

## DIFFERENTIAL EFFECTS OF LIVESTOCK USE ON HABITAT STRUCTURE AND RODENT POPULATIONS IN GREAT BASIN COMMUNITIES<sup>1</sup>

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Effects of livestock grazing on habitat structure, measured in terms of relative composition of plant life forms (trees, shrubs, forbs, graminoids), were assessed for 26 Great Basin habitat types in northeastern California and northwestern Nevada. Livestock grazing impact was quantified by comparison of "present" plant life form composition of each habitat type (determined by sampling 132 stands of vegetation) with estimates of "potential" plant life form composition based on U.S. Soil Conservation Service range site descriptions and other synecologic literature. Rodent populations were censused in livestock-grazed and -ungrazed communities of seven representative habitat types. Livestock grazing resulted in decreased relative abundance of herbaceous vegetation, particularly perennial bunchgrasses, in the study area. This had the effect of decreasing diversity of plant life forms in the more xeric habitats and increasing diversity of plant life forms in the more mesic habitats. Microtine rodents were consistently found in lower abundance in livestock-grazed than -ungrazed communities. Other species (*Eutamias minimus*, *Perognathus parvus*, and *Peromyscus maniculatus*) appeared to act as "decreasers" in xeric habitats and "increasers" in mesic habitats. Percentage change (from "potential" to "present" conditions) in rodent community diversity was positively correlated with percentage change in plant life form diversity. Change in plant life form diversity accounted for 79% of the variation in change in rodent species diversity.

### INTRODUCTION

The quality of habitat for animals is strongly dependent upon habitat structural features. Organisms are more able to partition their exploitation of resources in structurally complex than structurally simple environments, and animal species diversity has often been related to habitat structural diversity (Pimlott 1969, Pianka 1973, Balda 1975). Habitat diversity can be measured in many ways; species diversity and foliage cover diversity are two of the most common. Plant life forms (i.e., trees, shrubs, graminoids, forbs) also are important components of habitat structure (Bossenbroek *et al.* 1977) and some recent attempts to provide land management guidelines for habitat improvement have emphasized their importance to vertebrate fauna (Thomas *et al.* 1976).

Livestock grazing on rangelands exerts a controlling influence on plant community structure, primarily as a result of selective defoliation of forage species (Stoddart, Smith, and Box 1975). Grazing by domestic cattle and sheep has

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resulted in alteration of plant communities in many areas of western North America during the past century. This has been particularly true in the Great Basin region of the United States (U.S. Bureau of Land Management 1974; Box, Dwyer, and Wagner 1976.)

The nature of livestock grazing influence, however, varies with different types of biotic communities. An understanding of the differential effects of livestock impact on plant communities is, therefore, of value in interpreting livestock effects on native animal communities. It was the purpose of the present study to investigate the impact of livestock grazing on habitat structure, measured in terms of plant life forms, in a variety of Great Basin communities and to examine the implications of habitat change for rodent populations. Rodents are important components of consumer trophic levels and are potential prey for numerous carnivorous mammals, birds, and reptiles, as well as parasites and microorganisms. Rodent communities are relatively easily censused, and the typically small home range size of these animals minimizes problems associated with unraveling the confounding effects of juxtaposition of habitat patches on animal community structure.

#### Study Area

The study area was approximately 250,000 ha of rangeland located in and around Surprise Valley and the Warner Mountains, northeastern California and northwestern Nevada, near Cedarville, California. The area was stratified by habitat type, and 26 habitat types, ranging from shadscale-dominated, *Atriplex confertifolia*, to white fir, *Abies concolor*, communities (Table 1), were studied. A habitat type (*sensu* Daubenmire 1952) is all the area (sum of discrete units) that now supports—or within recent time has supported, and presumably is still capable of supporting—one plant association recognizable by a distinct assemblage of species and productivity. Thus, a given habitat type includes all land areas *potentially* capable of producing similar plant communities.

Elevation ranged from 1350 m in the lowest part of Surprise Valley to 3000 m at the crest of the Warner Mountains. Total annual precipitation averaged from 150 mm in the lowest areas to 500 mm in the Warner Mountains (Summerfield and Bagley 1974). The majority of the land area was characteristic of the Great Basin desert biome. Dominant plant species included shadscale, greasewood, *Sarcobatus vermiculatus*; low sagebrush, *Artemisia arbuscula*, big sagebrush, *A. tridentata*; silver sagebrush, *A. cana*; rabbitbrush, *Chrysothamnus* spp.; bitterbrush, *Purshia tridentata*; snowberry *Symphoricarpos albus*; western juniper, *Juniperus occidentalis*; curlleaf mountain mahogany, *Cercocarpus ledifolius*; yellow willow, *Salix lutea*; quaking aspen, *Populus tremuloides*; white fir; Nevada bluegrass, *Poa nevadensis*; Sandberg bluegrass, *P. secunda*; sedges, *Carex* spp.; baltic rush, *Juncus balticus*; Great Basin wildrye, *Elymus cinereus*; Idaho fescue *Festuca idahoensis*; bluebunch wheatgrass, *Agropyron spicatum*; Thurber needlegrass, *Stipa thurberiana*; squirreltail, *Sitanion hystrix*; Indian ricegrass, *Oryzopsis hymenoides*; and desert saltgrass, *Distichlis stricta*. The vegetation, soils, and general nature of the study area have been described by Summerfield and Bagley (1974).

The principal livestock use has been by cattle; there has been minor use by sheep and feral horses in recent years. Livestock utilized the study area between

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**TABLE 1. Vegetation Zones, Association Groups, and Habitat Types of the Study Area. These have been arranged tentatively along a soil moisture gradient, first by zones, then by association groups, and then by habitat type.**

	<i>Zones</i>	<i>Association groups</i>	<i>Habitat types</i>	
Xeric 	big sage/blue-bunch wheatgrass	shadscale	shadscale/Indian ricegrass shadscale-big sage	
			greasewood	greasewood/Great Basin wildrye greasewood/saltgrass
			low sagebrush	low sage/bluegrass-squirreltail low sage/Idaho fescue-Sandberg bluegrass low sage-rabbitbrush low sage/Idaho fescue
			big sagebrush	big sage/Indian ricegrass big sage/squirreltail-Indian ricegrass big sage/Great Basin wildrye low sage/bluebunch wheatgrass low sage/bluebunch wheatgrass-Great Basin wildrye big sage/bluebunch wheatgrass-Thurber needlegrass
			bitterbrush-big sage/bluebunch wheatgrass juniper/big sage/bluebunch wheatgrass big sage/Idaho fescue big sage-snowberry/Idaho fescue	big sage-silver sage/Great Basin wildrye
			curlleaf mountain mahogany	curlleaf mountain mahogany/ big sage/Idaho fescue
			silver sagebrush	silver sage/Nevada bluegrass
			baltic rush	baltic rush
			apsen	aspen
			Nevada bluegrass	willow/Nevada bluegrass Nevada bluegrass-sedge
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April and October each year at an average annual stocking rate of approximately 0.16 AUM (animal unit month—one adult cow with one calf for one month) per ha between 1972 and 1976; most of the shrub-dominated rangeland was in "fair" range condition with a "stable" trend in 1976 (U.S. Bureau of Land Management 1979). Greatest effects of overgrazing by sheep and cattle in this area are believed to have occurred during the late 19th and early 20th centuries (U.S. Bureau of Land Management, Susanville District Office, unpubl. manuscript).

## METHODS

### Vegetation

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Livestock grazing effects on habitat structure, measured in terms of changes in relative proportions of vascular plant life forms (trees, shrubs, graminoids, forbs), were quantified by comparison of measured "present" vegetation parameters with descriptions of the "potential" natural vegetation stratified by habitat type. The data were collected as part of a larger effort to obtain baseline data for livestock grazing management analysis.

During the summer of 1976, 132 stands of vegetation were sampled to determine species composition and canopy coverage of the 26 habitat types. Canopy coverage was defined as the percentage of the ground included in a vertical projection of the total natural spread of foliage of the individuals of a species; dead portions of the canopy were not included. The sampling was stratified by habitat type on the basis of soil type maps (Summerfield and Bagley 1974). The number of stands sampled per habitat type varied with our subjective appraisal of the relative importance (amount of area occupied and potential productivity) and heterogeneity of the present vegetation of each habitat type. Canopy coverage of herbaceous species was determined using a quadrat estimation technique (Daubermire 1959) with 30 0.1-m<sup>2</sup> (20 x 50 cm) quadrats systematically placed at 1.5-m intervals along two parallel 25-m transect lines in each stand. In tree-dominated (white fir, aspen, curleaf mountain mahogany) communities, canopy coverage of all species was determined in this manner. Canopy coverage of woody perennials in the shrub-grass communities was determined using the line-interception technique (Canfield 1941) and 25-m transect lines placed parallel to each other and systematically spaced at 5-m intervals. The number of transect lines used per stand varied as a function of vegetation heterogeneity and was determined on the basis of a mean-cover-sample-size curve (Hanley 1978) constructed in the field for each stand as it was being sampled. Shrub and tree canopy coverage in meadow and riparian communities was measured on low-level infrared aerial photographs taken according to procedures described by Meyer (1973).

Descriptions of the potential natural vegetation of the meadow and shrub-grass habitat types were provided by Soil Conservation Service range site descriptions (U. S. Soil Conservation Service 1965). These represented the best estimates of species composition and percentage of total net primary productivity contributed by each species in each habitat type in the absence of "unnatural disturbance" (see U. S. Soil Conservation Service 1976). They were based on evaluation of relict vegetation and associated soils in areas that have been

subjected to minimal "abnormal" disturbances, evaluation of similar areas currently disturbed in varying degrees, and relevant historical accounts and botanical literature of the area (U. S. Soil Conservation Service 1976). These descriptions had been prepared only for habitat types meeting the Soil Conservation Service's definition of "rangeland", however, and tree-dominated communities were not included. Synecologic descriptions of aspen (Houston 1954, Hutchins 1965, Beetle 1974), white fir (Franklin and Dyrness 1973), and curleaf mountain mahogany (Dealy 1975) habitat types provided similar descriptions of the potential natural vegetation of these habitat types.

Mean canopy coverage was calculated for each species in each of the 132 stands sampled, and mean canopy coverage of each species in each habitat type was subsequently calculated. Total canopy coverages of trees (including willow), shrubs, graminoids, and forbs were calculated and expressed as proportions of the total coverage of all species for each habitat type. These data represent the average percentage composition of these four plant life forms in each habitat type when sampled in 1976. Similar proportional values were determined for the potential natural vegetation on the basis of the appropriate Soil Conservation Service range site descriptions or other synecologic data.

Livestock grazing effects on structural diversity of the habitat types (see Whittaker 1965, McIntosh 1967, Hutchinson 1958) were determined by comparing diversity indices of the present plant life form composition with corresponding potential values for each habitat type. The diversity index used was the Shannon index (Shannon and Weaver 1949), which is appropriate for samples of "indefinitely large" communities (Pielou 1975). It is defined as

$$H' = -\sum P_i \log P_i$$

where  $P_i$  is the proportion of the community belonging to the  $i$ th category. For four categories (trees, shrubs, graminoids, forbs) the maximum value of  $H'$  is 0.602. The minimum value is always zero (and occurs when all dominance is concentrated in only one category). The index is influenced by category richness (number of categories) and evenness of distribution among categories. A measure of evenness may be obtained by dividing the calculated  $H'$  by the maximum possible value of  $H'$  for the corresponding number of categories. This is expressed as  $H'/H'_{max}$  and values range from greater than zero to a maximum of 1.000.

### Rodent Communities

Livestock grazing effects on rodent communities were quantified by comparison of rodent species composition of seven pairs of "grazed" and "ungrazed" habitat types censused during the summer of 1977: Shadscale/Indian ricegrass, greasewood/Great Basin wildrye, low sage/Idaho fescue, big sage/bluebunch wheatgrass-Thurber needlegrass, big sage/Idaho fescue, aspen, and Nevada bluegrass-sedge habitat types. Vegetation parameters were not measured at the sites where rodents were censused. However, the "grazed" communities were selected as being representative of the average plant species composition and life form structure of the habitat types sampled in 1976. The "ungrazed" communities were relict areas (*sensu* Clements 1934) of the respective habitat types and were representative of the potential plant species composition and life form

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Populations were censused by a systematic placement (two parallel lines 15 m apart with traps located at 6-m intervals) of 224 snap traps (196 museum specials and 28 commercial rat traps) baited with moistened oatmeal, 50 Sherman live traps baited with dry oatmeal, and 50 1-gallon pitfall can traps in each community sampled. Trapping was conducted during 3 consecutive days and nights with all traps being checked and baited twice daily. Densities of rodents were not determined; rather, abundance indices (total number captured) were used. However, densities and catch indices are usually highly correlated (Hanson 1967, Petticrew and Sadler 1970).

The Shannon index ( $H'$ ), species richness (number of species), and evenness ( $H'/H'_{max}$ ) were used as measures of rodent community diversity.

## RESULTS AND DISCUSSION

### Vegetation

#### *Plant Life From Composition*

The major difference between the present and potential structure of nearly all habitat types was a much reduced percentage composition of graminoids and a concomitant increased percentage composition of shrubs in the present vegetation (Table 2). Greatest differences occurred in the greasewood/saltgrass, big sage/Indian ricegrass, big sage/Great Basin wildrye, big sage/bluebunch wheatgrass, big sage-snowberry/Idaho fescue, and big sage-silver sage/Great Basin wildrye habitat types. The tall perennial bunchgrass dominants received the greatest adverse impact from livestock grazing. Cheatgrass, *Bromus tectorum*, and Sandberg bluegrass comprised most of the grass cover of these habitats when sampled in 1976.

TABLE 2. Percentage Composition of Plant Life Forms in Each Habitat Type at Potential and Present Conditions, Averaged by Association Groups (see Table 1).

Association group	Trees		Shrubs		Graminoids		Forbs		No. of stands sampled
	potential	present	potential	present	potential	present	potential	present	
Shadscale .....	0	0	82	99	15	1	3	0	9
Greasewood.....	0	0	41	91	56	4	3	5	7
Low sagebrush.....	1	1	42	52	36	33	21	14	18
Big sagebrush.....	4	3	29	65	56	28	11	4	54
Curleaf mountain mahogany.....	46	76	9	8	36	15	9	1	6
Silver sagebrush.....	0	0	39	72	48	21	13	7	3
Baltic rush .....	0	0	0	8	70	43	30	49	4
Aspen .....	79	83	4	4	1	8	16	5	7
Nevada bluegrass .....	38	15	1	23	52	42	9	20	18
White fir .....	95	95	1	1	3	3	1	1	6

The aspen habitat type was heavily used by livestock. Increased percentage composition of graminoids in the present as compared to the potential conditions was due to a marked decreased percentage composition of forbs in the aspen understory. The lush vegetation of perennial forbs that characterize the potential understory was not present in the livestock-grazed aspen stands sam-

pled in 1976. Total forb canopy coverage averaged only 5.9%. Also of importance was the absence of successful aspen reproduction due to consumption of the root sprouts by livestock. This made for a very open understory lacking a midstratum of young aspen trees.

Increased percentage composition of shrubs was evident in the wet meadow and willow riparian habitat types (Nevada bluegrass-sedge and willow/Nevada bluegrass habitat types, respectively). Percentage composition of trees (willow) in the willow/Nevada bluegrass habitat type decreased by approximately 60%, thus increasing the percentage composition of the other plant life forms. Another important difference between livestock-grazed and -ungrazed meadows was the 30–50 cm deep herbaceous layer of protected meadows versus the closely "mowed" surface of the grazed meadows.

The white fir habitat type did not show any appreciable effects of livestock use, presumably due to the reluctance of livestock to use these communities, except along their edges. The white fir overstory was very dense and the understory sparse. Total cover of nonconifer vascular understory averaged only 4.7%.

*Plant Life Form Diversity*

Livestock grazing-induced changes in the percentage composition of plant life forms caused a reduction in structural diversity in 65% of the habitat types (Table 3). The reductions were most pronounced in the drier habitats, such as the shadscale/Indian ricegrass, shadscale-big sage, greasewood/saltgrass, and big sage/Indian ricegrass habitat types, where shrubs presently dominated the communities to (or nearly to) the exclusion of herbaceous species. These were habitats where shrubs dominate the potential vegetation as well. Any reduction of herbs, with corresponding increased relative dominance of shrubs, tended to decrease the structural diversity within such habitats (Table 3).

**TABLE 3. Average Diversity (H') of Plant Life Forms in Habitat Types at Potential and Present Conditions and Average Percentage Change from Potential to Present. Habitat types have been grouped by their potential dominant life form.**

Potential dominant life form	Number of	Average diversity at potential	Average diversity at present	Average percent increase (+) or decrease (-)	Number of habitat types with increased diversity	Number of habitat types with decreased diversity
Tree <sup>1</sup> .....		0.295	0.321	+14.9	1	2
Shrub.....		0.360	0.189	-52.3	1	7
Graminoid.....		0.368	0.371	+11.5	6	8
Forb.....		-	-	-	0	0

<sup>1</sup> Four habitat types were potentially dominated by trees. The last two columns sum to 3, because there was no change in diversity in the white fir habitat type.

On the other hand, reduced percentage composition of herbaceous species with concomitant increased percentage composition of shrubs, in herb-dominated communities (such as the Nevada bluegrass-sedge and baltic rush habitat types), tended to increase the structural diversity within these communities. Increased structural diversity within the low sage-rabbitbrush habitat type resulted from invasion by juniper trees; and diversity within the bitterbrush-big sage/bluebunch wheatgrass habitat type increased as a result of both increased per-

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centage composition of juniper and decreased composition of grass. Plant life form diversity increased within the willow/Nevada bluegrass habitat type due to a reduction in the dominance of willows and an increased abundance of shrubs.

### Rodents

A total of 221 rodents was captured in the seven livestock-grazed communities as opposed to 302 captured in the ungrazed communities (Table 4), thus indicating a reduction in rodent density due to livestock grazing in those seven habitat types. However, responses varied greatly among rodent species and habitat types. Rodent community diversity also responded differentially to livestock grazing, decreasing in some habitat types and increasing in others.

#### *Differential Response by Species*

Species dependent upon perennial herbs for food and cover were consistently less abundant (or absent) in livestock-grazed than ungrazed communities. These included the little pocket mouse, *Perognathus longimembris*; desert wood rat, *Neotoma lepida*; all three microtine rodents (the montane vole, *Microtus montanus*, the long-tailed vole, *Microtus longicaudus*, and the sagebrush vole, *Lagurus curtatus*); and western jumping mouse, *Zapus princeps*. The little pocket mouse and desert wood rat were closely associated with Great Basin wildrye in the ungrazed greasewood/Great Basin wildrye community. The microtine rodents and western jumping mouse are dependent on dense herbage for both food and cover (Larrison 1976). It is probable that these species are consistent "decreasers" under livestock grazing pressure due to their strong dependence on herbaceous vegetation, particularly perennial grasses.

Three granivorous species, however, demonstrated differential responses to livestock grazing. These were the least chipmunk, *Eutamias minimus*; Great Basin pocket mouse, *Perognathus parvus*; and deer mouse, *Peromyscus maniculatus*. The least chipmunk and deer mouse were present in all of the seven habitat types; the Great Basin pocket mouse was present in all but two. These three widely occurring species exhibited similar responses to livestock grazing—they responded as "decreasers" in the driest habitat types (shadscale/Indian ricegrass and greasewood/Great Basin wildrye) and "increasers" in the mesic habitat types (Nevada bluegrass-sedge and quaking aspen).

#### *Differential Response by Habitat Type*

Rodent community responses to livestock grazing differed greatly by habitat type. In the driest habitats fewer individuals and species were captured in the livestock-grazed than ungrazed communities. The chisel-toothed kangaroo rat, *Dipodomys microps*, was the only rodent found in the grazed shadscale/Indian ricegrass community and was captured in greater abundance there than in the ungrazed shadscale/Indian ricegrass community. Shadscale leaves comprise the bulk of the diet of this species (Johnson 1961). Populations of all species except the chisel-toothed kangaroo rat and deer mouse appeared to be reduced by livestock grazing in the greasewood/Great Basin wildrye communities.

The least chipmunk, Great Basin pocket mouse, and deer mouse were the most abundant rodents in livestock-grazed and ungrazed sagebrush-dominated

TABLE 4. Number of Animals Captured, Number of Species, and Shannon Indices of Livestock-grazed and -ungrazed Communities (grazed/ungrazed).

Species	Shadscale/ Indian ricegrass	Greasewood/ Great Basin wildrye	Low sage/ Idaho fescue	Big sage/ bluebunch wheatgrass- Thurber needlegrass	Big sage/ Idaho fescue	Nevada bluegrass- sedge	Aspen	Total
<i>Spermophilus townsendi</i> .....	-	-	-	-	-	1/0	-	1/0
<i>Spermophilus lateralis</i> .....	-	-	-	-	-	-	4/0	4/0
<i>Ammospermophilus leucurus</i> .....	-	1/4	-	-	-	-	-	1/4
<i>Eutamias minimus</i> .....	0/2	0/4	0/9	5/11	33/8	13/0	1/0	52/34
<i>Eutamias amoenus</i> .....	-	-	-	-	-	-	0/2	0/2
<i>Perognathus longimembris</i> .....	0/2	0/9	-	-	-	-	-	0/11
<i>Perognathus parvus</i> .....	0/1	-	6/19	4/6	-	6/0	2/0	18/26
<i>Microdipodops megacephalus</i> .....	-	1/0	-	-	-	1/0	-	2/0
<i>Dipodomys ordi</i> .....	-	-	-	-	-	3/0	-	3/0
<i>Dipodomys microps</i> .....	5/3	4/4	-	-	-	-	-	9/7
<i>Dipodomys heermanni</i> .....	-	-	-	-	-	-	6/0	6/0
<i>Reithrodontomys megalotis</i> .....	-	1/8	1/0	-	-	-	-	2/8
<i>Peromyscus maniculatus</i> .....	0/3	10/2	3/16	8/14	26/26	11/4	52/33	120/98
<i>Onychomys leucogaster</i> .....	-	-	-	-	-	1/0	-	1/0
<i>Neotoma lepida</i> .....	-	0/4	-	-	-	-	-	0/4
<i>Microtus montanus</i> .....	-	-	-	0/1	-	0/76	-	0/77
<i>Microtus longicaudus</i> .....	-	-	-	0/4	-	-	0/14	0/18
<i>Lagurus curtatus</i> .....	-	-	0/5	0/4	1/2	1/0	-	2/11
<i>Zapus princeps</i> .....	-	-	-	-	-	-	0/2	0/2
TOTAL.....	5/11	17/35	10/49	27/40	60/36	37/80	65/51	221/302
Number of species.....	1/5	5/7	3/4	3/6	3/3	8/2	5/4	
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habitat types. Whereas the numbers of individuals and species captured were fewer in the grazed than ungrazed low sage/Idaho fescue and big sage/blue-bunch wheatgrass-Thurber needlegrass communities, approximately 67% more animals were captured in the grazed than ungrazed big sage/Idaho fescue habitat. Greatest effects on species composition of these rodent communities were on the microtine rodents, which were apparently absent (or greatly reduced) in the grazed communities. The least chipmunk, Great Basin pocket mouse, and deer mouse were much less affected. The least chipmunk was approximately four times more abundant in the grazed than ungrazed big sage/Idaho fescue communities.

Livestock-grazed Nevada bluegrass-sedge and aspen communities were characterized by invasion of rodent species from the more xeric, shrub-dominated habitats. This was particularly evident in the wet meadow (Nevada bluegrass-sedge) community. Species such as the least chipmunk, heteromyid rodents (*Perognathus* spp., *Microdipodops megacephalus*, and *Dipodomys* spp.) and deer mouse acted as "increasers" with livestock grazing in these mesic habitats. Microtine rodents were the greatest "decreasers", the montane vole in the Nevada bluegrass-sedge communities and the long-tailed vole in the aspen communities.

#### *Rodent Community Diversity*

Rodent community diversity differences between livestock-grazed and -ungrazed habitats paralleled differences in plant life form diversity. Decreased plant life form diversity was associated with decreased rodent community diversity, and increased plant life form diversity was associated with increased rodent community diversity (Figure 1, the aspen habitat type has been left out of this analysis because the dominance of the trees masks the differences in understory vegetation for these data).

Percentage change in plant life form diversity accounted for approximately 79% of the variation in percentage change in rodent community diversity ( $H'$ ) ( $r^2 = 0.785$ ). When the components of the Shannon index (species richness and evenness) are analyzed separately, it can be seen that both components responded similarly (Figure 1; none of the three regressions differ significantly,  $P < 0.05$ , from each other). Correlations between percentage change in plant life form diversity and percentage change in rodent species richness and evenness were very highly significant ( $P < 0.001$ ), even when the regressions were forced through the origin as in Figure 1. Approximately 89% of the variation in change in rodent species richness ( $r^2 = 0.888$ ) and 97% of the variation in change in evenness ( $r^2 = 0.972$ ) was accounted for by percentage change in plant life form diversity.

It therefore appears that livestock grazing has reduced rodent species diversity in the drier communities and increased rodent species diversity in the more mesic communities in our study area. Diversity of plant life forms appears to be an important factor determining the diversity of rodent communities in these habitats.

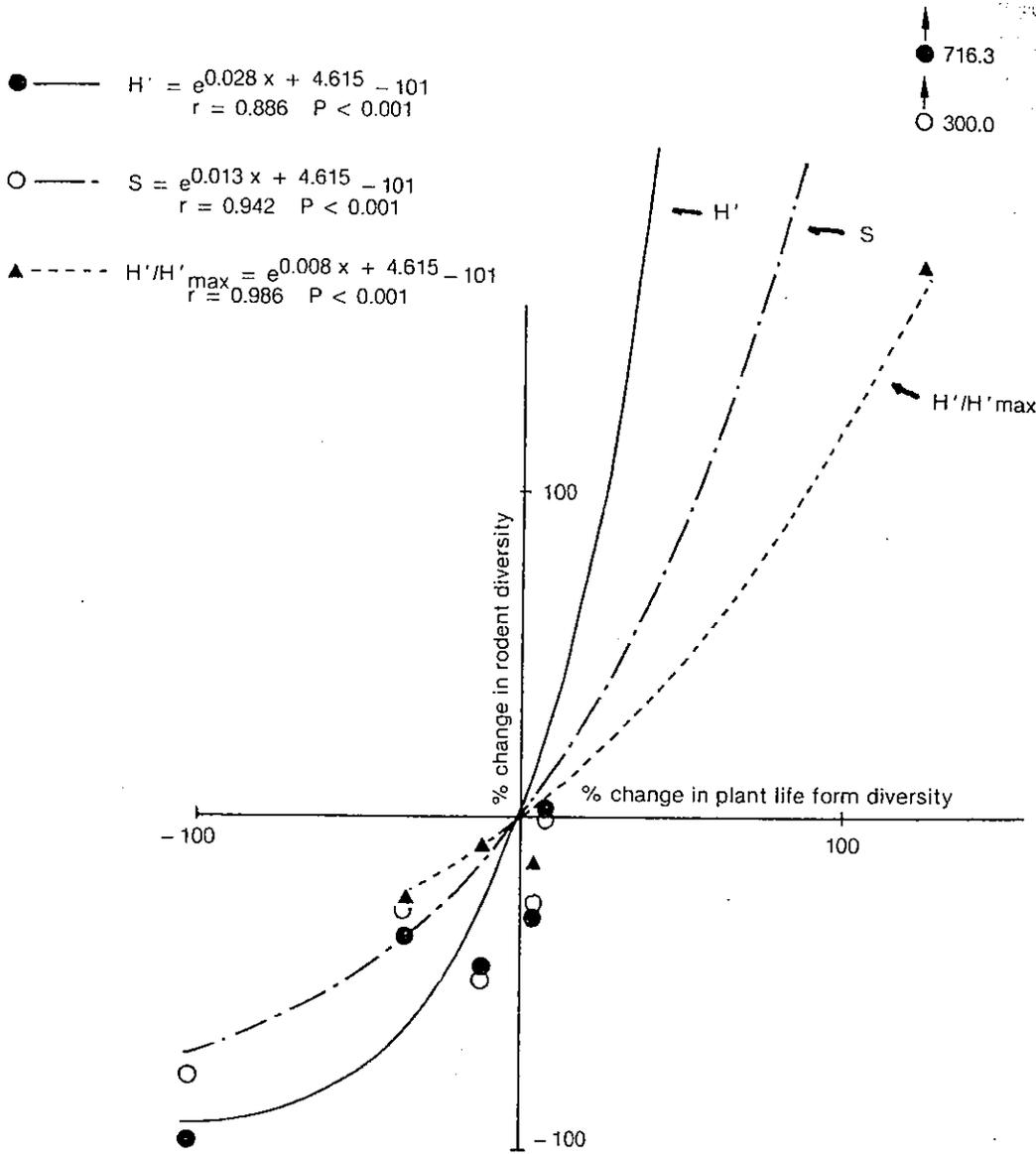


FIGURE 1. Relationships between percentage change in plant life form diversity (from "potential" to "present" conditions) and percentage change in rodent community diversity parameters.  $H'$  = Shannon's index of diversity,  $S$  = species richness,  $H'/H'_{max}$  = species evenness. Regressions have been forced through the origin. Rodent diversity parameters were coded by addition of the constant 101 to enable calculation of the exponential equations.

CONCLUSIONS

Livestock use in the study area has resulted in a marked decreased relative abundance of perennial herbs, particularly bunchgrasses, in all habitat types analyzed. This has had differential effects on plant and animal community structure, however, and these effects appear to be predictable on the basis of soil moisture relationships.

The most xeric habitat types are potentially dominated by shrubs, with lesser amounts of grasses and forbs. Reduction of herbaceous vegetation by livestock

grazing there communities dominated by shrubs. Reduction of shrubs as a result of livestock diversity (up between the reduced effects on rodent "decreasers" particularly fine rodents "increasers" least chipmunk as "range de Johnson 197 many instar

The differential effects on rodent life forms increased diversity increased rodent richness and

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The relationship is superficially easily recognized ecologic population solely to diversity community range of habitat. The small and a total and the re

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grazing therefore results in a reduction in plant life form diversity in these communities. On the other hand, the most mesic habitat types are potentially dominated by herbaceous vegetation, with lesser amounts of shrubby species. Reduction of herbaceous vegetation and concomitant increased abundance of shrubs as a result of livestock grazing results in an increase in plant life form diversity (up to a point) in these communities. Habitat types intermediate between these extremes respond similarly.

Reduced relative abundance of herbaceous vegetation results in differential effects on rodent populations. Some species consistently appear to react as "decreasers" with livestock grazing. These are species dependent upon herbs, particularly grasses, for both food and cover and are exemplified by the microtine rodents. Other species may react as "decreasers" in xeric habitats and "increasers" in mesic habitats. This kind of response was demonstrated by the least chipmunk, Great Basin pocket mouse, and deer mouse. Statements such as "range depletion favors an increase in deer mice populations" (Larrison and Johnson 1973:262; also see Phillips 1936), therefore, may not be appropriate in many instances.

The differential effects of livestock on plant life form diversity had parallel effects on rodent community diversity in this study. Reduced diversity of plant life forms in the xeric habitats was associated with reduced rodent diversity; increased diversity of plant life forms in the mesic habitats was associated with increased rodent diversity. These relationships were true for both rodent species richness and evenness.

Increased plant life form diversity probably increases the diversity of seed size and microhabitat as well as other factors, such as seed type and possibly resource predictability. Resource predictability may increase for an opportunistic forager, since different plant life forms tend to exploit different soil moisture resources (Solbrig and Orians 1977) and, thus, are not all similarly affected by climatic variability. In this respect, it is important to note that the greatest increases demonstrated by rodent species in the present study were by opportunistic (generalist) granivorous foragers—least chipmunk, Great Basin pocket mouse, and deer mouse. Thus, an increase in diversity of plant life forms probably results in an increase in several resource axes potentially suitable for partitioning—seed size, seed type, microhabitat, and interactions of any two or all three of these.

The relative composition of plant life forms is a very general and, perhaps, superficial component of habitat structure. Nevertheless, it is often the most easily recognized feature of a landscape; and our data indicate that it is of ecologic significance to rodents. We do not believe that the differences in rodent populations of our livestock-grazed and -ungrazed communities were related solely to differences in plant life form composition, but we do suggest that rodent communities respond to a complex of habitat changes identifiable over a wide range of habitat types by relative composition and diversity of plant life forms. The small sample sizes of only six or seven communities with comparative data and a total of 523 rodents captured limit the strength of this conclusion, however, and the relationship needs further verification.

We have examined livestock grazing effects on only one aspect of habitat quality. Equally (and perhaps more) important measures of habitat patchiness

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and juxtaposition of patches, foliar structure, layering, plant species diversity, productivity, etc., remain to be investigated. Furthermore, we do not intend to imply that the observed influences on habitat structure are static. For example, whereas livestock grazing may initially increase diversity of plant life forms in grass-dominated habitats by creating a more even distribution of dominance among herbs and woody species, further excessive livestock use may reduce plant life form diversity by further reduction (or elimination) of the herbaceous species. We have considered rodent diversity only *within* habitat types, not over the landscape as a whole. While livestock use may result in an increased rodent diversity within meadows, for example, this may result in a reduction in rodent diversity over the landscape as a whole due to the increased similarity of the meadows with the more widespread shrub-grass habitat types.

Historically, livestock grazing-induced changes in habitat structure are a very new type of disturbance to Great Basin communities. The effects must be recognized for an accurate interpretation of plant and animal community relationships, particularly in studies dealing with community structure, species packing, and evolutionary relationships.

Our data are of an extensive nature, but they do provide some insight into the influence of livestock grazing on a variety of types of vertebrate habitat in the Great Basin. They underscore the importance of assessing grazing impact on a "habitat type" basis, that is, assessing current conditions in relation to potential conditions and recognizing the different potentials of different biotic communities.

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