Habitat Selection in the Southern Bog Lemming, *Synaptomys cooperi,* and the Meadow Vole, *Microtus pennsylvanicus*, in Virginia

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Habitat of the Southern Bog Lemming (*Synaptomys cooperi*) was compared quantitatively with habitat of the Meadow Vole (*Microtus pennsylvanicus*) in Montgomery County, Virginia. Three study grids were located along a vegetation gradient from deciduous woodland/grass ecotone to old-field habitat. Determination of relative abundance of *Microtus* and *Synaptomys* and analysis of vegetation structure on these grids indicated that *Synaptomys* is found where ground cover is sparse and woody vegetation more abundant. Land-use practices that convert sparsely grassed woodland to pastures would adversely affect *Synaptomys*, although creation of clearings in forested areas would favor this species.

Key Words: habitat, Southern Bog Lemming, *Synaptomys cooperi*, Meadow Vole, *Microtus pennsylvanicus*, discriminant function analysis.

The microtine rodents *Synaptomys cooperi* and *Microtus pennsylvanicus* are sympatric species that are similar in size, appearance, and diet (herbaceous vegetation). *Synaptomys* has been reported from a wide variety of habitats throughout its range, including sphagnum bogs (Howell 1927; Coventry 1942; Poole 1943; Odum 1949; Buckner 1957; Connor 1959), grasslands (Barbour 1956; Gaines et al. 1977), openings in woodlands (Stewart 1943; Smyth 1946; Barbour 1956; Kirkland 1977), and heavily forested areas with non-grass ground cover (Goodwin 1932; Hamilton 1941; Coventry 1942). Although population densities of *Synaptomys* are highest in midwestern grasslands of the United States, studies in that region record the presence of shrubs in areas where *Synaptomys* occurs (Getz 1961; Gaines et al. 1977; Rose and Spevak 1978). Despite these casual observations, habitat characteristics of *Synaptomys* have never been quantitatively defined. On the other hand, the association of *Microtus* with heavy grass cover is well known, as is the fact that *Microtus* usually avoids woodland habitats (Eadie 1953; Getz 1961, 1970; Birney et al. 1976). Ecological relationships of *Synaptomys* are poorly understood in the eastern United States and Canada, where this species occurs in low densities and is infrequently captured. The present study compares vegetational characteristics of *Synaptomys* and *Microtus* habitats in an attempt to quantify patterns of habitat use by these species.

Study Area

The study area is situated above the valley of the North Fork of the Roanoke River (518–533 m), east of Blacksburg, Montgomery Co., Virginia (37° 13′N, 80° 23′W) (Figures 1 and 2). Three 0.25 ha sampling grids (5 m station interval) were established in habitats reflecting a vegetation gradient from deciduous woodland/grass ecotone to an open field with tall dense grass cover (Figure 2). A detailed description of the vegetation is given in Linzey (1981). Physical characteristics of the area, including scattered limestone outcrops and thin topsoil underlain by heavy clays, resemble cedar glades of Wisconsin and Missouri (Kucera and Martin 1957; Curtis 1959). The area is located within the Allegheny Mountain region of Virginia's Ridge and Valley Province (Hoffman 1969).

Two sampling grids were located in habitats dominated by Eastern Red Cedar, *Juniperus virginiana*, and Broomsedge, *Andropogon scoparius* (Figure 2). The Cedar grid was within the deciduous woodland/grass ecotone and had a heterogeneous mixture of microhabitats ranging from grassy patches with little tree canopy to shaded areas with deciduous leaf litter. The Indian Run grid was more homogeneous, with a continuous cover of *Andropogon*, large scattered cedar trees, and a few small deciduous trees and shrubs. The third grid, Layne Field, was in an area that had been converted from *Juniperus/Andropogon* to pasture and then abandoned. It had a dense growth of introduced grasses and a few large cedar trees, but almost no deciduous trees and shrubs.

Materials and Methods

As part of a more extensive study of *Synaptomys*, the Cedar grid was sampled by live trapping from July 1978–June 1979. Trapping was done monthly, with one small Sherman trap per station (98 stations) set for four nights. Although this technique established the presence of *Synaptomys*, six different individuals

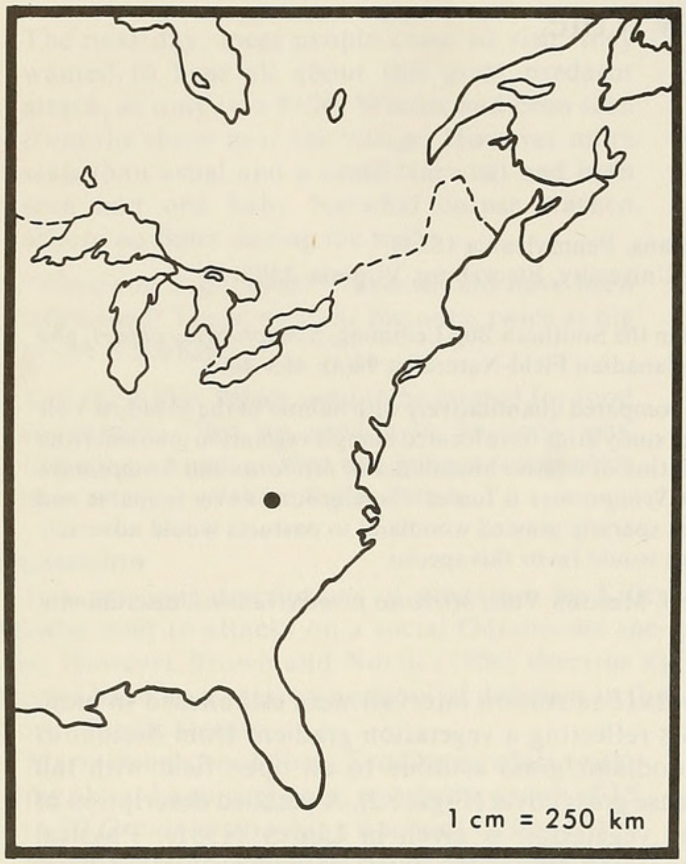

FIGURE 1. Map of eastern United States and southeastern Canada; dot indicates general geographic location of study area.

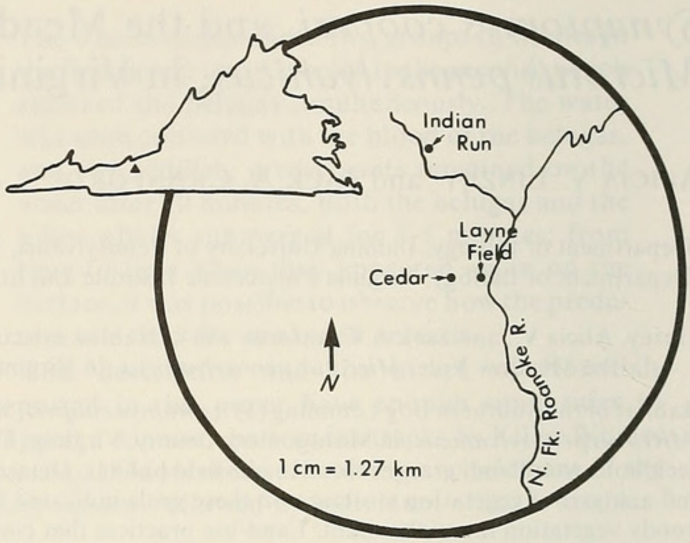

FIGURE 2. Relative location of three study grids. Insert map shows location of study area in southwestern Virginia (triangle).

were captured only 16 times during the sampling year. In contrast, eight different *Microtus* entered live traps 39 times. This differential response to trapping made it necessary to find another sampling technique that (1) would more quickly and reliably assess population density of *Synaptomys*, (2) would give more comparable results for *Microtus* and *Synaptomys*, and (3) could be used intensively without disturbing animal populations. Field testing of dropping boards indicated that they would be an appropriate sampling tool and they were used throughout the remainder of the study. Dropping stations were first employed by Eadie (1948) to collect *Blarina* scats for food habits analysis, and Mossman (1955) used them to assess distribution of *Microtus* relative to cover density. Although the technique was extensively tested by Emlen et al. (1957), it has seldom been used since then.

Dropping boards were cut to fit in runways (exterior plywood, 0.6 by 6.5 by 15 cm). One board was placed at each trap station and one in the center of each square formed by four stations (181 boards per 10 by 10 grid). Boards were cleared every second day (five times during a 10-day sample period) and data were recorded as total number of visits (one visit = one or more droppings on a board during a two-day interval) by each species. Successful use of the dropping board technique depends on accurate identification of scats. *Synaptomys* droppings are distinctively green, but those of *Microtus* are brown or black (Burt 1928; Cockrum 1952; Connor 1959). Also, *Synaptomys* droppings are smaller, blunt at both ends, and deposited singly; those of *Microtus* are blunt at one end, pointed at the other, and often adhere in groups of two to five. The only other small mammal that used the dropping boards was *Blarina brevicauda*, the droppings of which are distinctively amorphous.

The value of dropping boards to index relative population size was demonstrated by Emlen et al. (1957), who found that the number of droppings per board per time interval was a poor index, but that frequency of visits to boards was positively correlated with population size. The relationship between frequency of board use and population size in *Microtus* during the present investigation was determined by conducting 10-day board surveys followed by four-day live trapping sessions. This test involved two different grids in summer and winter ($n = 5$), thus incorporating variation in habitat and season. Population size was estimated by minimum number known alive, MNA (Krebs 1966). Analysis of the relationship between population size and frequency of board visits indicated that the two measures are highly correlated ($r = 0.90$, $y = 10.25 \times + 11.28$, $p < 0.05$). Population density of *Synaptomys* was determined during two tests. In one case, 55 visits to boards were recorded during a ten-day survey period. Six *Synaptomys* were taken during subsequent removal trapping. Similarly, on another grid, live-trapping revealed that five *Synaptomys* were responsible for 59 visits to dropping boards. These estimates indicate that comparisons using the dropping board technique may slightly underestimate *Synaptomys* numbers (4.2 animals predicted by 55 visits; 4.6 animals predicted by 59 visits).

Vegetation analysis consisted of measuring density of ground cover, trees, and shrubs by means of cover estimates and direct counts. Descriptions of variables are given in Table 2. Cover estimates were made during August at peak grass/forb development. Tree/shrub counts were made during two summers (1979, 1980) and were completed before leaf fall. Sampling units were squares formed by grid sampling stations (25 m^2). Sampling intensity was 100% (n = 78) on the Cedar grid and 33% (n = 27, randomly chosen) on the Indian Run and Layne Field study areas.

Cover estimates were obtained by using a 0.5 by 1 m cover board divided into three vertical levels (0–25 cm, 25–50 cm, 50–100 cm), with each level marked off in equal units (M'Closkey and Fieldwick 1975; Schreiber et al. 1976). The board was placed in the center of a grid square in a randomly chosen position. Percentage of area covered was estimated by reading both sides of the board, and final values for each category were obtained by averaging the two sides. Distance from observer to board was standardized at 75 cm because on the grid with densest ground cover this resulted in values consistently below 100%. This technique was designed primarily to quantify grass/forb cover and was less efficient as an estimator of tree/shrub density. Hence, direct counts of trees and shrubs in several height classes were also made on each sampled square. Shrub counts were based on numbers of vertical stems. When density of blackberries (including dewberries, *Rubus* sp.) exceeded 100 stems/square, the square was assigned a value of 100.

Statistical tests for normality indicated that nearly all variables showed significant skewness and/or kurtosis, although distributions of all variables were unimodal. Data were not transformed because of a preponderance of zero values for some variables. Discriminant function analysis (DFA) was used as a statistical tool to detect habitat differences between study grids. A stepwise routine (SPSS STEPWISE) selected variables that, in linear combination, contributed most to group separation (Nie et al. 1975). However, due to violations of assumptions of normality and homogeneity of within-group variance-covariance matrices, a formal test of no difference in habitat is not statistically valid (Green 1979). Duncan's multiple range test was used to detect statistically significant differences in individual variable means.

Results

Dropping board indices of population density in *Microtus* indicated that *Microtus* was least abundant on the Cedar grid and most abundant on the Layne Field (Table 1). *Microtus* had been present on the Cedar grid during the first six months (July 1978–January 1979) of live-trapping, but was not caught after January 1979. Absence of *Microtus* from the Cedar grid during spring and summer 1979 and subsequent recolonization, reflected an area wide four-year population cycle. *Microtus* populations in optimal habitat reached maximum densities of 398/ha in October 1978 and declined to 27/ha in March 1979 (Cranford, unpublished data). Regardless of the status of the *Microtus* population, *Synaptomys* was most abundant on the Cedar grid, rare at Indian Run, and absent from the Layne Field. However, a decline in *Synaptomys* numbers on the Cedar grid between 1979 and 1980 coincided with the increase in *Microtus* density (Table 1).

A comparison of vegetation characteristics of habitat where *Synaptomys* was most abundant (Cedar grid) with habitat where *Microtus* was most abundant (Layne Field) reveals significantly less grass cover and significantly more small and medium height trees, small shrubs (both categories) and large shrubs (other than *Rubus*/*Rosa*) in the *Synaptomys* habitat (Table 2). Means for these variables at Indian Run were either intermediate or similar to the Layne Field. The abundance and height of forbs reflected openness of the habitat. Forbs were sparse on the Cedar grid and remained small in this semi-shaded habitat. Small and medium height forbs were abundant at Indian Run, and tall forbs dominated the Layne Field. The large

Table 1. Number of visits to dropping boards during two ten-day sample periods in summer 1979 and summer 1980 (boards cleared every two days). Number of board units (one board unit = one board set for two days) indicates sampling intensity.

		1979		1980	
Grid	Board Units	*Microtus*	*Synaptomys*	*Microtus*	*Synaptomys*
Cedar	880	0	59	27	24
Indian Run	905	55	0	47	3
Layne Field	905	444	0	360	0

TABLE 2. Sample estimates of the means and standard errors (in parentheses) for habitat variables on three study grids (n = number of squares). Means not differing significantly are designated by the same letter (Duncan's multiple range test, $p > 0.05$).

	Cedar Grid n = 78	Indian Run n = 27	Layne Field n = 27
% Cover		0-25 cm high	
Grass	b 53.7 (3.34)	a 76.7 (5.45)	a 90.6 (2.60)
Forb	b 3.4 (0.47)	a 9.6 (3.58)	b 3.5 (1.26)
Shrub	a 3.1 (0.56)	b 0.6 (0.41)	b 1.2 (1.03)
Tree	ab 2.2 (0.53)	b 0.4 (0.29)	b 0.0 (0.00)
		26-50 cm high	
Grass	c 5.1 (0.66)	b 19.0 (2.51)	a 45.9 (5.02)
Forb	c 1.4 (0.28)	a 19.1 (4.82)	b 7.1 (1.68)
Shrub	a 3.2 (0.70)	a 7.5 (0.58)	a 2.2 (1.65)
Tree	a 3.6 (0.73)	ab 2.2 (0.93)	b 0.0 (0.00)
		51-100 cm high	
Grass	c 0.2 (0.04)	b 1.6 (0.26)	a 7.4 (1.07)
Forb	c 0.4 (0.18)	b 5.6 (1.95)	a 9.1 (1.91)
Shrub	a 1.0 (0.46)	a 0.1 (0.09)	a 0.1 (0.06)
Tree	a 6.8 (1.06)	ab 4.4 (1.61)	b 0.3 (0.28)
Number of Trees		< 1 m high	
Deciduous	a 13.0 (1.93)	b 1.7 (0.55)	b 0.5 (0.20)
Evergreen	a 10.2 (1.09)	b 1.2 (0.49)	b 0.0 (0.04)
		1-4 m high	
Deciduous	a 8.0 (2.00)	b 1.2 (0.57)	b 0.1 (0.08)
Evergreen	a 6.4 (0.57)	b 1.6 (0.37)	b 0.5 (0.13)
		> 4 m high	
Deciduous	a 0.2 (0.09)	a 0.0 (0.04)	a 0.0 (0.00)
Evergreen	ab 1.2 (0.12)	bc 0.8 (0.18)	c 0.1 (0.07)
Number of Shrubs		< 0.5 m high	
Rubus/Rosa	a 94.6 (1.55)	b 41.2 (6.47)	c 18.3 (6.21)
Other	a 15.1 (3.27)	b 0.2 (0.11)	b 0.0 (0.00)
		> 0.5 m high	
Rubus/Rosa	b 0.6 (0.34)	a 4.5 (2.34)	a 8.2 (3.01)
Other	a 6.1 (1.72)	b 0.2 (0.12)	b 0.1 (0.05)

Rubus/Rosa shrub category was composed mostly of tall blackberry canes (*Rubus allegheniensis*), which were least abundant on the shady Cedar grid and most abundant on the open Layne Field.

Discriminant function analysis of vegetation data indicated that 13 variables contributed significantly to separation of the three habitats (Table 3). Discriminant function 1 explained most of the variance (91.86%); variables contributing most to this function were grass cover (low, medium, high), forb cover (medium and high), and *Rubus/Rosa* shrubs (both heights). The general tendency expressed by the signs (+ or −) of the discriminant function coefficients was

TABLE 3. Summary of stepwise discriminant function analysis comparing Cedar, Indian Run, and Layne Field habitats.

	Discriminant Functions #1	#2
Eigenvalue	8.94358	0.79236
% Variance	91.86	8.14
Chi-square Statistic	349.98	70.90
Significance	0.0	0.0
Degrees of Freedom	28	13
Variable	Standardized DF Coefficient #1	#2
Grass 0–25 cm	0.29742	-0.48232
Grass 26–50 cm	0.26879	-0.00553
Forb 26–50 cm	0.45465	-1.09392
Shrub 26–50 cm	0.22820	-0.03259
Tree 26–50 cm	0.24552	-0.35107
Grass 51–100 cm	0.31612	0.58029
Forb 51–100 cm	0.15697	0.69754
Shrub 51–100 cm	-0.25083	0.03993
Deciduous trees < 1 m	-0.19220	0.21029
Deciduous trees 1–4 m	-0.26094	0.13019
Evergreen trees 1–4 m	-0.60062	0.39522
Rubus/Rosa shrubs < 0.5 m	-0.83015	0.08361
Rubus/Rosa shrubs > 0.5 m	0.49780	0.15380

Classification Matrix

Actual Group	n	Predicted Group Membership (%) Cedar	Indian Run	Layne Field
Cedar	78	100.0	0.0	0.0
Indian Run	27	7.4	85.2	7.4
Layne Field	27	0.0	7.4	92.6

an inverse relationship between ground cover and tree/shrub cover. A scatterplot of discriminant scores for each study grid shows that *Synaptomys* habitat (Cedar grid) is well segregated from *Microtus* habitat (Indian Run, Layne Field) (Figure 3). Conversely, individual sample squares were assigned to the correct grid with a high degree of accuracy (85.2–100%) (Table 3), indicating that the variables selected can be used to predict species' occurrence in a given habitat type.

Discussion

The results of this study demonstrate that *Synaptomys*, in comparison with *Microtus*, is found in habitats having more woody plants and sparser grass cover. The *Juniperus/Andropogon* habitat (Cedar grid) frequented by *Synaptomys* in this study supported extremely low densities of *Microtus*, a reflection of poor cover conditions and of the fact that *Andropogon* is a poor food for *Microtus* (Cole and Batzli 1979). The Layne Field, where *Andropogon* has

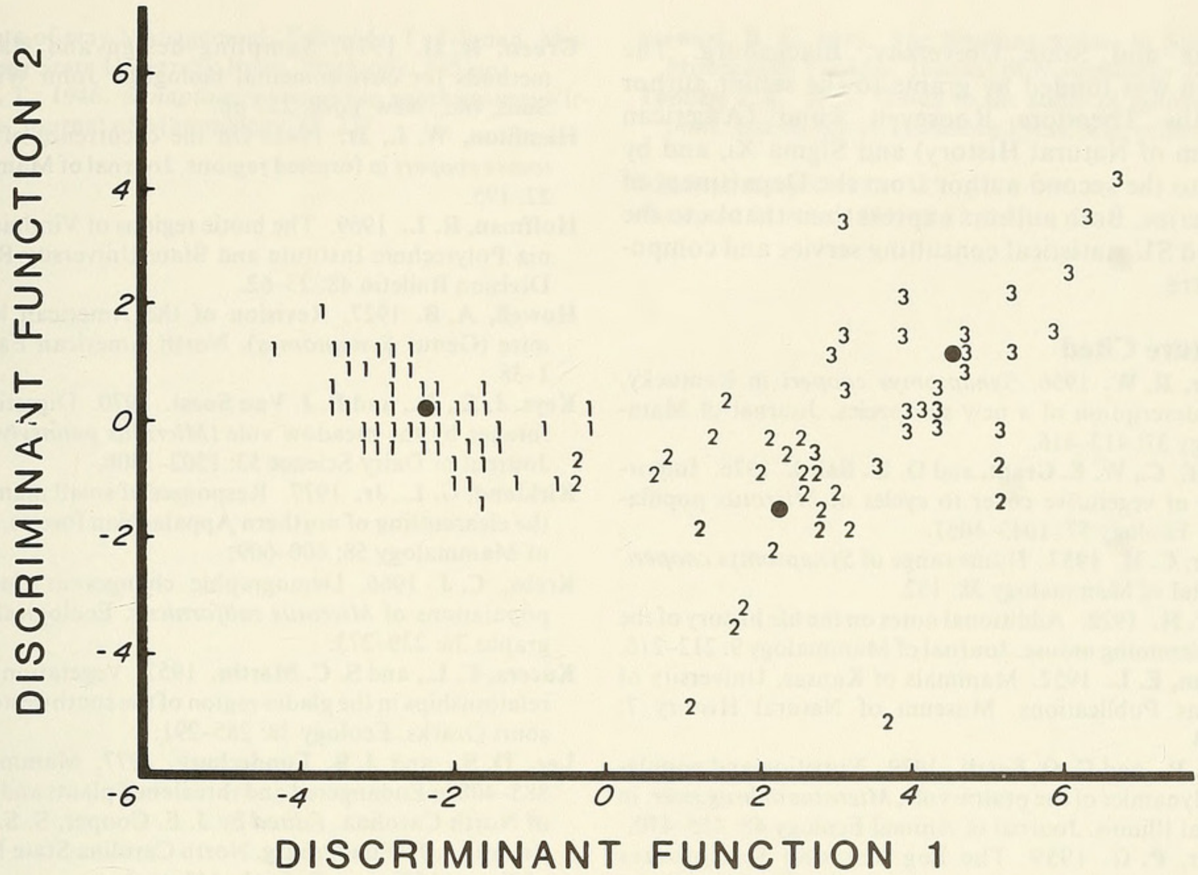

FIGURE 3. Scatterplot of discriminant function scores for each habitat. 1 = Cedar Grid; 2 = Indian Run Grid; 3 = Layne Field Grid. Dots indicate location of group centroids.

been replaced by introduced grasses and where forbs are also present, provides the best *Microtus* habitat. The fact that *Synaptomys* attains greater densities in the central plains states of the United States (Gaines et al. 1977, 1979) suggests that low densities in the eastern United States and Canada are not due to intrinsically lower reproductive rates, but may reflect poorer cover and food resources that are lower in digestible energy and nutrients.

Habitat selection by *Synaptomys* might result from either preference or availability. Concurrent removal experiments and observations of *Synaptomys* microhabitat during a *Microtus* population cycle indicate that *Synaptomys* prefers habitats normally occupied by *Microtus*, but gains access only to extremely poor *Microtus* habitats during the low phase of the *Microtus* population cycle (Linzey 1984). Even habitats of marginal quality for *Microtus* (Indian Run) are unavailable to *Synaptomys* if *Microtus* maintains minimal densities. Studies indicating that *Microtus ochrogaster* is behaviorally dominant to *Synaptomys* (Rose and Spevak 1978) and that the rate of dispersal by *Synaptomys* increases with increasing *Microtus* density (Gaines et al. 1979) provide additional support for the contention that distribution of *Synaptomys* is affected by competition with *Microtus*. These observations emphasize the need for careful qualification when describing habitat "preferences" of any species.

Quantification of habitat affinities of *Synaptomys* is of particular interest because of concern regarding the status of this species in several parts of its range. *Synaptomys* is referred to as rare in the Appalachian region (Kirkland 1977) and given the status of "special concern" in North Carolina (Lee and Funderburg 1977). The race inhabiting the Great Dismal Swamp of coastal Virginia and North Carolina (*S. c. helaletes*) was only recently "rediscovered" after a collecting hiatus of 82 years (Rose 1981). It is clear that the distribution of *Synaptomys* can be affected by human activities. Land use practices that convert open woodlands to pastures and that replace native grasses with introduced species will favor *Microtus*. However, the creation of clearings (clearcuttings, powerline rights-of-way) in the midst of extensive forested habitats will favor *Synaptomys*, especially if the probability of colonization by *Microtus* is low.

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