Small Mammal Community in a Juniper-woodland Sagebrush-grassland Mosaic in Southwestern Wyoming

Kevin M. Rompola, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY 82071-3166
Stanley H. Anderson, U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY 82071-3166

Abstract

We sampled small mammal specie in four distinct habitat types in a pinyon-juniper woodland and sagebrush-grassland mosaic in southwestern Wyoming. The sagebrush-grassland, pinyon-juniper woodland, pinyon-juniper rocky slope, and pinyon-juniper cliff habitats were identified as common components of the landscape. We used sherman live-traps to capture small mammals in the sagebrush-grasslands (n = 10 sites), pinyon-juniper woodlands (n = 10 sites), pinyon-juniper rocky slopes (n = 7 sites), pinyon-juniper cliffs (n = 7 sites) habitat types to identify the small mammal community and determine macrohabitat associations of the more abundant species. We measured six habitat variables at random points throughout each site to determine a habitat complexity index (HCI) for each habitat type based on structural diversity. The small mammal community of the combined four habitats was composed of 11 species with deer mice (*Peromyscus maniculatus*) being the most abundant species in all four habitats. Next to deer mice, the least chipmunk (*Tamias minimus*) was the most abundant species in three of four habitat types. The least chipmunk and cliff chipmunk (*T. dorsalis*) exhibited similar abundances in the cliff habitat type. The pinyon-juniper woodland, the most complex habitat (HCI = 1.74), had the second lowest small mammal diversity (0.583); only sagebrush had lower diversity. The cliff habitat type had the highest species richness (S = 8), highest diversity (H' = 1.011) and evenness (J' = 0.49). We did not find a correlation between habitat complexity and small mammal diversity although we did find a significant relationship ($P \leq 0.01$) between small mammal diversity and the percentage of ground covered by rock. Our findings suggest the importance of cliff habitat in maintaining small mammal diversity in the pinyon-juniper and sagebrush-grassland mosaic in southwestern Wyoming.

Key Words: community structure, diversity, habitat complexity, juniper woodland, rock cover, sagebrush-grassland, small mammals

Introduction

Small mammals are important components of ecosystems, and as such they must be considered in land management decisions. However, little is known about small mammal communities in most habitats, which may hamper effective decision-making. Small mammals serve as prey items for many avian and terrestrial predators and also are important seed dispersal agents. Gibson (1988) offers several reasons for giving small mammals special consideration with regard to management decisions of which one in particular includes a lack of basic ecological and life history information for many species.

Small mammal communities have been studied in a wide range of habitats all over the world. Much research has focused on the influence of interspecific competition and habitat structure on species diversity and community composition. The role of competition in structuring small mammal communities is not clear (compare Whitaker 1966 and Grant et al. 1985). However, there is evidence that small mammal species diversity is correlated with vegetation diversity and habitat structure (Rosenzweig and Winakur 1969, Germano and Lawhead 1986, O'Farrell and Clark 1986). By surveying four unique habitats we identified the small mammal community in a pinyon-juniper and sagebrush-grassland in southwestern Wyoming and compared their diversity with plant community diversity and structure.

The pinyon-juniper (*Pinus* spp. *Juniperus* spp.) habitat type is one of the most extensive plant communities in the United States (Sedgwick 1987). Estimates indicate that these pigmy woodlands, as they are called because of the small size of the trees (Clary et al. 1974), occupy up to 60 million ha in the southwest and Great Basin (Hurst 1977, West 1984, Evans 1988, Skousen et al. 1989). Clendenen (1977) estimated that these woodlands comprise approximately 32 percent of the forested land in the Rocky Mountains.

The states with the most extensive cover of pinyon-juniper woodlands include New Mexico, Utah, Arizona, Colorado, and Nevada. In these states the woodlands are an important multiple-use resource. Approximately 80 percent of the land area occupied by pinyon-juniper woodlands is used for livestock grazing (Evans 1988). Pinyon-juniper woodlands also are very important habitat for a variety of wildlife species. Although a few pinyon-juniper woodland obligate species exist, many species use them seasonally (Swenson 1977). Not only do they provide important winter habitat for mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) (Evans 1988, Gottffried and Severson 1994, Skousen et al. 1989, Swenson 1977), at least 75 bird species are associated with pinyon-juniper woodlands at various times throughout the year (Swenson 1977; Sedgwick 1987). In addition, pinyon-juniper woodlands also provide firewood, posts, Christmas trees, and pinyon nuts (Hurst 1977).

A significant increase in tree density and distribution of the pinyon-juniper habitat type throughout the western United States over the last 100-150 years has been well developed (Austin 1987). A common belief is that historical uses of this system, including overgrazing by livestock and fire suppression, have led to these changes. Overall, encroachment of pinyon-juniper woodlands on adjacent grasslands and shrublands leads to reduced production of understory vegetation. Since the 1970s encroachment and loss of understory has led to an ongoing debate over whether these woodlands should be managed for livestock forage production through overstory removal, or managed for production of multiple resource products (Gottfried and Severson 1994). Wyoming represents the northeastern extent of the pinyon-juniper woodland's distribution as the only true pinyon-juniper woodlands occur in the southwestern portion of the state near the Utah border (Knight 1994). Our objectives are to determine the composition of small mammals in this woodland. Understanding the small mammal component of the system can lead to a better understanding of the ecology of the pinyon pine community and therefore provide a better basis for management decisions.

Study Area

We live-trapped small mammals throughout a 1300-km^2 area around Flaming Gorge Reservoir south of Rock Springs, Wyoming, in south-central Sweetwater County. Study area boundaries included Interstate 80 on the north and the Utah state line to the south. In addition to Flaming Gorge Reservoir, Little Mountain, Pine Mountain, and The Glades were dominant geographical features of the area.

A "naturally patchy" pinyon-juniper and sagebrush-grassland mosaic characterized the study area. The woodlands were dominated by Utah juniper (*Juniperus osteosperma*) and Rocky Mountain juniper (*J. scopulorum*) with pinyon pine (*Pinus edulis*) occurring at very low densities in the extreme southern portion of the study area. Big sagebrush (*Artemisia tridentata*) dominated the lower elevations (<1860 m near Flaming Gorge Reservoir) with juniper woodlands occupying the ridges and slopes. At the highest elevations of Little Mountain and Pine Mountain (~ 2745 m), quaking aspen (*Populus tremuloides*) and Douglas-fir (*Psuedotsuga menziessi*) were the dominant cover types. True mountain mahogany (*Cercocarpus montanus*) was another common shrub species.

We identified four distinct habitat types that occurred throughout the pinyon-juniper woodland and sagebrush-grassland mosaic: sagebrush-grassland, pinyon-juniper woodlands, pinyon-juniper rock-slopes, and pinyon-juniper cliffs. The sagebrush-grassland habitat type was most common in areas in which the pinyon-juniper woodlands did not occur. Big sagebrush and various cool season and warm season grasses and forbes dominated this habitat type. The pinyon-juniper woodland habitat occurred on very low-gradient slopes with a moderate-to-high juniper canopy cover and variable amounts of understory vegetation. The pinyon-juniper rocky slopes occurred on moderate-gradient slopes with moderate-to-high juniper tree canopy cover and generally low understory cover. The rocky slope habitat type contained interspersed rock outcrops that potentially provide important structural diversity for small mammals. The cliff habitat type was characterized by high-gradient slopes and low juniper canopy cover. Shrubs, grasses, and forbs were common in the understory but occurred at very low densities.

METHODS

Small Mammal Trapping

We conducted small mammal surveys from mid-May through mid-August in 1998 and 1999. We sampled the sagebrush-grassland and juniper woodland habitat types in 1998 and the rocky slopes and cliffs in 1999.

In 1998 and 1999 the field season was divided into two trapping periods: the early period from 16 May in 1998 and 18 May in 1999 through 30 June during both years; the late period from 7 July through 12 August in both years. Ten sagebrush-grassland and 10 juniper woodland sites were sampled in 1998, and seven rocky slope and seven cliff sites were each sampled in 1999. We surveyed all sites once during the early trapping period and a second time in the late trapping period to compare relative abundance of each mammal species between early and late summer.

Small mammals were captured using 7-cm x 9-cm x 23-cm Sherman live traps. Traps were arranged in variable shaped grids of 50 traps in the sagebrush-grassland and pinyon-juniper woodlands, and 49 traps in the rocky slope and cliff habitat types, with 15-m spacing between traps. The exact configuration of the trapping grid depended on the shape of the habitat patch being sampled. For instance, cliff sites were often long and narrow requiring a rectangular grid. The area encompassed by each ranged from 0.74 to 0.81 ha.

Traps were baited with a combination of rolled oats and peanut butter and polyester bedding was added to each trap. Each trapping session consisted of four consecutive nights; traps were set in the evening at about 1900 hrs and checked and closed at about 0800 hrs. Traps remained closed during the day to eliminate small mammal mortality as a result of being captured during periods of extreme temperatures despite the fact that this could limit the capture of chipmunks and ground squirrels. Individuals were identified to species, sexed, and weighed.

Habitat Sampling

The habitat sampling procedure was similar to that used by Dueser and Shugart (1978). We measured 6 habitat variables at

21 randomly located, 0.02-ha circular sampling plots within each trapping grid to quantitatively compare the horizontal habitat complexity index (HCI) of each habitat type. The index was a measure of the horizontal diversity in each habitat, expressed by the equation:

$$HCI = - \Sigma p_i (l_n p_i)$$

where p_i represents the portion of the total ground cover of element i. Habitats that are dominated by a couple of elements are much less complex than those characterized by several elements.

We used criteria described by Dueser and Shugart (1978) to select the habitat variables that were measured. Each variable had to: 1) provide a measure of the structure of the environment that was either known or reasonably suspected to influence distribution and local abundance of small mammals; 2) be quickly and precisely measurable with nondestructive sampling procedures; 3) have small intra-seasonal variation relative to inter-seasonal variation; and 4) describe the environment in the immediate vicinity. Variables that we measured included tree canopy cover, shrub density, and percent cover of grass, forbs, shrubs, litter, bareground, and rock. Tree canopy cover was included because juniper overstory influences the understory and associated ground cover (Skousen et al. 1989, Vaitkus 1991). The variables selected occurred in 3 strata: overstory, understory, and ground level.

Data Analysis

We estimated relative abundance of each species by calculating the number captured/100 trap nights and used one-way ANOVA to determine differences in species abundance between years. Because trapping techniques in 1999 differed from those used in 199 , data were analyzed separately for ach year. Two-way ANOVA was used to compare the abundance of each species within each habitat type between the first and second trapping periods. Small mammal data from both trapping periods were combined for each habitat. We used correlation analysis to determine relationships between habitat complexity (HCI) and species richness (S), diversity (H'), and evenness (J') (Peet 1974). Correlation analysis was also used to examine relationships between each habitat component used to calculate the HCI and S, H', and J. Statistical significance was inferred at $P < 0.05$ for all tests.

Results

Small Mammal Trapping

Eleven small mammal species were captured (Table 1) in 1998 and 1999. Including recaptures, we obtained 3593 captures of these species over 13,295 trap nights for an overall trap success of 27 captures/100 trap nights. We obtained 1467 and 2126 total captures in 1998 and 1999, respectively. The deer mouse (*Peromyscus maniculatus*) was the species captured most often, accounting for 78 percent of the total captures. The least chipmunk (*Tamias minimus*) and the cliff chipmunk (*T. dorsalis*) were the species captured the next most frequently, but accounted for 16 percent of the total combined captures.

A higher capture rate in 1999 might have indicated that small mammals were more abundant in rocky slopes and cliffs than the sagebrush-grasslands and juniper-woodlands sampled in 1998. Because we did not trap all four types during the same year, we were unable to determine if the higher capture rate was due to habitat effect. Therefore, statistical comparisons were only made between habitats sampled the same year and not between habitat types sampled in different years.

To understand a change in seasonal abundance, we used ANOVA to compare captures/100 trap nights of each species between trapping periods during early and late summer for each habitat type. In the sagebrush-grassland type, the mean relative abundance of deer mice increased from 10/100 trap nights to 23/100 trap nights ($n = 20$, $F = 29.58$, $P < 0.05$); mean abundance of least chipmunks increased from 0.5 to

Table 1. Total number of small mammal captures , species richness (S), diversity (H'), and evenness (J') in each of four habitat types sampled in 1998 and 1999 in southwestern Wyoming.

	Habitat Type			
Species	Sagebrush-Grassland 1998	Juniper Woodland 1998	Juniper Rocky Slope 1999	Juniper Cliff 1999
Deer mouse (*Peromyscus maniculatus*)	643	614	851	755
Least chipmunk (*Tamias minimus*)	65	93	108	107
Cliff chipmunk (*Tamias dorsalis*)	0	23	68	114
Pinon mouse (*Peromyscus truei*	0	0	31	13
Canyon mouse (*Peromyscus crinitus*)*	0	0		18
Great-Basing pocket mouse (*Perognathus parvus*)	0	0	5	22
Golden-mantled ground squirrel (*Citellus lateralis*)	0	0	9	7
Bushytail woodrat (*Neotoma cinerea*)*	0	0		6
Sagebrush vole (*Lagurus curtatus*)*	15		0	0
Longtail vole (*Microutus longicaudus*)	12	0	0	0
Northern pocket gopher (*Thomomys talpoides*)*	0		0	0
Total captures	735	732	1074	1052
Species richness (S)	4	3	6	8
Species diversity (H')	0.48	0.53	0.76	1.01
Evenness (J')	0.34	0.48	0.42	0.49

* indicates species was captured <5 times in at least one habitat type and was not included as a component of the small mammal community in that type. S, H, and J reflect these exclusions.

3.0/100 trap nights ($n = 20$, F = 6.23, $P < 0.05$). In the juniper woodland habitat type, deer mouse abundance increased from 10 to 22 captures/100 trap nights ($n = 20$, F = 15.18, $P < 0.05$). We did not find any significant differences in relative abundance between trapping periods for any species in the rocky slope or cliff habitats that we sampled during 1999.

While most species increased from early to late summer, only increases among deer mice and least chipmunks were significant (Table 2). The longtail vole (*Microtus longicaudis*)was the only species to exhibit a decrease in relative abundance from early to late summer. We would expect abundance of small mammals to increase from early to late summer as young are born and recruited into the population.

In 1998 species richness (S) was the same for the sagebrush-grassland and juniper woodland habitat types. However, diversity (H') and evenness (J') were both higher in the juniper woodlands (Table 1). Deer mice and the least chipmunks were the most frequently captured species in both habitats. Sagebrush voles (*Lagarus curtatus*) and longtail voles were almo t

Table 2. Trapping results by session 1 (May-June) and session 2 (July-August). Sagebrush-grassland trapped in 1998 and Rocky hill and cliff trapped in 1999.

	PEMA			TAMI			TADO		
	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value
Sagebrush-grassland	10.34	23.37	0.0000	0.46	2.88	0.0220			
Juniper-woodland	9.60	21.55	0.0010	1.02	3.70	0.0570	0.46	0.71	0.42
Rocky hill	27.99	34.84	0.2570	5.82	2.15	0.1010	1.86	3.18	0.34
Cliff	26.97	29.97	0.4870	3.04	5.20	0.3660	4.41	4.30	0.95

	LACU			MILO			THAT		
	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value
Sagebrush-grassland	0.46	0.63	0.6300	0.51	0.10	0.0400			
Juniper-woodland	0.05	0.00	0.3310	0.00	0.05	0.3310	0.00	0.05	0.3310
Rocky hill									
Cliff									

	PETR			PEPA			CILA		
	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value
Sagebrush-grassland									
Juniper-woodland	0.05	0.00	0.3310						
Rocky hill	0.73	1.54	0.4600	0.08	0.30	0.4850	0.07	0.37	0.2700
Cliff	0.58	0.37	0.7200	1.14	0.52	0.5090	0.53	0.00	0.0870

	NECI			PECR		
	Session 1	Session 2	*P* value	Session 1	Session 2	*P* value
Sagebrush-grassland						
Juniper-woodland						
Rocky hill	0.00	0.07	0.3370	0.07	0.00	0.3370
Cliff	0.30	0.89	0.1970	0.90	0.45	0.5290

PEMA=Deer Mouse
TAMI=Least Chipmunk
TADO=Cliff Chipmunk
LACU=Sagebrush Vole
MILO=Long-Tailed Vole
THAT=Northern Pocket Gopher
PETR=Pinyon Mouse
CILA=Golden-Mantled Ground Squirrel
NECI=Bushy-Tailed Woodrat
PECR=Canyon Mouse

equally represented among captures in sagebrush-grasslands. Only one sagebrush vole was captured in the juniper woodland habitat, whereas the cliff chipmunks were not captured in the sagebrush-grassland habitat type. They were found in the juniper woodlands. Additionally, a northern pocket gopher (*Thomomys talpoides*) was captured in the juniper woodlands, which was most likely an incidental capture. This species may be present in each of the habitat types, but is not frequently captured in live trap (Szaro, et al. 1988).

In 1999 diversity and evenness were highest in the cliff habitat (Table 1). The deer mouse and the pinyon mouse (*P. truei*) were captured more often in the rocky slopes than in the cliffs. The cliff chipmunk, canyon mouse (*P. crinitus*), great basin pocket mouse (*Perognathus parvus*), and bushytail woodrat (*Neotoma cinerrea*) were captured more often in the cliffs than in the rocky slopes. The deer mouse and the least chipmunk were the most frequently captured species in the rocky slopes although the cliff chipmunk and the pinyon mouse also were commonly captured in this habitat type. In the cliffs, deer mice were the most frequently captured species but cliff chipmunks were captured more often than least chipmunks.

Habitat Structure

Juniper woodlands had the highest HCI value, whereas the sagebrush grasslands had the lowest (Table 3). Bareground accounted for the largest proportion horizontal ground cover in each of the habitat types. However, the juniper woodlands had the highest HCI value as a result of also having tree canopy cover and litter cover as important components of the horizontal diversity. Sagebrush-grasslands had the lowest HCI value because it lacked presence of a tree canopy cover and had very low rock cover. Tree canopy cover was highest in the juniper-woodland type and gradually declined in the rocky slopes and cliffs. Grass and shrub cover was highest in the sagebrush-grasslands and much lower in the other habitat types. Forb and litter cover was similar in all habitats, whereas rock cover was much higher in the cliffs.

Regression analysis did not indicate a significant relationship between HCI and small mammal species richness, diversity, or evenness within either year of the study. However, there was a trend of small mammal diversity and evenness being higher in the juniper woodlands and cliffs, which had the highest HCI values in the years in which they were sampled.

Once we recognized that there was not a relationship between small mammal species richness, diversity, or evenness and habitat type, we tested for relationships between these parameters and specific habitat variables. Regression analysis indicated a relationship between small mammal diversity and percent rock cover (R^2-sq = 62.6%, $P < 0.01$) in the rocky slopes and cliffs (Fig. 1). These results could be complicated by the fact that habitats were sampled in different years.

Discussion

Thirty species of small mammals have been identified in juniper-associated habitats throughout Wyoming (Wyoming Game and Fish Department 1993). We found an assemblage in the sagebrush-grassland and juniper-woodland mosaic in southwestern Wyoming consisted of 11 species of small mammals compared to 14 species actually found by the Wyoming Game and Fish Department (1993) in juniper-associated habitats statewide. However, it is fewer than the 17 small mammals species captured by Belitsky (1981) over an area that encompassed our study area. The difference in number of species that we identified and the latter may be that Belitsky (1981) used four different trap types compared to our use of one. Some small mammal species are more susceptible to being captured in one trap type compared to another. Small mammal numbers also change with time.

The species that we captured exhibit a range of habitat specialization. Deer mice and least chipmunks were relatively abundant in all habitat types sampled. These two species form the core of the small mammal community, as they were the most abundant species in the sagebrush-grassland, juniper woodland, and rocky slope habitat types. Cliff and least chipmunks occurred in similar abundance in the cliff habitat type.

The cliff chipmunk, piñon mouse, great-basin pocket mouse, and golden-mantled ground squirrel were intermediate habitat specialists, occurring in two or three

Table 3. Average values for each of the six habitat variables measured to determine the habitat complexity index (HCI) for the sagebrush-grassland, juniper woodland, rocky slope, and cliff habitat types.

Habitat Variable	Sagebrush Grassland 1998	Juniper Woodland 1998	Juniper Rocky Slope 1999	Juniper Cliff 1999
	Habitat Type			
Tree Canopy Cover		28.3	18.9	15.1
Grass	21.6	9.9	6.4	4.8
Forbs	5.0	2.8	2.4	1.9
Shrubs	18.3	6.3	4.3	4.9
Litter	15.5	29.0	20.4	17.8
Bareground	45.6	49.2	59.0	53.6
Rock	0.5	7.9	7.9	18.2
HCI	1.47	1.74	1.54	1.59

of the four habitat types surveyed. The canyon mouse, bushytail woodrat, sagebrush vole, and longtail vole were most abundant in a single habitat type, which suggested the most habitat specialization of all species captured.

Along with our study, others also have found that small mammal communities commonly include habitat specialists and habitat generalists (Ribble and Samson 1987, Mares et al. 1995). Morris (1996) suggested this as a common structure of "most natural assemblages." By using habitat at a larger spatial scale, generalists may exploit habitat that is unused or underused by specialist species (Morris 1996, Grant and Birney 1979).

We provide some evidence of a relationship between horizontal habitat complexity and small mammal species diversity and evenness. With few exceptions (Kirkland et al. 1997), other studies (Rozenzweig and Winakur 1969, Tomoff 1974, Yahner 1983, Germano and Lawhead 1986, Koehler and Anderson 1991, Els and Kerley 1996) have found strong positive relationships between small mammal diversity and habitat structure.

We found that the cliff habitat type had the greatest small mammal species richness and diversity. Ward and Anderson (1988) found that cliffs in southcentral Wyoming had more small mammal species than sites without cliffs. Maser et al. (1979) suggested that cliffs are important habitat for many species of wildlife for providing thermal shelter in addition to nesting and denning sites, and cliffs also may influence surrounding vegetation structure and density. Cliff sites may be important to small mammals for several reasons. In spring and early summer crevices between rocks are used as areas for rearing young by offering protection from predators and severe temperatures. Finally, several species of small mammals cache winter food stores in the cliffs. Further interpretation of our results could be confounded by the fact that we sampled sagebrush/grassland and juniper woodland in 1998 and rocky slopes and cliffs in 1999 in taking into account that year-to-year variation in small mammal abundance could occur.

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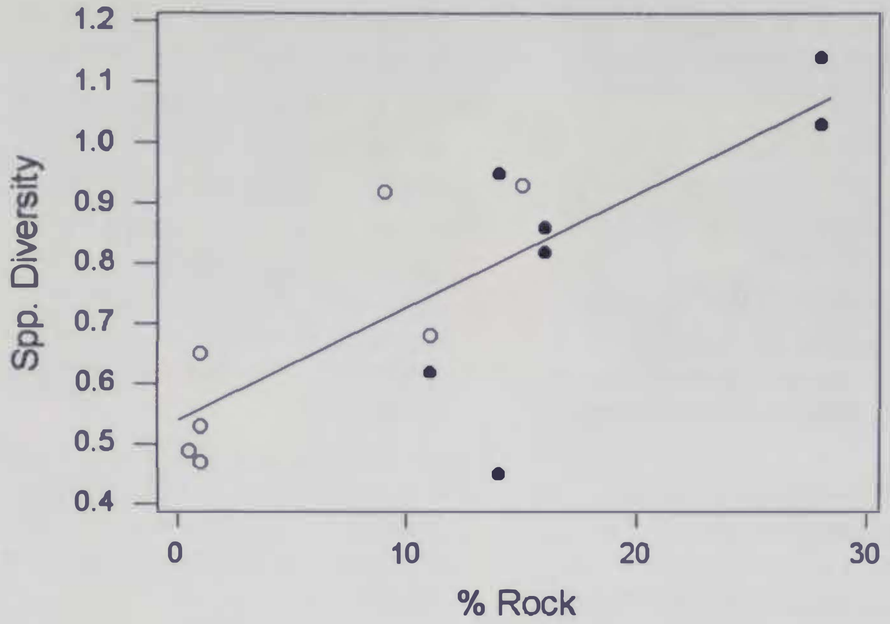

Figure 1. Relationship between small mammal species diversity and percent rock cover in the rocky slope (open circles) and the cliff (dark circles) habitat types.

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