Estimated Carrying Capacity for Cattle Competing with Prairie Dogs and Forage Utilization in Western South Dakota[1]

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Abstract.—Carrying capacities for cattle competing with black-tailed prairie dogs *(Cynomys ludovicianus)* were estimated by a linear programming technique for management of cool-season grasses in western South Dakota. Forage utilization was allowed to range from 20% to 80%. Under management for cool-season grasses (western wheatgrass *(Agropyron smithii)*; needlegrasses (*Stipa* spp.)), stocking rates of cows ranged from 43 to 214 per hectare over a 6-month grazing season, and cow-calf stocking rates ranged from 43 to 214 per hectare over a 6-month grazing season, and cow-calf stocking rates ranged from 23 to 161. Needlegrasses and needleleaf sedge *(Carex eleocharis)* were key forage species.

On the Great Plains, black-tailed prairie dogs *(Cynomys ludovicianus)* compete with livestock for forage and have been a major concern among livestock producers since the late 1800's (Merriam 1902). For livestock producers, increased cattle-carrying capacity on range land is the primary objective of large-scale prairie dog control programs (Collins et al. 1984). However, carrying capacities for cattle have not been fully evaluated comparing effects in the presence versus the absence of prairie dogs. Carrying capacities for cattle competing with prairie dogs for forage have historically been determined by estimating standing crop of herbage and then arriving at range condition and estimated carrying capacity. Information on diets of cattle and prairie dogs, consumption rates, production of forage, and prairie dog densities has never been collectively evaluated to determine carrying capacities on rangelands supporting both cattle and prairie dogs.

This study utilized a linear programming approach (GOAL) to determine carrying capacities of cattle as limited by prairie dog town sizes and forage utilization while still maintaining pastures in a near climax stage of mixed perennial cool-season grasses. Cool-season grasses included western wheatgrass *(Agropyron smithii)* and needlegrasses (*Stipa* spp.).

Study Area and Methods

The study was conducted in Conata Basin, approximately 29 km south of Wall, S. Dak. Average annual precipitation at the Cedar Pass Visitor Center, Badlands National Park, approximately 21 km east of the study area, is 39.7 cm, of which 79% falls from April through September. Average annual temperature is 10°C. Effective forage-year (October 1 to September 30) precipitation for plant growth was 46.3 cm.

Major graminoids of the study area included blue grama *(Bouteloua gracilis)*, buffalograss *(Buchloe dactyloides)*, western wheatgrass, needleleaf sedge *(Carex eleocharis)*, and red threeawn *(Aristida longiseta)*. Common forbs were scarlet globemallow *(Sphaeralcea coccinea)*, Patagonia Indianwheat *(Plantago patagonica)*, and prairie dogweed *(Dyssodia papposa)*. Shrubs were snakeweed *(Xanthocephalum sarothrae)* and silver sagebrush *(Artemisia cana)*.

The area is grazed by cattle and black-tailed prairie dogs. Prairie dogs graze within towns and were active throughout most of the year. Cattle grazed the entire area from approximately mid-May to the last of October. Stocking levels of cattle varied from year to year depending upon moisture levels and available forage.

We applied the GOAL computer program to a resource decision problem using data from a 2,100-ha pasture following similar procedures by Bartlett et al. (1976), Bottoms and Bartlett (1975), and Connolly (1974). Basic data collected on or near the pasture included cattle diet composition (Uresk 1986), black-tailed prairie dog diet composition (Uresk 1984), prairie dog densities (Cincotta 1985), and forage production (Uresk 1985). Forage consumption of a cow and cow-calf unit was estimated as 355 kg/month [1 AUM (Animal Unit Month)], and 485 kg/month (1.32 AUM), respectively (USDA 1968). Forage consumption of a black-tailed prairie dog over a 12-month period was estimated at 10.95 kg (Hansen and Cavender 1973). Prairie dog densities were estimated as 44 animals/ha (Cincotta 1985).

Seral stages (table 1) were estimated for the entire pasture, based on discriminant functions developed for canopy cover and frequency of occurrence of major plants. Climax or near-climax (seral stage A) was dominated by western wheatgrass; seral stage B was high in blue grama;

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while seral stage C was high in buffalograss. Range seral stage D consisted of approximately equal but smaller amounts of all three plant species. Estimates of forage production and area occupied by prairie dog towns were specified separately for each range seral stage in the analysis.

In the analysis, forage utilization was varied for the entire pasture at four levels (20%, 40%, 60% and 80%) when both cattle and prairie dogs were grazing. Prairie dog towns were allocated to seral stages B, C, and D; but not to range condition class A because prairie dogs do not occur in or near climax vegetation. Prairie dogs were confined to areas that totalled from 20 to 40 ha for the entire pasture. Forage utilization on these areas was adjusted to 100%.

Major forage plants of both herbivores included western wheatgrass blue grama, buffalograss, needleleaf sedge, sand dropseed *(Sporobolus cryptandrus)*, needlegrasses, scarlet globemallow and categories of other graminoids, and other forbs (Uresk 1984, Uresk 1986). Shrubs were excluded because they were minor components of the diets and rangeland. Average herbivore diets for the season were used in this linear programming analysis.

With linear programming, management options for amounts of forage utilization and area occupied by prairie dog towns were analyzed under management for cool-season grasses. Under management for cool-season grasses, no forage species was utilized over the selected percentages.

For the GOAL programming analysis, the following assumptions were made:

1. Adequate forage of major plant species were available within limits of prescribed utilization so that herbivores did not adjust their normal diets and consumption in response to a decrease in forage.
2. Common use of the range by the two herbivores did not alter the preference for forage within established utilization limits.
3. Forage consumption was proportional to population densities of the herbivore species.

Cattle stocking numbers were estimated as follows. Diet composition and forage consumption rates of both herbivores were specified and held constant. Forage availability was specified for each species by seral stage and held constant. Prairie dog density per hectare of town was specified and held constant. The management variables—percent forage utilization and hectares in dog towns—were varied within specified limits.

Finally, the GOAL program solved cattle-stocking numbers that could be supported by the available forage for a given forage utilization percentage and hectares in prairie dog towns. When present, prairie dogs were given first priority for forage.

Results

Plant Production

Forage production for individual species was greatest for western wheatgrass, followed by buffalograss and blue grama (table 1). The pasture at or near climax seral stage (A) had the lowest plant production (1970 kg/ha); seral stage C had the greatest overall production (2267 kg/ha). Most of the pasture was at or near climax seral stage A (58%) and did not have prairie dogs, a factor that results in a relatively low impact by prairie dogs. Seral stages B, C, and D made up 3%, 7%, and 32%, respectively, of the pasture. All had prairie dogs residing.

Carrying Capacity

Carrying capacity for mature cows without calves (6-month grazing period) on range with no prairie dogs competing ranged from 55 to 221 cows/2100 ha when forage utilization levels were from 20% to 80%

Table 1.—Estimated peak plant production (kg/ha) (Uresk 1985) by range class on a 2,100-ha pasture.

Plant taxa	Range seral stages[1] (ha) A (1226)	B (55)	C (144)	D (675)
Western wheatgrass *(Agropyron smithii)*	1354	514	72	301
Blue grama *(Bouteloua gracilis)*	204	441	396	88
Buffalograss *(Buchloe dactyloides)*	47	601	1172	192
Needleleaf sedge *(Carex eleocharis)*	9	12	43	38
Needlegrasses (*Stipa* spp.)	32	44	0	55
Sand dropseed *(Sporobolus cryptandrus)*	0	1	5	48
Other graminoids	138	180	253	372
Total graminoids	1784	1793	1941	1094
Scarlet globemallow *(Sphaeralcea coccinea)*	36	36	47	96
Total forbs	150	388	279	1046
Total production[2]	1970	2217	2267	2236

[1]*A = climax; D = low seral stage. Uresk, D. W. submitted. A quantitative method for estimating ecological stages in a mixed-grass prairie with multivariate techniques. J. Range Manage.*

[2]*Shrubs are not included in production estimates.*

(table 2). In estimating stocking rates, no single forage species was allowed to be utilized at levels greater than the set levels from 20% to 80%. Thus, a range of 1.6 to 6.4 ha/AUM was required. Numbers of cows decreased as hectares of prairie dog towns increased; stocking rates decreased by approximately 3 for every additional 20 ha of prairie dogs (880 prairie dogs or 293 prairie dogs/cow) up to 40 ha on the pasture.

Cow-calf stocking rates ranged from 40/2,100 ha to 161 (1 cow-calf unit = 7.92 AUMs for 6-months) when utilization levels varied from 20% to 80% without prairie dogs (table 2). At these stocking rates, approximately 2.1 to 8.7 ha were required for each AUM. Stocking rates decreased by approximately 2 cow-calf units for every additional 20 ha of prairie dogs.

Discussion

Needlegrasses and needleleaf sedge limited carrying capacity for cattle on pastures managed for cool-season grasses. Western wheatgrass was never a limiting species; that is, consumption of western wheatgrass by both herbivores never exceeded the amount available. The 80% level of utilization of some cool-season grasses is too high to maintain the viability of these plants, and lower utilization levels (30-45%) are recommended (Lewis et al. 1956). With fewer cattle grazing under management for cool-season grasses, cattle gain more weight per day, but fewer kilograms per hectare (Black et al. 1937, Lewis et al. 1956, Bement 1969).

Prairie dog expansion can be reduced under management for cool-season grasses because vertical cover and grass heights increase (Cincotta 1985). Prairie dogs did not significantly expand over a 4-year period on areas where cattle were excluded (Uresk et al. 1982). Furthermore, a lower stocking rate (management for cool-season grasses) would increase vertical grass cover on the range and would thereby further reduce prairie dog expansion. Snell and Hlavachick (1980) and Snell (1985) reported reduced expansion rates and elimination of prairie dog colonies by using a summer-deferred grazing system. Prairie dogs prefer habitat managed for warm-season grasses [blue grama *(Bouteloua gracilis)*, buffalograss *(Buchloe dactyloides)*]. Increased stocking rates of cattle and shortgrass stature with low vertical cover allows for prairie dog expansion (Uresk et al. 1982, Cincotta 1985).

Cattle stocking rates estimated in this study were conservative, because upper limits of forage consumption and prairie dog densities (44 animals/ha) were used in the analyses. The guidelines reported here for cow or cow-calf stocking rates for cool-season grasses represent viable options for management. Key forage species used to estimate cattle numbers and monitor utilization for management of cool-season grasses included needlegrasses and needleleaf sedge. Generally, stocking rates were limited by production and use of needlegrasses, although needleleaf sedge and sand dropseed also influenced cow numbers. When hectares of prairie dogs are high, needleleaf sedge can become the major limiting factor in determining cow numbers. Needlegrasses were generally the limiting plant component in determining cow-calf units. Sand dropseed can be limiting when the area with prairie dogs is greater than or equal to 200 ha.

This study only presents estimates for up to 40 ha of prairie dog colonies (approximate current levels of prairie dogs) on a 2,100-ha pasture, and limited extrapolation is suggested beyond data in table 2. An additional constraint is availability of needlegrasses and needleleaf sedge. Extrapolation of results to pastures with lower availability of these species should be done cautiously. In fact, where forage availability and composition are much different from the pasture studies, extreme care should be used in extrapolating results to other areas. The assumptions and required constraints for GOAL linear program analysis imposes some limitations on biological sensitivity.

Table 2.—Estimated 6-month carrying capacity for mature cows with and without calves with management for cool-season grasses. Stocking rates are related to hectares of prairie dogs and allowable forage utilization on a 2,100-ha pasture in western South Dakota. Consumption of needlegrasses and needleleaf sedge is 100% on prairie dog occupied areas.

Forage utilization %	Prairie dogs occupied areas (ha)					
	0	20	40	0	20	40
	Cow numbers[1]			Cow-calf numbers[2]		
20	55	53	50	40	39	37
40	110	108	105	81	79	77
60	166	163	160	121	119	117
80	221	218	214	161	159	157

[1] *355 kg of forage consumed/cow/month (1 AUM).*

[2] *485 kg of forage consumed/cow-calf/month (1.32 AUM).*

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Cattle Grazing and Small Mammals on the Sheldon National Wildlife Refuge, Nevada[1]

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Abstract.—We studied effects of cattle grazing on small mammal microhabitat and abundance in northwestern Nevada. Abundance, diversity, and microhabitat were compared between a 375-ha cattle exclosure and a deferred-rotation grazing allotment which had a three-year history of light to moderate use. No consistent differences were found in abundance, diversity, or microhabitat between the two areas.

Grazing by livestock is a common and economically important practice throughout much of the western United States. Because grazing alters wildlife habitat, much attention has centered on its impact on wildlife abundance, diversity, and habitat use. However, relatively little information exists on effects of grazing on small mammal communities. Such information would aid development of effective grazing programs where small mammals are a management concern.

Several authors have demonstrated that removal or alteration of cover can cause changes in small mammal communities (Birney et al. 1976, Geier and Best 1980, Grant et al. 1982, LoBue and Darnell 1959). More specifically, grazing altered rodent species diversity through changes in plant species diversity on several habitats in northeastern California (Hanley and Page 1982). Similarly, Grant et al. (1982) found differential changes in several small mammal community parameters between grazed and ungrazed sites in four western grassland communities; tallgrass and montane grasslands appeared to be most affected by grazing.

In assessing grazing impacts on small mammal communities, Hanley and Page (1982) stressed the importance of evaluating effects on a habitat-type basis. Grant et al. (1982) concluded that the response of a small mammal community to grazing depended on the site and the original mammal species composition.

In 1980, the Sheldon National Wildlife Refuge (SNWR) initiated a deferred-rotation grazing system on the 6,954-ha Badger Mountain grazing allotment to improve soil and range conditions. The management plan was designed to graze 1,444 animal-unit-months (AUMs) with the grazing period alternating between mid-June through early August during one year and early August through late October the next (five-year average, David Franzen, Range Conservationist, SNWR, pers. comm.). Prior to 1979, the allotment had been on a season-long grazing system from early April through September with an estimated 1,700 AUMs being removed from the unit (U.S. Fish and Wildlife Service 1980).

In Spring 1981, we constructed a 375-ha cattle exclosure on the Badger Mountain allotment to evaluate the effects of cattle grazing on wildlife and their habitat (Oldemeyer et al. 1983). The purpose of this element of the study was to evaluate the effect of the grazing system on small mammals. Specifically, we wanted to determine the following: (1) is there a difference in small mammal abundance and diversity between the areas over time, (2) is there a difference in the available small mammal habitat between areas, and (3) what microhabitat characteristics are indicative of capture sites by individual small mammal species for the two ecosites? We tested the null hypothesis of no significant difference between the exclosure and the allotment.

Study Area and Methods

The Badger Mountain allotment ranges from 1,890-2,152 m elevation and is composed of two dominant range ecosites (Anderson 1978). The shrubby rolling hills (SRH) ecosite occurs on moderate to deep soils and is dominated by big sagebrush *(Artemisia tridentata)* and antelope bitterbrush *(Purshia tridentata)* with grass understory dominated by Idaho fescue *(Festuca idahoensis)*. The mahogany rockland (MR) ecosite occurs on rocky ridges and slopes with bedrock outcrops. Curlleaf mountain mahogany *(Cercocarpus ledifolius)* is predominate in this ecosite with a grass understory dominated by western needlegrass *(Stipa occidentalis)* (fig. 1). Precipitation on Badger Mountain ranges from 27-33 cm an-

[1]*Paper presented at symposium, Management of Amphibians, Reptiles, and Small Mammals in North America. (Flagstaff, AZ, July 19-21, 1988.)*

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nually with most coming as snow and as spring and autumn rains (U.S. Fish and Wildlife Service 1980).

We conducted the study during the summers of 1983 and 1984, four and five years, respectively, after initiation of the deferred-rotation grazing system. Grazing intensities were 1,650 AUMs from 10 July to 10 August, 1980, 1,770 AUMs from 7 August to 30 September, 1981, and 1,036 AUMs from 24 June to 22 August, 1982. In 1983, cattle were grazed on the allotment from 1 August through 15 October at a rate of 980 AUMs. The following year, the unit supported 1,337 AUMs during a 28 June to 18 August grazing period (David Franzen, Range Conservationist, SNWR, pers. comm.).

In 1983, eight live trap grids were established with trap stations 15 m apart. Four grids were located inside the exclosure and four were located in the allotment. We arranged each 7 X 7 grid so that approximately half of the traps were in the SRH ecosite and half were in the MR ecosite. We sampled only four grids (two in the exclosure and two in the allotment) in 1984, but we increased the size of the grids to 64 (8 X 8) trap stations.

We trapped from 1 July through 11 August in 1983, and 19 June through 1 July in 1984. Only one pair of grids were trapped at a time (one grid in the exclosure, one in the allotment), for a total of four trap sessions in 1983, and two sessions in 1984. A Sherman live trap containing a handful of cotton wool and baited with rolled oats was placed at each station. Trapping began in the afternoon and continued for five consecutive days. Traps were opened each day between 1600-1730 hrs and closed the following morning between 0730-1100 hrs to prevent daytime trap mortality. Species, trap number, age (adult or juvenile), sex, weight and tag number were recorded. We used toe clips or aluminum ear tags to identify individuals.

We estimated relative abundance of small mammals as the total number of individuals captured per trap night (catch/effort) for each ecosite type, area and grid. Abundance was calculated for all small mammals as well as for each individual species.

Small mammal diversity was derived for each area using Patil and Taillie's (1979) diversity profiles. This is a graphic ordering of the diversity of two or more communities. The y-axis represents the percent of small mammals remaining in the sampled population when a species is removed. This is plotted against the number of species that have been removed from the sampled population, with species removal being cumulative.

The profile of an intrinsically more diverse community will plot above that of a less diverse community. If profile lines intersect, then the communities do not differ in diversity.

Vegetation measurements describing microhabitat structure were taken at each station prior to trapping. The characteristics we measured are similar to those reported in other small mammal studies (e.g. Geier and Best 1980, Hallett 1982). These included:

1. Percent canopy cover of grass, forbs, and litter (all downed dead material; e.g. twigs, dead grass, leaves) in a 1.0 X 0.5 m quadrat having the trap station stake as its center;

2. Height (cm) of the nearest shrub (crown foliage >2 dm in diameter) in each quarter around the trap station stake;

3. Line intercept distance (cm) of living and dead shrubs (in the 25 to 50 cm layer above the ground) occurring within two perpendicularly oriented 2-m transects centered at the trap station stake.

Five microhabitat variables were derived from these measurements for analysis. These included: (1) % forb cover, (2) % grass cover, (3) % litter cover, (4) total shrub interception distance (cm), and (5) mean height (cm) of the live shrubs around each stake.

Small mammal abundance data were analyzed using a three-way analysis of variance to determine if

Figure 1.—View from the study site on Badger Mountain, Sheldon National Wildlife Refuge, Nevada.

small mammal abundance differed between areas, years, and ecosites. We used a one-way analysis of variance test to detect differences between areas for individual years and ecosites. To determine the microhabitat preferences of individual species we coded trap locations as being either capture or non-capture stations. We employed a nested two-way analysis of variance to test these preferences among areas and codes, the interaction of areas by codes, and the nested interaction of grids within areas. We considered P<=0.1 to be significant. Subsequent discussion of small mammal microhabitat selection concerns only the two most abundant species, the deer mouse *(Peromyscus maniculatus)* and the least chipmunk *(Tamias minimus)*.

Results and Discussion

Species Composition

Species of small mammals occurring in the two ecosites of our study area are widely distributed throughout the Great Basin (Hall 1946). These species and their percentage of the total catch were: deer mouse (46.7%), least chipmunk (29.8%), Great Basin pocket mouse *(Perognathus parvus)* (12.3%), sagebrush vole *(Lagurus curtatus)* (7.8%), Townsend's ground squirrel *(Spermophilus townsendii)* (1.2%), golden-mantled ground squirrel *(Spermophilus lateralis)* (1.2%), and long-tailed vole *(Microtus longicaudis)* (0.6%).

Abundance

Total relative abundance of small mammals did not differ between year or area (table 1). However, more animals were captured in the SRH ecosite than in the MR ecosite (P=0.05).

There was a general decline in deer mouse (P=0.08) and least chipmunk (P=0.06) abundance from 1983 to 1984, although this probably reflects the difference in season and length of trapping between the two years. We found no significant difference in abundance for these two species between areas or ecosites. This is not surprising given the opportunistic, adaptable, nature of these small mammals. Others have found that heavy grazing in big sagebrush habitat appears to promote an increase in deer mice (Black and Frischknecht 1971, Larrison and Johnson 1973), and least chipmunk numbers (Larrison and Johnson 1973). Hanley and Page (1982) observed a different response for the two species on their big sagebrush-Idaho fescue site 60-80 km west of Badger Mountain. In that study, deer mice were captured in the same numbers in both grazed and ungrazed sites, while least chipmunks were four times more abundant in the grazed site than in the ungrazed site.

Great Basin pocket mice were more abundant (P<0.01) in 1983 than 1984, and they were more commonly captured in the SRH ecosite than in the MR ecosite (P=0.08). However, there was no significant difference in abundance between the areas. Others have found Great Basin pocket mice to be more abundant on ungrazed big sagebrush sites (Black and Fris-

Table 1.—Abundance of small mammals (number caught per trap night) by year, area and ecosite on the Sheldon National Wildlife Refuge, 1983-84.

Species	Area	Shrubby-Rolling Hills		Mohogany Rocklands	
		1983 #/trapnite(S.E.)	1984 #/trapnite(S.E.)	1983 #/trapnite(S.E.)	1984 #/trapnite(S.E)
Deer mouse	Excl.	0.081(0.012)	0.047(0.014)	0.061(0.019)	0.050(0.011)
	Allot.	0.063(0.005)	0.052(0.017)	0.064(0.027)	0.018(0.002)
Least chipmunk	Excl.	0.029(0.007)	0.020(0.005)	0.067(0.017)	0.037(0.006)
	Allot.	0.046(0.025)	0.031(0.010)	0.049(0.011)	0.005(0.005)
Great Basin	Excl.	0.013(0.005)	0.028(0.003)	0.003(0.003)	0.029(0.014)
pocket mouse	Allot.	0.011(0.007)	0.031(0.004)	0.005(0.003)	0.014(0.006)
Sagebrush vole	Excl.	0.019(0.010)	0.038(0.020)	0.002(0.002)	0.004(0.004)
	Allot.	0.004(0.003)	0.019(0.004)	0	0
Long-tailed vole	Excl.	0	0.004(0.004)	0	0
	Allot.	0	0.009(0.002)	0	0
Townsend's ground	Excl.	0	0	0	0
squirrel	Allot.	0.005(0.005)	0	0	0.005(0.005)
Golden-mantled	Excl.	0.006(0.006)	0	0.007(0.007)	0
ground squirrel	Allot.	0	0	0	0
Total Catch	Excl.	0.149(0.013)	0.135(0.027)	0.141(0.024)	0.120(0.028)
	Allot.	0.154(0.030)	0.143(0.005)	0.119(0.026)	0.042(0.018)

chknecht 1971), or more abundant on grazed sagebrush sites (Hanley and Page (1982).

Relative abundance of the sagebrush voles and long-tailed voles could not be compared statistically because of the small number of voles captured. There was, however, a general trend for microtine rodents to be more abundant in the SRH ecosite even though grass and forb cover in the MR ecosite were higher. Birney et al. (1976) and Grant et al. (1982) have discussed the importance of cover for microtine rodents in grasslands. Although grass cover was lower in the SRH ecosite, the combination of higher litter cover and shrub intercept in that ecosite may provide better habitat for these rodents. The sagebrush vole was more abundant in the exclosure than in the allotment. Although we were unable to test this trend, it is possible that the sagebrush vole found the exclosure, with its slightly greater grass and shrub cover, to be more inhabitable. It is apparent from other studies that grass and shrub cover are important components of sagebrush vole habitat (MacCracken et al. 1985, Maser et al. 1974, Maser and Strickler 1978, O'Farrell 1972).

Diversity

In 1983, diversity of small mammals in the exclosure was greater than in the grazing allotment (fig. 2). Relative abundance of deer mice, the most common species (table 1), was similar in both areas; however, we caught one more species in the exclosure. In 1984, small mammal diversity was greater in the allotment than in the exclosure. During that year, deer mice made up a somewhat smaller relative proportion of the small mammal total in the allotment (table 1); thus the line for the allotment starts higher on figure 2 indicating greater evenness in the percentage each species contributed to the population. We captured one more species in the allotment than in the exclosure which extended the tail of the profile further to the right. Because of this change from one year to the next, we were unable to conclude what impact the grazing system had on small mammal diversity. Hanley and Page (1982) observed a higher diversity index on their ungrazed sagebrush-Idaho fescue site 60-80 km west of Badger Mountain.

Vegetation on the Small Mammal Study Area

Generally, the SRH ecosite had lower grass and litter cover and a greater

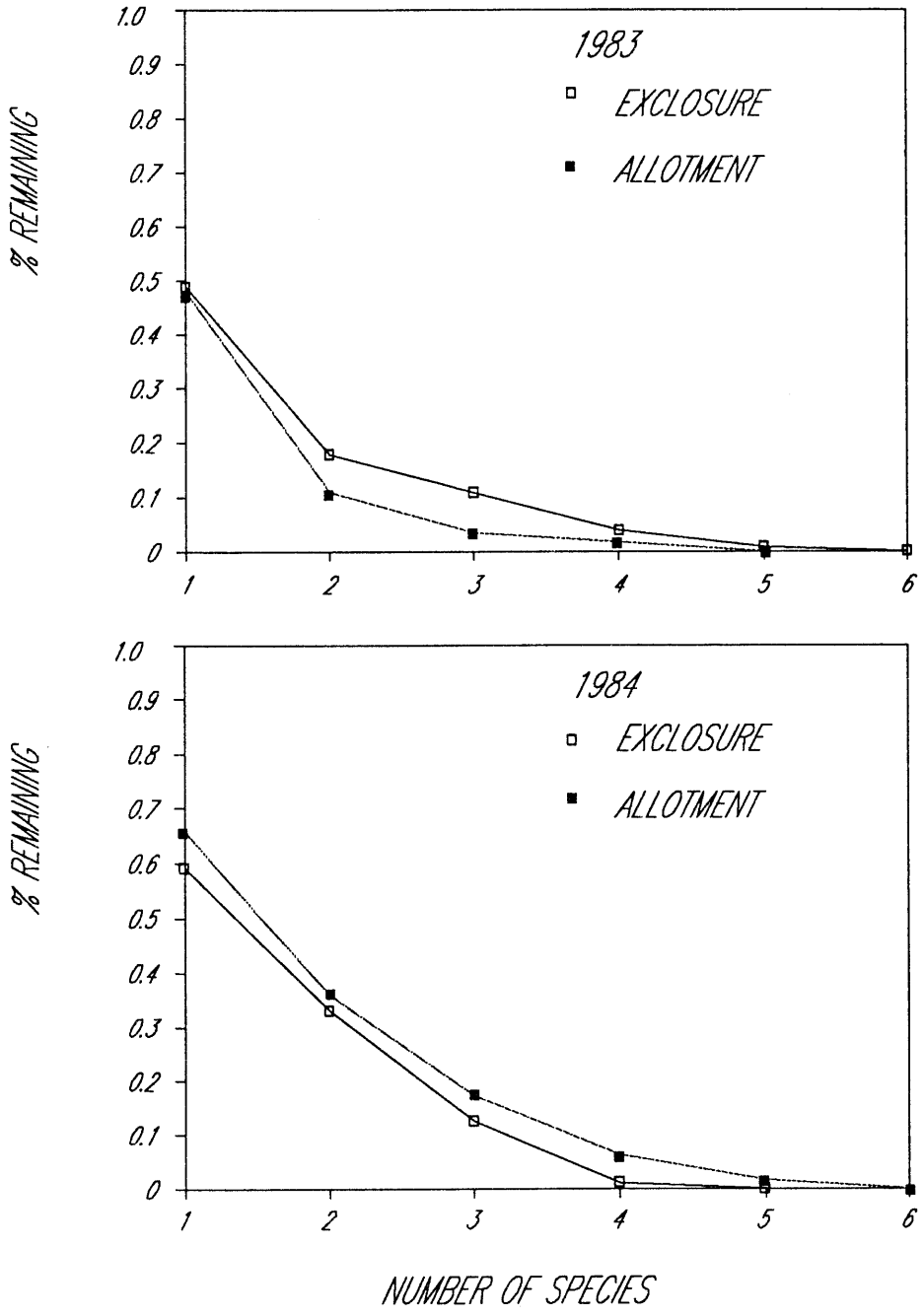

Figure 2.—Small mammal diversity profiles for the cattle exclosure and the allotment, Sheldon National Wildlife Refuge, 1983-84. If profile lines intersect, then diversity does not differ between areas (Patil and Taillie 1979).

shrub intercept value than did the MR ecosite (fig. 3). In the SRH ecosite, microhabitat characteristics did not differ between the exclosure and allotment, except for 1983 when shrub height in the allotment was lower (P<0.05) than that in the exclosure. In the MR ecosite, shrub intercept was lower (P<0.03) in the allotment than in the exclosure both years and grass cover was higher (P<0.10) in the exclosure in 1983. In both ecosites, there was a general trend for cover of both grasses and forbs to be lower in the allotment than in the exclosure.

This trend is probably due to the cattle grazing. However, the fact that the means are relatively similar (especially in the SRH ecosite) and do not differ significantly between areas indicates that the grazing effect is within goals established by the refuge.

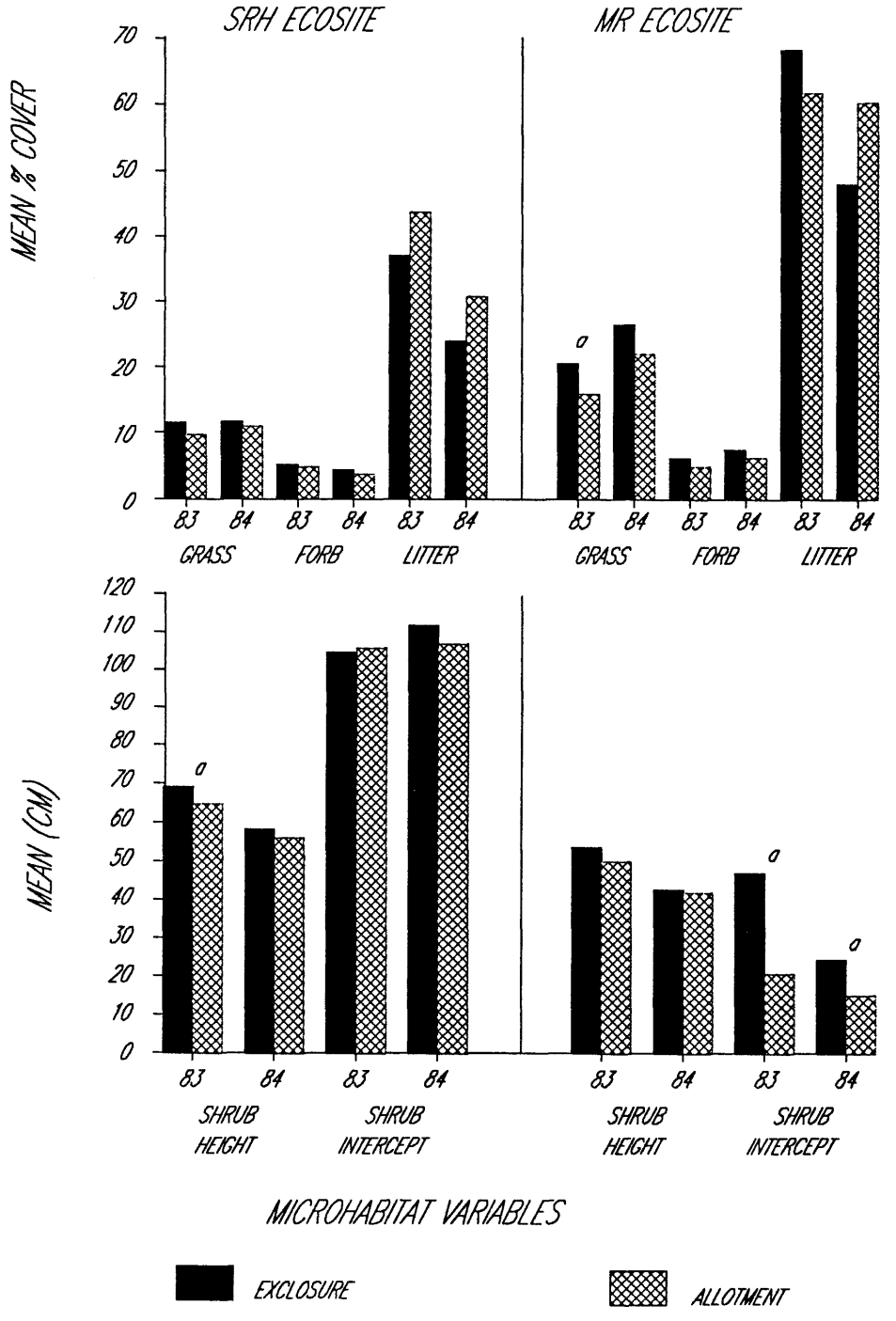

Figure 3.—Microhabitat characteristics around trap stations in the shrubby-rolling hills and mahogany rocklands, Sheldon National Wildlife Refuge. Variables with an "a" denote a P value of <0.1 between the two areas.

Microhabitat Characteristics of Deer Mice Catch Sites

In the SRH ecosite, traps where deer mice were caught had significantly greater litter cover (P=0.07 in 1984), shorter shrubs (P=0.09 in 1984), and greater shrub intercept (P=0.10 in 1983) than traps where deer mice were not caught (fig. 4). These patterns tended to hold for both years.

In the MR ecosite, litter cover, which is greater than in the SRH ecosite, did not appear to be a significant vegetative characteristic (fig. 4). Grass cover in 1984 was lower (P=0.06) and shrub height (P=0.02) and shrub intercept (P=0.08) were greater at traps where deer mice were caught than where they were not caught.

In both the SRH and MR ecosites, deer mice appeared to use microhabitat that had greater shrub intercept. This corresponds with the findings of Feldhamer (1979) who noted an increase in deer mouse density with increased foliage in the shrub layer. Other studies have found that deer mice were associated with light cover in heavily grazed sites (Black and Frischknecht 1971), with increasing forb cover (Geier and Best 1980), or with no measured habitat variable (Hallett 1982).

Microhabitat Characteristics of Chipmunk Catch Sites

In the SRH ecosite, shrub height was lower (P<0.08 in 1984) in catch locations in the exclosure and the allot-

ment than in non-catch locations. This pattern held in 1983 (fig. 5).

In the MR ecosite there were no consistent patterns of chipmunk microhabitat use (fig. 5). Shrub interception, in 1984, was greater ($P<0.05$) in chipmunk catch locations than non-catch locations; however this pattern was not evident in 1983.

Microhabitat selection by the least chipmunk lacked a consistent pattern for either ecosite or year. However, the fact that the least chipmunk is an opportunistic forager and is the most widespread of all North American chipmunks (Hall 1981), suggests that this rodent adapts rapidly to a variety of habitat types. Sullivan (1985) found that the least chipmunk was associated with a wide variety of ecological situations in the southwest and suggested that this species may be predisposed to exploiting marginal environments.

Conclusions

These results indicate that the grazing regime initiated on the Badger Mountain allotment had no discernible impact on the relative abundance and diversity of small mammals, four and five years after its implementation. The dominance of two opportunistic species on the study area probably contributed to this lack of difference. We suggest future monitoring of the study area to determine the long-term response of small mammals to the grazing program. Particular attention should be given to the two vole species which are the most sensitive to changes in cover.

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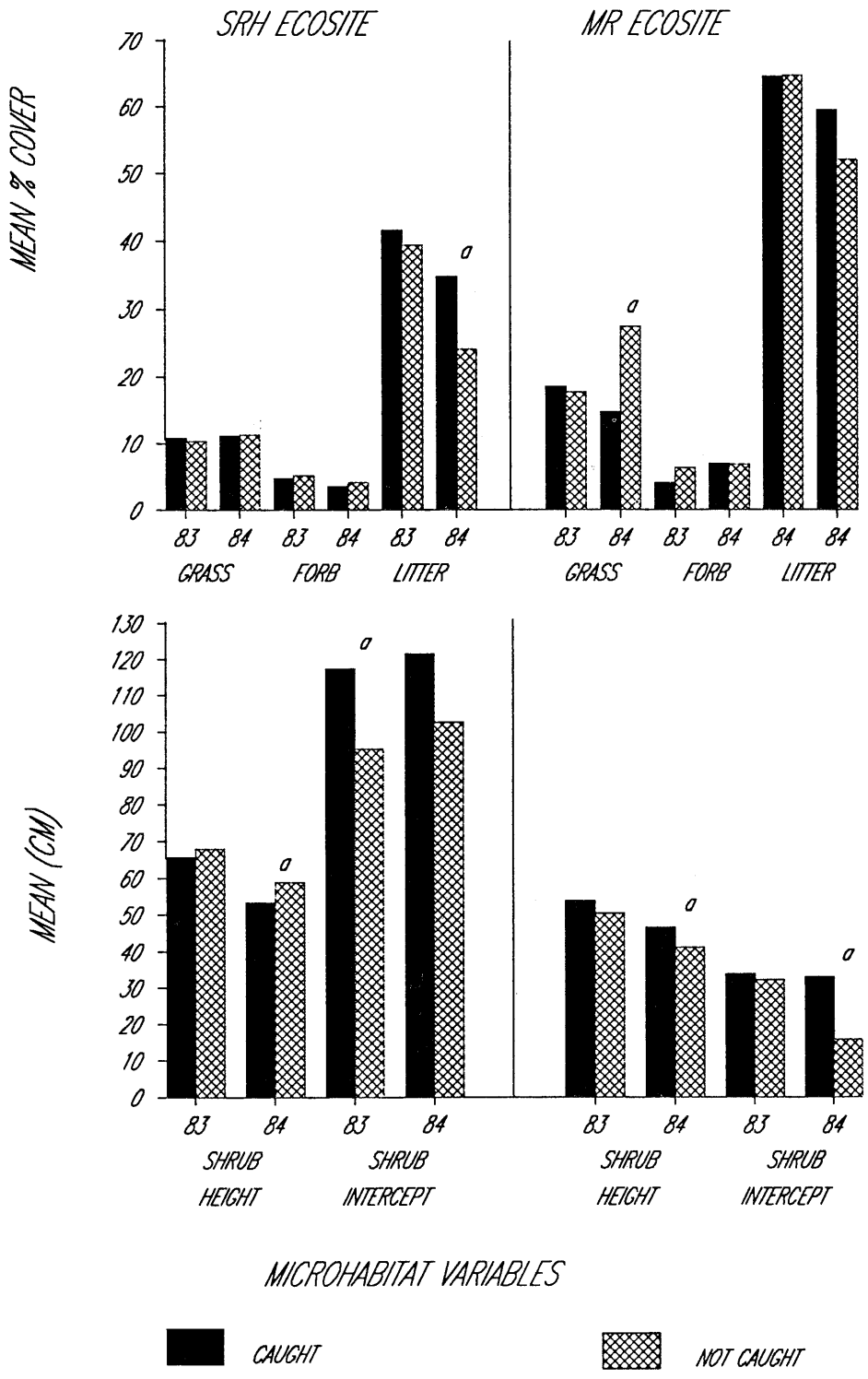

Figure 4.—Microhabitat characteristics around traps where deer mice were captured and not captured by year and ecosite, Sheldon National Wildlife Refuge. Variables with an "a" denote a P value of <0.1 between the two areas.

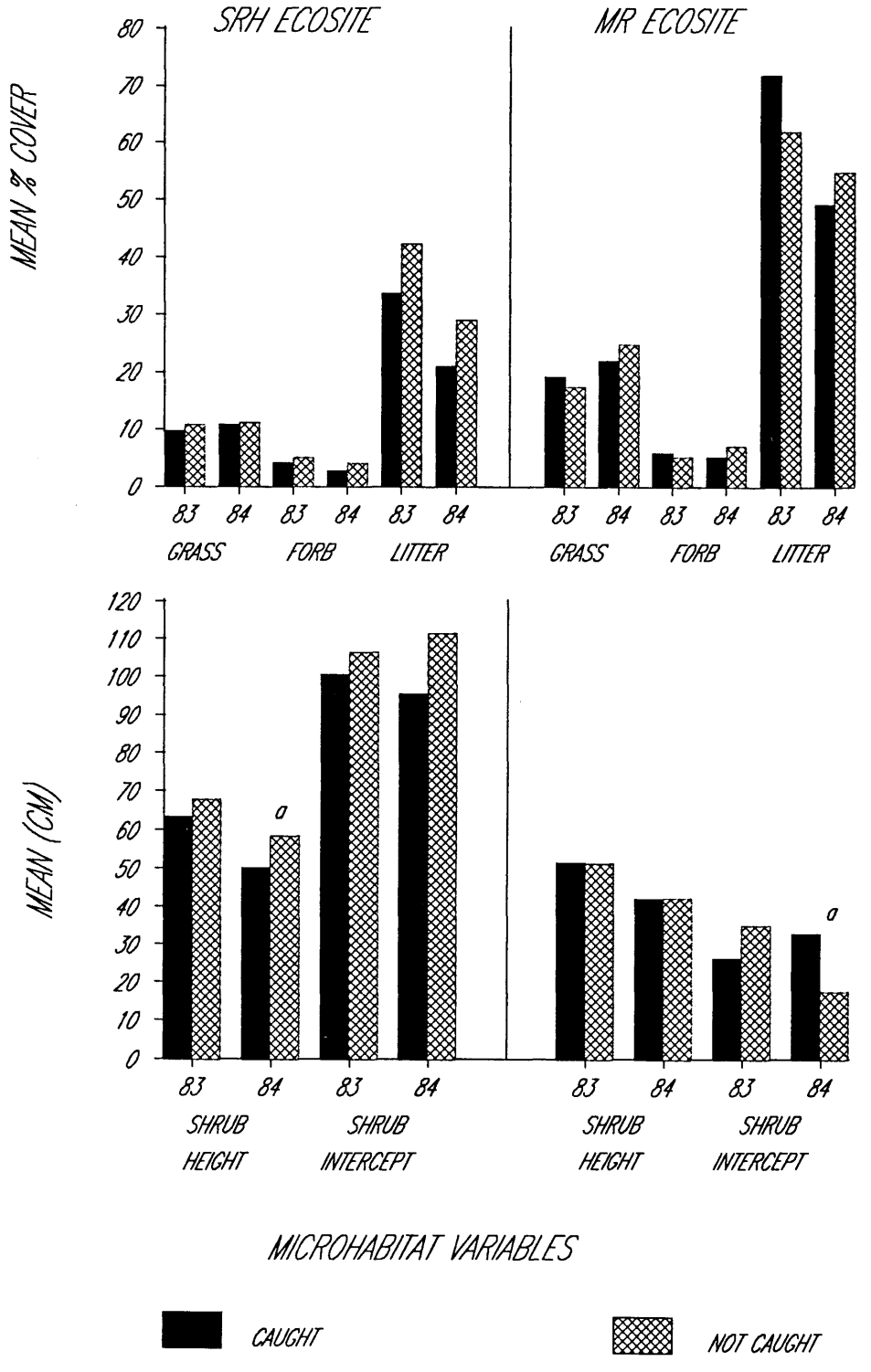

Figure 5.—Microhabitat characteristics around traps where least chipmunks were captured and not captured by year and ecosite, Sheldon National Wildlife Refuge. Variables with an "a" denote a P value of <0.1 between the two areas.

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