Western North American Naturalist 71(2), © 2011, pp. 151–157

A RECONNAISSANCE OF SMALL MAMMAL COMMUNITIES IN GARLAND AND GOVERNMENT PRAIRIES, ARIZONA

Joseph L. Ganey[1] and Carol L. Chambers[2]

ABSTRACT.—Small mammals play key ecological roles in grassland ecosystems, yet little is known regarding small mammal communities in large (>50 km^2), high-elevation prairies embedded in ponderosa pine (*Pinus ponderosa*) forests in north central Arizona. To provide information on community composition and habitat relationships, we live-trapped small mammals on 6 transects in 2 prairies in 2008. We captured 78 individuals in 5501 trap occasions. Capture rates were low and varied widely among transects. Community composition was simple, with only 3 species of small mammals captured. In order of relative abundance, these species were deer mouse (*Peromyscus maniculatus*, n = 44 individuals), Mogollon vole (*Microtus mogollonensis*, n = 22), and spotted ground squirrel (*Spermophilus spilosoma*, n = 12). Deer mice were captured on all transects and voles on all but one transect. In contrast, spotted ground squirrels were captured on only 2 transects and were relatively common on only one transect. There were no previous records of spotted ground squirrels in these prairies. Deer mice were positively associated with rock cover and vegetation height. Voles were positively associated with shrub cover and combined cover of live and dead vegetation and were negatively associated with bare ground. Spotted ground squirrels were positively associated with forb cover. This study provides baseline data on small mammal communities in these prairies and documents the presence of a previously unknown species. Further studies would be desirable to better understand spatial and temporal variation in these communities, habitat relationships, and effects of land-use practices on small mammals and their habitats.

RESUMEN.—Los mamíferos pequeños desempeñan papeles clave en los ecosistemas de pradera; sin embargo, se conoce poco con respecto a las comunidades de pequeños mamíferos en las grandes (>50 km^2) praderas altas, rodeadas por bosques de pino ponderosa (*Pinus ponderosa*) en la parte norte central de Arizona. Para proporcionar información sobre la composición de las comunidades y sus relaciones con el hábitat, colocamos trampas para pequeños mamíferos vivos en 2008 en 6 transectos en 2 praderas. Capturamos 78 individuos en 5501 ocasiones de trampeo. Las tasas de captura fueron generalmente bajas y variaron ampliamente entre transectos. La composición de las comunidades fue simple, con tan solo 3 especies de mamíferos pequeños capturados. Éstas fueron, en orden de abundancia relativa, el ratón ciervo (*Peromyscus maniculatus*, n = 44), el metorito Mogollon (*Microtus mogollonensis*, n = 22) y la ardilla moteada de tierra (*Spermophilus spilosoma*, n = 12). Los ratones ciervo fueron capturados en todos los transectos y los metoritos en todos, menos uno. En contraste, las ardillas moteadas de tierra fueron capturadas sólo en 2 transectos y fueron relativamente comunes en sólo uno. No había registros anteriores de ardillas moteadas de tierra en estas praderas. Los ratones ciervo estuvieron asociados positivamente con la rocosidad y la altura de vegetación. Los metoritos estuvieron asociados positivamente con la cobertura de arbustos y la cobertura combinada de vegetación viva y muerta, y asociados negativamente con el suelo desnudo. Las ardillas moteadas de tierra estuvieron asociadas positivamente con la cobertura de maleza. Este estudio proporciona datos de referencia sobre las comunidades de pequeños mamíferos en estas praderas, y documenta la presencia de una especie previamente desconocida. Sería conveniente llevar a cabo estudios adicionales para entender mejor la variación espacial y temporal en estas comunidades, sus relaciones con el hábitat y los efectos de prácticas del uso del suelo en equeños mamíferos y sus hábitats.

Knowledge of the structure and composition of wildlife communities provides an important basis for informed management decisions, yet data are sparse for many areas and vegetation types. For example, little is known about the structure and composition of the small mammal communities occupying large (>50 km^2), high-elevation prairies embedded within ponderosa pine (*Pinus ponderosa*) forests in northern Arizona. Small mammals may play key ecological roles in these prairies as herbivores (Weltzin et al. 1997), seed predators (Schnurr et al. 2004), and dispersers of seeds (Williams et al. 2008) and fungal spores (Orrock and Pagels 2002). In addition, their burrowing may affect water infiltration (Laundre 1993) and other soil properties (Reichman and Seabloom 2002), and they can serve as an important part of the prey base for both aerial predators (Salamolard et al. 2000) and terrestrial carnivores (Small et al. 1993). Small mammal communities may be affected by land-use practices such as grazing (Grant et al. 1982) or burning

[1]USDA Forest Service, Rocky Mountain Research Station, Flagstaff, AZ. E-mail: jganey@fs.fed.us
[2]School of Forestry, Northern Arizona University, Flagstaff, AZ.

TABLE 1. Mean percent ground cover (SE) on 6 transects sampled for small mammals in Garland and Government Prairies, northern Arizona. Shown are transect names, UTM coordinates (datum NAD 27 CONUS) for transect starting points, transect orientation, and dates sampled.

Transect name	UTM coordinates	Transect bearing	Dates sampled	N[a]	Bare ground	Litter	Rock
Garland-E	412056 E, 3897695 N	307°	25–29 Aug 2008	30	33.1 (2.2)	61.5 (2.6)	6.1 (1.5)
Garland-F	412015 E, 3897268 N	140°	25–29 Aug 2008	30	32.4 (2.3)	48.7 (2.5)	23.3 (2.8)
Garland-G	411372 E, 3893827 N	150°	11–15 Aug 2008	62	31.6 (2.1)	65.8 (2.1)	1.5 (0.6)
Garland-RNA	412977 E, 3899719 N	30°	22–26 Sep 2008	55	6.0 (1.2)	77.3 (1.7)	12.8 (1.4)
Government-E	417307 E, 3907840 N	110°	18–22 Aug 2008	51	28.5 (2.0)	65.8 (1.6)	6.2 (1.3)
Government-G	418561 E, 3909774 N	152°	15–19 Sep 2008	52	28.4 (1.6)	63.2 (1.3)	5.6 (1.3)

[a]Number of trap stations included in estimate

(Kilgore et al. 2009). Consequently, land managers need information on the composition and structure of small mammal communities in these prairies to inform planning and conservation efforts.

To provide information on small mammal communities, we live-trapped small mammals on 2 northern Arizona prairies in 2008. Our primary objectives were to determine which species of small mammals were present within these prairies and to gather preliminary information on relative abundance, distribution, and habitat associations of these species.

METHODS

Study Areas

All study areas were located within Garland and Government prairies, south and northeast, respectively, of Parks in north central Arizona. These prairies are large grasslands embedded in a matrix of ponderosa pine forest. Terrain within the prairies is flat to gently rolling, and the prairies are surrounded by volcanic mountains and ridges. Soils were either typic argiborolls or lithic argiborolls, both formed in residuum from basaltic parent materials (USDA Forest Service 1991). Both prairies were dominated by graminoids. Common species included blue grama (*Bouteloua gracilis*), Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), squirreltail (*Elymus elymoides*), and muttongrass (*Poa fendleriana*). Less common grass species included pine dropseed (*Blepharoneuron tricholepis*), smooth brome (*Bromus inermis*), Junegrass (*Koeleria macrantha*), spike muhly (*Muhlenbergia wrightii*), and *Sporobolus* species. We observed a variety of forbs, especially at Government Prairie. Shrubs were present but uncommon, and shrub communities were dominated by rabbitbrush (*Chrysothamnus nauseosus*).

Field Sampling

We sampled small mammals and associated vegetation on 27 trapping grids, each grid containing 30 trap stations, located along 6 transects in 2 prairies. Because our objective was to sample small mammals in the interior of these prairies, we selected locations that allowed for placement of 1-km transects in areas of prairie interior. Therefore, all transects started at least 300 m from forest edges and extended from that point into the prairie interior.

We sampled 2 transects in Government Pairie and 4 transects in Garland Prairie (see Table 1). Both transects in Government Prairie contained 5 trapping grids each, whereas one Garland Prairie transect had 6 grids, one had 5 grids, and 2 had 3 grids. Thus, we sampled 10 grids in Government Prairie (n = 300 trap stations) and 17 grids in Garland Prairie (n = 510 trap stations). We sampled transects from each prairie in alternate weeks to minimize potential differences between prairies due to phenology.

Placement of trapping grids varied among transects. The first 2 transects sampled (Garland–G and Government–E; Table 1) were 1 km long with 5 trap grids per transect at distances of 75, 250, 500, 750, and 1000 m from the starting point. Because we caught only 2 animals on one transect (Garland–G) in the first few days of trapping, we added a supplemental grid to that transect for the final 2 days of the trap session. This supplemental grid sampled an area with several visible burrows that appeared to be in active use by small mammals.

We shortened transects in the next Garland Prairie trapping session to allow sampling of 2 transects simultaneously. This allowed us to broaden spatial replication by trapping geographically discrete areas. The shorter transects were 500 m long, with grids located at 100, 250, and 500 m from the transect starting point.

During the second trapping session, the presence of large numbers of domestic cattle (*Bos taurus*) at one of our proposed Government Prairie transects precluded trapping there due to concerns about trampling of traps. Consequently, we eliminated that transect and placed a single 1-km-long transect containing 5 grids at the other transect location.

The final transect that we trapped (1 km long, 5 grids) was in a 134-ha area nominated and managed as a Research Natural Area (RNA) at the northern end of Garland Prairie. This area was added to sample an area not grazed by domestic livestock. It was fenced in 1988 to exclude domestic livestock while allowing access by elk (*Cervus elaphus*) and pronghorn (*Antilocapra americana*). Unpublished documents (on file at Kaibab National Forest, Williams, Arizona) describe the area as "a prime example of Arizona fescue grassland in good range condition."

All trapping grids consisted of 2 parallel lines of 15 traps each, with 10-m spacing between traplines and 5-m spacing between traps along lines. Grids were placed perpendicular to transect direction, with alternate grids on opposite sides of the transect (i.e., if the first grid was located to the left of the transect, the second grid was located to the right of the transect).

We used large (8 × 9 × 23-cm) Sherman live traps baited with a mixture of rolled oats and chicken scratch. We placed polyester batting in each trap to provide insulation, and all traps were covered with a wooden shingle to provide cover from rain and solar insolation. We set traps in the evening of day 1, checked them early in the morning and in the evening of days 2–4, and checked and collected them the morning of day 5. All captured animals were identified to species. We marked newly captured individuals by trimming a small patch of hair in the center of the crown with scissors. This temporary mark persisted during the short trapping session, allowing us to distinguish new individuals from recaptures.

Using 20 × 50-cm Daubenmire quadrats (Daubenmire 1959), we sampled vegetation cover and composition at every third trap station along each grid, as well as at most trap stations where animals were captured. Although this method is based on subjective visual estimates, it is relatively efficient, precise, and repeatable in prairie and grassland vegetation (Symstad et al. 2008).

We sampled 4 quadrats at each station sampled, with quadrats located 2 m from the marked station and offset 45° from the grid axis to reduce the potential effects of trampling caused by travel along the trap line. We sampled 2 strata within each quadrat, one representing ground surface cover and one representing aboveground vegetative canopy cover. For each stratum, we visually estimated percent coverage by category, and recorded one of 7 cover classes for each category (0, trace–5%, 6%–25%, 26%–50%, 51%–75%, 76%–95%, and 96%–100% cover). Categories recognized for ground cover included bare ground, litter, and rock. Litter included both live and dead vegetation at ground level. For aboveground vegetation canopy cover, we recognized the categories of graminoids (all grasses), shrubs (woody plants), forbs (all other plants), and total vegetation (previous 3 categories combined). Because estimates were based on canopy cover (see Daubenmire 1959), and because canopies could overlap among categories, total vegetation was estimated visually, not by summing the other categories. We also estimated modal vegetation height (nearest 5 mm) within each quadrat using a meter stick. This was defined as the estimated height of overall, rather than tallest, vegetation and did not include inflorescences for graminoids. We did not quantify species composition of vegetation due to time constraints.

Data Analysis

We summarized trap occasions for each transect as [number of traps × times checked] – number of traps shut but empty or otherwise unavailable. For each transect, we summarized trapping results in terms of capture rates (standardized as captures of unique individuals/1000 trap occasions), both overall and by individual species.

We summarized vegetation and ground cover for each trapping grid by averaging quadrats within trapping stations, then we summarized cover for grids and transects by averaging across the sample of trap stations included. We used category midpoints (0%, 2.5%, 15.5%, 38.0%, 63.0%, 85.5%, and 98.0% cover) in averaging cover across quadrats (Daubenmire 1959). We compared vegetation and ground cover among transects using Kruskall–Wallis tests (Conover 1980).

We compared vegetation cover and composition between grids where particular species were and were not captured. Because capture data

TABLE 2. Vegetation height and canopy cover on 6 transects sampled for small mammals in Garland and Government Prairies, Arizona, 2008. Shown are means and standard errors (in parentheses). Sample sizes are shown in Table 1.

Transect	Vegetation height (mm)	% Grass cover	% Forb cover	% Shrub cover	All vegetation (%)
Garland-E	77.0 (8.6)	58.8 (2.9)	2.9 (0.7)	1.4 (0.9)	62.1 (2.6)
Garland-F	114.2 (6.3)	49.7 (2.2)	5.4 (1.2)	1.7 (1.0)	56.5 (2.5)
Garland-G	39.5 (1.6)	57.8 (2.3)	4.3 (0.7)	0.2 (0.2)	63.0 (2.0)
Garland-RNA	128.7 (6.9)	60.0 (2.7)	8.9 (1.4)	1.3 (0.6)	70.6 (2.3)
Government-E	157.3 (6.4)	56.2 (2.3)	26.4 (2.4)	0.7 (0.4)	74.8 (1.4)
Government-G	188.7 (4.4)	54.0 (1.4)	20.7 (1.4)	0.2 (0.2)	65.1 (1.3)

TABLE 3. Capture rates for small mammals trapped on 6 transects in Garland and Government Prairies, Arizona, 2008.

		Capture rate[a]		
Transect	Trap occasions[b]	Deer mouse	Mogollon vole	Spotted ground squirrel
Garland-E	624	6.4	8.0	1.6
Garland-F	621	8.1	0.0	0.0
Garland-G	1158	1.7	1.7	0.0
Garland-RNA	1026	15.6	9.8	0.0
Government-E	1028	7.8	1.0	10.7
Government-G	1044	7.7	3.8	0.0

[a]Number of unique individuals captured per 1000 trap nights
[b]Number of traps × number of times checked (morning and evening each day) – number of sprung or otherwise unavailable traps

were sparse, we were not able to model trap results as a function of multivariate vegetation characteristics. Instead, we conducted univariate comparisons between grids using Mann–Whitney tests (Conover 1980). Therefore, we consider this an exploratory analysis aimed at suggesting potential relationships that warrant further study.

RESULTS

We sampled vegetation at 280 of the 810 trap stations. Ground cover varied significantly among transects (all P values <0.001), but most transects were dominated by bare ground and litter with lesser amounts of rock cover (Table 1). The conspicuous exception was the Garland Prairie RNA, which was not grazed by domestic livestock. Here, mean bare ground was lower and mean litter cover was greater than on all other transects.

All variables relating to vegetation canopy cover differed (all P values <0.023) among transects, except shrub cover ($P = 0.077$). Percent shrub cover was low on all transects, and percent grass cover was relatively high on all transects (Table 2). Mean forb cover was considerably greater on the Government Prairie transects than on all Garland Prairie transects. Considering all vegetation combined, mean cover ranged from approximately 56% to 75% across transects (Table 2). Mean vegetation height ranged from approximately 40 to almost 190 mm across transects, and tended to be greater for transects at Government Prairie than for transects at Garland Prairie (Table 2).

We trapped small mammals between 11 August and 26 September 2008 (Table 1), obtaining 138 total captures representing 78 individual animals in 5501 trap occasions (Table 3). Capture rates were low and variable among transects. Species composition of small mammal communities was simple, with only 2–3 species represented on individual transects. Deer mice (*Peromyscus maniculatus*, $n = 44$ individuals) were captured on 21 grids (77.7% of grids) representing all 6 transects. Mogollon voles (*Microtus mogollonensis*, $n = 22$ individuals) were captured on 9 grids (33.3%) representing 5 transects (83.3%). Spotted ground squirrels (*Spermophilus spilosoma*, $n = 12$) were captured on 7 grids (25.9%) representing 2 transects (33.3%), including one transect from each prairie. Only a single squirrel was captured in Garland Prairie; thus, this species was restricted largely to one transect in Government Prairie.

Grids where deer mice were captured had greater rock cover and taller vegetation than grids where deer mice were not captured. Grids where voles were captured had greater shrub and litter cover and less bare ground than grids where voles were not captured. Grids where spotted ground squirrels were captured had greater forb cover than grids without captures (Table 4).

DISCUSSION

Small mammal communities appeared to be simple in these prairies, at least during the short period in which we trapped. This is consistent

TABLE 4. Selected habitat characteristics at trapping grids in Garland and Government Prairies, north central Arizona, 2008. Shown are means and standard errors (SE) for parameters that differed significantly with capture status for 3 species of small mammals.

			Capture		No capture		
Species	*N*[a]	Parameter	Mean	SE	Mean	SE	*P*[b]
Deer mouse	21, 6	% rock	10.1	1.9	2.9	1.6	0.013
		Veg. height (mm)	133.9	11.5	71.0	19.7	0.019
Mogollon vole	9, 18	% shrubs	1.5	0.4	0.4	0.2	0.017
		% litter	71.4	2.8	61.7	2.1	0.023
		% bare ground	18.5	2.8	29.8	2.3	0.031
Spotted ground squirrel	2, 25	% forbs	22.7	6.1	9.3	1.7	0.036

[a]Number of grids with and without captures, respectively
[b]*P* values from Mann–Whitney test comparing parameter between grids with and without captures of a particular species

with general knowledge of small mammal communities in structurally simple ecosystems, such as grasslands, that contain voles (Rose and Birney 1985). Our capture rates also were similar to capture rates in other studies of grasslands in this area (Yarborough and Chambers 2007).

We observed heterogeneity in vegetation and small mammals both within and between prairies, but we are uncertain what caused that heterogeneity. Both prairies occurred in similar soil types, but land-use histories differed both within and between prairies. For example, Government Prairie has undergone several prescribed burnings under direction of Kaibab National Forest managers, whereas Garland Prairie has no recent fire history (W. Noble and K. Menasco, Kaibab National Forest, personal communication). Similarly, grazing histories may differ between these prairies, in terms of both intensity and species involved (e.g., domestic cattle vs. domestic sheep [*Ovis aries*]). Evaluating grazing history and its potential effects was beyond the scope of this study, but differences in land-use history may at least partially explain the greater forb cover observed at Government Prairie.

With respect to habitat, our results support existing information. For example, deer mice were captured on most grids and all transects, consistent with the generalist nature of this species (Hoffmeister 1986). However, deer mice may seek the additional structure provided by rocks and tall vegetation in these structurally simple grasslands (Table 4).

Mogollon voles also were widely distributed within these prairies, but they were captured in smaller numbers at fewer grids than deer mice. Voles were positively associated with shrub and litter cover and negatively associated with bare ground (Table 4), consistent with previous studies relating abundance and distribution of Mogollon voles (and/or Mexican voles [*Microtus mexicanus*]) to vegetation cover (Ward 2001, Yarborough and Chambers 2007). Litter cover as defined here referred to a combination of live and dead vegetation which formed dense mats that provide potential hiding cover for voles (as did shrubs).

In contrast to the species discussed so far, spotted ground squirrels were captured on only 2 transects. They were relatively common on one of these (Government Prairie), but were not captured at a second transect in that prairie. Only one individual was captured at Garland Prairie. Thus, this species appeared to be far more restricted in distribution than deer mice or Mogollon voles. There were no known records of spotted ground squirrels in these prairies prior to this study (W. Noble, Kaibab National Forest, personal communication). These prairies are within the geographic range for this species (Hoffmeister 1986), however, and a specimen exists from Hart Prairie approximately 12 km east of Government Prairie (Vertebrate Collections, Colorado Plateau Biodiversity Center, Department of Biological Sciences, Northern Arizona University). Consequently, we suspect that spotted ground squirrels historically inhabited these prairies, and that our results do not represent a range expansion by this species.

Spotted ground squirrels reportedly prefer sandy soils and sparse vegetation (Streubel and Fitzgerald 1978). The soils in these prairies were not sandy, and estimated vegetation cover was relatively high even though there was considerable bare ground (Table 1). Spotted ground squirrels were positively associated with forb cover (Table 4), which was relatively high at Government Prairie (Table 2). Many of these forbs were relatively tall and had spreading aboveground cover that provided canopy cover over bare ground. This forb characteristic resulted in considerable open space under the vegetative canopy, and this open space may have facilitated movement by ground squirrels, while tall forbs provided hiding cover. Despite capturing 11 ground squirrels on one Government Prairie transect, we never observed a free-ranging squirrel there in more than a week of sampling, suggesting that available hiding cover was effective. Spotted ground squirrels are active during daylight (Streubel and Fitzgerald 1978), and thus were available for observation during the day (they were also captured during daylight hours).

This study provides a preliminary reconnaissance of small mammal communities in Government and Garland prairies, and documents the presence of a species previously unknown in the area; however, further work will be required to better understand these communities and the factors influencing small mammal abundance and distribution. Such work logically should include both intensive and extensive trapping. Intensive trapping on larger grids, for example, could allow estimation of capture probabilities and small mammal density for particular areas, while extensive trapping could provide better information on small mammal abundance and distribution in relation to topographic, edaphic, and vegetative heterogeneity within these prairies. It also would be desirable to include multiple seasons and years of trapping to provide a better understanding of temporal variability in small mammal abundance. Information on vegetative species composition as well as cover also might prove helpful in understanding small mammal distribution and abundance. Finally, managers clearly would benefit from experiments assessing the result of factors such as grazing and prescribed fire on cover and composition of vegetation and small mammal abundance.

ACKNOWLEDGMENTS

Funding for this study was provided by the Kaibab National Forest. Thanks to W.O. Noble, B. Higgins, and S. Lovejoy for obtaining funding and providing logistical support; S.C. Vojta, L.F. Doll, and R. Joos for assistance with small mammal trapping and vegetation sampling; and R. Richardson for providing information about the Garland Prairie Research Natural Area. C.H. Sieg and J.F. Fowler provided advice on sampling prairie vegetation and loaned us sampling equipment. T.W. Theimer provided information on spotted ground squirrel specimens in the Vertebrate Collections at Northern Arizona University. D. Turner provided advice on statistical methods, and comments from 2 anonymous reviewers greatly improved this paper.

LITERATURE CITED

CONOVER, W.J. 1980. Practical nonparametric statistics. 2nd edition. John Wiley & Sons. New York, NY.

DAUBENMIRE, R.F. 1959. A canopy coverage method of vegetation analysis. Northwest Science 33:43–64.

GRANT, W.E., E.C. BIRNEY, N.R. FRENCH, AND D.M. SWIFT. 1982. Structure and productivity of grassland small mammal communities relating to grazing-induced changes in vegetative cover. Journal of Mammalogy 63: 248–260.

HOFFMEISTER, D.F. 1986. Mammals of Arizona. University of Arizona Press, Tucson, AZ. 602 pp.

KILGORE, A., E. JACKSON, AND W.G. WHITFORD. 2009. Fire in Chihuahuan desert grassland: short-term effects on vegetation, small mammal populations, and faunal pedoturbation. Journal of Arid Environments 73:1029–1034.

LAUNDRE, J.W. 1993. Effects of small mammal burrows on water infiltration in a cool desert environment. Oecologia 94:43–48.

ORROCK, J.L., AND J.F. PAGELS. 2002. Fungus consumption by the southern red-backed vole (*Clethrionomys gapperi*) in the southern Appalachians. American Midland Naturalist 147:413–418.

REICHMANN, O.J., AND E.W. SEABLOOM. 2002. The role of pocket gophers as subterranean ecosystem engineers. Trends in Ecology and Evolution 17:44–49.

ROSE, R.K., AND E.C. BIRNEY. 1985. Community ecology. Pages 310–339 *in* R.H. Tamarin, editor, Biology of the new world *Microtus.* Special Publication 8, American Society of Mammalogists, Boston, MA.

SALAMOLARD, M., A. BUTET, A. LEROUX, AND V. BRETAGNOLLE. 2000. Responses of an avian predator to variations in prey density at a temperate latitude. Ecology 81:2428–2441.

SCHNURR, J.L., C.D. CANHAM, R.S. OSTFELD, AND R.S. INOUYE. 2004. Neighborhood analyses of small-mammal dynamics: impacts on seed predation and seedling establishment. Ecology 85:741–755.

SMALL, R.J., V. MARCSTRÖM, AND T. WILLEBRAND. 1993. Synchronous and nonsychronous population fluctuations of some predators and their prey in central Sweden. Ecography 16:360–364.

STREUBEL, D.P., AND J.P. FITZGERALD. 1978. *Spermophilus spilosoma.* Mammalian Species 101:1–4.

SYMSTAD, A.J., C.L. WIENK, AND A.D. THORSTENSON. 2008. Precision, repeatability, and efficiency of two canopy-cover estimate methods in northern Great Plains vegetation. Rangeland Ecology and Management 61: 419–429.

USDA FOREST SERVICE. 1991. Terrestrial ecosystem survey of the Kaibab National Forest. USDA Forest Service, Southwestern Region, Albuquerque, NM.

WARD, J.P., JR. 2001. Ecological responses by Mexican Spotted Owls to environmental variation in the Sacramento Mountains, New Mexico. Doctoral dissertation, Colorado State University, Fort Collins, CO.

WELTZIN, J.F., S. ARCHER, AND R.K. HEITSCHMIDT. 1997. Small-mammal regulation of vegetation structure in a temperate savanna. Ecology 78:751–763.

WILLIAMS, P.A., B.J. KARL, P. BANNISTER, AND W.G. LEE. 2008. Small mammals as potential seed dispersers in New Zealand. Austral Ecology 25:523–532.

YARBOROUGH, R.F., AND C.L. CHAMBERS. 2007. Using visual evidence of Mogollon voles (*Microtus mogollonensis*) to predict their presence in northern Arizona. Southwestern Naturalist 52:511–519.

Received 2 February 2010
Accepted 11 February 2011