seeds from shrubs and trees comprised 0–4.6% of the total across all habitats studied (Stamp and Ohmart 1978). Plant species contributing >1% of any single habitat's cheek pouch seeds were as follows (values are mean proportions across all habitats): *Schismus barbatus* (34%), *Erodium cicutarium* (24%), *Vulpia* [*Festuca*] *octoflora* (5%), *Lotus* sp. (2%), *Astragalus* sp. (9%), *Larrea tridentata* (1%), *Plantago ovata* [*insularis*] (13%), *Pectocarya recurvata* (0.6%), *Trifolium* sp. (0.5%), *Croton* sp. (0.2%), an unidentified grass (Poaceae; 3%), *Stylocline* sp. (0.8%), *Chamaesyce* [*Euphorbia*] sp. (0.6%), and *Ambrosia deltoidea* (0.5%; Stamp and Ohmart 1978).

In another study in southern Arizona, Reynolds (1958) analyzed cheek pouch contents (though again, not any stomach contents) of 1,001 *D. merriami*, and recorded over 60 species of plants. Seeds made up 95% of cheek pouch contents, consisting mostly of grasses (49%) and forbs (33%), with shrubs a relatively minor component (12%). Vegetation parts contributed only 5%, with no arthropods reported. Dominant seed species (with percentage occurrence values) were as follows: the annual grass *Aristida adscensionis* (32.4%), perennial *Aristida* spp. (*A. ternipes* var. *gentilis* [*hamulosa*], *A. ternipes*, and *A. divaricata*; 20.1%), *Bouteloua aristidoides* (19.3%), *Boerhaavia spicata* [*torreyana*] (11.7%), *Sida abutifolia* [*diffusa*] (10.3%), *Prosopis glandulosa* [*juliflora*] (9.4%), *Evolvulus arizonicus* (8.3%), *Lotus humistratus* (7.0%), *Aristida californica* [*glabrata*] (6.0%), *Opuntia engelmanni* (4.9%), *Chamaesyce* [*Euphorbia*] spp. (4.4%), *Pectocarya*

recurvata (4.1%), *Digitaria* [*Trichachne*] *californica* (3.8%), *Opuntia* spp. (3.%), *Urochloa* [*Panicum*] *arizonicum* (3.0%), and *Bouteloua rothrockii* (2.9%). Reynolds (1958) observed that many, but not all, of these seed species were most commonly found in cheek pouches during each plant species' peak seed-production season of the year. Reynolds (1958) also noted considerable year-to-year variation in seed composition of cheek pouch contents, and this was clearly correlated to intra- and inter-annual rainfall patterns producing varying amounts of seeds for each plant species.

In his earlier study of *D. merriami* on Arizona desert grasslands with and without livestock grazing, Reynolds (1950) noted that plant species composition (shrubs vs. perennial grasses vs. annual grasses vs. forbs) influenced abundance and distribution of *D. merriami*, with rodent densities decreasing with greater cover by perennial grasses. Reynolds (1950) had analyzed cheek pouch contents of 252 *D. merriami*, and observed that *D. merriami* preferred plants that produced large seeds (e.g., perennial grasses, mesquite and cacti). However, annual grass and forb seeds were much more abundant in habitats with livestock grazing and could therefore support larger *D. merriami* populations by virtue of the much greater biomass of food resources (albeit "low-preference" resources; Reynolds 1950).

In the Mojave Desert of southern Nevada, Bradley and Mauer (1971, 1973) examined stomach contents of 740 *D. merriami*, and found that seeds (primarily of grasses and winter annual forbs) made up ~65% of the diet volume in spring (February–June) and nearly 100% in autumn (September – November). Green vegetation contributed ~35% to spring diet, while arthropods made up <1%; the few arthropods observed in the diet (mostly beetles and moths) occurred principally in August–September. In addition, Bradley and Mauer (1971, 1973) also analyzed cheek pouch contents of 411 *D. merriami*, and found the following seed species (with percentage frequency occurrence): Grasses (5 species, 74.2% overall occurrence) included *Achnatherum* [*Oryzopsis*] *hymenoides* (52.5%), *Pleuraphis* [*Hilaria rigida*] (24.8%), *Poa* spp. (2.2%), *Dasyochloa* [*Tridens*] *pulchella* (2.0%), and *Bromus rubens* (1.0%); annual forbs (9 species, 37.4% overall occurrence) included *Eriogonum* spp. (30.9%), *Pectocarya* spp. (6.3%), *Chaenactis fremontii* (5.5%), *Oenothera* sp. (1.8%), *Plantago ovata* [*insularis*] (1.0%), *Phacelia* spp. (0.5%), *Dimorphocarpa* [*Dithyrea*] spp. (0.3%), *Erodium cicutarium* (0.3%), and *Tribulus terrestris* (0.2%); perennial plants (4 species, 3.8% overall occurrence) included *Larrea tridentata* (2.0%), *Yucca schidigera* (1.2%), *Xylorhiza* [*Machaeranthera*] *tortifolia* (0.5%), and *Ephedra funerea* (0.3%). Bradley and Mauer (1971, 1973) also reported occasional vegetative plant parts in cheek pouches (7.4% occurrence), composed of *Erodium cicutarium* (5.5%), *Ambrosia* [*Franseria*] *dumosa* (2.2%), *Phacelia* spp. (0.7%), *Atriplex canescens* (0.3%), and *Lycium* spp. (0.3%). Arthropod parts occurred in cheek pouches with a frequency of only 0.3% (Bradley and Mauer 1971).

In a second extensive study in the Mojave Desert of southern California, Soholt (1973) examined stomach contents and cheek pouches of 172 *D. merriami* collected through all months of the year. Based on analysis of stomach contents (expressed as percentage mass), Soholt (1973) found that in summer (June–August), seeds and fruits comprised 93% of the diet, followed by arthropods (4%), leaf materials (2%) and stems (<0.5%). In autumn (September – November), seeds and fruits made up 84%, followed by leaf materials (12%), stems (3%), and arthropods (<0.5%). In winter (December–February), proportion of the diet from seeds and fruits dropped to 64%, while leaf materials (from newly germinated winter annuals) increased to 35%, and some flower parts making up the remainder (1%); arthropods disappeared from the diet during this time. Spring diet (March–May) consisted of 65% seeds and fruits, 21% leaf materials, 6% flower parts, 1% stems, and 1% arthropods. Dominant plant species in the diet (again, based on mass in stomach contents) included *Erodium cicutarium* (67%), *Bouteloua barbata* (4%), *Chaenactis fremonti* (3%), *Eriophyllum* spp. (2%), and trace amounts (<0.5%) of *Amaranthus fimbriatus*, *Anisocoma acaulis*, *Malacothrix glabrata* [*californica*], *Camissonia* [*Oenothera*] *brevipes*, *Cryptantha* spp., *Larrea tridentata*, *Chamaesyce* [*Euphorbia*] *polycarpa*, *Croton californicus*, *Senna* [*Cassia*] *armata*, and other unknown species accounting for 22% of the mass of stomach contents (Soholt 1973).

Cheek pouch contents from these same animals contained 99% seeds, occasional other plant parts, and no arthropods (Soholt 1973). Plant species represented in cheek pouches were nearly the same as in stomach contents, dominated by *Erodium cicutarium* (68%), *Bouteloua barbata* (9%), and *Chaenactis fremontii* (11%). Four plant species found in stomach contents were missing from cheek pouches (*Malacothrix glabrata* [*californica*], *Camissonia* [*Oenothera*] *brevipes*, *Chamaesyce* [*Euphorbia*] *polycarpa*, and *Croton californicus*), while at least three additional taxa appeared solely in cheek pouches in small numbers: *Coreopsis bigelovii*, *Eriastrum eremicum* [*Hugelia eremica*], and *Eriogonum* spp. (Soholt 1973).

Reingestion of fecal pellets (coprophagy) has been recorded in many rodent taxa as a means of increasing protein and water intake (see Kenagy and Hoyt [1980] and references therein). In a laboratory study, *D. merriami* only rarely consumed its own fecal pellets; of four individuals observed for 24 h (during which time an average of 25 fecal pellets/individual were produced), only two individuals consumed a single fecal pellet each

(Kenagy and Hoyt 1980). In contrast, another kangaroo rat species, *D. microps*, reingested 26% of all fecal pellets produced. When combined with results of observations of various other rodent taxa, Kenagy and Hoyt (1980) concluded that rodent species with more herbivorous diets (e.g., *D. microps* and *Microtus californicus*) exhibited higher levels of coprophagy, whereas granivorous species, such as *D. merriami* and several species of *Perognathus*, only rarely reingested fecal pellets. Fecal pellets have been noted as "occasionally present" in cheek pouch contents of *D. merriami* and several *Perognathus* species in the Sonoran Desert (Stamp and Ohmart 1978), and in *D. spectabilis* in Texas (Miller 1939).

***Dipodomys ordii* Woodhouse 1853**
Ord's Kangaroo Rat

Ord's kangaroo rats were collected in three habitats of the Sevilleta NWR, including short-grass steppe (n=21), mesquite savanna (n=11), and Chihuahuan Desert scrubland (n=1); long-term studies of rodent populations conducted by Sevilleta LTER researchers have indicated that *D. ordii* is a dominant rodent species in grassland habitats on the Sevilleta NWR, and occurs relatively rarely in scrublands (Friggens 2003).

Like its close relative *D. merriami*, *D. ordii* also was found to be a generally granivorous species, with seeds occurring in the diet with a frequency of 100% in all seasons (Table 8) and comprising 68% of average annual diet volume (Table 9). Unlike *D. merriami*, *D. ordii* consumed considerably more green plant material (25% by volume) but only 7% arthropod material (Table 9; compare with values in Table 7). Seeds were the most frequently encountered items in samples from stomach contents (100% of all samples) and were the exclusive items found in cheek pouches (also 100% of all samples). Seeds had been harvested from 39 plant taxa, including 24 forbs, 7 grasses, 6 shrubs, 1 cactus, and 1 tree (Table 8). Averaged across all habitats and seasons, forbs made up 57% of seeds found in stomach contents, followed by grasses (30%) and shrubs (13%). Green vegetation was observed only in stomach contents (not in cheek pouches; Table 8), and shifted in importance from summer (54% frequency, 34% by volume) to winter (23% frequency, 21% volume) to spring (43% frequency, 17% volume; Tables 8 and 9). Similarly, arthropods also were found only in stomach contents. Arthropods were observed in the diet most frequently during spring (71% frequency, 20% by volume), with lower frequencies in summer (9% frequency, 2% volume) and winter (15% frequency, 4% volume; Tables 8 and 9). Conversely, seeds made up 75% of the volume of diet in winter, and dropped somewhat in relative importance during spring (63%) and summer (64%) seasons (Table 9).

Forb seeds dominated in the diet of *D. ordii* in all seasons (Table 8). In summer, 11 species of forbs were recorded in stomach contents, while 7 and 8 species were observed in winter and spring, respectively. Grass seeds were consumed most frequently during the winter period. As with *D. merriami*, the common grasses in the diet of *D. ordii* were dominated by genera found on disturbed soils (*Aristida*, *Dasyochloa*, and *Achnatherum* [especially in the spring]; see Table 8). However, seeds of other perennial grasses (*Bouteloua* spp. and *Sporobolus* sp.) that typify more stable native grasslands were commonly observed in stomach contents during summer and winter.

In comparing cheek pouch data with stomach contents data for *D. ordii*, counts of all cheek pouch seeds (when grouped into grass/forb/shrub/cactus/tree categories) did not consistently correspond well with stomach contents data. Of all seeds within cheek pouches, 83% were forb seeds, 5% were grass seeds, 11% were shrub/cactus seeds, and virtually none were tree seeds (except for a single *Prosopis glandulosa* seed; Table 8). These plant type values were substantially different from those of stomach contents for seeds of forbs (57%) and grasses (30%), although values for seeds of shrubs/cacti (13%) and trees (0%) appeared more similar (Table 9). In addition, at the plant species level, differences in taxonomic composition between cheek pouch and stomach contents were apparent, with 11 of 39 plant species (28%) present only in cheek pouches, and 15 of 39 plant species (38%) present exclusively in stomach contents; only 13 of 39 plant species (33%) were recorded from both cheek pouches and stomach contents in *D. ordii* (Table 8).

Historical accounts of food habits of *D. ordii* compare well with our Sevilleta NWR data (Garrison and Best 1990). Many early accounts of *D. ordii* food items were based almost entirely on cheek pouch contents, rather than stomach contents, and should be viewed as incomplete with regard to components of arthropods and plant foliage. For example, Cary (1911) described contents of cheek pouches for *D. ordii* (synonym: *Perodipus montanus richardsoni*) in Colorado as consisting of "various seeds and the stems of grass and wheat". In cheek pouch contents collected at Salida in November of 1907, Cary (1911) found equal quantities of leaves of *Atriplex canescens* and seeds of a species of *Chrysothamnus*. In New Mexico, Bailey (1931, p. 267) described the diet of *D. ordii* as consisting of "seeds of a great variety of desert plants." Cheek pouches of specimens collected in the winter of 1889 contained seeds of wild sunflowers (*Helianthus* sp.) and parosela (*Dalea* sp.), while in the summer of 1908 in the same area, *D. ordii* were collecting mesquite seeds (*Prosopis glandulosa*) (Bailey 1931). Other plant seeds retrieved from New Mexican *D. ordii* cheek pouches included various sunflowers (*Helianthus* sp., *Verbesina encelioides* [*Ximenesia exauriculata*]), rag bush (*Ambrosia* [*Gaertneria*] *acanthicarpa*), sandbur (*Cenchrus*

TABLE 8. List of items discovered in the diet of Ord's kangaroo rat (*Dipodomys ordii*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season; values for cheek pouch contents represent total numbers of seeds.

Items	Stomach contents			Cheek pouch contents		
	Winter (n=13)	Spring (n=7)	Summer (n=13)	Winter (n=9)	Spring (n=6)	Summer (n=11)
Arthropods	15	71	9	0	0	0
Vegetation	23	43	54	0	0	0
Seeds	100	100	100	139	821	149
Trees:						
Prosopis glandulosa	—	—	—	1	—	—
Shrubs/cacti:						
Dalea formosa	—	—	—	—	—	92
Fallugia paradoxa	8	29	—	—	—	—
Gutierrezia sarothrae	46	—	—	15	—	—
Larrea tridentata	—	—	—	—	—	1
Opuntia sp.	—	14	31	—	—	13
Psorothamnus scoparius	—	—	—	3	—	5
Senecio sp.	—	—	—	1	—	—
Grasses:						
Achnatherum hymenoides	—	29	—	—	16	—
Aristida sp.	77	—	—	35	—	—
Bouteloua eriopoda	—	—	—	5	—	—
Bouteloua sp.	23	—	—	—	—	—
Dasyochloa pulchellum	15	14	8	1	—	—
Poaceae, unidentified species	—	14	23	—	—	—
Sporobolus sp.	54	—	15	—	—	—
Forbs:						
Allium macropetalum	—	14	—	—	—	—
Asteraceae, unidentified species	15	29	—	—	—	—
Astragalus lentiginosus	—	—	—	—	—	25
Astragalus nuttallianus	—	—	—	—	660	—
Astragalus sp.	8	14	31	—	—	1
Bahia sp.	—	—	8	—	—	—
Brassicaceae, unidentified species	15	—	—	—	—	—
Cymopterus acaulis	—	14	8	—	—	—
Dalea nana	—	—	—	62	—	—
Dalea sp.	—	—	15	—	—	—
Descurania obtusa	—	29	—	—	20	—
Fabaceae, unidentified species	23	—	—	—	25	—
Gaillardia pulchella	—	—	—	1	—	—
Hoffmanseggia glauca	—	14	—	—	—	—
Hymenopappus filifolius	8	29	38	—	50	—
Ipomopsis pumila	—	14	—	—	—	—
Lappula occidentalis	—	—	15	—	—	1
Machaeranthera spinulosis	—	14	—	9	—	—
Oenothera albicaulis	—	14	—	—	—	—
Pectis angustifolia	8	—	—	—	—	—
Plantago sp.	—	—	31	—	—	—
Plantago patagonica	—	—	38	—	50	11
Sphaeralcea sp.	8	14	—	5	—	—
Thelesperma megapotamicum	—	—	—	1	—	—

TABLE 9. Summary of prey types of the Ord's kangaroo rat (*Dipodomys ordii*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Mesquite savanna	Winter	3	93	0	7	0	8	67	25
	Spring	2	67	1	22	0	20	30	50
	Summer	6	79	21	0	0	23	18	59
Short-grass steppe	Winter	10	70	27	3	0	18	41	41
	Spring	5	62	19	19	0	9	9	82
	Summer	6	47	53	0	0	0	12	88
Chihuahuan Desert scrubland	Summer	1	75	0	25	0	0	100	0
Total means (%)		33	68	25	7	0	13	30	57

sp.), croton (*Croton* sp.), desert willow (*Chilopsis linearis*), silverscale saltbush (*Atriplex argentia* ssp. *expansa*), marsh fleabane (*Pluchea sericea*), purslane (*Portulaca oleracea*), creosotebush (*Larrea tridentata*), and a variety of unidentified Asteraceae species; in addition, some specimens were carrying bundles of clipped grass stems in their cheek pouches (Bailey 1931). No mention was made of arthropods in cheek pouches.

In another study of *D. ordii* in southern New Mexico, Gaby (1972) examined the cheek pouches of 114 individuals and recorded seeds of 25 plant taxa; in addition, cheek pouches often contained stems, leaves and floral parts of various species, although no arthropods were observed. Gaby (1972) calculated an "importance value" for each seed taxon, based upon its frequency of occurrence, numbers of seeds present, and seed mass. In decreasing order of importance values (given in parenthesis), seed taxa were: *Salsola kali* (44.18), *Descurania* sp. (12.31), *Senna* [*Cassia*] *bauhinioides* (12.30), *Chenopodium* sp. (11.89), *Aristida adscensionis* (5.52), *Tribulus terrestris* (3.87), *Astragalus allochrous* [*wootoni*] (3.03), *Dimorphocarpa* [*Dithyrea*] *wislizeni* (2.99), *Boerhaavia* spp. (1.60), *Bouteloua* spp. (0.78), *Gutierrezia sarothrae* (0.76), *Dasyochloa* [*Tridens*] *pulchella* (0.30), *Lepidium* sp. (0.17), *Bahia absynthifolia* (0.09), unknown seed #II (0.08), *Prosopis gladulosa* [*juliflora*] (0.07), *Rhus microphylla* (0.03), *Baileya multiradiata* (0.02), *Acacia constricta* (0.01), and five taxa with values <0.01 (*Ziziphus obtusifolia* [*Condalia lycioides*], *Larrea tridentata, Pectis papposa, Verbesina encelioides*, and *Zinnia acerosa* [*pumila*]). Gaby (1972) observed little seasonal difference in seed species collected by *D. ordii*, and believed that abundance of seeds on his study site during 1967-1970 was sufficiently high that all seed species were constantly available.

Dunham (1968) provided additional analyses of cheek pouch contents from 151 *D. ordii* specimens collected from various locations in New Mexico during 1961–63 and 1966–67. Dunham (1968) identified seeds from 24 species of plants, including *Agropyron* sp., *Atriplex* sp., *Astragalus* sp., *Boerhaavia* sp., *Bouteloua* sp., *Cenchrus* sp., *Chenopodium* sp., *Croton* sp., *Cryptantha* sp., *Machaeranthera* [*Haplopappus*] sp., *Lappula occidentalis* [*redowskii*], *Muhlenbergia* sp., *Oenothera* sp., *Achnatherum* [*Oryzopsis*] sp., *Phacelia* sp., *Poa reflexa*, *Prosopis glandulosa* [*juliflora*], *Prosopis pubescens*, *Rumex* sp., *Salsola kali*, *Solanum* sp., *Solidago* sp., *Sphaeralcea fendleri*, and *Tribulus terrestris*. The seeds of *Salsola kali* were most common (63%), collected in large numbers throughout the year; *Tribulus terrestris*, *Agropyron* sp. and *Cryptantha* sp. were prominent in cheek pouches in spring and summer, while *Prosopis glandulosa* seeds were the second most frequent item collected in autumn (Dunham 1968).

The first diet analysis of *D. ordii* from New Mexico based on stomach contents was conducted on the Jornada del Muerto near Las Cruces by Wood (1969), although few details were reported. Wood (1969) estimated diet volumes of general food categories from 72 *D. ordii*, and found that, on average, seeds comprised 66% of food volume, green vegetation contributed 15%, and succulent vegetation (defined as *Opuntia* pods and *Yucca* flowers and culms) added 9%. Insects averaged 10% of the total diet volume, composed mostly of caterpillars (Lepidoptera larvae) (Wood 1969).

In a more detailed study in shinnery oak-mesquite habitat in southeastern New Mexico, Best et al. (1993) analyzed stomach contents of 384 *D. ordii* over a 22-month period (March 1978–December 1979). From this study, 51 plant taxa were identified in the diet, along with fungi and arthropod materials. The most frequently encountered plant species (seeds and/or vegetative parts; frequency > 5%) included *Triplasis purpurea* (44% frequency value), *Prosopis glandulosa* (42%), *Chamaesyce* [*Euphorbia*] sp. (36%), unidentified seed #3 (30%), *Croton* sp. (22%), *Oenothera* sp. (19%), an unidentified grass seed (16%), *Aristida* sp. (15%), *Cenchrus spinifex* [*insertus*] (12%), an unidentified seed (11%), *Bouteloua* sp. (10%), *Paspalum setaceum* (10%), *Sphaeralcea* sp. (8%), *Eriogonum* sp. (8%), *Descurania pinnata* (8%), *Chenopodium* sp. (8%), *Astragalus* sp. (8%), *Amaranthus albus* (6%), and *Linum aristatum* (6%). Green vegetation and miscellaneous plant fibers occurred in 14% of the specimens. Arthropod remains were observed in stomach contents of 36% of 384 specimens, with greater occurrences in spring and summer than in autumn and winter; fungi occurred in 16 specimens (Best et al. 1993).

In the Guadalupe Mountains of west Texas, O'Connell (1979) examined stomach contents (n=58) of *D. ordii* collected from various habitats during monthly sampling in 1974-1975. Analyses of stomach contents indicated that annual diet of *D. ordii* was composed of 89.5% seeds (41% grasses, 27% forbs, 15.5% shrubs, and 6% succulents), 7.5% green vegetation, and 3.1% insects. Seasonal differences in composition of diet were apparent, with seeds most important in late autumn through winter (~90% of total diet), insects peaking in autumn (~10% of total diet), and green vegetation maximum in spring and summer (~15% of total diet). O'Connell (1979) recorded seeds from 32 plant genera in stomach contents of *D. ordii*, of which 19 contributed >1% of the total: *Bouteloua* (17.8%), *Sporobolus* (17.0%), *Nerisyrenia* (8.8%), *Atriplex* (6.4%), *Larrea* (5.1%), *Croton* (4.6%), *Prosopis* (4.1%), *Oenothera* (3.1%), *Opuntia* (3.0%), *Kallstroemia* (2.4%), *Chamaesyce* [*Euphorbia*] (2.0%), *Fallugia* (1.9%), *Yucca* (1.7%), *Chilopsis* (1.6%), *Dasyochloa* [*Erioneuron*] (1.4%), *Physaria* [*Lesquerella*] (1.1%), *Sphaeralcea* (1.1%), *Dasyochloa* [*Tridens*] (1.1%), and *Gutierrezia* (1.0%).

In mesquite grassland habitat of west Texas, Alcoze and Zimmerman (1973) studied stomach contents of 83 *D. ordii* during winter and spring, and recorded 18 plant items and 4 animal items in the diet. Seeds comprised 77% volume of stomach contents. Major plant food items included *Paspalum setaceum* [*stramineum*], *Prosopis glandulosa* [*juliflora*], *Croton glandulosus*, *Sorghum halepense*, *Ambrosia artemisiifolia*, and *Helianthus annuus*; other plants of less incidence in the diet included *Opuntia engelmannii* [var. *lindheimeri*], *Cenchrus spinifex* [*pauciflorus*], *Andropogon hallii*, *Gaillardia pulchella*, *Yucca treculeana*, *Solanum elaeagnifolium*, and *Mammillaria* sp. Leaves of *Prosopis glandulosa* [*juliflora*] also were commonly observed in stomach contents, along with unidentified vegetation materials. A species of *Endogone* fungus appeared in winter diet, comprising 4.1% by volume. Animal materials (arthropods) composed 8% of winter diet by volume, and 18.3% of spring diet; dominant animal taxa included ants (Hymenoptera: Formicidae) and caterpillars (Lepidopteran larvae) in winter, and ground beetles (Coleoptera: Carabidae) and antlion larvae (Neuroptera: Myrmeleontidae) in spring.

In Canyonlands National Park, Utah, Armstrong (1982) examined cheek pouches of 24 *D. ordii*, and found seeds of 18 plant genera: *Salsola*, *Achnatherum* [*Oryzopsis*], *Polygonum*, *Purshia*, *Bromus*, *Descurainia*, *Townsendia*, *Vulpia* [*Festuca*], *Oenothera*, *Agrostis*, *Lepidium*, *Gilia*, *Rumex*, *Sporobolus*, *Astragalus*, *Lupinus*, *Cleome*, and *Cryptantha*. Stomach analyses of *D. ordii* specimens revealed that 90% of the diet was seed materials, 5% was plant foliage, 4% flowers, and 1% fungi; no arthropods were recorded (Armstrong 1982). In northern Arizona, Hoffmeister (1986, p. 299) observed that *D. ordii* fed "extensively on seeds of many kinds," including bull-thorn and Indian paintbrush (*Castilleja* sp.) (Hoffmeister and Durham 1971).

Johnson (1961) analyzed stomach contents of 111 *D. ordii* and cheek pouch contents from 71 specimens taken from five different rangeland habitats in southern Idaho during spring and summer in 1957, and reported frequencies of occurrences of various food items. Seeds and leaves of halogeton (*Halogeton glomeratus*) were dominant in spring (100% frequency) and remained important in summer; other plant species in the diet included tansy mustard (*Descurania pinnata*), tumbleweed (*Salsola kali*), grasses (including cheatgrass, *Bromus tectorum*), prickly pear cactus (*Opuntia polyacantha*), shadscale (*Atriplex confertifolia*), peppergrass (*Lepidium perfoliatum*), sweet clover (*Melilotus alba*), kochia (*Kochia americana*), salt sage (*Atriplex nuttallii*) and big sagebrush (*Artemisia tridentata*). Arthropods were recorded with frequencies of 7% in spring and 13% in summer (Johnson 1961). Cheek pouch analyses revealed seeds of 7 plant taxa (*Halogeton*, *Descurania*, *Lepidium*, *Hackelia*, *Opuntia*, *Atriplex nuttallii*, and grass) and leaves of 3 taxa (grass, *Halogeton* and *Lepidium*) (Johnson 1961).

In central Oklahoma, Trowbridge and Whitaker (1940) analyzed contents of *D. ordii* cheek pouches, finding seeds of cockleburs (*Xanthium* sp.), wild bean (*Strophostyles helvola*), lesser ragweed (*Ambrosia artemisiifolia*), *Chamaesyce* [*Euphorbia*], sand grass (*Triplasis purpurea*), and switch grass (*Panicum virgatum*). In addition, leaf fragments of *P. virgatum* were observed; no arthropods or other animal materials were found. Further diet studies of *D. ordii* from Oklahoma (n=423)

by Best and Hoditschek (1982) identified 8 seed species (presented in decreasing frequency order): *Strophostyles helvola* (42.6%), *Cycloloma atriplicifolium* (15.9%), *Trifolium* sp. (14.9%), *Chamaecrista* [*Cassia*] *fasciculata* (10.8%), *Corispermum americanum* [*hyssopifolium*] (4.1%), *Helianthus* sp. (2.1%), *Aristida* sp. (1.5%), and *Populus deltoides* (0.5%). Unidentified green foliage, unknown seeds, and dead plant debris constituted a substantial fraction of cheek pouch contents, particularly in winter and spring; arthropods were not observed (Best and Hoditschek 1982).

A third food habits study of Oklahoma populations of *D. ordii* provided a comprehensive diet analysis based on both stomach contents and cheek pouch contents. McCulloch (1959) analyzed stomach contents of *D. ordii* collected from rangelands with varying levels of livestock grazing on the Southern Plains Experimental Range in northwestern Oklahoma over a two-year period (1956-58). McCulloch (1959) recorded seeds of 16 plant taxa from stomach contents of 171 specimens, and seeds of 45 plant taxa from cheek pouches of 294 specimens. In addition to seeds in the cheek pouches, McCulloch (1959) also found a variety of grass leaves and stems, arthropod parts, cow manure, rodent feces, and roots of grasses. Seed endosperm and seed husks comprised 80–90% of the volume of stomach contents in all seasons. Dominant species (from both stomach contents and cheek pouch contents) included seeds of sand dropseed (*Sporobolus cryptandrus*), purple sandgrass (*Triplasis purpurea*), and flatsedge (*Cyperus schweinitzii*). Green plant materials in stomach contents were usually composed of grass and forb leaves and stems, seed husks, seed capsules and finely chewed green seeds; these materials generally contributed <10% to the total diet volume. Arthropod parts constituted from near zero to 10% of diet by volume, and included grasshopper eggs (Orthoptera) and fleas (Siphonaptera); McCulloch (1959, p. 107) suggested that carcasses of frost-killed grasshoppers may have been scavenged by *D. ordii* during cold periods.

As described for *D. merriami*, Kerley et al. (1997) found that *D. ordii* contributed to the observed clipping of grass tillers in Chihuahuan Desert grasslands. Kerley et al. (1997) experimentally removed all *Dipodomys* spp. from grassland study plots, and found that when kangaroo rat species were absent, tussock-forming grasses experienced clipping frequencies of only 0.25%, whereas when *Dipodomys* spp. were present, 58.25% of grass tussocks suffered tiller clipping. These grass species included (in order of decreasing clipping intensity) *Digitaria californica*, *Bothriochloa barbinodis*, *Sporobolus airoides*, *Aristida ternipes*, *Setaria leucophila*, *Sporobolus flexuosus*, *Sporobolus cryptandrus*, *Aristida purpurea*, *Eragrostis lehmanniana*, *Bouteloua curtipendula*, *Pleuraphis* [*Hilaria*] *mutica*, and *Bouteloua eriopoda* (Kerley et al. 1997). While some of these grasses may have been consumed as food, others may have been used in nest construction.

In the eastern plains of Colorado, Flake (1973) analyzed the stomach contents of 216 *D. ordii* over a one year period (1969-70), and found that plant materials constituted an average of 96% of food volume, with animal matter making up ~4% of annual total volume. Seasonal shifts in diet composition ranged from 90% plant and 10% animal in spring to 99% plant and 1% animal in late summer. Seeds contributed an annual average volume of 74.2% (seed species identifications were not determined), and ranged from 55.5% of volume in spring (May-June) to 92.9% of volume in winter (November-December). Plant foliage, stems, and flower parts were consumed by *D. ordii* mostly in spring (33.5% by volume), with lesser amounts in autumn (9.7%) and winter (2.2%). Forbs dominated the plant materials component (0.2% in winter to 30.5% in spring) compared to grasses and sedges (0.7% in winter to 9.6% in summer). Flake (1973) documented 18 plant taxa based on vegetative parts in the diet of *D. ordii*, of which 5 species contributed >1% of total annual volume: *Kochia scoparia* (4.5%), *Medicago sativa* (1.8%), *Salsola kali* (1.8%), *Tradescantia occidentalis* (1.2%), and *Leucocrinum montanum* (1%). Of the arthropod components, Flake (1973) found 6 orders of insects, various spiders, and a variety of unidentified arthropod materials. Dominant arthropod taxa included adult beetles (Coleoptera, 1.6% average annual volume), caterpillars (Lepidoptera, 1.2%), larval beetles (0.3%), spiders (Araneae, 0.1%), adult flies (Diptera, 0.1%), leaf hoppers (Homoptera: Cicadellidae, 0.1%), fleas (Siphonaptera, 0.1%), adult ants (Hymenoptera: Formicidae, <0.05%), and adult moths (Lepidoptera, <0.05%); unidentified arthropod material made up 1% of the diet volume. Of particular interest was Flake's (1973) observation that grasshoppers and crickets (Orthoptera), though plentiful at the site in spring, summer and autumn, were never found in the *D. ordii* diet.

Dipodomys spectabilis Merriam 1890
Banner-tailed Kangaroo Rat

On the Sevilleta NWR, the banner–tailed kangaroo rat was widespread in short-grass steppe and Chihuahuan Desert scrubland habitats, as evidenced by their highly visible mounds; however, only three individuals were captured during this study (all in the spring sample), greatly limiting diet analysis for this species. The stomach samples examined contained an average volume of 60% plant materials (which appeared to be mostly stems and stem bases of grasses), 7% seeds, and 3% arthropods; unidentifiable materials (but likely seed endosperm and

finely macerated leaves and stems) made up the remaining 30% of stomach volumes. Seeds of *Lappula occidentalis*, *Plantago patagonica*, and a species of *Opuntia*, were observed in stomach contents. Cheek pouches of one individual contained entirely grass material and cheek pouches of other individuals were empty.

Considering the importance of *D. spectabilis* at the Sevilleta NWR in grassland and scrubland, a brief summary of literature on its diet is useful in further evaluating the types of food likely consumed in central New Mexico (see also Best 1988).

During Bailey's (1905, 1931) studies on *D. spectabilis* in agricultural and rangeland settings in Texas and New Mexico, diet was composed entirely of seeds and green vegetation. Stomachs typically contained seed endosperm (but with little seed coat material by which to identify species) and plant vegetative parts, while cheek pouches and food caches contained a variety of grass and forb seeds, including grama grasses (*Bouteloua hirsuta*, *B. gracilis* [*oligostachya*], and *B. curtipendula*), seeds and flowers of snakeweed (*Gutierrezia sarothrae*), leaves of sand sage (*Artemisia filifolia*), and seeds of wild sunflower (*Verbesina encelioides* [*Ximenesia exauriculata*]), purslane (*Portulaca oleracea*), plantain (*Plantago patagonica*), Russian thistle (*Salsola tragus* [*pestifer*]), and false buffalo grass, *Munroa squarrosa*; no mention is made of arthropods in the diet (Bailey 1931). Dalquest (1953) noted that cheek pouches of *D. spectabilis* in central Mexico were packed with dried grasses. In west Texas, Miller (1939) noted that cheek pouches of several *D. spectabilis* contained dry and weathered kangaroo rat fecal pellets, and suggested these *D. spectabilis* might deliberately re-ingest feces to supplement their diet during periods of food scarcity.

In a foraging behavior study in central New Mexico, approximately 50 km south of the Sevilleta NWR, Schroder (1979) excavated mounds of *D. spectabilis* and examined contents within storage chambers of the burrow systems. The layered plant materials included seed heads of *Aristida pansa*, and seeds and stems of *Sporobolus, Plantago, Tridens,* and *Gutierrezia*. Schroder (1979) also noted that *Sporobolus* stems had been cut into 3 cm lengths, and included seed heads that had not yet emerged from their sheaths. Cut grass tufts and lower stems were more commonly observed in July and August; loose seeds did not appear to be a common storage item in mounds (Schroder 1979).

In southern New Mexico, Wood (1969) examined stomach contents of 18 *D. spectabilis*, and found that plant materials made up 90% of the diet. Green vegetation composed 42% of the food volume, succulent plant materials (*Opuntia* pods and *Yucca* flowers and culms) composed 11%, and seeds composed 37% (Wood 1969). In addition to plant materials, Wood (1969) reported that caterpillars (Lepidoptera larvae) constituted 4% of diet volume, while 6% of the diet was derived from animal parts of other rodents, indicating a predatory or scavenging nature of *D. spectabilis* not reported by other authors (although inter- and intra-specific agonistic behavior in *D. spectabilis* has long been recognized; see Bailey [1931, pp. 250–251, p. 259]). Wood (1969) also excavated 21 dens of *D. spectabilis* and found food caches to be dominated by *Gutierrezia* sp. (43% by volume), annual grasses (23%), perennial grasses (18%), and *Lepidium* sp. (7%); a total of 21 plant species were present in these caches, and average mass of materials per cache was 1.04 kg. However, it is important to note that contents of nest caches gathered by *D. spectabilis* may not accurately reflect the actual diet, but rather comprises a range of food items from which the animal may select consumable items at a future time; many items may ultimately be rejected, buried and forgotten, or lost to decomposition (e.g., Rebar and Reichman 1983, Reichman and Rebar 1985). Nonetheless, selective harvesting of plant materials by *D. spectabilis* (2.6 kg/ha in Wood's [1969] study), whether consumed or not, can have considerable impacts on local ecological communities.

Additional studies of contents and quantities of *D. spectabilis* caches have been conducted in Arizona. Vorhies and Taylor (1922) analyzed contents of 22 dens in the Santa Rita Mountains, and recorded 12 species of grasses (dominated by crowfoot grama [*Bouteloua rothrockii*], Humboldt needlegrass [*Aristida divaricata*], six-weeks grama [*B. aristidoides*], and another grama grass [*B. radicosa*]; in addition, 28 species of forbs, shrubs, and cacti were present, of which mesquite (*Prosopis velutina*), slender goldenweed (*Machaeranthera* [*Aplopappus*] *gracilis*), largebract spiderling (*Boerhaavia wrightii*), and milkwort (*Polygala obscura* [*puberula*]) were most common. Vorhies and Taylor (1922) also noted that stomachs of some *D. spectabilis* in the spring period were full of buds and flowers of Mexican poppy (*Eschscholzia californica* [*mexicana*]).

A second study in Arizona provided additional information on *D. spectabilis* caches. Monson and Kessler (1940) examined 64 caches, and noted 56 species of plants collected, of which 59.7% (by volume) were annual grasses, 15.2% were annual forbs, 13.4% were perennial grasses, and 8.2% were perennial forbs, shrubs and yuccas; dominant genera (contributing >5% by volume) included *Bouteloua* and *Aristida*. In a similar study in southern Arizona, Monson (1943) analyzed 65 dens for food materials cached by *D. spectabilis*. Seeds and other plant parts of 60 species were identified, dominated by perennial grasses (45.9% volume), annual forbs (22.2%), annual grasses (17.2%) and other perennials (13.4%, including forbs, shrubs, and yuccas); dominant genera

(contributing >5% by volume) included *Bouteloua*, *Dasyochloa* [*Triodia*], *Aristida*, *Machaeranthera* [*Aplopappus*], and *Guilleminea* [*Brayulinea*] (Monson 1943).

In west Texas, Ramsey and Carley (1970) excavated 13 mounds of *D. spectabilis*, and found stems, plant bases, fruits, and inflorescences of various grasses and forbs, including *Sporobolus compositus* [*asper*], *Erioneuron* [*Tridens*] *pilosum*, *Chenopodium* spp., *Setaria leucopila*, *Solanum elaeagnifolium*, *Astragalus nuttallinanus*, *Chloris cucullata*, *Amaranthus albus* [*graecizans*], *Lepidium austrinum*, *Verbena bracteata*, *Physaria* [*Lesquerella*] *ovalifolia*, *Selinocarpus* spp., and *Gutierrezia sarothrae*.

In an experimental assessment of the overall diet and food item selection preferences of *D. spectabilis*, Frank (1988) proposed that diet composition was driven by the need to maximize net metabolic water production (this may apply to many, if not all, heteromyid rodents). Frank (1988 and references therein) noted that *D. spectabilis* acquires virtually all of its water via preformed water in dietary items, as well as water produced metabolically by oxidation of foods during catabolism. Different food components yield different amounts of metabolic water, and these differences change with ambient humidity. For *D. spectabilis* living in humid conditions and having a positive physiological water balance, both carbohydrate and lipid metabolism produce large net water gains, whereas protein metabolism produces a large net water loss. Under dry ambient conditions when *D. spectabilis* is under water stress, carbohydrate metabolism still produces a large net water gain, but lipid metabolism results in a net water loss, and protein metabolism causes an even larger net water loss. Frank (1988) demonstrated that under conditions of positive water balance, *D. spectabilis* preferred a diet high in carbohydrates and lipids, and intermediate in protein, but under water-stressed conditions, *D. spectabilis* selected a diet with high carbohydrate content, reduced lipid content, and low protein content. The shift in diet selectivity away from lipids and proteins reduced overall amount of water required during metabolism, thereby improving total water balance. Frank (1988) concluded that if dietary energy contents were equal under different environmental conditions, *D. spectabilis* would select food items (seed types, green vegetation, or arthropods) that would maximize net metabolic water gain.

FAMILY MURIDAE

Reithrodontomys megalotis (Baird 1857)

Western Harvest Mouse

Though the western harvest mouse is widespread (Webster and Jones 1982), it was not abundant during this study (n=21), and was collected most commonly in juniper-oak savanna (n=14); occasional specimens were found in piñon-juniper woodland (n=2), mesquite savanna (n=4), and Chihuahuan Desert scrubland (n=1; Table 1). While *R. megalotis* has been caught on a regular basis during ongoing Sevilleta LTER studies, during this study it was almost exclusively collected during the winter sampling period. As such, a seasonal comparison of diet for this species was not possible. However, based on winter and spring samples, diet analysis showed that *R. megalotis* was predominantly granivorous (100% frequency occurrence of seeds), with arthropods an important dietary component (79–100% frequency); by volume, seeds averaged 60% of the diet, and arthropods averaged 30% (Tables 10, 11). During winter period, one-seed juniper berries and grass seeds (6 species) made up the majority of seed types consumed, with forb seeds of secondary importance (Table 10). Green vegetation was a relatively minor component of the diet (10% by volume, Table 11).

Previous reports on diet composition of *R. megalotis* in the western United States are both scant and inconsistent. Early studies in New Mexico by Bailey (1931) described *R. megalotis* as seed eaters, occasionally taking green vegetation, but no arthropods were mentioned. Davis and Schmidly (1994, p. 162) stated that in Texas, R. megalotis "are almost entirely vegetarians and feed on the green parts of seeds and plants." In partial agreement, Hoffmeister (1986, p. 330) noted that *R. megalotis* "feed extensively on seeds and probably eat very little green vegetation. Grasses must provide the main source of seeds but other plants must provide seeds also."

In contrast, Meserve (1976) found that *R. megalotis* in California coastal sage scrub habitat consumed mostly seeds of shrubs (6 species) and grasses (unidentified); forbs (6 species) were a minor diet component. However, arthropods (including adult insects, caterpillars and spiders) contributed ~19% of average monthly total volume (Meserve 1976). In southeastern Utah, Armstrong (1982, p. 123) reported *R. megalotis* stomach contents "contained about two thirds insect remains and one-third seeds." In the Great Basin Desert of Idaho, Johnson (1961) found arthropods in 64% of *R. megalotis* sampled in spring, and up to 87% of individuals collected in summer. In addition, Johnson (1961) recorded seeds and/or leaves of *Halogeton glomeratus*, *Atriplex confertifolia*, *Lepidium perfoliatum*, *Opuntia* sp., *Artemisia tridentata*, *Melilotis alba*, *Salsola kali*, *Descurainia sophia*, and *Agropyron cristatum*.

The results of Meserve (1976), Armstrong (1982) and Johnson (1961) were comparable to limited results from our study, as well as findings of diet studies of *R. megalotis* in the eastern United States (see Whitaker and Mumford (1972) and references therein), in that arthropods were found to be an important dietary component. In addition, our results are at least in partial

TABLE 10. List of items discovered in the diet of the western harvest mouse (*Reithrodontomys megalotis*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season. No specimens were collected during summer.

Item	Winter (n=19)	Spring (n=2)
Arthropods	79	100
Vegetation	37	50
Seeds	100	100
Trees:		
Juniperus monosperma	63	—
Shrubs:		
Fallugia paradoxa	16	—
Larrea tridentata	5	—
Grasses:		
Achnatherum hymenoides	5	—
Aristida sp.	21	—
Bouteloua sp.	5	—
Muhlenbergia sp.	10	—
Poaceae, unidentified species	5	—
Sporobolus sp.	53	—
Forbs:		
Asteraceae, unidentified species	10	—
Bahia sp.	5	—
Brassicaceae, unidentified species	10	—
Eriogonum sp.	5	—
Fabaceae, unidentified species	5	—
Linum sp.	—	50
Vicia sp.	—	50

TABLE 11. Summary of prey types of the western harvest mouse (*Reithrodontomys megalotis*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Montane piñon-juniper woodland	Winter	1	33	0	67	0	0	100	0
	Spring	1	75	0	25	0	0	0	100
Juniper-oak savanna	Winter	13	68	9	23	32	8	52	8
	Spring	1	25	50	25	0	0	0	100
Mesquite savanna	Winter	4	35	12	53	0	0	70	30
Chihuahuan Desert scrubland	Winter	1	100	0	0	0	33	33	33
Total means (%)		21	60	10	30	20	6	52	22

agreement with previous reports from Texas and Arizona that indicate importance of grass seeds in the diet.

***Peromyscus boylii* (Baird 1855)**
Brush Mouse

During this study, brush mice (n=44) were found solely within piñon-juniper habitat (Table 1). Diet of *P. boylii* was composed mostly of arthropods and the fruits and nuts of the common tree species (Tables 12, 13). Arthropods appeared in the diet 87–100% of the time (Table 12), with maximum consumption of arthropods during summer (82% of total volume; Table 13). Overall, 12 species of plant seeds were found in the diet (Table 12). Acorns (*Quercus turbinella*) and one-seed juniper berries (*Juniperus monosperma*) were common in the diet during all periods, while seeds of shrubs and forbs were most common during spring; grass seeds were rarely observed. Plant leaf materials were present in the diet mostly during winter (Table 12), but composed only a small percentage of total food volume consumed (Table 13).

Previous studies on food habits of *P. boylii* have reported varying degrees of importance of arthropods in the diet. Smartt (1976, 1978) and Jameson (1952) found that arthropod material comprised between 31% and 50% of the diet in *P. boylii* from northern New Mexico and California, respectively. Both Brown (1964) and Clark (1952) reported arthropods (particularly camel crickets [Orthoptera: Raphidophoridae; *Ceuthophilus* sp.] and ground beetles [Coleoptera: Carabidae]) as being a major diet component of *P. boylii* in Missouri and Texas. In Arizona, Duran (1973) observed seasonal frequencies of arthropods in the diet of *P. boylii*, with 5% frequency in January and 23% in July. In contrast, Bailey (1931) and Long (1961) found little trace of insect parts in the diet of *P. boylii* captured in various sites in New Mexico and Kansas due to the finely masticated nature of food items in stomach contents.

At the Sevilleta NWR, *P. boylii* were usually collected in association with oak trees (*Quercus turbinella*), and acorns were found in the diet during all seasons, particularly in summer. Fruits of one-seed juniper (*Juniperus monosperma*) also were common in the diet. Piñon pine (*Pinus edulis*) was represented in the spring diet by pollen cones. During late spring, piñon pines were laden with pollen cones, and *P. boylii* consumed large quantities of them. Few pollen cones had fallen to the ground at the time of spring sampling, indicating that *P. boylii* were likely climbing trees to harvest pollen cones. Smartt (1978) showed that *P. boylii* in northern New Mexico were well adapted for climbing compared with other

TABLE 12. List of items discovered in the diet of the brush mouse (*Peromyscus boylii)* on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season.

Items	Winter (n=23)	Spring (n=16)	Summer (n=5)
Arthropods	87	100	100
Vegetation	39	12	0
Seeds	100	100	60
Trees:			
Juniperus monosperma	87	13	40
Pinus edulis	—	88	—
Quercus turbinella	74	50	60
Shrubs:			
Chenopodium sp.	9	—	—
Fallugia paradoxa	—	6	—
Rhus trilobata	—	44	—
Grasses:			
Aristida sp.	4	—	—
Bouteloua eriopoda	4	—	—
Forbs:			
Fabaceae, unidentified species	—	25	—
Astragalus sp.	—	6	—
Lupinus kingii	—	6	—
Physaria fendleri	—	6	—

TABLE 13. Summary of prey types of the brush mouse (*Peromyscus boylii*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Montane piñon-juniper woodland	Winter	23	51	10	39	72	4	12	12
	Spring	16	60	3	37	61	21	0	18
	Summer	5	18	0	82	89	0	11	0
Total means (%)		44	51	6	43	70	10	7	13

Peromyscus species, and also reported several food items from trees (juniper fruits and pollen cones, pine nuts, and mistletoe [*Phoradendron juniperinum*]).

Bailey (1905, 1931) found *P. boylii* in New Mexico and western Texas consumed acorns, pine nuts, and seeds and fruits of juniper, hackberry and cactus. Similarly, Davis and Schmidly (1994) described diets of *P. boylii* in the Guadalupe Mountains of Texas as consisting of pine nuts, Douglas fir seeds, and acorns. In southeastern Kansas, *P. boylii* consumed primarily acorns of blackjack oak, *Quercus marilandica* (Long, 1961), and in Missouri, acorns and other (unidentified) seeds made up 60% of the annual diet (Brown 1964). In California, Jameson (1953) also reported that *P. boylii* consumed acorns, manzanita berries, and pine nuts, while Kalcounis-Rüppell and Millar (2002) found *P. boylii* food caches containing acorns of live oak (*Quercus agrifolia*). Piñon pine nuts were not found in the diet of *P. boylii* on the Sevilleta NWR (nor in any other rodent species) during this study, likely due to a poor crop of pine nuts in 1998 (R. Zlotin, unpublished LTER data). However, juniper and oak had both produced extensive mast crops. It is likely that *P. boylii* utilize all three species of tree depending on relative abundance of seed crops at any time.

While trees apparently constitute a large proportion of the diet of *P. boylii*, seeds of other plants also are consumed. In addition to juniper, pine, and mistletoe, Smartt (1976) listed 20 additional plant species in *P. boylii* diets in northern New Mexico, including mountain mahogany (*Cercocarpus montanus*), Apache plume (*Fallugia paradoxa*), winterfat (*Kraschenninikovia lanata*), purple nightshade (*Solanum elaeagnifolium*), verbena (*Glandularia* [*Verbena*] *bipinnatifida*), hedgehog cactus (*Echinocereus triglochidiatus*), prickly pear cactus (*Opuntia* sp.), and alkali sacaton (*Sporobolus airoides*), plus 12 additional unidentified species. However, on an annual basis, all of these items together comprised only 27% of the diet of *P. boylii* (Smartt 1976). In Utah, seeds (species not identified) comprised more than 90% of the diet of *P. boylii* during summer and fall (Armstrong 1982), and more than 80% of their diet in Arizona (Duran 1973). Thus, it appears that while arthropods and tree species are the major components of the diet, other species of plants (shrubs, forbs, and to a limited extent, grasses) may be important during some seasons and in certain locales.

***Peromyscus eremicus* (Baird 1857)**
Cactus Mouse

Only 4 individuals of the cactus mouse were collected during this study, 3 found in the mesquite savanna and 1 in Chihuahuan Desert scrubland (Table 1). Limited captures of this species may reflect proximity of the Sevilleta NWR to the northern distributional limit of *P. eremicus* in New Mexico (Findley et al. 1975; Veal and Caire 1979). In mesquite savanna, the specimen captured during winter had consumed only arthropods, while diets of the two individuals captured during summer contained arthropods, plant materials, and seeds of mesquite (*Prosopis glandulosa*) and white ragweed (*Hymenopappus filifolius*). The individual collected in the Chihuahuan Desert scrubland contained plant leaf materials and the seeds of indigo bush (*Psorothamnus scoparius*), creosotebush (*Larrea tridentata*), three-awn grass (*Aristida* sp.), muhly grass (*Muhlenbergia* sp.), and buckwheat (*Eriogonum* sp.).

While limited by small sample size, these results are consistent with previous reports. Davis and Schmidly (1994) found that *P. eremicus* in Texas fed on seeds of desert annuals, mesquite, and hackberry, as well as insects and green vegetation. Bailey (1931) reported a diet of mainly seeds, and noted hackberry seeds as a common constituent in southern New Mexico. In the Sonoran Desert near Tucson, Arizona, Reichman and Van de Graff (1973) recorded a *P. eremicus* diet of mostly insects, while in the Mojave Desert near Las Vegas, Nevada, Bradley and Mauer (1973) found *P. eremicus* to be more omnivorous, having consumed "seeds, insects, and green vegetation in various amounts depending upon seasonal

availability" (Bradley and Mauer 1973, p. 340). Finally, in coastal sage scrub of California, Meserve (1976) found that the diet of *P. eremicus* contained mostly seeds, flowers, and foliage of shrubs (principally *Rhus integrifolia* and *Lotus scoparius*, but also *Eriogonum fasciculatum*, *Salvia apiana* and *Artemisia californica*), along with several species of forbs and grasses; insects comprised 2–18% of the diet, depending on season (less common in winter).

***Peromyscus leucopus* (Rafinesque 1818)**
White-footed Mouse

The abundant white-footed mouse (n=160) occurred in all 6 habitats (Table 1), with maximum abundances in juniper-oak savanna (n=70) and cottonwood riparian forest (n=70). The diet frequency analyses revealed that diet was composed mainly of arthropods and seeds (especially one-seed juniper), with vegetation occurring much less often (Table 14). Within the seed category, diet of *P. leucopus* was composed of 44 plant taxa, including 4 species of trees, 5 species of shrubs, 2 species of cactus, at least 8 species of grasses, and at least 25 species of forbs (Table 14). This large breadth of dietary items attests not only to the general nature of foraging, but also to the wide range of habitats in which *P. leucopus* is found. Seasonal shifts in diet were observed (Table 15), with arthropods comprising an average of 32% by volume in winter, and becoming more common during spring (64%) and summer (48%); seeds were most commonly consumed in summer (47%) and winter (62%) compared to spring (33%). Vegetative plant material was rare in the diet, ranging from 3% in spring, to 5% in summer, to 6% in winter. Overall, this seasonal diet pattern matches seasonal availability of arthropods and seeds,

TABLE 14. List of items discovered in the diet of the white-footed mouse (*Peromyscus leucopus*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season.

Items	Winter (n=67)	Spring (n=44)	Summer (n=49)
Arthropods	72	98	92
Vegetation	22	9	12
Seeds	96	73	94
Trees:			
Elaeagnus angustifolia	—	—	26
Juniperus monosperma	58	14	14
Pinus edulis	—	2	—
Prosopis glandulosa	—	—	2
Shrubs/cacti:			
Atriplex canescens	3	—	—
Echinocereus triglochidiatus	1	—	—
Gutierrezia sarothrae	1	—	—
Larrea tridentata	1	—	—
Opuntia sp.	—	—	4
Rhus trilobata	—	2	—
Senecio multilobatus	—	—	2
Grasses:			
Achnatherum hymenoides	—	2	—
Aristida adscensionis	1	—	—
Aristida sp.	19	—	—
Bouteloua gracilis	6	—	—
Bouteloua sp.	1	—	—
Panicum obtusum	—	—	6
Poaceae, unidentified species	3	2	—
Sporobolus sp.	1	—	8

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emphasizing the opportunistic nature of foraging of *P. leucopus*.

Of the seed material, forb seeds were consumed in the greatest quantities (51% of all seeds), with tree seeds also consumed in large amounts (27%); grass and shrub seeds appeared less important (Table 15). These results, along with habitat specific results discussed below, indicate that *P. leucopus* was a generalist feeder, reflecting also its ability to inhabit all Sevilleta NWR ecosystem types.

In the cottonwood riparian forest *P. leucopus* was the only rodent species collected, and in great abundance (Table 1). Arthropods were consumed year-round, and made up the largest volume during spring (Table 15). Seeds were second in terms of volume, with seeds of Russian olive (*Elaeagnus angustifolia*) found most often during winter. An additional 10 species of shrubs, grasses and forbs were recorded. Seeds of the most common tree, the valley cottonwood (*Populus deltoides*), were not observed in the *P. leucopus* diet, presumably due to their extremely small size.

In piñon-juniper woodland and juniper-oak savanna habitats, arthropods were somewhat less prevalent in the diet than seeds, while vegetation remained a relatively small proportion (Table 15). Fruit/seeds of one-seed juniper was the single most abundant food species. Seeds of *Astragalus* spp. also were common in spring and summer diets, and in late summer, prickly-pear cactus and cholla seeds (*Opuntia* spp.) were consumed by most *P. leucopus* examined. Often, entire cactus seeds were found in stomachs, possibly due to very thick seed coats for these species that resist rodent gnawing. Assuming these seeds are eventually defecated intact, *P. leucopus* may function as a seed disperser for these cacti species.

In mesquite savanna habitat, arthropods constituted >45% of the diet in all seasons, with seeds comprising a similar proportion (Table 15). As in other habitats, arthropods were found most during spring. Seeds of mesquite (*Prosopis glandulosa*), one-seed juniper (*Juniperus monosperma*), four-wing saltbush (*Atriplex canescens*) and Indian rice grass (*Achnatherum hymenoides*), plus several other species of grasses and forbs were consumed.

[TABLE 14, continued]

Items	Winter (n=67)	Spring (n=44)	Summer (n=49)
Forbs:			
Allium macropetalum	—	4	—
Asteraceae, unidentified species	10	14	2
Astragalus missouriensis	—	7	—
Astragalus sp.	—	18	4
Bahia sp.	1	—	—
Baileya multiradiata	1	—	—
Brassicaceae, unidentified species	4	2	2
Chaetopappa ericoides	—	2	—
Chamaesaracha coniodes	—	—	2
*Chamaesyc*e sp.	6	—	2
Cirsium ochrocentrum	—	—	6
Cymopterus acaulis	—	2	—
Dalea sp.	—	—	2
Eriogonum sp.	4	—	—
Erysimum asperum	1	—	—
Fabaceae, unidentified species	—	—	2
Hoffmanseggia glauca	—	2	—
Hymenopappus filifolius	—	—	2
Melilotus albus	—	—	8
Oenothera albicaulis	1	—	—
Physaria fendleri	1	7	2
Pseudocymopterus montanus	—	—	2
Ratibida sp.	1	—	—
Solanum elaeagnifolium	—	—	4
Sphaeralcea sp.	1	—	4

TABLE 15. Summary of prey types of the white-footed mouse (*Peromyscus leucopus*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Cottonwood	Winter	22	40	6	54	0	0	17	83
riparian forest	Spring	23	24	1	75	0	0	0	100
	Summer	25	46	0	54	46	4	11	39
Montane piñon-	Winter	1	66	17	17	33	0	33	33
juniper woodland	Spring	1	20	0	80	0	0	0	100
Juniper-oak	Winter	39	74	6	20	58	3	21	18
savanna	Spring	13	54	5	41	29	4	4	63
	Summer	18	47	13	40	20	40	16	24
Mesquite	Winter	1	50	0	50	0	33	33	33
savanna	Spring	4	20	7	73	0	0	50	50
	Summer	3	46	8	46	60	0	0	40
Short-grass	Spring	1	80	0	20	0	0	0	100
steppe	Summer	1	20	0	80	0	100	0	0
Chihuahuan	Winter	4	76	5	19	0	18	46	36
Desert scrubland	Spring	2	10	0	90	0	0	0	100
	Summer	2	67	0	33	0	25	0	75
Total means (%)		160	50	5	45	27	8	14	51

Only two specimens of *P. leucopus* were collected in short-grass steppe habitat, and these had consumed only arthropods and seeds (Table 15). Seed species included *Opuntia* sp., *Allium macropetalum*, *Cymopterus acaulis*, *Hoffmanseggia glauca*, and *Oenothera albicaulis*.

In Chihuahuan desert scrubland habitat, arthropods were abundant in the diet during summer, but less common at other times of year (Table 15). Seed species found in the diet included *Gutierrezia sarothrae*, *Larrea tridentata*, *Opuntia* sp., *Aristida* sp., *Bouteloua* sp., *Allium macropetalum*, *Chaetopappa eriocoides*, *Chamaesaracha coniodes*, *Eriogonum* sp., *Chamaesyce* sp., and *Sphaeralcea* sp. There was only rare evidence of green vegetation in the diet during winter in this habitat type.

For such a widespread and common rodent species, little detailed information is available in the literature on *P. leucopus* diets, particularly for western states (see Lackey et al. [1985] for a summary of food items east of the Mississippi River). Schmidly (1977) and Davis and Schmidly (1994) described *P. leucopus* diets in Texas as generally including mesquite beans, acorns, pecans, various seeds, insects, snails, and other invertebrates. In Colorado, Fitzgerald et al. (1994) reported insects as the most common prey, followed by a variety of seeds. Bailey (1931) provided two second-hand reports of *P. leucopus* consuming seeds of creosotebush (*Larrea tridentata*) and crickets in New Mexico. The most detailed study was conducted in northern New Mexico by Smartt (1976, 1978), who found that *P. leucopus* diet was composed of arthropods (38%), juniper (*Juniperus monosperma*) fruit (8%), juniper seed (4%), juniper pollen cones (1%), piñon pine (*Pinus edulis*) nuts (7%), prickly-pear cactus tissue (19%), and juniper mistletoe (*Phoradendron juniperinum*) (<1%). The remaining diet portion (22%) was composed of 26 additional species of plant seeds and other items that usually occurred in small quantities, including mountain mahogany (*Cercocarpus montanus*), Apache plume (*Fallugia paradoxa*), winterfat (*Krascheninnikovia lanata*), snakeweed (*Gutierrezia sarothrae*), wild buckwheat (*Eriogonum corynbosum*), hedgehog cactus

(*Echinocereus triglochidiatus*), purple nightshade (*Solanum elaeagnifolium*), verbena (*Glandularia* [*Verbena*] sp.), and alkali sacaton (*Sporobolus airoides*), plus 17 other unidentified species of seed or green vegetation (Smartt 1976). Smartt (1978) concluded that *P. leucopus* preferred to forage on the ground, compared with more arboreal species of *Peromyscus* in the same habitats (e.g., *P. boylii* and *P. truei*). Taking all of these results together, and combining them with our findings, it appears that *P. leucopus* feeds primarily on insects (particularly in spring and summer months), with seeds playing a nearly equal role in the diet. Green vegetation, while occasionally consumed, appears to be of relatively minor importance as a food item.

***Peromyscus truei* (Shufeldt 1885)**
Piñon Mouse

The piñon mouse was found in five of six habitats sampled, although it was only commonly captured in piñon-juniper woodland and juniper-oak savanna (Table 1). Combined data from all *P. truei* specimens (n=115) over all habitats show that seed material was consumed

TABLE 16. List of items discovered in the diet of the piñon mouse (*Peromyscus truei*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season.

Items	Winter (n=34)	Spring (n=56)	Summer (n=25)
Arthropods	68	86	96
Vegetation	18	18	24
Seeds	100	100	72
Trees:			
Juniperus monosperma	94	75	52
Pinus edulis	—	34	32
Quercus turbinella	—	11	28
Shrubs/cacti:			
Atriplex canescens	—	2	—
Fallugia paradoxa	—	2	—
Opuntia sp.	—	4	12
Rhus trilobata	—	12	—
Grasses:			
Achnatherum hymenoides	—	5	—
Aristida sp.	6	—	—
Bouteloua gracilis	9	—	—
Bouteloua sp.	3	—	—
Poaceae, unidentified species	3	—	—
Forbs:			
Allium macropetalum	—	2	—
Asteraceae, unidentified species	—	2	—
Astragalus sp.	—	11	8
Brassicaceae, unidentified species	3	7	12
Chamaesyce sp.	—	—	4
Eriogonum sp.	—	2	—
Hymenopappus filifolius	—	7	—
Ipomopsis pumila	—	2	—
Juncus bufonius	—	4	—
Lupinus kingii	—	20	—
Oenothera albicaulis	—	2	—
Physaria fendleri	9	18	4
Townsendia annua	—	2	—

most frequently (100% occurrence in winter and spring; 72% in summer), followed by arthropod material (68–96%, Table 16). Vegetation material occurred in the diet in <25% of specimens. Of the seed material, *P. truei* consumed a large diversity of species (at least 25 taxa), including 3 tree species, 3 shrub species, 1 cactus, 5 grass species, and at least 13 forb species (Table 16). Seeds, fruits, and pollen cones of one-seed juniper (*Juniperus monosperma*) and piñon pine (*Pinus edulis*) occurred most frequently in the diet. By volume, arthropods comprised 35% of the average diet on an annual basis, although this varied among habitats and seasons (Table 17). Arthropods were most commonly consumed during spring (36% by volume) and summer (58%), when they were most available in the environment; the winter diet averaged only 18% arthropods by volume (Table 17). Seed materials averaged 59% of the diet annually, with the highest seed consumption during the winter (78% by volume) compared to 59% in spring and 33% in summer. Plant vegetative materials averaged only 6% of the diet (4% in winter to 9% in summer by volume), and never exceeded 20% at any time or in any habitat (Table 17). Tree species contributed 65% of the diet's seed/fruit/pollen cone component, while forbs contributed an additional 23%; seeds of shrubs and grasses comprised a relatively minor proportion of the diet (Table 17).

In piñon-juniper woodland and in juniper-oak savanna habitats, arthropods and seeds displayed inversely proportional seasonal shifts in diet volume; seeds (particularly those from tree species) were most commonly consumed during winter, when arthropod abundance was lowest, while the situation was reversed during summer (Table 17). Large numbers of juniper berries were consumed by *P. truei* during winter and spring however, importance of juniper berries declined in late spring and summer, a period that corresponded to formation of pollen cones on piñon pine and acorns on oak. Winter was the only season in which grass seeds were present in the diet, while limited numbers of shrub and forb seeds were consumed during spring and summer (Table 17). In piñon-juniper woodland habitat these shrub, grass, and forb taxa included *Rhus trilobata*, *Opuntia* sp., *Aristida* sp., *Bouteloua gracilis*, *Astragalus* sp., *Juncus bufonius*, *Physaria fendleri*, and an unidentified mustard (Brassicaceae). In juniper-oak savanna, species consumed included *Atriplex canescens*, *Fallugia paradoxa*, *Opuntia* sp. *Rhus trilobata*, *Bouteloua gracilis*, *Astragalus* sp., *Eriogonum* sp., *Chamaesyce* sp., *Physaria fendleri*, *Lupinus kingii*, and an unidentified mustard (Brassicaceae).

In mesquite savanna habitat, sample size was low (n=10), but dietary patterns similar to those of montane

TABLE 17. Summary of prey types of the piñon mouse (*Peromyscus truei*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Montane piñon-juniper woodland	Winter	17	76	5	19	89	0	11	0
	Spring	25	54	4	42	68	11	0	21
	Summer	15	32	6	62	79	7	0	14
Juniper-oak savanna	Winter	15	85	3	12	72	0	14	14
	Spring	24	69	6	25	49	10	0	41
	Summer	6	27	15	58	56	11	0	33
Mesquite savanna	Winter	2	46	9	46	0	0	67	33
	Spring	5	35	0	65	30	0	30	40
	Summer	3	50	19	31	100	0	0	0
Short-grass steppe	Spring	1	60	0	40	0	0	0	100
Chihuahuan Desert scrubland	Spring	1	60	20	20	0	0	0	100
	Summer	1	25	0	75	0	0	0	100
Total means (%)		115	59	6	35	65	6	6	23

habitats were observed. Arthropods and seeds were again most commonly consumed, and green vegetation consumed only rarely (Table 17). When *P. truei* specimens were collected in proximity to scattered juniper trees, they nearly always had fed upon juniper berries. In late spring, large quantities of seeds of Indian rice grass (*Achnatherum hymenoides*) and ragweed (*Hymenopappus filifolius*) were produced as a result of plentiful moisture resulting from the 1998 El Niño. Seeds of these species were eaten not only by *P. truei*, but also by most other rodent species caught during late spring in this habitat. Other seeds consumed in this habitat included those of *Aristida* sp., *Bouteloua* sp., and an unidentified mustard (Brassicaceae).

Only one specimen of *P. truei* was collected in short–grass steppe, and only two specimens were collected in adjacent Chihuahuan Desert scrubland. As *P. truei* is not normally associated with these habitats (Findley et al. 1975; Hoffmeister 1981; Findley 1987), we surmise that these individuals were dispersing through the study areas. As they were collected in spring and summer, arthropods were present in their stomach contents, as were seeds of *Allium macropetalum*, *Ipomopsis pumila*, *Oenothera albicaulis*, *Sphaeralcea* sp., *Townsendia annua*, and an unidentified aster (Asteraceae).

Results from our study are consistent with other reports on diet of *P. truei*, but we have considerably expanded the list of seed species consumed by *P. truei*. Bailey (1931) first described the diet of *P. truei* in New Mexico as consisting of insects, pine nuts, and juniper berries. Subsequent studies by Smartt (1976, 1978) found that in northern New Mexico, diet of *P. truei* was composed of 30% arthropods, 31% one-seed juniper fruit (*Juniperus monosperma*), 12% juniper pollen cones, 3% juniper seeds, 3% piñon pine nuts (*Pinus edulis*), 7% mistletoe berries (*Phoradendron juniperinum*), 2% mountain mahogany seeds (*Cercocarpus montanus*), 4% cactus tissue (*Opuntia* sp.), and 8% other plant taxa, including oak (*Quercus* sp.), Apache plume (*Fallugia paradoxa*), hedgehog cactus (*Echinocereus triglochidiatus*), wild buckwheat (*Eriogonum corynbosum*), winterfat (*Krascheninnikovia lanata*), snakeweed (*Gutierrezia sarothrae*), purple nightshade (*Solanum elaeagnifolium*), verbena (*Glandularia* [*Verbena*] *bipinnatifidia*), and 12 other unidentified seeds and tissues.

In southwestern Colorado, Douglas (1969) recorded *Juniperus osteosperma*, *Pinus edulis*, *Artemisia nova*, *Artemisia* sp., *Gutierrezia sarothrae*, *Yucca* sp., *Eriogonum* sp., *Penstemon barbatus*, *Penstemon linarioides*, *Poa fendleriana*, spider legs, and bird feathers in the diet of *P. truei*, and also determined that juniper berries were the primary food item, particularly during winter. In chaparral of California, Bradford (1974) found that arthropods (insects and spiders) made up the bulk of the diet in summer, with acorns becoming most important in autumn; fungi, seeds (unidentified), and foliage made up the remainder. One stomach contained 60% mammal remains, indicating a capability for carnivory or scavenging on carrion (Bradford 1974).

***Onychomys arenicola* Mearns 1896**
Mearn's Grasshopper Mouse

Specimens of Mearn's grasshopper mouse (n=55) were collected in every habitat except the Rio Grande cottonwood riparian forest, and in all seasons (Table 1). Arthropods were present in 100% of specimens examined in all seasons, with seeds occurring in the diet predominantly during winter; vegetation materials were rarely observed (Table 18). Plant seeds were consumed from 18 taxa, including 2 tree species, 1 shrub, 1 cactus, 4 species of grasses, and at least 10 species of forbs (Table 18). By volume, arthropod materials averaged 84% of the diet on an annual basis, ranging from 60–100% depending on habitat and season; consumption of arthropods was consistently high in all habitats (Table 19). Arthropod volume in the diet ranged from 76% in winter (across all habitats) to 95% in spring and dropped only slightly to 90% in summer; average seed volume in the diet on an annual basis was 15%, but was only 5% in spring and 9% in summer, with a maximum of 22% in winter. Vegetative materials amounted to only 1% of annual diet volume (Table 19).

Often, O. arenicola consumed only arthropod materials, and stomach contents rarely had more than 25% seed and plant material. Many soil-dwelling beetle larvae (Coleoptera) and termites (Isoptera) were found in the diet. In addition, some stomachs contained reptilian scales, feathers, fur and bone, though rarely. Most specimens were collected in open areas and rarely underneath trees or shrubs. This was consistent with relative counts of different seed types eaten, with tree seeds and fruits rarely observed. Only in juniper-oak savanna habitat did *O. arenicola* consume small quantities of juniper berries (*Juniperus monosperma).* Forbs (61%) and grasses (21%) were the most common seed components in the diet (Tables 18, 19).

These results closely match the few other diet studies of *O. arenicola* in the southwest. In western Texas, Bailey (1905, p. 94) found that stomach contents of *O. arenicola* (classified as a subspecies of *O. torridus* at the time) contained "besides a small portion of seeds or grain, a larger share of scorpions, grasshoppers, crickets, beetles, and various other insects."

Later, when surveying southern New Mexico, Bailey (1931) described *O. arenicola* stomach contents containing a whitish pulp of seed materials, a large proportion of insect remains, and hair and flesh of other rodent species; these latter items (hair and flesh) were

TABLE 18. List of items discovered in the diet of Mearn's grasshopper mouse (*Onychomys arenicola*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season.

Items	Winter (n=27)	Spring (n=7)	Summer (n=21)
Arthropods	100	100	100
Vegetation	7	0	5
Seeds	74	29	19
Trees:			
Juniperus monosperma	11	14	0
Prosopis glandulosa	—	—	5
Shrubs/cacti:			
Gutierrezia sarothrae	4	—	—
Opuntia sp.	7	—	5
Grasses:			
Aristida sp.	11	—	—
Muhlenbergia sp.	4	—	—
Poaceae, unidentified species	7	—	5
Sporobolus sp.	7	—	—
Forbs:			
Asteraceae, unidentified species	4	—	5
Astragalus sp.	4	—	—
Brassicaceae, unidentified species	4	—	—
Chamaesyce sp.	7	—	—
Eriogonum sp.	7	—	—
Fabaceae, unidentified species	7	—	—
Ipomopsis pumila	—	14	—
Lappula occidentalis	—	—	5
Plantago patagonica	—	—	5
Sphaeralcea sp.	4	—	5

attributed to *O. arenicola* foraging upon other nearby snap-trapped rodents. Winter samples contained approximately equal proportions of seeds and animal matter in the diet (Bailey, 1931).

Given that *O. arenicola* was originally classified as part of the *O. torridus* group, we deem it appropriate to include a review of the very detailed scat analyses by Horner et al. (1965) of *O. torridus* in Nevada. The scats (from 49 specimens) were collected during summer (June, July, and August), and consisted almost exclusively of arthropods. Scorpions had been consumed by 37% of sampled mice, followed by grasshoppers and crickets (Orthoptera; ~25%) and scarab beetles (Coleoptera: Scarabaeidae) in the genus *Polyphylla* (~20%). Other arthropods in the diet included spiders (Araneae), mites (Acarina), beetles (Coleoptera: Staphylinidae, Tenebrionidae, Histeridae), ant lions (Neuroptera), ants (Hymenoptera), and caterpillars (Leptidoptera). In addition, occasional evidence of reptile scales and vertebrate bones was present, along with wood fragments and sand grains (Horner et al., 1965). No mention was made of seeds or other plant materials; these items would have been infrequent in summer diet (based on similar results obtained in all other studies reviewed above); no winter period samples were examined by Horner et al. (1965), so extent of winter herbivory could not be assessed.

Onychomys leucogaster (Wied-Neuwied 1841)
Northern Grasshopper Mouse

In this study, northern grasshopper mice (n=13) were collected only from the mesquite savanna habitat (Table 1). The dominant diet components were arthropod materials, particularly during spring and summer, followed by seeds and vegetation (Table 20). The amount of arthropod material consumed was relatively low in winter

TABLE 19. Summary of prey types of the Mearn's grasshopper mouse (*Onychomys arenicola*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Montane piñon-juniper woodland	Winter	2	8	0	92	0	100	0	0
Juniper-oak savanna	Winter	8	18	0	82	33	22	45	0
	Spring	1	17	0	83	100	0	0	0
	Summer	8	9	0	91	0	0	0	0
Mesquite savanna	Winter	1	0	0	100	0	0	0	0
	Summer	1	20	20	60	50	0	0	50
Short-grass steppe	Winter	11	29	4	67	0	0	29	71
	Spring	4	0	0	100	0	0	0	0
	Summer	5	11	0	89	0	33	0	67
Chihuahuan Desert scrubland	Winter	5	26	0	74	0	0	29	71
	Spring	2	10	0	90	0	0	0	100
	Summer	7	6	0	94	0	0	50	50
Total means (%)		55	15	1	84	8	10	21	61

and increased through the year. Seed materials were most commonly encountered during winter and spring periods, and vegetation materials were observed only during winter (Table 20). By volume, arthropod and seed materials comprised annual means of 58% and 38% respectively; vegetation constituted only a minor portion of the diet (10% during winter; Table 21). Of the 11 species of seeds found in the diet, shrub and forb species were most common during winter, while Indian rice grass (*Achnatherum hymenoides*) was very common in spring (when it typically produces seeds). This pattern indicates that arthropods are preferred food, but more seed materials are consumed when arthropod availability is low.

Virtually every review of *Onychomys* natural history has justifiably attributed near-legendary hunting skills to these mice, depicting them as voracious stalkers of arthropods, rodents, lizards and other small vertebrates (e.g., McCarty 1975; Schmidly 1977; McCarty 1978; Jones et al. 1983; Hoffmeister 1986; Findley 1987; Caire et al. 1989; Davis and Schmidly 1994; Fitzgerald et al. 1994; Hall 1995). Indeed, their prowess as predators has been well documented in numerous field studies. In Texas, Bailey (1905) found that *O. leucogaster* stomachs contained "finely chewed seeds and grain, an interesting assortment of grasshoppers, crickets, beetles, scorpions and small insects, and occasionally parts of a lizard or mouse" (Bailey, 1905; p. 94). In New Mexico, Bailey (1931) reported a wide variety of arthropods in the diet of *O. leucogaster,* including grasshoppers, crickets, scorpions, mole crickets, beetles, caterpillars, cutworms, and insect eggs; Bailey also found remnants of other rodents (in this case, presumably scavenged from dead rodents captured in nearby snap-traps), lizards and a variety of "weed seeds" (Bailey 1931, p. 138). Throughout the range of *Onychomys*, Bailey and Sperry (1929) concluded that diet in summer was nearly exclusively arthropods and vertebrates (rodents and lizards), whereas in winter, arthropod prey, while still present in the diet, was diminished and replaced by an increased presence of seeds and vegetation materials.

Experiments with captive *O. leucogaster* proved that these mice would readily kill and devour other rodents of equal or greater body mass, including deer mice (*Peromyscus maniculatus*), montane voles (*Microtus montanus*), and Great Basin pocket mice (*Perognathus parvus*; Bailey and Sperry 1929). Additional studies have shown that *O. leucogaster* can successfully kill Ord's kangaroo rat (*Dipodomy ordii*), hispid pocket mice

TABLE 20. List of items discovered in the diet of the northern grasshopper mouse (*Onychomys leucogaster*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season.

Items	Winter (n=5)	Spring (n=6)	Summer (n=2)
Arthropods	60	100	100
Vegetation	40	0	0
Seeds	80	83	50
Shrubs/cacti:			
Atriplex canescens	20	—	—
Fallugia paradoxa	20	—	—
Larrea tridentata	20	—	—
Psorothamnus scoparius	20	—	—
Grasses:			
Achnatherum hymenoides	—	83	—
Forbs:			
Astragalus sp.	—	17	—
Chamaesyce sp.	40	—	—
Fabaceae, unidentified species	40	17	—
Helianthus sp.	40	—	—
Hymenopappus filifolius	—	17	50
Pseudocymopterus montanus	20	—	—

(*Perognathus hispidus*), western harvest mice (*Reithrodontomys megalotis*), white-footed mice (*Peromyscus leucopus*), hispid cotton rats (*Sigmodon hispidus*) and house mice (*Mus musculus*) under laboratory conditions (Egoscue 1960; Ruffer 1968; Pellis and Pellis 1992). Some evidence of cannibalism exists in confined laboratory settings (Ruffer 1968) and in field situations where the carcasses of dead snap-trapped *O. leucogaster* had been eaten by conspecifics (Bailey 1931, p. 138), but no direct observation of conspecific killing and cannibalism in nature has been recorded.

In southeastern New Mexico, Best et al. (1993) found that 57% of 190 *O. leucogaster* had consumed arthropods, but no evidence of vertebrate prey was observed. In addition, Best et al. (1993) recorded 22 plant taxa in the diet, including (in order of importance) *Chamaesyce* [*Euphorbia*] sp., *Prosopis glandulosa*, *Triplasis purpurea*, an unidentified grass seed, *Oenothera* sp., *Helianthus petiolaris*, *Croton* sp., *Quercus havardii*, *Phacelia crenulata* [*corrugata*], *Linum aristatum*, *Palafoxia sphacelata*, *Gutierrezia sarothrae*, *Descurania pinnata*, *Bouteloua* sp., *Sporobolus cryptandrus*, *Astragalus* sp., *Sphaeralcea* sp., 5 unidentified plant species, and an unidentified species of fungus. Arthropods were most prevalent in the diet during summer, while plant materials and seeds became more important during winter; some individuals had consumed only plant materials during the winter (Best et al. 1993).

In short-grass prairie of northeastern Colorado, Flake (1973) reported that animal materials comprised 74% of diet volume in *O. leucogaster,* with proportions changing from winter (62% of volume) to summer (86%). Plant materials (seeds and other plant parts) varied from 14% of volume in spring to 38% of volume in winter. Flake (1973) found that both arthropods and plant materials occurred in the diet in approximate proportions to their seasonal availability; larval beetles and caterpillars were most common in spring, and adult beetles were most common in summer and fall. Grasshoppers were taken by *O. leucogaster* nearly year-round, although overall volume amounts declined in winter. Seeds were more abundant in the diet during fall and winter, presumably due to decreased availability of arthropods during this period. In total, Flake (1973) found that *O. leucogaster* diet included 7 orders of insects (Diptera, Coleoptera, Heteroptera, Hymenoptera, Lepidoptera, Orthoptera, and Siphonoptera), as well as spiders and centipedes, and 3 classes of vertebrates (mammals [rodents], birds and reptiles [lizards]). Plants were represented by 22 species of forbs (constituting 6.6% by volume of the average annual diet, and dominated by *Sphaeralcea coccinea* and *Kochia scoparia*), 10 species of grasses and sedges (7.1%

TABLE 21. Summary of prey types of the northern grasshopper mouse (*Onychomys leucogaster*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Mesquite savanna	Winter	5	55	10	35	0	42	0	58
	Spring	6	34	0	66	0	0	63	37
	Summer	2	9	0	91	0	0	0	100
Total means (%)		13	38	4	58	0	16	29	55

of average annual diet volume, and dominated by *Bouteloua gracilis*), and 4 species of shrubs (1.7% of average annual diet volume, dominated by *Artemisia frigida*); fungi (0.7%), lichens (0.3%), and mosses (0.1%) also occurred in small quantities (Flake 1973). On an annual basis, plant seeds (species not identified) contributed an average of 6.6% total volume to the diet of *O. leucogaster* (Flake 1973).

In a second grassland region of eastern Colorado, Hansen (1975) examined stomach contents of 136 *O. leucogaster,* and found that arthropods (mostly adults and larvae of Coleoptera, Orthoptera, and Lepidoptera) comprised 87% of the diet, with plants (7%), seeds (4%), fungus (1%) and vertebrates (mammals and reptiles, 1%) making up the remainder. Hansen (1975) further suggested that plant materials found in the diet may have been acquired through consumption of herbivorous arthropods (grasshoppers or caterpillars) that had leaf materials in their digestive tracts when consumed by *O. leucogaster*. While it is virtually certain that arthropod-ingested leaf materials would appear in stomachs of *O. leucogaster*, it is also likely that *O. leucogaster* consumes some leaf materials directly, particularly during winter when arthropods are not as available. Three lines of evidence support this conclusion: First, plant materials consumed by arthropods are very finely masticated, much more so than leaf parts consumed directly by *O. leucogaster*, and in our study, some of these leaf parts appeared too large for arthropods to have consumed them first; second, if the majority of leaf materials were derived from arthropod gut contents, then we would have expected to observe leaf materials in the diet of *O. leucogaster* throughout the year, particularly in spring and summer (when arthropods typically consume vegetative materials) – however, such was not the case, as we observed plant materials in the diet primarily in winter; and third, in captivity, *O. leucogaster* readily accepts a wide variety of leafy plant materials, including cactus, lettuce, spinach, celery, clover, grass and carrots (Bailey and Sperry 1929). Hence, it would appear that leaf materials found in *Onychomys* are the result of both directly consumed leaf materials and those materials from digestive tracts of their arthropod prey species.

Other studies also have noted the predatory nature of this species. In western Oklahoma, McCulloch (1959) recorded arthropods in 100% of 79 *O. leucogaster* collected in all seasons, and noted increased seed use in winter (33–50% occurrence frequency) compared to spring through autumn (0–14%). Seed species identified in the diet included Indian rushpea (*Hoffmanseggia glauca* [*densiflora*]), sunflower (*Helianthus annuus*), sand dropseed grass (*Sporobolus cryptandrus*), sand paspalum (*Paspalum setaceum* [*ciliatifolium*]), and toadflax (*Nuttallanthus* [*Linaria*] *canadensis*); green vegetation was detected only in the stomach of a single individual (McCulloch 1959).

In Great Basin scrublands of southern Idaho, Johnson (1961) found that *O. leucogaster* consumed arthropods almost exclusively, although some bird feathers also were observed in stomachs. Armstrong (1982) reported that during midsummer, the diet of *O. leucogaster* in southeastern Utah was approximately two thirds arthropods and one third plant materials. Finally, Hoffmeister (1986) examined a single specimen's stomach contents in Grand Canyon National Park, Arizona, and found only arthropods (mostly beetles).

Neotoma albigula Hartley 1894
White-throated Woodrat

The white-throated woodrat as described in this study is not currently recognized as a single species. Based on a phylogenetic analysis by Edwards et al. (2001), individuals previously assigned to *Neotoma albigula* that occur east of the Rio Grande were recognized as *Neotoma*

leucodon, being more closely related to, but distinct from, *Neotoma micropus*. Baker et al. (2003) recognized *N. albigula* and *N. leucodon* as distinct species, as is also reflected in Wilson and Reeder (2005). However, for this study we have maintained the use of Wilson and Reeder (2003) as our standard for mammal taxonomy. Partly this is because Wilson and Reeder (2005) suggest further investigation of these putative species to bolster evidence for their independent specific status. Also, the Sevilleta NWR straddles the hypothesized boundary zone of *N. albigula* and *N. leucodon*, and would likely support spatially–mixed populations of both species (as the Rio Grande occasionally runs dry in the summer, removing any physical barrier to dispersal in either direction). In addition to this study, all previous diet analyses as described below consider *N. albigula* and *N. leucodon* as a single species. We acknowledge the most recent taxonomy, but for the purposes of this study as a comparative framework with previous works, we maintain the single status of *N. albigula* for all populations within the Sevilleta NWR. In the following account, populations occurring within juniper-oak savanna, piñon-juniper woodland, and short-grass steppe habitats should be noted as a separate taxonomic unit from populations occurring in mesquite savanna. However, from this study and previous research of *N. albigula* and throughout the southwest region, there are striking similarities between all populations and taxonomic units in their foraging preferences.

During this study, *N. albigula* (from here including *N. leucodon*) (n=78) were collected primarily from mesquite savanna (n=37) and juniper-oak savanna (n=24) habitats, with fewer numbers occurring in piñon-juniper woodland (n=11) and short-grass steppe (n=6) habitats (Table 1). In mesquite savanna habitat, most specimens were collected in close proximity to either juniper or mesquite. In short grass steppe habitat, specimens were all caught near rubber rabbitbrush shrubs (*Ericameria nauseosa*).

While *N. albigula* consumed both seeds and arthropods, the most frequent dietary constituent was vegetative plant material (Table 22). While no attempt was made to identify species of vegetative materials in stomachs, visual evidence of *Neotoma* damage to pads and stems of prickly pear cacti (*Opuntia englemannii, O. phaeacantha, O. polyacantha, O. macrocentra*) and walking-stick cholla (*O. imbricata*) in the study area attested to the importance of these species in the diet. Arthropod occurrence frequencies displayed seasonal variation (less in winter, more in summer), whereas occurrence of green vegetation and seeds remained high year–round. Across all habitats, *N. albigula* consumed 29 taxa of plant seeds, including 3 tree species, 3 shrub and at least 1 cactus species, 4 grasses, and at least 18 species of forbs (Table 22). In juniper-oak savanna and piñon-juniper woodland habitats where juniper trees were abundant, *N. albigula* consumed large numbers of juniper berries. Both flesh and seeds of these berries were eaten, the seeds themselves sometimes being cracked open but more often swallowed whole. Also in late summer, *Opuntia* cacti had set seed and *N. albigula* consumed a large number of these seeds (Table 22). Curiously, while late summer was the peak production period for mesquite pods and seeds (*Prosopis glandulosa*), and *N. albigula* had collected many of these pods in their nests, few mesquite seeds actually appeared in the diet.

By volume, *N. albigula* diet was dominated by green vegetation, followed by seeds and arthropods (Table 23). Seasonal shifts in diet were noted in all food categories. The vegetation component peaked in spring (78%), and was lower in summer (54%) and winter (66%). Seeds comprised 31% of winter diet, 16% in spring, and 30% in summer. In contrast, arthropods made up 16% of diet volume in summer, but only 6% in spring and 3% in winter (Table 23). Of the seed material eaten, grass seeds were eaten least, likely due to their small size compared with these large rodents; rather, seeds of trees, shrubs, cacti and forbs appeared most commonly (Table 23).

These results are consistent with previous studies of *N. albigula* throughout its range in the United States and Mexico (Macêdo and Mares 1988). The most comprehensive study was conducted in Arizona, where Vorhies and Taylor (1940) examined stomach contents of 360 *N. albigula* collected throughout the year. They found diet was composed of 44% cacti (*Opuntia* spp.), 30% mesquite (*Propospis* spp.), 2% carpetweed (*Mollugo verticillata*), 5% grasses, and 7% other plants (28 taxa, including *Boerhaavi*a sp., *Chamaesyce* spp., *Machaeranthera* [*Applopappus*] spp., *Eriogonum* sp., *Amaranthus* sp., *Celtis pallid*a, *Lepidium* sp., *Physaria* [*Lesquerella*] sp., *Artemisia* sp., and unidentified species in the Asteraceae, Chenopodiaceae, Mimosaceae, and Solanaceae). Arthropods averaged <1% of the diet volume over the year, with a maximum of 8% in June, and included a wide array of taxa. These included Homoptera (cicadas), Isoptera (termites), Hymenoptera (ants, bees and wasps), Coleoptera (scarab beetles and other beetles), Diptera (robber flies), Orthoptera (grasshoppers and mantids) and Lepidoptera (butterflies and moths). Several bird feathers also were recorded (Vorhies and Taylor, 1940).

In Texas and New Mexico, Bailey (1905, 1931) also reported importance of cacti in the diet, including such species as *Opuntia macrocentra, O. phaeacantha* var. *major* [cyclodes], and *Echinocereus* sp. (probably *E. triglochidiatus*). In addition, basal parts of *Yucca* spp., *Agave* spp., *Dasylirion* sp. and *Nolina* sp. were consumed, while their leaves were cut off and used for nest construction. Shrubs (fruits, seeds, bark and/or leaves) in the diet in-

TABLE 22. List of items discovered in the diet of the white-throated woodrat (*Neotoma albigula*) on the Sevilleta National Wildlife Refuge, New Mexico. Numbers represent percentage frequency of occurrence of each item in stomachs by season.

Item	Winter (n=15)	Spring (n=32)	Summer (n=31)
Arthropods	20	53	74
Vegetation	87	100	100
Seeds	80	78	84
Trees:			
Juniperus monosperma	60	19	39
Pinus edulis	—	9	—
Prosopis glandulosa	—	—	13
Shrubs/cacti:			
Atriplex canescens	7	—	—
Chenopodium album	—	3	—
Fallugia paradoxa	13	9	—
Opuntia sp.	20	—	45
Grasses:			
Achnatherum hymenoides	—	3	—
Aristida sp.	—	3	—
Lycurus phleoides	—	3	—
Sporobolus sp.	7	—	—
Forbs:			
Asteraceae, unidentified species	—	3	13
Astragalus nuttallianus	—	3	—
Astragalus sp.	—	3	3
Bahia sp.	7	3	—
Bahia dissecta	7	—	—
Brassicaceae, unidentified species	13	9	6
Dalea sp.	—	—	10
Descurainia richardsoni	—	6	—
Dimorphocarpa wislizeni	—	3	—
Fabaceae, unidentified species	—	3	3
Helianthus sp.	7	—	—
Hymenopappus filifolius	7	22	6
Macaeranthera spinulosis	—	6	—
Pectis sp.	—	3	—
Physaria fendleri	—	10	—
Physaria sp.	—	3	—
Plantago patagonica	—	3	—
Solanum elaeagnifolium	—	—	6

cluded mesquite (*Prosopis glandulosa*), acacias (*Acacia* sp.), althorn (*Koberlinia spinosa*), ocotillo (*Fouquieria splendens*), sumac (*Rhus* sp., probably *R. trilobata* and/or *R. microphylla*), juniper (*Juniperus* spp.), oak (*Quercus* spp.), walnut (*Juglans major*), and piñon pine (*Pinus edulis*). Arthropods were not specifically mentioned, nor were grass or forb seeds (Bailey, 1931). In southern New Mexico, Wood (1969) found that *N. albigula* diet consisted of 97% plant materials (mostly unidentified, but including *Opuntia* sp. pads, *Yucca* sp. [probably *Y. elata*] leaves, flowers and culms, flower heads of Asteraceae taxa, and small quantities of *Ephedra* sp. materials and various seeds), and 3% animal materials (including insects, caterpillars, and small quantities of rodent remains).

Other studies contribute additional breadth to *N. albigula* diet. In central Arizona, Spencer and Spen-

TABLE 23. Summary of prey types of the white-throated wood rat (*Neotoma albigula*) on the Sevilleta National Wildlife Refuge, New Mexico. Values are mean percentage contributions of each category to total diet of the rodent.

Habitat	Sampling period	n	Prey type by volume (%) Seed	Plant	Arthropod	Seed type by count (%) Tree	Shrub	Grass	Forb
Montane piñon-juniper woodland	Winter	2	38	50	12	25	75	0	0
	Spring	7	17	76	7	63	0	0	37
	Summer	2	46	36	18	0	67	0	33
Juniper-oak savanna	Winter	4	70	26	4	66	17	0	17
	Spring	3	28	67	5	80	0	0	20
	Summer	17	29	50	21	39	44	0	17
Mesquite savanna	Winter	9	12	87	1	31	15	8	46
	Spring	16	18	74	8	0	8	12	80
	Summer	12	28	62	10	33	10	5	52
Short-grass steppe	Spring	6	2	95	3	0	67	0	33
Total means (%)		78	24	66	10	30	24	4	42

cer (1941) observed that food caches typically contained both prickly pear and cholla cacti (*Opuntia* spp., including *O. spinosior* and *O. fulgida*), along with green leaves of mesquite (*Prosopis* sp.), catclaw acacia (*Acacia greggii*), acacia (*Acacia* sp.), and hackberry (*Celtis* sp.). In southeastern Arizona and southwestern New Mexico, Monson and Kessler (1940) excavated 82 *N. albigula* dens, and listed 51 species of plants found within; of these, direct evidence of consumption was observed for mesquite (*Prosopis glandulosa*), catclaws (*Acacia greggi* and *A. constricta*), soapweed yucca (*Yucca elata*), cholla (*Opuntia versicolor*), and prickly pear cacti (*Opuntia engelmannii* and *O. macrocentra*); grasses were rarely found in dens. In west Texas, Schmidly (1977, p. 120) described N. albigula diet as including "cactus, mesquite beans and pods, herbs, and some grasses." In Utah, Armstrong (1982) described items of a *N. albigula* food cache as containing *Opuntia* sp. pads, *Yucca* sp. leaves, *Juniperus* sp. berries, a *Pinus monophylla* cone, and cuttings of *Salsola* sp., *Mahonia* sp., and *Fraxinus* sp.

In northern Arizona, where cacti were not commonly found, Dial (1988, p. 533) analyzed *N. albigula* fecal samples, and found diet was composed of "*Yucca* (29%), *Juniperus* (24%), *Chrysothamnus* (7%), *Rhus* (6%), *Fallugia* (5%), *Artemisia* (4%), *Atriplex* (4%), *Ephedra* (3%), and numerous other plants in lower quantities." Arthropods were not mentioned in this account (Dial, 1988). It is interesting to note that the high quantity of juniper vegetative materials reported by Dial (1988) indicate that *N. albigula* is apparently capable of coping with high concentrations of secondary plant compounds found in *Juniperus* and other plant species (see Dearing et al. 2000, Boyle and Dearing 2003, and references therein).

Finally, in Colorado, Finley (1958) reported on diets of 3 subspecies of *N. albigula*, listing 13 plant species found as "food litter" in dens of *N. a. brevicauda*, 41 plant species in dens of *N. a. laplataensis*, and 38 plants species in dens of *N. a. warreni*. The most frequent (occurring in >1 den) plant taxa found included leaves, flowers, fruits, and/or seeds of 7 species of cacti (*Opuntia phaeacantha, O. polyacantha, O. imbricata* [*arborescens*], *O. tunicata* [*davisii*], *O. humifusa, Echinocerus coccineus, E. whipplei*), 5 tree species, including juniper (*Juniperus utahensis, J. monosperma, J. scopulorum*), piñon pine (*Pinus edulis*), and Gambel oak (*Quercus gambelii*), 3 species of yucca (*Yucca angustissima, Y. baccata, Y. glauca*), 13 species of shrubs, including sagebrush (*Artemisia tridentata*), rabbitbrush (*Ericameria* [*Chrysothamnus*] *nauseosa*), serviceberry (*Amelanchier* sp.), saltbush (*Atriplex canescens*), shadscale (*Atriplex confertifolia*), mountain mahogany (*Cercocarpus montana*), winterfat (*Krascheninnikovia lanata*), horsebrush (*Tetradymia spinosa*), blackbrush (*Coleogyne ramosissima*), Mormon tea (*Ephedra viridis*), snakeweed (*Gutierrezia microcephala*), wolfberry (*Lycium pallidum*), skunkbrush (*Rhus trilobata*), cliff fendlerbush (*Fendlera rupicola*), 20 species of forbs, including ground-

sel (*Senecio* sp.), buffalo burr (*Solanum rostratum*), thistle (*Cirsium* sp.), gayfeather (*Liatris punctata*), lavenderleaf sundrops (*Calylophus* [*Oenothera*] *lavandulifolius*), scurfpea (*Pediomelum* [*Psoralea*] *linearifolium*), pigweed (*Amaranthus albus, A. retroflexus*), bladderpod (*Physaria* [*Lesquerella*] *fendleri, P. ovalifolia*), sunflower (*Helianthus annuus*), rubberweed (*Hymenoxys richardsonii*), hairy false goldaster (*Heterotheca* [*Chrysopsis*] *villosa*), yellow sweetclover (*Melilotus officinalis*), ground cherry (*Physalis* sp.), tumbleweed (*Salsola kali*), milkweed (*Asclepias* sp.), lupine (*Lupinus* sp.), penstemon (*Penstemon* sp.), showy four-o'clock (*Mirabilis multiflor*a), and 3 species of grasses, including blue grama grass(*Bouteloua gracilis*), galleta grass (*Pleuraphis* [*Hilaria*] *jamesii*), and cheatgrass brome (*Bromus tectorum*).

In general, our results were consistent with those of previous studies, in that diet of *N. albigula* was primarily herbivorous, with cacti, trees, and shrubs constituting the majority of food materials. Forbs contributed a smaller proportion to the diet, but comprised a wide array of taxa, indicating that *N. albigula* employed a flexible and opportunistic foraging behavior. Arthropods generally made up only a small proportion of the diet, with our study results constituting the highest proportion of animal matter (10%) reported for this species. In spite of its low proportional volumetric contribution, arthropods may have been an important source of protein in the diet of *N. albigula*.

***Neotoma micropus* Baird 1855**
Southern Plains Woodrat

This species was found only rarely (n=6), and was collected in both Chihuahuan Desert scrubland habitat (n=5) and juniper-oak savanna habitat (n=1). The Sevilleta NWR is near the northwestern edge of the distributional range of *N. micropus* (Braun and Mares 1989), which may account for small numbers of specimens collected. Individuals from Chihuahuan Desert scrubland habitat were all collected adjacent to middens located in patches of cacti. While sample size was very small and only represented spring and summer sampling periods, it appeared that during these seasons, *N. micropus* consumed similar proportions of seed (33%), vegetation (48%) and arthropod (19%) material to *N. albigula* (compare to Table 23). Predominant seeds found in the diet were from forbs (64%) and cacti/shrubs (19%), including prickly pear cactus and chollas (*Opuntia* spp.), creosotebush (*Larrea tridentata*), buckwheat (*Eriogonum* sp.), and unidentified species of Asteraceae. The single *N. micropu*s individual from juniper–oak savanna had consumed only juniper berries (*Juniperus monosperma*). No grasses were found in the *N. micropus* diet in this study.

Previous studies have reported on diet of *N. micropus*, although detailed dietary information is not nearly as extensive as for *N. albigula*. In Texas and New Mexico, Bailey (1905, 1931) described diet as consisting "largely of the flesh and fruit of cactus, but includes also a great variety of green vegetation, fruit, and seeds" (Bailey 1931, p. 174), including beans and pods of mesquite (*Prosopis* spp.), nuts and acorns. In southern New Mexico, Wood (1969) found the diet of *N. micropu*s to be very similar to sympatric populations of *N. albigula*, and composed of 98% plant materials (mostly unidentified, but including *Opuntia* sp. pads, *Yucca* sp. [probably *Y. elata*] leaves, flowers and culms, flower heads of Asteraceae species, and *Ephedra* sp. materials and various seeds), and 2% animal materials (including caterpillars and a trace of other insects [Coleoptera and Homoptera]), and small quantities of rodent remains.

In southwest Texas, Johnson (1952) examined *N. micropus* stomach contents, and found that in summer and autumn, *N. micropus* fed primarily on beans of mesquite (*Prosopis glandulosa*), guajillo (*Acacia berlandieri*) and blackbrush (*Acacia rigidula* [*amentacea*], *A. tortuosa*); uneaten quantities of these species also were cached in dens of *N. micropus*. Other seeds and berries consumed during these seasons included soapbush (*Guajacum* [*Porliera*] *angustifolium*), persimmon (*Diospyros* [*Brayodendron*] *texana*), knifeleaf condalia (*Condalia spathulata*) and other unidentified shrubs. During winter, *N. micropus* would climb as high as 10 m into persimmon trees to gnaw on bark; cactus pads (*Opuntia lindheimeri*) also were consumed in winter. Johnson (1952) also noted that one *N. micropus* specimen had consumed the carcass of a snap-trapped rodent (*Peromyscus leucopus*) near its den.

In south Texas, Raun (1966, p. 4) reported that *N. micropus* consumed "cactus fruit, mesquite beans [*Prosopis juliflora*], and granjeno berries [*Celtis pallida*]" during summer, but that the year-round staple appeared to be cactus pads (*Opuntia engelmanii* var. *lindheimeri*). Also in south Texas, Box (1959) examined the contents of *N. micropus* dens and middens, and reported partially eaten berries of algerita (*Mahonia* [*Berberis*] *trifoliolata*) and hackberry bushes (*Celtis pallida*).

In shinnery oak–mesquite grassland habitats in southeastern New Mexico, Best et al. (1993) found that vegetation comprised the majority of the diet, including leaves, fruits and/or seeds of *Prosopis glandulosa, Quercus havardii, Chamaesyce* [*Euphorbia*] sp., *Sphaeralce*a sp., *Yucca campestris, Opuntia phaeacantha, Helianthus petiolaris, Croton* sp., *Sporobolus cryptandrus, Chenopodium* sp., *Palafoxia sphacelata, Aristida* sp., *Triplasis purpurea, Phacelia corrugata, Oenothera* sp., and a variety of unidentified forbs and grasses; arthropod materials occurred in stomachs of 13 of 66 specimens (20%) examined. In southeastern Colorado, Finley (1958) reported that

N. micropus fed primarily upon tree cholla (*Opuntia imbricata* [*arborescens*]), with the remainder of the diet made up of prickly pear cacti (*Opuntia polyacantha* and *O. humifusa*), tumbleweed (*Salsola kali*), blue grama grass (*Bouteloua gracilis*), and yucca (*Yucca glauca*); 10 other plant taxa were recorded as occurring only rarely in the diet. Arthropod materials were not mentioned in Finley's (1958) report.

In a western Oklahoma sand sagebrush grassland (without any cacti species present), McCulloch (1959) found *N. micropus* to feed primarily on green vegetation in spring (98% of stomach volume, n=9), with reduced reliance on green vegetation in autumn (61% by volume, n=9) and winter (35% by volume, n=2). Seeds were occasionally observed, and included taperleaf ground-cherry (*Physalis longifolia* [*subglabrata*]), showy partridgepea (*Chamaecrista* [*Cassia*] *fasciculata*), sunflower (*Helianthus annuus*), sand mentzelia (*Mentzelia nuda* [*stricta*]), prairie pepperweed (*Lepidium densiflorum*), skunkbrush sumac (*Rhus aromatica*), and purple sandgrass (*Triplasis purpurea*). Arthropods and unidentified animal flesh comprised < 2% by volume during spring to autumn, but increased to 10% during winter (McCulloch 1959).

Rodent Diets: Community Analyses

Comparisons Among Species of Rodent

The rodent species included in this study comprise numerically dominant members of rodent communities in central New Mexico. As such, through an examination of the diets of all these species collectively, one can develop a community perspective of how rodents partition their food resources among species and habitats.

First, a graphical synthesis of rodent diet categories (seeds, green vegetation and arthropod components across all habitats combined) reveals breadth of diet variability among rodent species of the Sevilleta NWR (Fig. 3). Seeds make up approximately 50% of total rodent community diet, and species diet data presented in Figure 3 is arranged based upon ranked dietary seed use. Not surprisingly, heteromyid rodents (kangaroo rats and pocket mice) dominate the top rankings of dietary seed components, with murids and sciurids relying more on green vegetation and arthropods. The woodrats (*Neotoma* spp.) and spotted ground squirrel (*Speromophilus spilosoma*) utilize the most green vegetation, while grasshopper mice (*Onychomys* spp.) consume the greatest proportions of arthropods. *Peromyscine* rodent species generally exhibit somewhat even proportions of seeds and arthropods, with little inclusion of green vegetation.

Within the seed category, rodents as a group tend to collect forb seeds more than other types of seed (Fig. 4). Grass seeds, particularly Indian rice grass (*Achnatherum hymenoides*), are also widely consumed, but are usually of lesser importance compared to forb seeds; harvest mice (*Reithrodontomys megalotis*) and Merriam's kangaroo rat (*Dipodomys merriami*) are the largest consumers of grass seeds among the rodents examined in this study. Tree seeds (from mesquite, juniper and piñon pine) are taken by many rodent species, and are particularly important for *Peromyscus* spp. (Fig. 4). Nearly all rodents include shrub seeds and cacti fruit/seeds in their diets, with woodrats (*Neotoma* spp.) consuming the greatest proportions.

Comparisons Among Communities of Plants

The six habitats sampled in this study differed considerably in plant species composition, vegetation cover, and physiognomy; as such, they each provided their resident rodent communities with a unique assemblage of food resources. Given differences in available food materials and differences in rodent species composition among the six habitats, the question arises as to how each rodent community utilizes their respective food resources over the course of a year and how diet compositions from different habitats varied. To address this question, diet results (volumes of the main three prey categories [seeds, plant, and arthropod material]) for all rodent species were pooled within each habitat during each sampling period. Overall rodent diet compositions among habitats and seasons are displayed in pie charts for general comparison (Figs. 5, 6). In addition, Kruskal–Wallis statistical tests were performed to test for differences in dietary prey categories among habitats and between seasons.

Food resource utilization in cottonwood riparian forest (Fig. 5) was only represented in this study by a single rodent species, *Peromyscus leucopus* (n=70; Table 1). The results show that arthropods were the major food source all through the year, and that plant materials constituted only a very small portion of the diet. Seeds also were important in the diet, particularly in summer and winter.

Piñon-juniper woodland habitat supported six murid rodent species (n=118 individuals; Table 1), and showed remarkable stability in resource utilization by rodents throughout the year (Fig. 5). The only notable change was in late summer when rodent consumption of arthropods increased and consumption of seed material decreased.

In juniper-oak savanna habitat, where the rodent community also was dominated by murids (6 species) with occasional individuals of two heteromyid species (n=178 total individuals; Table 1), the arthropod diet component remained very stable through the year with only a

slight increase in summer (Fig. 5). Seed material was the largest component in all sampling periods, but particularly important in winter when juniper berries were commonly consumed by murid species. The large amount of dietary plant material observed during summer is related to a higher number of largely herbivorous *N. albigula* collected during this time (Table 1).

The mesquite savanna habitat, with 12 rodent species (n=138 individuals, Table 1), showed least percentage variability of rodent resource use throughout the year (Fig. 5). The only changes were a slight increase in seed consumption in summer and a small increase in arthropod consumption in winter. Plant material utilization remained virtually constant year-round.

In short-grass steppe habitat (eight rodent species, n=63 individuals; Table 1), there was a marked increase in amounts of plant materials consumed during late spring when *N. albigula* were collected (Fig. 5). Aside from this, prey categories remained very stable over the year, particularly within the seed category; this was likely related to greater numbers of heteromyids present in the community (Table 1).

The Chihuahuan Desert scrubland habitat supported 11 rodent species (n=58 individuals; Table 1), and exhibited considerably more seed material consumed by rodents during winter (Fig. 5). During the other two sampling periods, the most noticeable change was an increase in plant material consumed in spring and summer. These patterns were likely due to the dominance of rodents in the genera *Peromyscus* and *Onychomys* in winter, two taxa that consume relatively little vegetative matter, and the presence of more herbivorous heteromyids and *N. micropus* in spring and summer samples (Table 1).

In comparing all habitats and seasons, results of statistical analysis show that rodent food resource utilization significantly differed among the six habitats within each sampling period (Table 24). In addition, rodent food resource utilization by category varied to differing

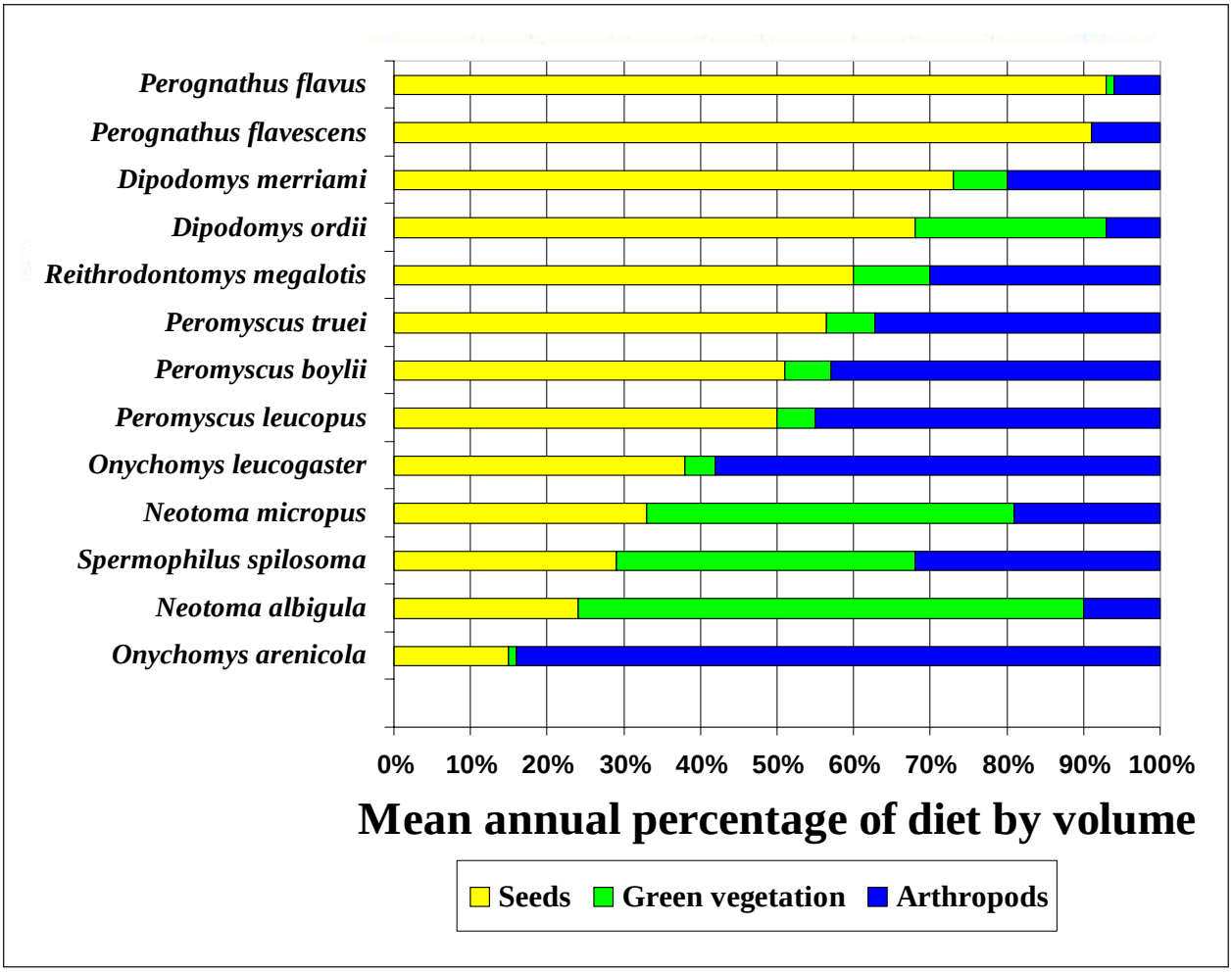

Figure 3. Variation in composition of diets by rodent species at the Sevilleta National Wildlife Refuge, Socorro County, New Mexico. Species are listed based on rank order of volume of seeds in the diet for all habitats combined.

extents between sampling periods among different habitats (Table 25). Only rodent diets in juniper-oak savanna habitat varied significantly between seasons for all three food resource categories, while rodent diets in mesquite savanna did not significantly vary in any prey categories between sampling periods. In addition, rodent diets in Chihuahuan Desert scrubland habitat also showed no significant seasonal differences, despite a wide swing in seasonal seed use (Fig. 5); this result was likely due entirely to small rodent sample sizes obtained in summer and winter in this habitat.

As different as habitats were in terms of broad food resource categories in diets of rodent species, they varied considerably more in types of seeds consumed (Fig. 6). In habitats where trees were abundant, tree seeds constituted a substantial proportion of seed occurrences. Cottonwood riparian forest shows forbs seeds being consumed most often, however, due to a general lack of cottonwood seeds in the rodent diets; what tree seeds did occur in the diet were from Russian olive trees (*Elaeagnus angustifolia*; see Tables 14–15). Piñon-juniper woodland shows the highest proportion of tree seeds, which is understandable as this habitat contained three main tree species (*Pinus edulis, Juniperus monosperma,* and *Quercus turbinella*), all of which provided extensive quantities of either large seeds and/or pollen cones. In addition to this, predominant rodent species were *Peromyscus* mice, which focused their diet on tree seeds. In juniper-oak savanna, the greater variety of rodent species as well as seed species displayed a more even spread of seed types. Mesquite savanna habitat showed highest occurrence of grass seeds, and this is likely due to a heavy crop of *Achnatherum hymenoides* seeds, which were consumed by most rodent species. Short–grass steppe and Chihuahuan Desert scrubland habitats were the only two habitats that

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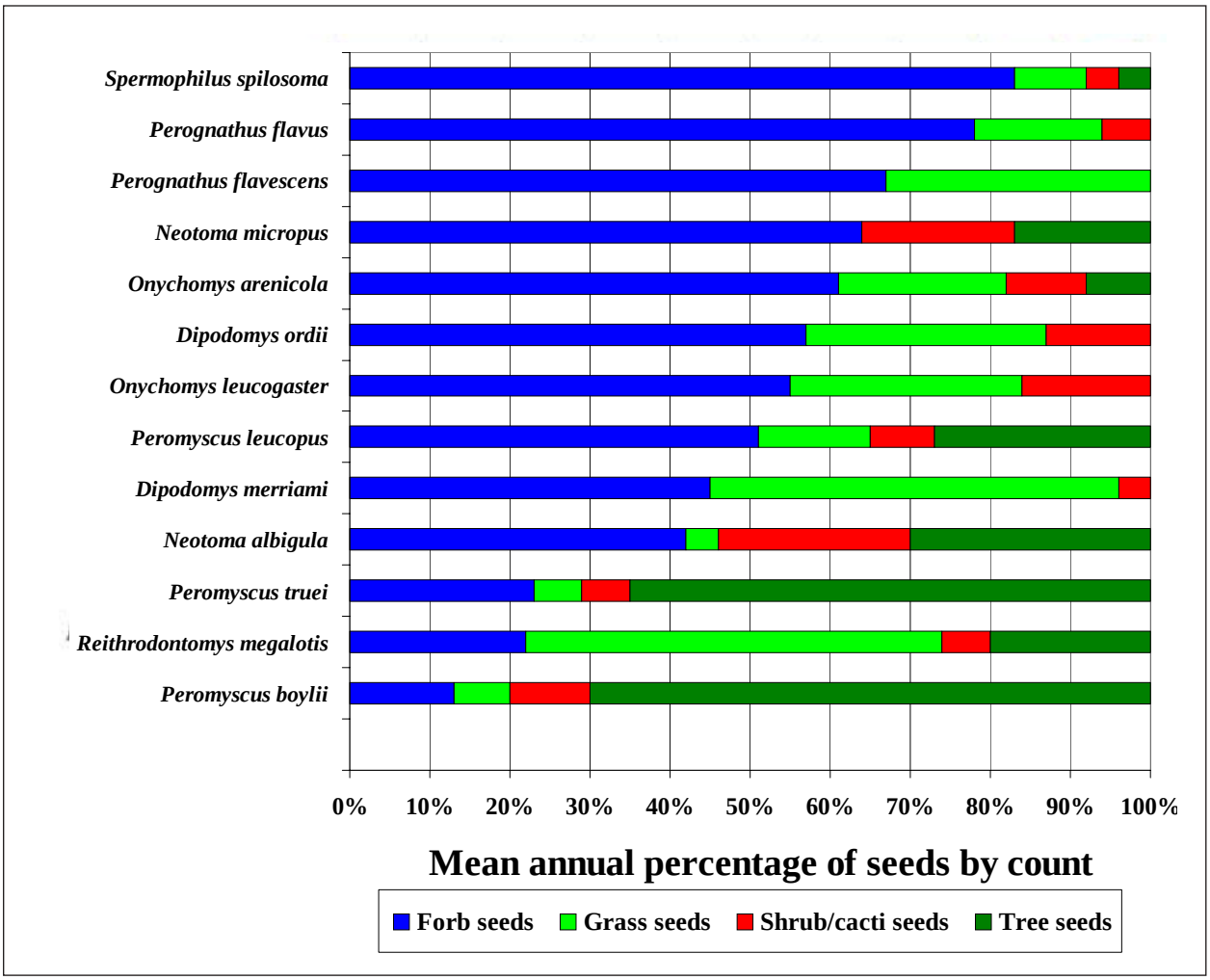

Figure 4. Variation in composition of seed categories consumed by rodent species at the Sevilleta National Wildlife Refuge, Socorro County, New Mexico. Species are listed based on rank order of abundance of forb seeds in the diet for all habitats combined.

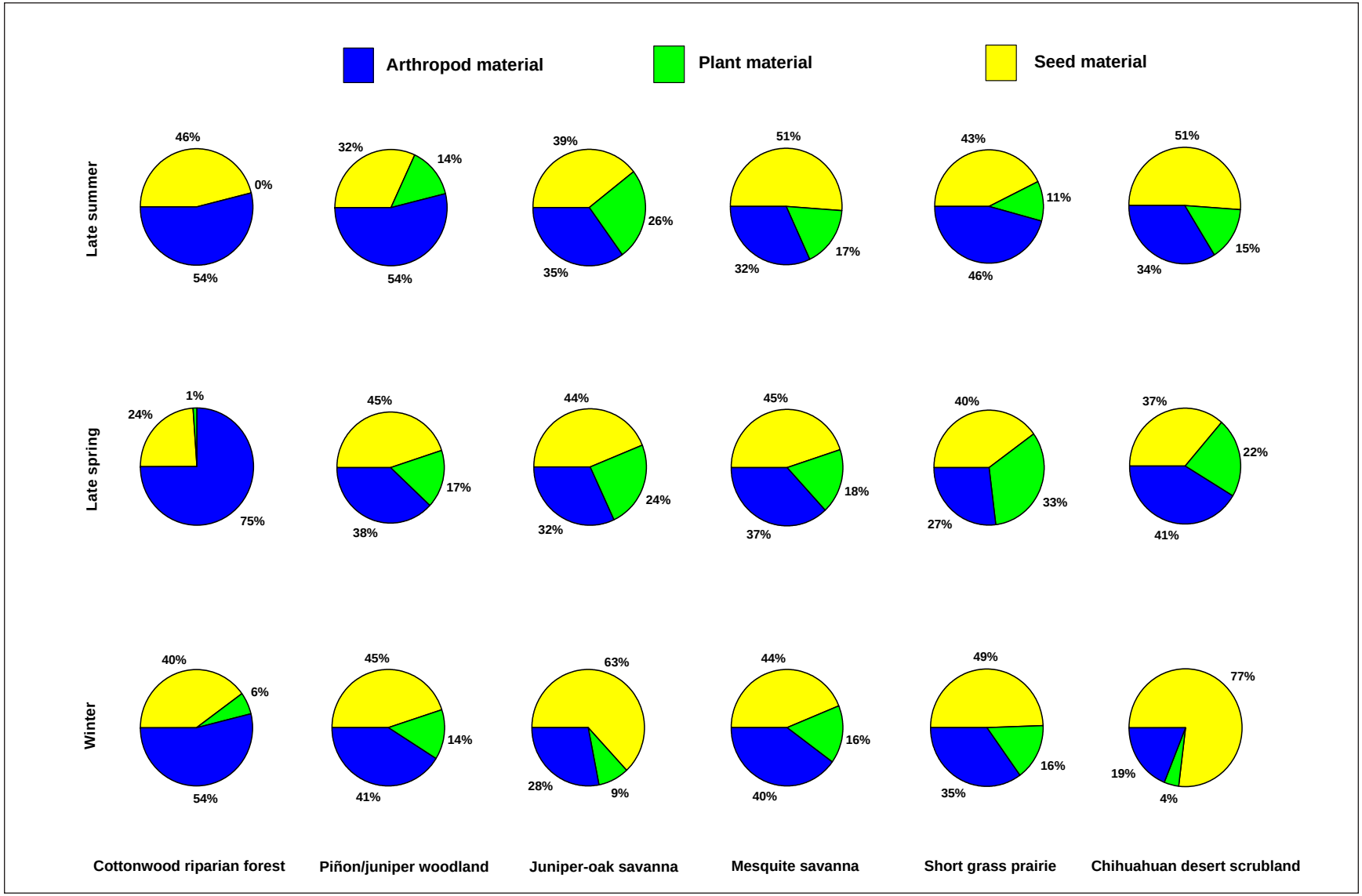

Figure 5. Pie charts representing total rodent consumption of arthropod, plant, and seed materials by percentage volume according to both habitat type and season. The three seasons: winter, late spring, and late summer represent the three sampling periods from this study. Values for each chart are averaged percentages from all individual rodents of all species collected.

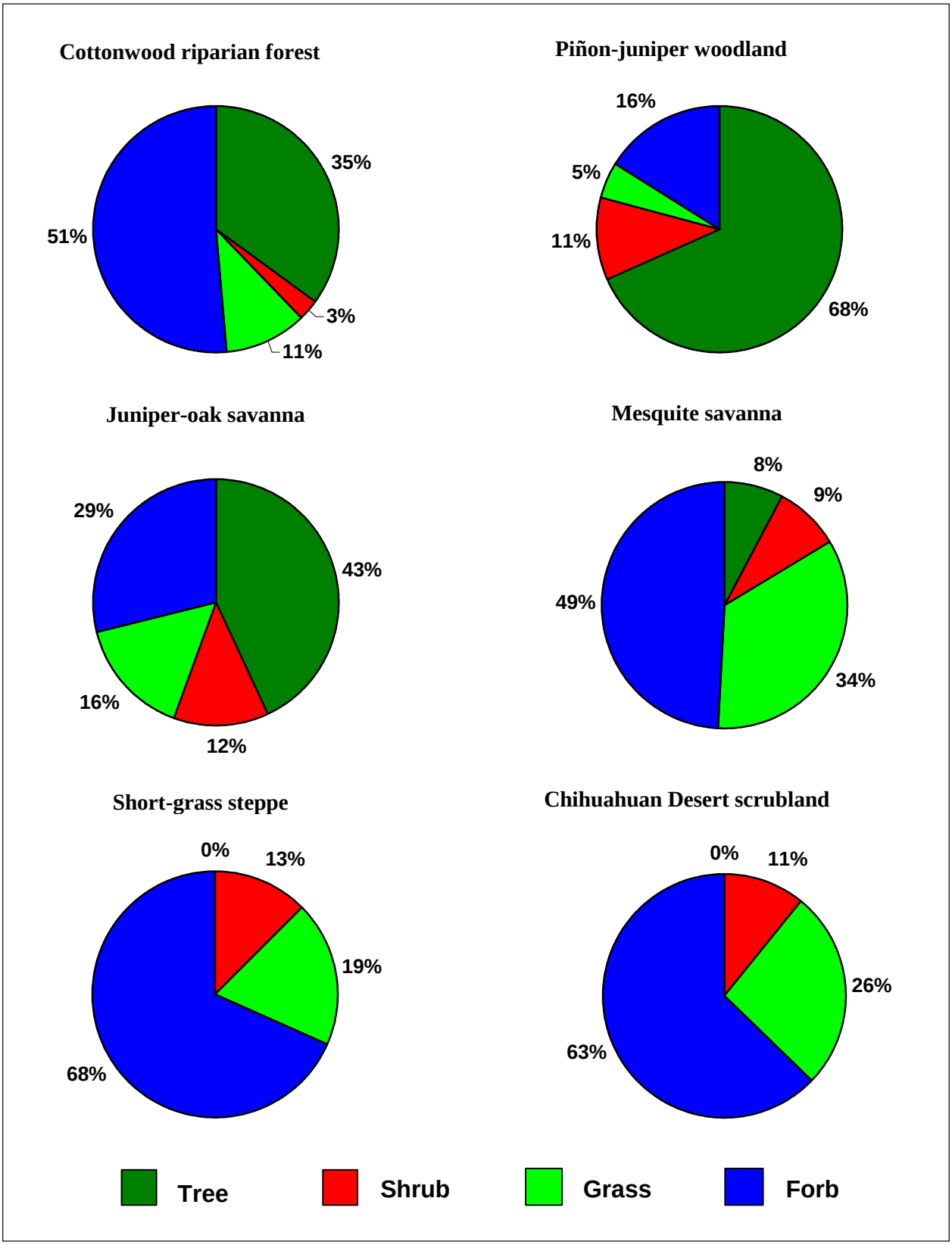

Figure 6. Pie charts illustrating variation in composition of seed categories consumed. Each chart represents results for all rodents examined within a particular habitat type for all sampling periods combined.

TABLE 24. Significance results (P-values) from Kruskal-Wallis statistical tests. Tests were performed to analyze differences among habitats in amounts of each food resource category consumed within seasons.

Season	Food resource category		
	Arthropod	Plant	Seed
Winter	0.0001**	0.0006**	0.0006**
Late spring	0.0001**	0.0003**	0.0001**
Late summer	0.0001**	0.0013**	0.0158**

**denotes significant differences between habitats at the P≤0.05 level.

closely resembled each other in terms of occurrences of seed categories—forb seeds were consumed most often followed by grass seeds. Shrub and cactus seeds were never dominant components of the diet in any habitats, although they appeared consistently at low levels (3–13%, Fig. 6).

Plant Seeds as Food Resources for Rodents

The overall results of this study, combined with literature reports cited herein, clearly support the conclusion that plant seeds constitute a diverse and quantitatively important dietary resource for rodents. In all, the dietary analyses of the 15 rodent species examined in this project revealed that seeds and leaf materials of at least 77 plant taxa on the Sevilleta NWR were consumed by resident rodents (Table 26). These plant taxa represented 5 tree species, 9 shrubs, 2 cacti, 12 grasses, and 49 forbs. The plant list from literature sources cited in our review of rodent diets in the western United States include 408 taxa (see Appendix I). In addition, our rodent dietary literature review was restricted to only the 15 rodent species considered in our project; inclusion of additional rodent species found in other parts of western North America would certainly increase this plant taxa list considerably.

The variety of seeds found in rodent diets on the Sevilleta NWR is summarized at the bottom of Table 26. While clearly influenced by total sample sizes of rodents examined during this study, results indicate that rodents consume seeds from a large number of species. For example, *Peromyscus leucopus* consumed at least 44 seed taxa across all habitats sampled. *Peromyscus truei*

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TABLE 25. Significance results (P-values) from Kruskal-Wallis statistical tests. Tests were performed to analyze differences between seasons in amounts of each food resource category consumed for each habitat type.

Habitat Type	Food resource category		
	Arthropod	Plant	Seed
Cottonwood riparian forest	0.0011**	0.0606	0.0012**
Montane pinon-juniper woodland	0.0009**	0.0926	0.0001**
Juniper-oak savanna	0.0041**	0.0001**	0.0001**
Mesquite savanna	0.0690	0.6829	0.1261
Short-grass steppe	0.7666	0.0401**	0.1909
Chihuahuan Desert shrubland	0.1043	0.1464	0.0838

** denotes significant differences between sampling periods at the P≤0.05 level.

TABLE 26. List of seed species by group (trees, shrubs, cacti, grasses, forbs) consumed by rodents in central New Mexico.

Seed Species	*Spermophilus spilosoma*	*Perognathus flavescens*	*Perognathus flavus*	*Dipodomys merriami*	*Dipodomys ordii*	*Dipodomys spectabilis*	*Reithrodontomys megalotis*	*Peromyscus boylii*	*Peromyscus eremicus*	*Peromyscus leucopus*	*Peromyscus truei*	*Onychomys arenicola*	*Onychomys leucogaster*	*Neotoma albigula*	*Neotoma micropus*	**Total Rodent Species**
Trees																
Elaeagnus angustifolia										X						1
Juniperus monosperma							X	X		X	X	X		X	X	7
Pinus edulis								X		X	X			X		4
Prosopis glandulosa	X								X	X		X		X		5
Quercus turbinella								X			X					2
Shrubs																
Atriplex canescens				X						X	X		X	X		5
Chenopodium sp.								X								1
Chenopodium album													X			1
Fallugia paradoxa				X	X		X	X			X		X	X		7
Gutierrezia sarothrae					X					X		X				3
Larrea tridentata							X		X	X			X		X	5
Psorothamnus scoparia									X				X			2
Rhus trilobata								X		X	X					3
Pakera multilobatus										X						1
Cacti																
Echinocereus triglochidiatus											X					1
Opuntia sp.	X		X		X	X				X	X	X		X	X	9

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[TABLE 26, continued] List of seed species by group (tree, shrubs, cacti, grasses, forbs) consumed by rodents in central New Mexico.

Seed Species	*Spermophilus spilosoma*	*Perognathus flavescens*	*Perognathus flavus*	*Dipodomys merriami*	*Dipodomys ordii*	*Dipodomys spectabilis*	*Reithrodontomys megalotis*	*Peromyscus boylii*	*Peromyscus eremicus*	*Peromyscus leucopus*	*Peromyscus truei*	*Onychomys arenicola*	*Onychomys leucogaster*	*Neotoma albigula*	*Neotoma micropus*	**Total Rodent Species**
Grasses																
Poaceae, unidentified species		X			X		X			X	X	X				6
Achnatherum hymenoides	X	X		X	X		X			X	X		X	X		9
Aristida sp.		X	X	X	X		X	X	X	X	X	X		X		11
Aristida adscensionis										X						1
Bouteloua sp.				X	X		X			X	X					5
Bouteloua eriopoda								X								1
Bouteloua gracili										X	X					2
Dasyochloa pulchellum			X	X	X											3
Lycurus phleoides														X		1
Muhlenbergia sp.	X		X				X		X			X				5
Panicum obtusum										X						1
Sporobolus sp.		X	X	X	X		X			X		X				7
Forbs																
Asteraceae, unidentified species	X		X	X	X		X			X	X	X		X	X	10
Brassicaceae, unidentified species			X	X	X		X			X	X	X		X		8
Fabaceae, unidentified species				X	X		X	X		X		X	X	X		8
Allium macropetalum					X					X	X					3
Astragalus sp.	X		X	X	X			X		X	X	X	X	X		10
Astragalus missouriensis			X							X						2
Astragalus nuttallianus														X		1
Bahia sp.				X	X		X			X				X		5

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[TABLE 26, continued] List of seed species by group (tree, shrubs, cacti, grasses, forbs) consumed by rodents in central New Mexico.

Seed Species	*Spermophilus spilosoma*	*Perognathus flavescens*	*Perognathus flavus*	*Dipodomys merriami*	*Dipodomys ordii*	*Dipodomys spectabilis*	*Reithrodontomys megalotis*	*Peromyscus boylii*	*Peromyscus eremicus*	*Peromyscus leucopus*	*Peromyscus truei*	*Onychomys arenicola*	*Onychomys leucogaster*	*Neotoma albigula*	*Neotoma micropus*	**Total Rodent Species**
(Forbs, continued)																
Bahia dissecta														X		1
Bahia pedata				X												1
Baileya multiradiata										X						1
Chaetopappa ericoides										X						1
Chamaesaracha coniodes										X						1
Chamaesyce sp.		X	X	X						X	X	X	X			7
Cirsium ochrocentrum										X						1
Cryptantha crassisepala	X		X													2
Cymopterus acaulis					X					X						2
Dalea sp.	X			X	X					X				X		5
Descurainia obtusa			X		X										X	3
Descurainia incana spp. *Incana*														X		1
Dimorphocarpa wislizeni														X		1
Eriogonum sp.		X	X				X		X	X	X	X				7
Erysimum capitatum var. *capitatum*										X						1
Helianthus sp.	X												X	X		3
Hoffmannseggia glauca	X		X		X					X						4
Hymenopappus filofolius		X	X	X	X				X	X	X		X	X		9
Ipomopsis pumila			X	X	X						X	X				5
Juncus bufonius											X					1
Lappula occidentalis	X		X	X	X							X				5
Linum sp.	X						X									2

...continued on next page

[TABLE 26, continued] List of seed species by group (tree, shrubs, cacti, grasses, forbs) consumed by rodents in central New Mexico.

Seed Species	*Spermophilus spilosoma*	*Perognathus flavescens*	*Perognathus flavus*	*Dipodomys merriami*	*Dipodomys ordii*	*Dipodomys spectabilis*	*Reithrodontomys megalotis*	*Peromyscus boylii*	*Peromyscus eremicus*	*Peromyscus leucopus*	*Peromyscus truei*	*Onychomys arenicola*	*Onychomys leucogaster*	*Neotoma albigula*	*Neotoma micropus*	**Total Rodent Species**
(Forbs, continued)																
Lupinus kingii								X			X					2
Machaeranthera canescens	X				X									X		3
Melampodium leucanthum			X													1
Melilotus alba										X						1
Oenothera albicaulis	X		X	X	X					X	X					6
Pectis sp.														X		1
Pectis angustifolia					X											1
Phacelia integrifolia			X													1
Physaria sp.	X													X		2
Physaria fendleri								X		X	X			X		4
Plantago patagonica	X		X		X	X						X		X		6
Pseudocymopterus montanus										X			X			2
Ratibida sp.										X						1
Solanum elaeagnifolium										X				X		2
Sphaeralcea sp.	X				X					X	X	X				5
Townsendia annua				X							X				X	3
Verbena wrightii			X													1
Vicia sp.				X			X									2
Total Number of Seed Species Eaten	17	7	22	21	27	2	16	12	7	44	26	18	11	28	6	

collected seeds from 26 plant taxa, while *Neotoma albigula* consumed seeds of 28 taxa. The predominantly granivorous kangaroo rats also fed upon a wide variety of plant seeds, with *Dipodomys ordii* collecting 28 taxa and *D. merriami* collecting 21 taxa; similarly, the silky pocket mouse, *Perognathus flavus*, collected 22 taxa. Even the predominantly predaceous grasshopper mouse, *Onychomys leucogaster*, consumed 28 taxa of seeds (Table 26).

Finally, it is interesting to note that some plants produced seeds that were utilized by a wide variety of rodents (as shown in the far right column of Table 26), while other plant taxa were rarely observed in rodent diets. Among tree species, *Juniperus monosperma* fruits were consumed by 7 species of rodents, while *Pinus edulis* nuts were collected by 4 rodent species (this latter rodent species number might have been higher in a "mast year" of greater piñon nut production). Among the shrubs, *Fallugia paradoxa* and *Atriplex canescens* seeds were consumed by 7 and 5 rodent species respectively, while prickly pear and cholla cacti seeds (*Opuntia* spp.) were taken by 9 rodent species. The most commonly collected grass seeds included the three-awn grasses (*Aristida* spp.), found in the diets of 11 rodent species, Indian rice grass (*Achnatherum hymenoides*), collected by 9 rodent species, and drop seed grasses (*Sporobolus* spp.), consumed by 7 rodent species. Forb species varied considerably in rodent diet utilization, ranging from *Astragalus* spp. (10 rodent species) and *Hymenopappus filifolius* (9 rodent species) downward to a number of forb taxa consumed by only a single rodent species (Table 26). Obviously, plant taxa that occur in low densities or in specialized microhabitats in central New Mexico would likely be rarely observed in rodent diets; similarly, plant seeds that contain effective chemical or morphological defenses against granivores would be observed less frequently in rodent diets. However, many plant species produce fruits and seeds that are palatable to rodents, presumably so that rodents and other granivores can assist with seed dispersal and enhanced germination/recruitment of future plant generations (Harper 1977). In forests, woodlands, grasslands and scrublands of central New Mexico, rodents are clearly a major consumer of seeds from a wide range of plant taxa; it is our hope that future research studies may reveal the detailed extent to which rodent food habits influence the structure and functioning of these plant communities.

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LITERATURE CITED

Alcoze, T. M. and E. G. Zimmerman. 1973. Food habits and dietary overlap of two heteromyid rodents from the mesquite plains of Texas. Journal of Mammalogy 54:900-908.

Armstrong, D. M. 1982. Mammals of the Canyon Country. Canyonlands Natural History Association, Moab, UT. 263 pp.

Bailey, V. 1905. Biological Survey of Texas. North American Fauna No. 25. United States Department of Agriculture, Bureau of Biological Survey, Washington, D.C. 222 pp.

Bailey, V. 1931. Mammals of New Mexico. North American Fauna No. 53. United States Department of Agriculture, Bureau of Biological Survey, Washington, D.C. 412 pp.

Bailey, V. and C. C. Sperry. 1929. Life history and habits of grasshopper mice, genus *Onychomys*. Technical Bulletin No. 145, United States Department of Agriculture, Washington, D.C. 19 pp.

Baker, R. H. 1954. The silky pocket mouse (*Perognathus flavus*) of Mexico. University of Kansas Publications, Museum of Natural History 7:339-347.

Baker, R. J., L. C. Bradley, R. D. Bradley, J. W. Dragoo, M. D. Engstrom, R. S. Hoffman, C. A. Jones, F. Reid, D. W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Museum of Texas Tech University Occasional Papers 229:1-23.

Beatley, J. C. 1969. Dependence of desert rodents on winter annuals and precipitation. Ecology 50:721-724.

Best, T. L. 1988. *Dipodomys spectabilis*. Mammalian Species 311:1-10.

Best, T. L. and B. Hoditschek. 1982. Analysis of cheek pouch contents of Ord's kangaroo rat (*Dipodomys ordii*). Southwestern Naturalist 27:117-124.

Best, T. L. and M. P. Skupski. 1994. *Perognathus flavus*. Mammalian Species 471:1-10.

Best, T. L. M. P. Skupski, and R. A. Smartt. 1993. Food habits of sympatric rodents in the shinnery oak-mesquite grasslands of southeastern New Mexico. Southwestern Naturalist 38:224-235.

Blakely, G. 1936. Notes on the life habits of the silky pocket mouse (*Perognathus flavus* Baird). M.S. Thesis, University of New Mexico, Albuquerque, NM. 24 pp.

Bowers, M. A. 1982. Foraging behavior of Heteromyid rodents: field evidence of resource partitioning. Journal of Mammalogy 63:361-367.

Box, T. W. 1959. Density of plains wood rat dens on four plant communities in south Texas. Ecology 40:715-716.

Boyle, R. and M. D. Dearing. 2003. Ingestion of juniper foliage reduces metabolic rates in woodrat (*Neotoma*) herbivores. Zoology 106:151-158.

Bradford, D. F. 1974. Water stress of free-living *Peromyscus truei*. Ecology 55:1407-1414.

Bradley, W. G. and R. A. Mauer. 1971. Reproduction and food habits of Merriam's kangaroo rat, *Dipodomys merriami*. Journal of Mammalogy 52:497-507.

Bradley, W. G. and R. A. Mauer. 1973. Rodents of a creosote bush community in southern Nevada. Southwestern Naturalist 17:333-344.

Braun, J. K. and M. A. Mares. 1989. *Neotoma micropus*. Mammalian Species 33:1-9.

Brown, J. H. 1975. Geographical ecology of desert rodents. Pages 314-341, in: M. L. Cody and J. M. Diamond (eds.). Ecology and Evolution of Communities. Belknap Press of Harvard University Press, Cambridge, MA. 545 pp.

Brown, J. H. and G. A. Lieberman. 1973. Resource utilization and coexistence of seed-eating desert rodents in sand dune habitats. Ecology 54:788-797.

Brown, J. H. and R. A. Ojeda. 1987. Granivory: patterns, processes, and consequences of seed consumption on two continents. Revista Chilena de Historia Natural 60:337-349.

Brown, J. H., D. W. Davidson, and O. J. Reichman. 1979. An experimental study of competition between seed-eating desert rodents and ants. American Zoologist 19:1129-1143.

Brown, L. N. 1964. Ecology of three species of *Peromyscus* from southern Missouri. Journal of Mammalogy 45:189-202.

Burt, W. H. 1934. The mammals of southern Nevada. Transactions of the San Diego Society of Natural History 7:375-427.

Caire, W., J. D. Tyler, B. P. Glass, and M. A. Mares. 1989. Mammals of Oklahoma. University of Oklahoma Press, Norman, Oklahoma. 567 pp.

Cary, M. 1911. A biological survey of Colorado. North American Fauna No. 33. United States Department of Agriculture, Bureau of Biological Survey, Washington, D.C. 256 pp.

Chew, R. M., and A. E. Chew. 1970. Energy relationships of the mammals of a desert shrub (*Larrea tridentata*) community. Ecological Monographs 40:1-21.

Clark, W. K. 1952. Isolating mechanisms, competition, and geographical variation of the *Peromyscus boylii* group in Oklahoma and Texas. Ph.D. dissertation, University of Texas, Austin, TX. 100 pp.

Dalquest, W. W. 1953. Mammals of the Mexican state of San Luis Potos¡. Louisiana State University Press, Baton Rouge, LA. 229 pp.

Davidson, D. W., J. H. Brown, and R. S. Inouye. 1980.

Competition and the structure of granivore communities. BioScience 30:233-238.
Davis, W. B. and D. J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife, Austin, TX. 338 pp.
Dearing, M. D., A. M. Mangione, and W. H. Karasov. 2000. Diet breadth of mammalian herbivores: nutrient versus detoxification constraints. Oecologia 123:397-405.
DeBlase, A. F. and R. E. Martin. 1981. Diet analysis. In: A Manual of Mammalogy (With Keys to Families of the World). Second edition. Wm. C. Brown Company Publishers, Dubuque, Iowa. 436 pp.
Dial, K. P. 1988. Three sympatric species of *Neotoma*: dietary specialization and coexistence. Oecologia 76:531-537.
Douglas, C. L. 1969. Comparative ecology of pinyon mice and deer mice in Mesa Verde National Park, Colorado. University of Kansas Publications, Museum of Natural History 18:421-504.
Dunham, M. 1968. A comparative food habit study of two species of kangaroo rats - *Dipodomys ordi* and *Dipodomys merriami*. M.S. Thesis, University of New Mexico, Albuquerque, NM. 25 pp.
Duran, J. C. 1973. Field investigations and energy determination of stomach contents of *Peromyscus boylii* in the Granite Basin Area, Yavapai County, Arizona. D.A. dissertation, University of Northern Colorado, Greeley, CO. 62 pp.
Edwards, C. W., C. F. Fulhorst, and R. D. Bradley. 2001. Molecular phylogenetics of the *Neotoma albigula* species group: further evidence of a paraphyletic assemblage. Journal of Mammology, 82:267-279.
Egoscue, H. J. 1960. Laboratory and field studies of the northern grasshopper mouse. Journal of Mammalogy, 41:99-110.
Findley, J. S. 1987. The Natural History of New Mexican Mammals. University of New Mexico Press, Albuquerque, NM. 164 pp.
Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque, NM. 360 pp.
Finley, R. B., Jr. 1958. The wood rats of Colorado: distribution and ecology. University of Kansas Publications, Museum of Natural History 10:213-552.
Fitzgerald, J. P., C. A. Meaney, and D. M. Armstrong. 1994. Mammals of Colorado. Denver Museum of Natural History, Denver, CO. 467 pp.
Flake, L. D. 1973. Food habits of four species of rodents on a short-grass prairie in Colorado. Journal of Mammalogy 54:636-647.
Forbes, R. B. 1962. Notes on food of silky pocket mice. Journal of Mammalogy 43:278-279.
Frank, C. L. 1988. Diet selection by a heteromyid rodent: role of net metabolic water production. Ecology 69:1943-1951.
Frey, J. K. 2004. Taxonomy and distribution of the mammals of New Mexico: An annotated checklist. Occasional Papers, Number 240, Museum of Texas Tech University, Lubbock, TX. 32 pp.
Friggens, M. T. 2003. Relating small mammal population dynamics to precipitation and vegetation on the Sevilleta National Wildlife Refuge, New Mexico. M.S. Thesis, University of New Mexico, Albuquerque, NM. 140 pp.
Gaby, R. S. 1972. Comparative niche utilization by two species of kangaroo rats (genus *Dipodomys*). Ph.D. Dissertation, New Mexico State University, Las Cruces, NM. 71 pp.
Garrison, T. E. and R. L. Best. 1990. *Dipodomys ordii*. Mammalian Species 353:1-10.
Hall, E. R. 1995. Mammals of Nevada. University of Nevada Press, Las Vegas, NV. 710 pp.
Hansen, R. M. 1975. Plant matter in the diet of *Onychomys*. Journal of Mammalogy 56:530-531.
Harper, J. L. 1977. Population biology of plants. Academic Press, New York. 892 pp.
Harris, J. H. 1984. An experimental analysis of desert rodent foraging ecology. Ecology 65:1579-1584.
Harris, J. H. 1986. Microhabitat segregation in two desert rodent species: the relation of prey availability to diet. Oecologia 68:417-421.
Haufler, J. B. and J. G. Nagy. 1984. Summer food habits of a small mammal community in the pinyon-juniper ecosystem. Great Basin Naturalist 44:145-150.
Hibbard, E. A. and J. R. Beer. 1960. The plains pocket mouse in Minnesota. Flicker 32:89-94.
Hoffmeister, D. F. 1981. *Peromyscus truei*. Mammalian Species 161:1-5.
Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press, Tucson, AZ. 602 pp.
Hoffmeister, D. F. and F. E. Durham. 1971. Mammals of the Arizona Strip including Grand Canyon National Monument. Technical Series No. 11, Museum of Northern Arizona, Flagstaff, AZ. 44 pp.
Hoffmeister, D. F. and W. W. Goodpaster. 1954. The mammals of the Huachuca Mountains, southeastern Arizona. Illinois Biological Monographs, 24:1-152.
Horner, B. E., J. M. Taylor, and H. A. Padykula. 1965. Food habits and gastric morphology of the grasshopper mouse. Journal of Mammalogy 45:513-535.
Inouye, R. S., G. Byers, and J. H. Brown. 1980. Effects of predation and competition on survivorship, fecundity and community structure of desert annuals. Ecology 61:1344-1351.
Jameson, E. W., Jr. 1952. Food of deer mice, *Peromyscus maniculatus* and *P. boylei*, in the northern Sierra Ne-

vada, California. Journal of Mammalogy 33:50-60.
Jenkins, S. H. and R. Ascanio. 1993. A potential nutritional basis for resource partitioning by desert rodents. American Midland Naturalist 130:164-172.
Johnson, C. W. 1952. The ecological life history of the packrat, *Neotoma micropus*, in the brushlands of Southwest Texas. M.S. Thesis, University of Texas, Austin, TX. 115 pp.
Johnson, D. R. 1961. The food habits of rodents on rangelands of southern Idaho. Ecology 42: 407-410.
Johnson, W. R. 1988. Soil survey of Socorro County Area, New Mexico. United States Department of Agriculture, Soil Conservation Service, Albuquerque, New Mexico. 328 pp.
Jones, J. K., D. M. Armstrong, R. S. Hoffmann, and C. Jones. 1983. Mammals of the Northern Great Plains. University of Nebraska Press, Lincoln, NE. 379 pp.
Kalcounis-R•ppell, M. C. and J. S. Millar. 2002. Partitioning of space, food, and time by syntopic *Peromyscus boylii* and *P. californicus*. Journal of Mammalogy 83:614-625.
Kelrick, M. I., J. A. MacMahon, R. R. Parmenter, and D. V. Sisson. 1986. Native seed preferences of shrub-steppe rodents, birds and ants: the relationships of seed attributes and seed use. Oecologia 68:327-337.
Kenagy, G. J. 1973. Daily and seasonal patterns of activity and energetics in a heteromyid rodent community. Ecology 54:1201-1219.
Kenagy, G. J. and D. F. Hoyt. 1980. Reingestion of feces in rodents and its daily rhythmicity. Oecologia 44:403-409.
Kerley, G. I., W. G. Whitford, and F. R. Kay. 1997. Mechanisms for keystone status of kangaroo rats: graminivory rather than granivory? Oecologia 111:422-428.
Lackey, J. A., D. G. Huckaby, and B. G. Ormiston. 1985. *Peromyscus leucopus*. Mammalian Species 247:1-10.
Lemen, C. A. 1978. Seed size selection in heteromyids. A second look. Oecologia, 35:13-19.
Lemen, C. A. and P. W. Freeman. 1985. Tracking mammals with fluorescent pigments: A new technique. Journal of Mammalogy 66:134-136.
Long, C. A. 1961. Natural history of the brush mouse (*Peromyscus boylii*) in Kansas with description of a new subspecies. University of Kansas Publications, Museum of Natural History 14:99-110.
Macˆdo, R. H. and M. A. Mares. 1988. *Neotoma albigula.* Mammalian Species 310:1-7.
MacMillen, R. E. and E. A. Christopher. 1975. The water relations of two populations of noncaptive desert rodents. Pp. 117-137, in N. F. Hadley (ed.). Comparative Physiology of Desert Organisms. Dowden, Hutchinson and Ross, Stroudsburg, PA.
Mares, M. A. and D. Williams. 1977. Experimental support for food particle size resource allocation in heteromyid rodents. Ecology, 58:1186-1190.
McCarty, R. 1975. *Onychomys torridus*. Mammalian Species, 59:1-5.
McCarty, R. 1978. *Onychomys leucogaster*. Mammalian Species, 87:1-6.
McCloskey, R. T. 1980. Spatial patterns in sizes of seeds collected by four species of Heteromyid rodents. Ecology 61:486-489.
McCulloch, C. Y., Jr. 1959. Populations and range effects of rodents on the sand sagebrush grasslands of western Oklahoma. Ph.D. Dissertation, Oklahoma State University, Stillwater, OK. 159 pp.
Meserve, P. L. 1976. Food relationships of a rodent fauna in a California coastal sage scrub community. Journal of Mammalogy 57:300-319.
Miller, F. W. 1939. Re-assimilation of food by the banner-tail kangaroo rat. Journal of Mammalogy 20:378-379.
Mitchell, W. A., Z. Abramsky, B. P. Kotler, B. Pinshow and J. S. Brown. 1990. The effect of competition on foraging activity in desert rodents: theory and experiments. Ecology 71:844-854.
Mohamed, R. M. 1989. Ecology and biology of *Perognathus* species in a grassland ecosystem in northeastern Colorado. Ph.D. Dissertation, University of Northern Colorado, Greeley, CO. 177 pp.
Monk, R. R. and J. K. Jones, Jr. 1996. *Perognathus flavescens*. Mammalian Species, 525:1-4.
Monson, G. 1943. Food habits of the banner-tailed kangaroo rat in Arizona. Journal of Wildlife Management 7:98-102.
Monson, G. and W. Kessler. 1940. Life history notes on the banner-tailed kangaroo rat, Merriam's kangaroo rat, and the white-throated wood rat in Arizona and New Mexico. Journal of Wildlife Management 4:37-43.
Morton, S. R. and R. E. MacMillen. 1982. Seeds as sources of preformed water for desert-dwelling granivores. Journal of Arid Environments 5:61-67.
Morton, S. R., D. S. Hinds, and R. E. MacMillen. 1980. Cheek pouch capacity in heteromyid rodents. Oecologia 46:143-146.
O'Connell, M. A. 1979. Coexistence of two species of kangaroo rats (Genus *Dipodomys*) in the Guadalupe Mountains National Park, Texas. Pp. 349-371, in H. H. Genoways and R. J. Baker (eds.). Biological Investigations in the Guadalupe Mountains National Park, Texas. National Park Service, Proceedings and Transactions Series Number Four, Washington, D.C.
Parmenter, R. R. and J. A. MacMahon. 1988a. Factors limiting populations of arid-land darkling beetles

(Coleoptera: Tenebrionidae): predation by rodents. Environmental Entomology 17:280-286.
Parmenter, R. R. and J. A. MacMahon. 1988b. Factors influencing species composition and population sizes in a ground beetle community (Carabidae): predation by rodents. Oikos 52:350-356.
Parmenter, R. R., J. A. MacMahon and S. J. Vander Wall. 1984. The measurement of granivory by desert rodents, birds and ants: a comparison of an energetics approach and a seed dish technique. Journal of Arid Environments 7:75-92.
Pellis, S. M. and V. C. Pellis. 1992. Analysis of the targets and tactics of conspecific attack and predatory attack in northern grasshopper mice *Onychomys leucogaster*. Aggressive Behavior, 18:301-316.
Poole, R. W. and P. Gentili. 1996-1997. Nomina Insecta Nearctica. A Check List of the Insects of North America. Volumes 1-4. Entomological Information Services, Rockville, MD.
Price, M. V. 1983. Laboratory studies of seed size and species selection by heteromyid rodents. Oecologia 60:259-263.
Price, M. V. and O. J. Reichman. 1987. Distribution of seeds in Sonoran desert soils: implications for Heteromyid rodent foraging. Ecology 68:1797-1811.
Price, M. V. and N. W. Waser. 1985. Microhabitat use by the heteromyid rodents: effects of artificial seed patches. Ecology 66:211-219.
Ramsey, P. R. and C. J. Carley. 1970. Additions to the known range and ecology of three species of *Dipodomys*. Southwestern Naturalist 14:351-353.
Raun, G. G. 1966. A population of woodrats (*Neotoma micropus*) in southern Texas. Bulletin of the Texas Memorial Museum 11:1-62.
Rebar, C., and O. J. Reichman. 1983. Ingestion of moldy seeds by heteromyid rodents. Journal of Mammalogy 64:713-715.
Reed, K. M. and J. R. Choate. 1986. Natural history of the plains pocket mouse in agriculturally disturbed sandsage prairie. Prairie Naturalist 18:79-90.
Reichman, O. J. 1975. Relation of desert rodent diets to available resources. Journal of Mammalogy 56:731-751.
Reichman, O. J. 1977. Optimization of diets through food preferences by heteromyid rodents. Ecology 58:454-457.
Reichman, O. J. and C. Rebar. 1985. Seed preferences by desert rodents based on levels of mouldiness. Animal Behavior 33:726-729.
Reichman, O. J. and D. Oberstein. 1977. Selection of seed distribution types by *Dipodomys merriami* and *Perognathus amplus*. Ecology 58:636-643.
Reichman, O. J. and M. V. Price. 1993. Ecological aspects of heteromyid foraging. Pp. 539-574, in H. H. Genoways and J. H. Brown (eds.). Biology of the Heteromyidae. Special Publication No. 10, The American Society of Mammalogists, Norman, OK. 719 pp.
Reichman, O. J., and K. M. Van De Graaff. 1973. Seasonal activity and reproductive patterns of five species of Sonoran Desert rodents. American Midland Naturalist 90:118-126.
Reichman, O. J. and K. M. Van De Graaff. 1975. Association between ingestion of green vegetation and desert rodent reproduction. Journal of Mammalogy 56:503-506.
Reynolds, H. G. 1950. Relation of Merriam kangaroo rats to range vegetation in southern Arizona. Ecology 31:456-463.
Reynolds, H. G. 1958. The ecology of the Merriam kangaroo rat (*Dipodomys merriami* Mearns) on the grazing lands of southern Arizona. Ecological Monographs 28:111-127.
Ruffer, D. G. 1968. Agonistic behavior of the northern grasshopper mouse (*Onychomys leucogaster breviauritus*). Journal of Mammalogy 49:481-487.
Samson, D. A., T. E. Philippi, and D. W. Davidson. 1992. Granivory and competition as determinants of annual plant diversity in the Chihuahuan desert. Oikos 65:61-80.
Schmidly, D. J. 1977. The Mammals of the Trans-Pecos Texas. Texas A&M University Press, College Station, TX. 225 pp.
Schmidt-Nielsen, B. and K. Schmidt-Nielsen. 1951. A complete account of the water metabolism in kangaroo rats and an experimental verification. Journal of Cellular and Comparative Physiology 38:165-181.
Schmidt-Nielsen, K. 1964. Desert animals: physiological problems of heat and water. Oxford University Press, London, England. 277 pp.
Schmidt-Nielsen, K. 1975. Animal physiology: adaptation and environment. Cambridge University Press, London, England. 699 pp.
Schroder, G. D. 1979. Foraging behavior and home range utilization of the bannertail kangaroo rat (*Dipodomys spectabilis*). Ecology 60:657-665.
Sipos, M. P., M. C. Andersen, W. G. Whitford, and W. R. Gould. 2002. Graminivory by *Dipodomys ordii* and *Dipodomys merriami* on four species of perennial grasses. Southwestern Naturalist 47:276-281.
Smartt, R. A. 1976. A comparison of ecological and morphological overlap in a *Peromyscus* community. Ph.D. dissertation, University of New Mexico, Albuquerque, NM. 69 pp.
Smartt, R. A. 1978. A comparison of ecological and morphological overlap in a *Peromyscus* community.

Ecology 59:216-220.
Smigel, B. W. and M. L. Rosenzweig. 1974. Seed selection in *Dipodomys merriami* and *Perognathus penicillatus*. Ecology 55:329-339.
Soholt, L. F. 1973. Consumption of primary production by a population of kangaroo rats (*Dipodomys merriami*) in the Mojave Desert. Ecological Monographs 43:357-376.
Soholt, L. F. 1977. Consumption of herbaceous vegetation and water during reproduction and development of Merriam's kangaroo rat, *Dipodomys merriami*. American Midland Naturalist 98:445-457.
Spencer, D. A. and A. L. Spencer. 1941. Food habits of the white-throated wood rat in Arizona. Journal of Mammalogy 22:280-284.
Stamp, N. E. and R. D. Ohmart. 1978. Resource utilization by desert rodents in the lower Sonoran desert. Ecology 59:700-707.
Streubel, D. P. 1975. Behavioral features of sympatry of *Spermophilus spilosoma* and *Spermophilus tridecemlineatus* and some aspects of the life history of *S. spilosoma*. D. A. Dissertation, University of Northern Colorado, Greeley, CO. 130 pp.
Streubel, D. P. and J. P. Fitzgerald. 1978. *Spermophilus spilosoma*. Mammalian Species, 101:1-4.
Sumrell, F. 1949. A life history study of the ground squirrel, *Citellus spilosoma major* (Merriam). M.S. Thesis, University of New Mexico, Albuquerque, NM. 100 pp.
Trowbridge, A. H. and H. L. Whitaker. 1940. A new kangaroo rate from Oklahoma. Journal of Mammalogy, 21:343-345.
Van De Graaff, K. M., and R. P. Balda. 1973. Importance of green vegetation for reproduction in the kangaroo rat, *Dipodomys merriami merriami*. Journal of Mammalogy 54:509-512.
Vander Wall, S. B. 1993. Salivary water loss to seeds in yellow pine chipmunks and Merriam's kangaroo rat. Ecology 74:1307-1312.
Vaughan, T. A. 1974. Resource allocation in some sympatric subalpine rodents. Journal of Mammalogy 55:764-795.
Veal, R. and W. Caire. 1979. *Peromyscus eremicus*. Mammalian Species 118:1-6.
Vorhies, C. T. and W. P. Taylor. 1922. Life history of the kangaroo rat, *Dipodomys spectabilis spectabilis* Merriam. Technical Bulletin, College of Agriculture, University of Arizona 1:1-40.
Vorhies, C. T. and W. P. Taylor. 1940. Life history and ecology of the white-throated wood rat, *Neotoma albigula albigula* Hartley, in relation to grazing in Arizona. Technical Bulletin, College of Agriculture, University of Arizona 86:454-529.
Webster, W. K. and J. K. Jones, Jr. 1982. *Reithrodontomys megalotis*. Mammalian Species 167:1-5.
Whitaker, J. O. Jr. and R. E. Mumford. 1972. Ecological studies on *Reithrodontomys megalotis* in Indiana. Journal of Mammalogy 53:850-860.
Wilson, D. E. and D. M. Reeder (eds.). 1993. Mammal Species of the World. Smithsonian Institution Press, Washington, D.C. 1,206 pp.
Wilson, D. E. and D. M. Reeder (eds.). 2005. Mammal Species of the World. Smithsonian Institution Press, Washington, D.C. 2,142 pp.
Wilson, D. E. and S. Ruff. 1999. The Smithsonian Book of North American Mammals. Smithsonian Institution Press, Washington, D.C. 750 pp.
Wood, J. E. 1969. Rodent populations and their impact on desert rangelands. New Mexico State University, Agricultural Experiment Station Bulletin 555:1-17.
Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Appendix 1. Nomenclature for plants referenced in text.

Current nomenclature was obtained from USDA web site (http://plants.usda.gov/)

Species name (current - 2006)	Species name (as found in literature)	Common name	Authority	Family	Group
Acacia berlandieri	*Acacia berlandieri*	Guajillo	Benth.	Fabaceae	Forb
Acacia constricta	*Acacia constricta*	White-thorn acacia	Benth.	Fabaceae	Forb
Acacia greggi	*Acacia greggi*	Catclaw acacia	Benth.	Fabaceae	Forb
Acacia rigidula	*Acacia amentacea*	Blackbrush acacia	Benth.	Fabaceae	Forb
Acacia sp.	*Acacia sp.*	Acacia	P. Mill.	Fabaceae	Forb
Acacia tortuosa	*Acacia tortuosa*	Poponax	(L.) Willd	Fabaceae	Forb
Achnatherum hymenoides	*Oryzopsis hymenoides*	Indian ricegrass	(Roemer & J.A. Schultes) Barkworth	Poaceae	Grass
Achnatherum sp.	*Oryzopsis sp.*	Needlegrass	Beauv.	Poaceae	Grass
Agave sp.	*Agave sp.*	Agave	L.	Agavaceae	Agave
Agropyron cristatum	*Agropyron cristatum*	Crested wheatgrass	(L.) Gaertn.	Poaceae	Grass
Agropyron sp.	*Agropyron sp.*	Wheatgrass	Gaertn.	Poaceae	Grass
Agrostis sp.	*Agrostis sp.*	Bentgrass	L.	Poaceae	Grass
Allium macropetalum	*Allium macropetalum*	Largeflower Onion	Rydb.	Liliaceae	Forb
Amaranthus albus	*Amaranthus alba*	Prostrate pigweed	L.	Amaranthaceae	Forb
Amaranthus albus	*Amaranthus graecizans*	Prostrate pigweed	L.	Amaranthaceae	Forb
Amaranthus fimbriatus	*Amaranthus fimbriatus*	Fringed amaranth	(Torr.) Benth. ex. S. Wats.	Amaranthaceae	Forb
Amaranthus retroflexus	*Amaranthus retroflexus*	Redroot amaranth	L.	Amaranthaceae	Forb
Ambrosia acanthicarpa	*Gaertneria acanthicarpa*	Flatspine burr ragweed	Hook.	Asteraceae	Forb
Ambrosia artemisiifolia	*Ambrosia artemisiifolia*	Annual Ragweed	L.	Asteraceae	Forb
Ambrosia deltoidea	*Ambrosia deltoidea*	Triangle burr ragweed	(Torr.) Payne	Asteraceae	Forb
Ambrosia dumosa	*Franseria dumosa*	Burrobush	(Gray) Payne	Asteraceae	Shrub
Ambrosia sp.	*Ambrosia sp.*	Ragweed	L.	Asteraceae	Forb
Amelanchier sp.	*Amelanchier sp.*	Serviceberry	Medik.	Rosaceae	Shrub
Andropogon hallii	*Andropogon hallii*	Sand bluestem	Hack.	Poaceae	Grass
Anisocoma acaulis	*Anisocoma acaulis*	Scalebud	Torr. & Gray	Asteraceae	Forb
Aristida adscensionis	*Aristida adscensionis*	Six-weeks threeawn	L.	Poaceae	Grass
Aristida californica var. glabrata	*Aristida glabrata*	Santa Rita threeawn	Thurb. ex S. Wats. Vasey var. *glabrata*	Poaceae	Grass
Aristida divaricata	*Aristida divaricata*	Poverty threeawn	Humb. & Bonpl. ex Willd	Poaceae	Grass
Aristida purpurea	*Aristida purpurea*	Purple threeawn	Nutt.	Poaceae	Grass
Aristida purpurea var. longiseta	*Aristida longiseta*	Fendler threeawn	Nutt. var. *longiseta* (Steud.) Vasey	Poaceae	Grass
Aristida sp.	*Aristida sp.*	Threeawn	L.	Poaceae	Grass
Aristida ternipes	*Aristida ternipes*	Spidergrass	Cav.	Poaceae	Grass

Species name (current - 2006)	Species name (as found in literature)	Common name	Authority	Family	Group
Aristida ternipes var. gentilis	*Aristida hamulosa*	Spidergrass	Cav. var. *gentilis* (Henr.) Allred	Poaceae	Grass
Artemisia californica	*Artemisia californica*	Coastal sagebrush	Less.	Asteraceae	Shrub
Artemisia filifolia	*Artemisia filifolia*	Sand sagebrush	Torr.	Asteraceae	Shrub
Artemisia frigida	*Artemisia frigida*	Prairie sagewort	Willd.	Asteraceae	Shrub
Artemisia nova	*Artemisia nova*	Black sagebrush	A. Nels.	Asteraceae	Shrub
Artemisia sp.	*Artemisia sp.*	Sagebrush	L.	Asteraceae	Shrub
Artemisia tridentata	*Artemisia tridentata*	Big sagebrush	Nutt.	Asteraceae	Shrub
Asclepias sp.	*Asclepias sp.*	Milkweed	L.	Asclepiadaceae	Forb
Astragalus allochrous var. playanus	*Astragalus wootoni*	Halfmoon milkvetch	Gray var. *playanus* Isely	Fabaceae	Forb
Astragalus missouriensis	*Astragalus missouriensis*	Missouri milkvetch	Nutt.	Fabaceae	Forb
Astragalus nuttallianus	*Astragalus nuttallianus*	Smallflowered milkvetch	DC.	Fabaceae	Forb
Astragalus nuttallianus	*Astralgalus nuttalinana*	Smallflowered milkvetch	DC.	Fabaceae	Forb
Astragalus sp.	*Astragalus sp.*	Milkvetch	L.	Fabaceae	Forb
Atriplex argentia ssp. *expansa*	*Atriplex expansa*	Silverscale saltbush	Nutt. ssp. *expansa* (S. Wats.) Hall & Clem	Chenopodiaceae	Shrub
Atriplex canescens	*Atriplex canescens*	Fourwing saltbush	(Pursh) Nutt.	Chenopodiaceae	Shrub
Atriplex confertifolia	*Atriplex confertifolia*	Shadscale saltbush	(Torr. & Frem) S. Wats.	Chenopodiaceae	Shrub
Atriplex nuttallii	*Atriplex nuttallii*	Nuttall's saltbush	S. Wats.	Chenopodiaceae	Shrub
Atriplex sp.	*Atriplex sp.*	Saltbush	L.	Chenopodiaceae	Shrub
Bahia absinthifolia	*Bahia absynthifolia*	hairyseed bahia	Benth.	Asteraceae	Forb
Bahia dissecta	*Bahia dissecta*	Ragleaf bahia	(Gray) Britt.	Asteraceae	Forb
Bahia pedata	*Bahia pedata*	Bluntscale bahia	Gray	Asteraceae	Forb
Bahia sp.	*Bahia sp.*	Bahia	Lag.	Asteraceae	Forb
Baileya multiradiata	*Baileya multiradiata*	Desert marigold	Harvey & Gray ex Gray	Asteraceae	Shrub
Boerhavia sp.	*Boerhavia sp.*	Spiderling	L.	Nyctaginaceae	Forb
Boerhavia intermedia	*Boerhavia intermedia*	Fivewing spiderling	M. E. Jones	Nyctaginaceae	Forb
Boerhavia spicata	*Boerhavia torreyana*	Creeping spiderling	Choisy	Nyctaginaceae	Forb
Boerhavia wrightii	*Boerhavia wrightii*	Largebract spiderling	Gray	Nyctaginaceae	Forb
Bothriochloa barbinodis	*Bothriochloa barbinodis*	Cane bluestem	(Lag.) Herter	Poaceae	Grass
Bouteloua aristidoides	*Bouteloua aristidoides*	Needle grama	(Kunth) Griseb	Poaceae	Grass
Bouteloua barbata	*Bouteloua barbata*	Sixweeks grama	Lag.	Poaceae	Grass
Bouteloua curtipendula	*Bouteloua curtipendula*	Sideoats grama	(Michx.) Torr.	Poaceae	Grass
Bouteloua eriopoda	*Bouteloua eriopoda*	Black grama	(Torr.) Torr.	Poaceae	Grass
Bouteloua gracilis	*Bouteloua gracilis*	Blue grama	(Willd. ex Kunth) Lag. ex Griffiths	Poaceae	Grass
Bouteloua gracilis	*Bouteloua oligostachya*	Blue grama	(Willd. ex Kunth) Lag. ex Griffiths	Poaceae	Grass
Bouteloua hirsuta	*Bouteloua hirsuta*	Hairy grama	Lag.	Poaceae	Grass

Species name (current - 2006)	Species name (as found in literature)	Common name	Authority	Family	Group
Bouteloua radicosa	*Bouteloua radicosa*	Purple grama	(Fourn.) Griffiths	Poaceae	Grass
Bouteloua rothrockii	*Bouteloua rothrockii*	Rothrocks grama	Vasey	Poaceae	Grass
Bouteloua sp.	*Bouteloua sp.*	Grama	Lag.	Poaceae	Grass
Bromus rubens	*Bromus rubens*	Red brome	L.	Poaceae	Grass
Bromus sp.	*Bromus sp.*	Brome	L.	Poaceae	Grass
Bromus tectorum	*Bromus tectorum*	Cheatgrass	L.	Poaceae	Grass
Caesalpinia drepanocarpa	*Hoffmannseggia drepanocarpa*	Sicklepod holdback	(Gray) Fisher	Fabaceae	Forb
Calylophus lavandulifolius	*Oenothera lavandulifolius*	Lavenderleaf sundrops	(Torr. & Gray) Raven	Onagraceae	Forb
Camissonia brevipes ssp. brevipes	*Oenothera brevipes*	Golden suncup	(Gray) Raven	Onagraceae	Forb
Carex sp.	*Carex sp.*	Sedge	L.	Cyperaceae	Forb
Castilleja sp.	*Castilleja sp.*	Indian paintbrush	Mutis ex L.f.	Scrophulariaceae	Forb
Celtis pallida	*Celtis pallida*	Spiny hackberry	Torr.	Ulmaceae	Shrub
Celtis sp.	*Celtis sp.*	Hackberry	L.	Ulmaceae	Tree
Cenchrus sp.	*Cenchris sp.*	Sandbur	L.	Poaceae	Grass
Cenchrus spinifex	*Cenchrus insertus*	Coastal sandbur	Cav.	Poaceae	Grass
Cenchrus spinifex	*Cenchrus pauciflorus*	Coastal sandbur	Cav.	Poaceae	Grass
Cenchrus spinifex	*Cenchrus pauciflorus*	Coastal sandbur	Cav.	Poaceae	Grass
Cercocarpus montanus	*Cerocarpus montanus*	Alderleaf mountain mahogany	Raf.	Rosaceae	Shrub
Chaenactis fremontii	*Chaenactis fremontii*	Pincushion flower	Gray	Asteraceae	Forb
Chaetopappa ericoides	*Chaetopappus ericoides*	Rose heath	(Torr.) Nesom	Asteraceae	Forb
Chamaecrista fasciculata var. fascicu .	*Cassia fasciculata*	Sleepingplant	(Michx.) Greene	Fabaceae	Forb
Chamaesaracha coniodes	*Chamaesaracha coniodes*	Gray five eyes	(Moric. ex Dunal) Britt.	Solanaceae	Forb
Chamaesyce albomarginata	*Euphorbia albomarginata*	Whitmargin sandmat	(Torr. & Gray) Small	Euphorbiaceae	Forb
Chamaesyce polycarpa	*Euphorbia polycarpa*	Smallseed sandmat	(Benth.) Millsp. ex Parish	Euphorbiaceae	Forb
Chamaesyce sp.	*Chamaesyce sp.*	Sandmat	Gray	Euphorbiaceae	Shrub
Chamaesyce sp.	*Euphorbia sp.*	Sandmat	S. F. Gray	Euphorbiaceae	Forb
Chenopodium album	*Chenopodium album*	Lambsquarters	L.	Chenopodiaceae	Shrub
Chenopodium sp.	*Chenopodium sp.*	Goosefoot	L.	Chenopodiaceae	Forb
Chilopsis linearis	*Chilopsis linearis*	Desert willow	(Cav.) Sweet	Bigoniaceae	Tree
Chilopsis sp.	*Chilopsis sp.*	Desert willow	D. Don	Bigoniaceae	Tree
Chloracantha spinosa	*Chloracantha spinosa*	Spiny chloracantha	(Benth.) Nesom	Asteraceae	Forb
Chloris cucullata	*Chloris cucullata*	Hooded windmill grass	Bisch.	Poaceae	Grass
Cirsium ochrocentrum	*Cirsium ochrocentrum*	Yellowspine thistle	Gray	Asteraceae	Shrub
Cirsium sp.	*Cirsium sp.*	Thistle	P. Mill.	Asteraceae	Forb
Clematis ligusticifolia	*Clematis ligusticifolia*	Western white clematis	Nutt.	Ranunculaceae	Forb

Species name (current - 2006)	Species name (as found in literature)	Common name	Authority	Family	Group
Cleome sp.	*Cleome sp.*	Spiderflower	L.	Capparaceae	Forb
Cleomella brevipes	*Cleomella brevipes*	Shortstalk stinkweed	S. Wats.	Capparaceae	Forb
Coleogyne ramosissima	*Coleogyne ramosissima*	Blackbrush	Torr.	Rosaceae	Shrub
Condalia spathulata	*Condalia spathulata*	Knifeleaf condalia	Gray.	Rhamnaceae	Shrub
Convolvulus arvensis	*Convolvulus arvensis*	Field bindweed	L.	Convulvulaceae	Forb
Coreopsis bigelovii	*Coreopsis bigelovii*	Bigelow's tickseed	(Gray) Hall	Asteraceae	Forb
Corispermum americanum	*Corispermum hyssopifolium*	American bugseed	(Nutt.) Nutt.	Chenopodiaceae	Forb
Croton californicus	*Croton californicus*	California croton	Muell.-Arg.	Euphorbiaceae	Shrub
Croton glandulosus	*Croton glandulosus*	Vente conmigo	L.	Euphorbiaceae	Shrub
Croton pottsii	*Croton corymbulosus*	Leatherweed	Muell.-Arg.	Euphorbiaceae	Shrub
Croton sp.	*Croton sp.*	Croton	L.	Euphorbiaceae	Forb
Croton texensis	*Croton texensis*	Texas croton	(Klotzsch) Muell.-Arg.	Euphorbiaceae	Forb
Cryptantha circumscissa	*Cryptantha circumcissa*	Cushion cryptantha	(Hook. & Arn.) I. M. Johnston	Boraginaceae	Forb
Cryptantha crassisepala	*Cryptantha crassisepala*	Thicksepal cryptantha	(Torr. & Gray) Greene	Boraginaceae	Forb
Cryptantha fendleri	*Cryptantha fendleri*	Sanddune cryptantha	(Gray) Greene	Boraginaceae	Forb
Cryptantha sp.	*Cryptantha sp.*	Cryptantha	ex G. Don.	Boraginaceae	Forb
Cucurbita foetidissima	*Curcubita foetidissima*	Missouri gourd	Kunth	Cucurbitaceae	Forb
Cycloloma atriplicifolium	*Cycloloma atriplicifolium*	Winged pigfeet	(Spreng.) Coult.	Chenopodiaceae	Forb
Cymopterus acaulis	*Cymopterus acaulis*	Plains springparsley	(Pursh) Raf.	Apiaceae	Forb
Cyperus schweinitzii	*Cyperus schweinitzii*	Schweinitz's flatsedge	Torr.	Cyperaceae	Grass
Dalea sp.	*Dalea sp.*	Prairie clover	L.	Fabaceae	Forb
Dalea sp.	*Parosela sp.*	Prairie clover	L.	Fabaceae	Forb
Dasylirion sp.	*Dasylirion sp.*	Sotol	Zucc.	Liliaceae	Forb
Dasyochloa pulchella	*Tridens pulchellus*	Low woollygrass	(Kunth.) Willd. ex Rydb.	Poaceae	Grass
Dasyochloa pulchellum	*Erioneuron pulchellum*	Low woolygrass	(Kunth) Willd. ex Rydb.	Poaceae	Grass
Dasyochloa sp.	*Erioneuron sp.*	Woolygrass	Willd. ex Rydb.	Poaceae	Grass
Descurainia incana ssp. incana	*Descurainia richardsonii*	Mountain tansymustard	(Bernh. Ex Fisch. & C.A. Mey.) Dorn	Brassicaceae	Forb
Descurainia obtusa	*Descurania obtusa*	Blunt tansymustard	(Greene) O. E. Schulz	Brassicaceae	Forb
Descurainia pinnata	*Descurania pinnata*	Western tansymustard	(Walt.) Britt.	Brassicaceae	Forb
Descurainia sophia	*Descurania sophia*	Herb sophia	(L.) Webb ex Prantl	Brassicaceae	Forb
Descurainia sp.	*Descurainia sp.*	Tansymustard	Webb & Berth.	Brassicaceae	Forb
Digitaria californica	*Digitaria californica*	Arizona cottontop	(Benth.) Henr.	Poaceae	Grass
Digitaria californica	*Trichachne califonica*	Arizona cottontop	(Benth.) Henr.	Poaceae	Grass
Digitaria sp.	*Digitaria sp.*	Crabgrass	Haller	Poaceae	Grass
Dimorphocarpa sp.	*Dithyrea sp.*	Spectaclepod	Rollins	Brassicaceae	Forb

Species name (current - 2006)	Species name (as found in literature)	Common name	Authority	Family	Group
Dimorphocarpa wislizeni	*Dithyrea wislizeni*	Touristplant	(Engelm.) Rollins	Brassicaceae	Forb
Diospyros texana	*Brayodendron texanum*	Texas persimmon	Scheele	Ebenaceae	Tree
Dyssodia sp.	*Dyssodia sp.*	Dysodia	Cav.	Asteraceae	Forb
Echinocereus coccineus	*Echinocereus coccineus*	Scarlet hedgehog cactus	Engelm.	Cactaceae	Cactus
Echinocereus sp.	*Echinocereus sp.*	Hedgehog cactus	Engelm.	Cactaceae	Cactus
Echinocereus triglochidiatus	*Echinocereus triglochidiatus*	Kingcup cactus	Engelm.	Cactaceae	Cactus
Elaeagnus angustifolia	*Elaeagnus angustifolia*	Russian olive	L.	Elaeagnaceae	Tree
Ephedra funerea	*Ephedra funera*	Death Valley jointfir	Coville & Morton	Ephedraceae	Shrub
Ephedra sp.	*Ephedra sp.*	Jointfir	L.	Ephedraceae	Shrub
Ephedra viridis	*Ephedra viridis*	Mormon tea	Coville	Ephedraceae	Shrub
Eragrostis lehmanniana	*Eragrostis lehmanniana*	Lehmann lovegrass	Nees	Poaceae	Grass
Eriastrum eremicum	*Hugelia eremica*	Desert woolystar	(Jepson) Mason	Polemoniaceae	Forb
Ericameria nauseosa	*Chrysothamnus nauseosus*	Rubber rabbitbrush	(Pallas ex Pursh) Nesom & Baird	Asteraceae	Shrub
Ericameria sp.	*Chrysothamnus sp.*	Goldenbush	Nutt.	Asteraceae	Shrub
Eriogonum corymbosum	*Eriogonum corynbosum*	Crispleaf buckwheat	Benth.	Polygonaceae	Shrub
Eriogonum fasciculatum	*Eriogonum fasciculatum*	Eastern Mojave buckwheat	Benth.	Polygonaceae	Shrub
Eriogonum sp.	*Eriogonum sp.*	Buckwheat	Michx.	Polygonaceae	Shrub
Erioneuron pilosum	*Tridens pilosus*	Hairy woollygrass	(Buckl.) Nash	Poaceae	Grass
Eriophyllum sp.	*Eriophyllum sp.*	Wooly sunflower	Lag.	Asteraceae	Forb
Erisimum capitatum var. capitatum	*Erysimum asperum*	Sanddune wallflower	(Dougl. ex Hook.) Greene	Brassicaceae	Forb
Erodium cicutarium	*Erodium cicutarium*	Redstem stork's bill	(L.) L'Her. ex Ait.	Geraniaceae	Forb
Eschscholzia califonica	*Eschscholzia mexicana*	California poppy	Cham.	Papaveraceae	Forb
Evolvulus arizonicus	*Evolvulus arizonicus*	Wild dwarf morning-glory	Gray	Convulvulaceae	Forb
Fallugia paradoxa	*Fallugia paradoxa*	Apache plume	(D. Don) Endl. ex Torr.	Rosaceae	Shrub
Fallugia sp.	*Fallugia sp.*	Apache plume	Endl.	Rosaceae	Shrub
Fendlera rupicola	*Fendlera rupicola*	Cliff fendlerbush	Gray	Hydrangeaceae	Shrub
Flourensia sp.	*Flourensia sp.*	Tarwort	DC.	Asteraceae	Shrub
Fouquieria splendens	*Fouquieria splendens*	Ocotillo	Engelm.	Fouquieriaceae	Shrub
Fraxinus sp.	*Fraxinus sp.*	Ash	L.	Oleaceae	Tree
Gaillardia pulchella	*Gaillardia pulchella*	Firewheel	Foug.	Asteraceae	Forb
Gilia sp.	*Gilia sp.*	Gilia	Ruiz & Pavon	Polemoniaceae	Forb
Gladularia bipinnatifida	*Verbena bipinnatifida*	Dakota mock vervain	(Nutt.) Nutt.	Verbenaceae	Forb
Guajacum angustifolium	*Porliera angustifolia*	Texas lignum-vitae	Engelm.	Zygophyllaceae	Tree
Guilleminea sp.	*Brayulinea sp.*	Matweed	Kunth	Amaranthaceae	Forb
Gutierrezia microcephala	*Gutierrezia microcephala*	Threadleaf snakeweed	(DC.) Gray	Asteraceae	Shrub

Species name (current - 2006)	Species name (as found in literature)	Common name	Authority	Family	Group
Gutierrezia sarothrae	*Gutierrezia sarothrae*	Broom snakeweed	(Pursh) Britt. & Rusby	Asteraceae	Shrub
Gutierrezia sp.	*Gutierrezia sp.*	Snakeweed	Lag.	Asteraceae	Shrub
Hackelia sp.	*Hackelia sp.*	Stickseed	Opiz	Boraginaceae	Forb
Halogeton glomeratus	*Halogeton glomeratus*	Saltlover	(Bieb.) C. A. Mey	Chenopodiaceae	Forb
Halogeton sp.	*Halogeton sp.*	Saltlover	C. A. Mey	Chenopodiaceae	Forb
Helianthus annuus	*Helianthus annuus*	Common sunflower	L.	Asteraceae	Forb
Helianthus petiolaris	*Helianthus petiolaris*	Prairie sunflower	Nutt.	Asteraceae	Forb
Helianthus sp.	*Helianthus sp.*	Sunflower	L.	Asteraceae	Forb
Hesperostipa comata	*Stipa comata*	Needle and thread	(Trin. & Rupr.) Barkworth	Poaceae	Grass
Heterotheca villosa var. villosa	*Chrysopsis villosa*	Hairy false goldaster	(Pursh) Shinners	Asteraceae	Forb
Hoffmannseggia glauca	*Hoffmannseggia glauca*	Indian rushpea	(Ortega) Eifert	Fabaceae	Forb
Hoffmannseggia glauca	*Hoffmannseggia densiflora*	Indian rushpea	(Ortega) Eifert	Fabaceae	Forb
Hymenopappus filifolius	*Hymenopappus filifolius*	Fineleaf hymenopappus	Hook.	Asteraceae	Forb
Hymenoxys richardsonii	*Hymenoxys richardsonii*	Pingue rubberweed	(Hook.) Cockerell	Asteraceae	Forb
Ipomopsis pumila	*Ipomopsis pumila*	Dwarf ipomopsis	(Nutt.) V. Grant	Polemoniaceae	Forb
Juglans major	*Juglans major*	Arizona walnut	(Torr.) Heller	Juglandaceae	Tree
Juncus bufonius	*Juncus bufonius*	Toad rush	L.	Juncaceae	Forb
Juniperus monosperma	*Juniperus monosperma*	Oneseed juniper	(Engelm.) Sarg.	Cupressaceae	Tree
Juniperus osteosperma	*Juniperus osteosperma*	Utah juniper	(Torr.) Little	Cupressaceae	Tree
Juniperus osteosperma	*Juniperus utahensis*	Utah juniper	(Torr.) Little	Cupressaceae	Tree
Juniperus scopulorum	*Juniperus scopulorum*	Rocky Mountain juniper	Sarg.	Cupressaceae	Tree
Juniperus sp.	*Juniperus sp.*	Juniper	L.	Cupressaceae	Tree
Kallstroemia sp.	*Kallstroemia sp.*	Caltrop	Scop.	Zygophyllaceae	Forb
Kochia americana	*Kochia americana*	Green molly	S. Wats.	Chenopodiaceae	Shrub
Kochia scoparia	*Kochia scoparia*	Mexican fireweed	(L.) Schrad.	Chenopodiaceae	Forb
Koeberlinia spinosa	*Koberlinia spinosa*	Crown of thorns	Zucc.	Capparaceae	Tree
Krameria erecta	*Krameria parvifolia*	Littleleaf ratany	Willd. ex J. A. Schultes	Krameriaceae	Shrub
Krascheninnikovia lanata	*Krascheninnikovia lanata*	Winterfat	(Pursh) A. D. J. Meeuse & Smit	Chenopodiaceae	Shrub
Lappula occidentalis	*Lappula redowskii*	Flatspine stickseed	(S. Wats.) Greene	Boraginaceae	Forb
Lappula occidentalis	*Lappula texana*	Flatspine stickseed	(S. Wats.) Greene	Boraginaceae	Forb
Larrea sp.	*Larrea sp.*	Creosote bush	Cav.	Zygophyllaceae	Shrub
Larrea tridentata	*Larrea tridentata*	Creosote bush	(Sesse & Moc. ex DC.) Coville	Zygophyllaceae	Shrub
Lepidium austrinum	*Lepidium austrinum*	Southern pepperwort	Small	Brassicaceae	Forb
Lepidium densiflorum	*Lepidium densiflorum*	Common pepperweed	Schrad.	Brassicaceae	Forb
Lepidium perfoliatum	*Lepidium perfoliatum*	Clasping pepperweed	L.	Brassicaceae	Forb

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Lepidium sp.	*Lepidium sp.*	Pepperweed	L.	Brassicaceae	Forb
Lesquerella fendleri	*Lesquerella fendleri*	Fendler's bladderpod	(Gray) S. Wats.	Brassicaceae	Forb
Lesquerella gordoni	*Lesquerella gordoni*	Gordon's bladderpod	(Gray) S. Wats.	Brassicaceae	Forb
Lesquerella ovalifolia	*Lesquerella ovalifolia*	Roundleaf bladderpod	Rydb. ex Britt.	Brassicaceae	Forb
Lesquerella sp.	*Lesquerella sp.*	Bladderpod	S. Wats.	Brassicaceae	Forb
Leucocrinum montanum	*Leucocrinum montanum*	Common starlily	Nutt. ex gray	Liliaceae	Forb
Liatris punctata	*Liatus punctata*	Dotted blazing star	Hook.	Asteraceae	Forb
Linum aristatum	*Linum aristatum*	Bristle flax	Engelm.	Linaceae	Forb
Linum sp.	*Linum sp.*	Flax	L.	Linaceae	Forb
Lithospermum incisum	*Lithospermum incisum*	Narrowleaf stoneseed	Lehm.	Boraginaceae	Forb
Lithospermum sp.	*Lithospermum sp.*	Stoneseed	L.	Boraginaceae	Forb
Lolium perenne	*Lolium perenne*	Perennial ryegrass	L.	Poaceae	Grass
Lotus humistratus	*Lotus humistratus*	Foothill deervetch	Greene	Fabaceae	Forb
Lotus scoparius	*Lotus scoparius*	Common deerweed	(Nutt.) Ottley	Fabaceae	Shrub
Lotus sp.	*Lotus sp.*	Trefoil	L.	Fabaceae	??
Lupinus kingii	*Lupinus kingii*	King's lupine	S. Wats.	Fabaceae	Forb
Lupinus pusillus	*Lupinus pusillus*	Rusty lupine	Pursh	Fabaceae	Forb
Lupinus sp.	*Lupinus sp.*	Lupine	L.	Fabaceae	Forb
Lycium pallidum	*Lycium pallidum*	Pale desert-thorn	Miers	Solanaceae	Shrub
Lycium sp.	*Lycium sp.*	Desert-thorn	L.	Solanaceae	Shrub
Lycopus sp.	*Lycopus sp.*	Waterhorehound	L.	Lamiaceae	Forb
Lycurus phleoides	*Lycurus phleoides*	Common wolfstail	Kunth	Poaceae	Grass
Machaeranthera canescens ssp. cane	*Macaeranthera spinulosis*	Hoary tansyaster	(Pursh) Gray	Asteraceae	Forb
Machaeranthera gracilis	*Applopappus gracilis*	Slender goldenweed	(Nutt.) Shinners	Asteraceae	Forb
Machaeranthera sp.	*Haplopappus sp.*	Tansyaster	Nees	Asteraceae	Forb
Mahonia sp.	*Mahonia sp.*	Barberry	Nutt.	Berberidaceae	Shrub
Mahonia trifoliolata	*Berberis trifoliata*	Algerita	(Moric.) Fedde	Berberidaceae	Shrub
Mahonia trifoliolata	*Mahonia trifolioliata*	Algerita	(Moric.) Fedde	Berberidaceae	Shrub
Malacothrix glabrata	*Malacothrix californica*	Smooth desertdandelion	(Gray ex DC. Eat.) Gray	Asteraceae	Forb
Malacothrix sp.	*Malacothrix sp.*	Desertdandelion	DC.	Asteraceae	Forb
Malacothrix torreyi	*Malacothrix torreyi*	Torrey's desertdandelion	Gray	Asteraceae	Forb
Mammillaria sp.	*Mammillaria sp.*	Globe cactus	Haw.	Cactaceae	Cactus
Medicago sativa	*Medicago sativa*	Alfalfa	L.	Fabaceae	Forb
Melampodium leucanthum	*Melampodium leucanthum*	Plains blackfoot	Torr. & Gray	Asteraceae	Forb
Melilotus alba	*Melilotis alba*	White sweetclover	Medikus	Fabaceae	Forb

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Melilotus officinalis	*Melilotus officinalis*	Yellow sweetclover	(L.) Lam.	Fabaceae	Forb
Melilotus sp.	*Melilotus sp.*	Sweetclover	P. Mill.	Fabaceae	Forb
Mentzelia nuda	*Mentzelia nudastricta*	Bractless blazingstar	(Pursh) Torr. & Gray	Loasaceae	Forb
Mentzelia nuda	*Mentzelia stricta*	Bractless blazingstar	(Pursh) Torr. & Gray	Loasaceae	Forb
Mentzelia pumila	*Mentzelia pumila*	Dwarf mentzelia	Nutt. ex Torr. & Gray	Loasaceae	Forb
Mentzelia sp.	*Mentzelia sp.*	Blazingstar	L.	Loasaceae	Forb
Mirabilis multiflora	*Mirabilis multiflora*	Colorado four o'clock	(Torr.) Gray	Nyctaginaceae	Forb
Mollugo verticillata	*Mollugo verticillata*	Green carpetweed	L.	Molluginaceae	Forb
Monroa squarrosa	*Munroa squarrosa*	False buffalograss	(Nutt.) Torr.	Poaceae	Grass
Muhlenbergia sp.	*Muhlenbergia sp.*	Muhly	Schreb.	Poaceae	Grass
Nerisyrenia sp.	*Nerisyrenia sp.*	Fanmustard	Greene	Brassicaceae	Forb
Nolina microcarpa	*Nolina microcarpa*	Sacahuista	S. Wats.	Liliaceae	Shrub
Nolina sp.	*Nolina sp.*	Beargrass	Michx.	Liliaceae	Shrub
Nuttallanthus canadensis	*Linaria canadensis*	Canada toadflax	(L.) D. A. Sutton	Scrophulariaceae	Forb
Oenothera albicaulis	*Oenothera albicaulis*	Whitest evening primrose	Pursh	Onagraceae	Forb
Oenothera sp.	*Oenothera sp.*	Evening primrose	L.	Onagraceae	Forb
Opuntia clavata	*Opuntia clavata*	Club cholla	Engelm.	Cactaceae	Cactus
Opuntia engelmanii var. lindheimeri	*Opuntia lindheimeri*	Texas pricklypear	Salm-Dyck var. *lindheimeri* (Engelm.) Parfi	Cactaceae	Cactus
Opuntia engelmannii	*Opuntia engelmannii*	Cactus apple	Salm-Dyck	Cactaceae	Cactus
Opuntia fulgida	*Opuntia fulgida*	Jumping cholla	Engelm.	Cactaceae	Cactus
Opuntia humifusa	*Opuntia humifusa*	Devil's-tongue	(Raf.) Raf.	Cactaceae	Cactus
Opuntia imbricata	*Opuntia arborescens*	Tree cholla	(Haw.) DC.	Cactaceae	Cactus
Opuntia imbricata	*Opuntia imbricata*	Tree cholla	(Haw.) DC.	Cactaceae	Cactus
Opuntia macrocentra	*Opuntia macrocentra*	Purple pricklypear	Engelm.	Cactaceae	Cactus
Opuntia macrocentra	*Opuntia violacea*	Purple pricklypear	Engelm.	Cactaceae	Cactus
Opuntia phaeacantha	*Opuntia phaeacantha*	Tulip pricklypear	Engelm.	Cactaceae	Cactus
Opuntia phaeacantha var. major	*Opuntia cyclodes*	Mojave pricklypear	Engelm.	Cactaceae	Cactus
Opuntia polyacantha	*Opuntia polyacantha*	Plains pricklypear	Haw.	Cactaceae	Cactus
Opuntia sp.	*Opuntia sp.*	Pricklypear	P. Mill.	Cactaceae	Cactus
Opuntia spinosior	*Opuntia spinosior*	Walkingstick cactus	(Engelm.) Toumey	Cactaceae	Cactus
Opuntia tunicata	*Opuntia davisii*	Thistle cholla	(Lehm.) Link & Otto	Cactaceae	Cactus
Opuntia versicolor	*Opuntia versicolor*	Staghorn cholla	Engelm. ex Coult.	Cactaceae	Cactus
Packera multilobata	*Senecio multilobatus*	Lobeleaf groundsel	(Torr. & Gray ex Gray) W. A. Weber & A. ..	Asteraceae	Forb
Palafoxia sphacelata	*Palafoxia sphacelata*	Othake	(Nutt. ex Torr.) Cory	Asteraceae	Forb
Panicum miliaceum	*Panicum millefolium*	Broomcorn millet	L.	Poaceae	Grass

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Panicum obtusum	*Panicum obtusum*	Vine mesquite	Kunth	Poaceae	Grass
Panicum virgatum	*Panicum virgatum*	Switchgrass	L.	Poaceae	Grass
Paspalum setaceum	*Paspalum ciliatifolium*	Thin paspalum	Michx.	Poaceae	Grass
Paspalum setaceum	*Paspalum setaceum*	Thin paspalum	Michx.	Poaceae	Grass
Paspalum setaceum	*Paspalum stramineum*	Thin paspalum	Michx.	Poaceae	Grass
Paspalum sp.	*Paspalum sp.*	Crowngrass	L.	Poaceae	Grass
Pectis angustifolia	*Pectis angustifolia*	Lemonscent	Torr.	Asteraceae	Forb
Pectis papposa	*Pectis papposa*	Manybristle cinchweed	Harvey & Gray	Asteraceae	Forb
Pectis sp.	*Pectis sp.*	Cinchweed	L.	Asteraceae	Forb
Pectocarya platycarpa	*Pectocarya platycarpa*	Broadfruit combseed	(Munz & Johnston) Munz & Johnston	Boraginaceae	Forb
Pectocarya recurvata	*Pectocarya recurvata*	Curvenut combseed	I. M. Johnston	Boraginaceae	Forb
Pectocarya sp.	*Pectocarya sp.*	Combseed	DC. ex Meisn	Boraginaceae	Forb
Pediomelum linearifolium	*Psoralea linearifolia*	Narrowleaf Indian breadroot	(Torr. & Gray) J. Grimes	Fabaceae	Forb
Pennisetum glaucum	*Setaria glauca*	Pearl millet	(L.) R. Br.	Poaceae	Grass
Penstemon barbatus	*Penstemon barbatus*	Beardlip penstemon	(Cav.) Roth	Scrophulariaceae	Forb
Penstemon linarioides	*Penstemon linarioides*	Toadflax penstemon	Gray	Scrophulariaceae	Forb
Penstemon sp.	*Penstemon sp.*	Beardtongue	Schmidel	Scrophulariaceae	Forb
Phacelia crenulata	*Phacelia corrugata*	Cleftleaf wildheliotroph	Torr. ex. S. Wats	Hydrophyllaceae	Forb
Phacelia integrifolia	*Phacelia integrifolia*	Gypsum phacelia	Torr.	Hydrophyllaceae	Forb
Phacelia sp.	*Phacelia sp.*	Phacelia	Juss.	Hydrophyllaceae	Forb
Phlox sp.	*Phlox sp.*	Phlox	L.	Polemoniaceae	Forb
Phoradendron juniperinum	*Phoradendron juniperinum*	Juniper mistletoe	Engelm. ex Gray	Viscaceae	Shrub
Physalis longifolia	*Physalis subglabrata*	Longleaf groundcherry	Nutt.	Solanaceae	Forb
Physalis sp.	*Physalis sp.*	Groundcherry	L.	Solanaceae	Forb
Physaria sp.	*Physaria sp.*	Twinpod	(Nutt. ex Torr. & Gray) Gray	Brassicaceae	Forb
Pinus edulis	*Pinus edulis*	Twoneedle piñon	Engelm.	Pinaceae	Tree
Pinus monophylla	*Pinus monophylla*	Singleleaf pinon	Torr. & Frem.	Pinaceae	Tree
Plantago ovata	*Plantago inularis*	Desert Indianwheat	Forsk.	Plantaginaceae	Forb
Plantago patagonica	*Plantago ignota*	Woolly plantain	Jacq.	Plantaginaceae	Forb
Plantago patagonica	*Plantago patagonica*	Woolly plantain	Jacq.	Plantaginaceae	Forb
Pleuraphis jamesii	*Hilaria jamesii*	James' galleta	Torr.	Poaceae	Grass
Pleuraphis jamesii	*Pleuraphis jamesii*	James' galleta	Torr.	Poaceae	Grass
Pleuraphis mutica	*Hilaria mutica*	Tobosagrass	Buckl.	Poaceae	Grass
Pleuraphis rigida	*Hilaria rigida*	Big galleta	Thurb.	Poaceae	Grass
Pluchea sericea	*Pluchea sericea*	Arrowweed	(Nutt.) Coville	Asteraceae	Shrub

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Poa fendleriana	*Poa fendleriana*	Muttongrass	(Steud.) Vasey	Poaceae	Grass
Poa reflexa	*Poa reflexa*	Nodding bluegrass	Vasey & Scribn. ex Vasey	Poaceae	Grass
Poa sp.	*Poa sp.*	Bleugrass	L.	Poaceae	Grass
Polygala obscura	*Polygala puberula*	Velvetseed milkwort	G. Bentham	Polygalaceae	Forb
Polygonum aviculare	*Polygonum ariculare*	Prostrate knotweed	L.	Polygonaceae	Forb
Polygonum convolvulus	*Polygonum convolvulus*	Black bindweed	L.	Polygonaceae	Forb
Polygonum sp.	*Polygonum sp.*	Knotweed	L.	Polygonaceae	Forb
Populus deltoides	*Populus deltoides*	Eastern cottonwood	Bartr. ex Marsh.	Salicaceae	Tree
Portulaca oleracea	*Portulaca oleracea*	Little hogweed	L.	Portulacaceae	Forb
Prosopis glandulosa	*Prosopis glandulosa*	Honey mesquite	Torr.	Fabaceae	Shrub
Prosopis glandulosa	*Prosopis juliflora*	Honey mesquite	Torr.	Fabaceae	Shrub
Prosopis pubescens	*Prosopis pubescens*	Screwbean mesquite	Benth.	Fabaceae	Shrub
Prosopis sp.	*Prosopis sp.*	Mesquite	L.	Fabaceae	Shrub
Prosopis velutina	*Prosopis velutina*	Velvet mesquite	Woot.	Fabaceae	Shrub
Pseudocymopterus montanus	*Pseudocymopterus montanus*	Alpine false springparsley	(Gray) Coult. & Rose	Apiaceae	Forb
Psoralidium sp.	*Psoralia sp.*	Scurfpea	P. Rydberg	Fabaceae	Forb
Psorothamnus scoparius	*Dalea scoparia*	Broom dalea	(Gray) Rydb.	Fabaceae	Shrub
Psorothamnus scoparius	*Psorothamnus scoparia*	Broom dalea	(Gray) Rydb.	Fabaceae	Shrub
Purshia sp.	*Purshia sp.*	Bitterbush	DC. ex Poir	Rosaceae	Shrub
Quercus agrifolia	*Quercus agrifolia*	California live oak	Nee	Fagaceae	Tree
Quercus gambelii	*Quercus gambelii*	Gambel oak	Nutt.	Fagaceae	Tree
Quercus havardii	*Quercus havardii*	Havard oak	Rydb.	Fagaceae	Tree
Quercus marilandica	*Quercus marilandica*	Blackjack oak	Muenchh.	Fagaceae	Tree
Quercus sp.	*Quercus sp.*	Oak	L.	Fagaceae	Tree
Quercus turbinella	*Quercus turbinella*	Sonoran scrub oak	Greene	Fagaceae	Tree
Ratibida sp.	*Ratibida sp.*	Prairie coneflower	Raf.	Asteraceae	Forb
Rhus aromatica	*Rhus aromatica*	Fragrant sumac	Ait.	Anacardiaceae	Shrub
Rhus integrifolia	*Rhus integrifolia*	Lemonade sumac	(Nutt.) Benth. & Hook. f. ex Brewer & S.	Anacardiaceae	Shrub
Rhus microphylla	*Rhus microphylla*	Littleleaf sumac	Engelm. ex Gray	Anacardiaceae	Shrub
Rhus sp.	*Rhus sp.*	Sumac	L.	Anacardiaceae	Shrub
Rhus trilobata	*Rhus trilobata*	Skunkbush sumac	Nutt.	Anacardiaceae	Shrub
Rumex sp.	*Rumex sp.*	Dock	L.	Polygonaceae	Forb
Salsola kali	*Salsola kali*	Russian thistle	L.	Chenopodiaceae	Forb
Salsola sp.	*Salsola sp.*	Russian thistle	L.	Chenopodiaceae	Forb
Salsola tragus	*Salsola pestifer*	Prickly Russian thistle	L.	Chenopodiaceae	Forb

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Salvia apiana	*Salvia apiana*	White sage	Jepson	Lamiaceae	S
Schismus barbatus	*Schismus barbatus*	Common Mediterranean grass	(Loefl. ex L.) Thellung	Poaceae	Grass
Sclerocactus papyracanthus	*Echinocactus papyracanthus*	Paperspine fishhook cactus	(Engelm.) N. P. Taylor	Cactaceae	Cactus
Sclerocactus whipplei	*Echinocereus whipplei*	Whipple's fishhook cactus	(Engelm. & Bigelow) Britt. & Rose	Cactaceae	Cactus
Selinocarpus sp.	*Selinocarpus sp.*	Moonpod	Gray	Nyctaginaceae	Forb
Senecio sp.	*Senecio sp.*	Ragwort	L.	Asteraceae	Forb
Senna armata	*Cassia armata*	Desertsenna	(S. Wats.) Irwin & Barneby	Fabaceae	Shrub
Senna bauhinioides	*Cassia bauhinioides*	Twinleaf senna	(Gray) Irwin & Barneby	Fabaceae	Shrub
Setaria leucopila	*Setaria leucopila*	Streambed bristlegrass	(Scribn. & Merr.) K. Schum.	Poaceae	Grass
Setaria sp.	*Setaria sp.*	Bristlegrass	Beauv.	Poaceae	Grass
Setaria viridis	*Setaria viridis*	Green bristlegrass	(L.) Beauv.	Poaceae	Grass
Sida abutifolia	*Sida diffusa*	Spreading fanpetals	P. Mill.	Malvaceae	Forb
Silene antirrhina	*Silene antirrhina*	Sleepy silene	L.	Caryophyllaceae	Forb
Solanum elaeagnifolium	*Solanum elaeagnifolium*	Silverleaf nightshade	Cav.	Solanaceae	Forb
Solanum rostratum	*Solanum rostratum*	Buffalobur nightshade	Dunal	Solanaceae	Forb
Solanum sp.	*Solanum sp.*	Nightshade	L.	Solanaceae	Forb
Solidago sp.	*Solidago sp.*	Goldenrod	L.	Asteraceae	Forb
Sorghum halepense	*Sorghum halepense*	Johnsongrass	(L.) Pers.	Poaceae	Grass
Sphaeralcea coccinea	*Sphaeralcea coccinea*	Scarlet globemallow	(Nutt.) Rydb.	Malvaceae	Forb
Sphaeralcea fendleri	*Sphaeralcea fendleri*	Fendler's globemallow	Gray	Malvaceae	Forb
Sphaeralcea sp.	*Sphaeralcea sp.*	Globemallow	St.-Hil.	Malvaceae	Forb
Sporobolus airoides	*Sporobolus airoides*	Alkali sacaton	(Torr.) Torr.	Poaceae	Grass
Sporobolus compositus	*Sporobolus asper*	Composite dropseed	(Poir.) Merr.	Poaceae	Grass
Sporobolus contractus	*Sporobolus contractus*	Spike dropseed	A.S. Hitchc.	Poaceae	Grass
Sporobolus cryptandrus	*Sporobolus cryptandrus*	Sand dropseed	(Torr.) Gray	Poaceae	Grass
Sporobolus flexuosus	*Sporobolus flexuosus*	Mesa dropseed	(Thurb. ex Vasey) Rydb.	Poaceae	Grass
Sporobolus spp.	*Sporobolus spp.*	Dropseed	R. Br.	Poaceae	Grass
Strophostyles helvola	*Strophostyles helvola*	Trailing fuzzybean	(L.) Ell.	Fabaceae	Forb
Stylocline sp.	*Stylocline sp.*	Nestclaw	Nutt.	Asteraceae	Forb
Tamarix ramosissima	*Tamarix ramosissima*	Saltcedar	Ledeb.	Tamaricaceae	Tree
Tetradymia spinosa	*Tetradymia spinosa*	Shortspine horsebrush	Hook. & Arn.	Asteraceae	Shrub
Thelesperma megapotamicum	*Thelesperma megapotamicum*	Hopi tea greenthread	(Spreng.) Kuntze	Asteraceae	Forb
Townsendia annua	*Townsendia annua*	Annual Townsend daisy	Beaman	Asteraceae	Forb
Townsendia sp.	*Townsendia sp.*	Townsend daisy	Hook.	Asteraceae	Forb
Tradescantia occidentalis	*Tradescantia occidentalis*	Prairie spiderwort	(Britt.) Smyth	Commelinaceae	Forb

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Tribulus terrestris	*Tribulus terrestris*	Puncturevine	L.	Zygophyllaceae	Forb
Tribulus terrestris	*Tribulus tribuloides*	Puncturevine	L.	Zygophyllaceae	Forb
Tridens sp.	*Tridens sp.*	Tridens	Roemer & J.A. Schultes	Poaceae	Grass
Trifolium sp.	*Trifolium sp.*	Clover	L.	Fabaceae	Forb
Triplasis purpurea	*Triplasis purpurea*	Purple sandgrass	(Walt.) Chapman	Poaceae	Grass
Urochloa arizonica	*Panicum arizonicum*	Arizona signalgrass	(Scribn. & Merr.) O. Morrone & F. Zuloag	Poaceae	Grass
Verbena bracteata	*Verbena bracteata*	Bigbract verbena	Lag. & Rodr.	Verbenaceae	Forb
Verbena wrightii	*Verbena wrightii*	Davis Mountain mock vervain	(Gray) Umber	Verbenaceae	Forb
Verbesina encelioides	*Verbesina encelioides*	Golden crownbeard	(Cav.) Benth. & Hook. f. ex Gray	Asteraceae	Forb
Verbesina encelioides	*Ximenesia exauriculata*	Golden crownbeard	(Cav.) Benth. & Hook. f. ex Gray	Asteraceae	Forb
Vicia sp.	*Vicia sp.*	Vetch	L.	Fabaceae	Forb
Vulpia octoflora	*Festuca octoflora*	Sixweeks fescue	(Walt.) Rydb.	Poaceae	Grass
Vulpia sp.	*Festuca sp.*	Fescue	K. C. Gmel.	Poaceae	Grass
Xanthium sp.	*Xanthium sp.*	Cocklebur	L.	Asteraceae	Forb
Xylorhiza tortifolia var. tortifolia	*Machaeranthera tortifolia*	Mojave woodyaster	(Torr. & Gray) Greene	Asteraceae	Shrub
Yucca angustissima	*Yucca angustissima*	Narrowleaf yucca	Endelm. ex Trel.	Agavaceae	Yucca
Yucca baccata	*Yucca baccata*	Banana yucca	Torr.	Agavaceae	Yucca
Yucca campestris	*Yucca campestris*	Plains yucca	McKelvey	Agavaceae	Yucca
Yucca elata	*Yucca elata*	Soaptree yucca	(Engelm.) Engelm.	Agavaceae	Yucca
Yucca glauca	*Yucca glauca*	Soapweed yucca	Nutt.	Agavaceae	Yucca
Yucca schidigera	*Yucca schidigera*	Mojave yucca	Roezl ex Ortgies	Agavaceae	Yucca
Yucca sp.	*Yucca sp.*	Yucca	L.	Agavaceae	Yucca
Yucca treculeana	*Yucca treculeana*	Don Quixote's lace	Carr.	Agavaceae	Yucca
Zea mays	*Zea mays*	Corn	L.	Poaceae	Grass
Zinnia acerosa	*Zinnia pumila*	Desert zinnia	(DC.) Gray	Asteraceae	Shrub
Ziziphus obtusifolia	*Condalia lycioides*	Lotebush	(Hook. ex Torr. & Gray) Gray	Rhamnaceae	Shrub