Wetlands Ecology and Management **7:** 219–224, 1999.

Microhabitat selection by small mammals in a southern Appalachian fen in the USA

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Received 1 July 1998; accepted in revised form 5 April 1999

Key words: fen, microhabitat, North Carolina, *Ochrotomys*, *Peromyscus*, southern Appalachians, small mammals, wetlands

Abstract

Little ecological information is available on small mammals inhabiting wetlands in the southern Appalachian mountains of the USA. These wetland systems are becoming rare features in southern landscapes due to human activities. We investigated the small mammal fauna and examined the microhabitat associations of the two most abundant species in a southern Appalachian fen. Four species of small mammals were captured: the meadow jumping mouse (*Zapus hudsonius*), short-tailed shrew (*Blarina brevicauda*), white-footed mouse (*Peromyscus leucopus*), and golden mouse (*Ochrotomys nuttalli*). *Peromyscus* and *Ochrotomys*, which were caught in the largest numbers, preferred sites characterized by moderate herbaceous cover and substantial canopy closure. *Peromyscus*, however, selected areas with greater canopy closure and higher tree densities, suggesting that they are greater habitat specialists than *Ochrotomys* in this wetland community.

Introduction

Mountain fens are rare wetland communities in the southern Appalachians of the United States, with fewer than 500 remaining in the Appalachian Highlands (Moorhead and Rossell, 1998). Losses and degradation have occurred due to highway construction, residential and recreational development, and industrial and agricultural activities (Murdock, 1994). These wetland systems are very unique, differing from their northern counterparts in that peat deposits are shallower, and plant communities include southern Appalachian species, as well as disjunct coastal plain species (Moorhead and Rossell, 1998).

There is great interest in conserving and restoring the remaining southern mountain fens, in part because of their role in providing habitat for common as well as rare species of wildlife. Other research has shown that small wetlands are important for maintaining biodiversity and habitat connectance across landscapes (Semlitsch and Bodie, 1998). However, virtually no information is available on how southern mountain wetlands are utilized by wildlife, because few comprehensive faunal surveys have been conducted (Boynton, 1994; Moorhead and Rossell, 1998). To better understand the use of these systems by wildlife, we investigated the small mammal fauna in a remnant southern Appalachian fen, and examined the microhabitat associations of the most abundant species.

Methods

Study area

Our study site was a remnant 1-ha depressional fen located in the Tulula Creek floodplain in Graham County, North Carolina (elev. 800 m). Although this site is known locally as Tulula Bog, the term ‘bog’ is a misnomer. Based on its soils, hydrology, and plant composition, Tulula Bog more closely fits the description of a fen (Moorhead and Rossell, 1998). Nevertheless, this site has been classified as a forest-gap bog complex by the North Carolina Natural Heritage Pro-

Table 1. Sampling procedures for measuring microhabitat variables in each of 50, 10 × 10 m plots in a western North Carolina fen.

Variable	Method
Herbaceous cover	Mean cover (%) of foliage < 0.5 m estimated at nine points using 0.25-m^2 quadrat.
Shrub thickness	Mean cover (%) of vegetation 0.5–2 m sampled at nine points using shrub-profile board (Hays, 1981).
Canopy closure	Mean canopy closure (%) sampled at nine points using concave spherical densiometer (Hays, 1981).
Woody debris	Total length (m) of logs > 10 cm diameter.
Microtopography	Percent of nine sample points designated as flat, hummock, or hollow.
Moss	Percent of nine sample points covered by moss.
Shrub density	Total stem count (stems/100 m^2) of woody species 2.5–10 cm dbh, measured in a 4 × 4 m plot.
Tree density	Total stem count (stems/100m^2) of trees > 10 cm dbh in a 10 × 10 m plot.

gram (Schafale and Weakley, 1990). A comprehensive description of the flora, fauna, soils, and hydrology at this site can be found in Rossell et al. (1999).

The study site is divided approximately equally into closed and open canopy regions. The closed canopy region is dominated by red maple (*Acer rubrum*), with black gum (*Nyssa sylvatica*) and white pine (*Pinus strobus*) interspersed throughout. Shrubs include elderberry (*Sambucus canadensis*), tag alder (*Alnus serrulata*), winterberry (*Ilex verticillata*), and red and black chokeberry (*Sorbus arbutifolia* and *S. melanocarpa*). Other important species include swamp dewberry (*Rubus hispidus*), cinnamon fern (*Osmunda cinnamonea*), tussock sedge (*Carex stricta*), and peat mosses (*Sphagnum* spp.). The open canopy region is at an earlier stage of succession, and is dominated by red maple saplings, tag alder, elderberry, and red and black chokeberry. Dominant herbs include soft rush (*Juncus effusus*), tussock sedge, and peat mosses. Soils are classified as Nikwasi loam (Typic Fluvaquents) (United States Department of Agriculture, 1995).

Small mammal sampling

We established a grid of 10 × 10 m plots (N = 93) throughout the fen. A Sherman live trap (7.6 × 7.6 × 25.4 cm) was placed near the center of each of 50 randomly selected plots (25 in each canopy region). Traps were baited with rolled oats to minimize lure effects and ensure that only animals using the plot were sampled (Dueser and Shugart, 1978). To avoid the effects of seasonal microhabitat shifts, trapping was limited to the summer months (Kitchings and Levy, 1981), and occurred during 3-day trap sessions held at 1–2 week intervals between 26 June and 3 August 1995. Traps were set daily between 1600 and 1700 h, and checked between 0700 and 1000 h the following day. Due to the high water table across the site, we were unable to use pitfall traps as part of the survey efforts. Captured animals were identified to species, sexed, marked (by making a stripe the length of their bellies with a permanent marker), and released at the capture site.

Microhabitat sampling

Microhabitat characteristics in the 50 plots were measured between 20 June and 25 July 1995. Microtopography (hummock, hollow, or flat), herbaceous cover, presence of moss, understory thickness, and canopy closure were determined at 9 points along two diagonal transects within each plot. Overstory and understory tree density and the total length of logs were measured in each plot. Sampling procedures used for each variable are provided in Table 1.

Data analysis

Because of sample size constraints, microhabitat associations were examined for only the two most abundant species, the white-footed mouse (*Peromyscus leucopus*) and golden mouse (*Ochrotomys nuttalli*). Each of the 50 plots was assigned to one of three types: those in which *Peromyscus* were captured, those in which *Ochrotomys* were captured, or those in which neither species was captured. Eight plots were included in two groups because they were capture sites of both species. Consequently, the analysis is conservative for distinguishing differences in microhabitat variables between plot types (Dueser and Shugart,

Table 2. ANOVA results comparing microhabitat variables in a western North Carolina fen for three types of plots: those where *Peromyscus* were captured, those where *Ochrotomys* were captured, and those where neither species was captured (alpha = 0.003).

Variable	F	P>F
Herbaceous cover	12.1	0.0001
Shrub thickness	0.3	0.7103
Overstory cover	15.5	0.0001
Woody debris	3.5	0.0366
Flat	0.0	0.9777
Hollow	1.1	0.3464
Hummock	0.2	0.8094
Moss	3.9	0.0257
Shrub density	0.4	0.6601
Tree density	8.3	0.0007

1978). Plot type was used as the independent variable in all analyses.

An analysis of variance (ANOVA) was used to compare the three plot types for each of the ten microhabitat variables. If a significant difference occurred, then Tukey's multiple comparison procedure was used to determine which plot types differed (Zar, 1974). A Bonferroni-type adjustment of the alpha level was used because multiple comparisons were made (Tabachnik and Fidell, 1989). The experiment-wise error rate was set at 0.1, with a comparison-wise error rate (alpha level) of 0.003. A discriminant function analysis was performed to determine which microhabitat variables best distinguished the three groups. This technique identifies linear combinations of variables (canonical variates) that differentiate among groups (Williams, 1983). Statistical Analysis System (SAS) programs were used for all analyses (SAS Institute Inc., 1990).

Results

A total of 92 captures of four species occurred during 432 trap nights. These included 3 captures of 3 meadow jumping mice (*Zapus hudsonius*), 5 captures of 4 short-tailed shrews (*Blarina brevicauda*), 39 captures of 10 *Peromyscus*, and 45 captures of 13 *Ochrotomys*.

The results of the ANOVA comparing the ten microhabitat variables among the three plot types are presented in Table 2. None of the variables differed significantly between the two types of mouse plots (Table 3). Both types of mouse plots were characterized by significantly less herbaceous cover and significantly more canopy closure than no-capture plots. Overstory tree density was significantly greater in *Peromyscus* plots than in no-capture plots.

Two canonical variables resulted from the discriminant function analysis. The first variable had a canonical correlation of 0.6783 and accounted for 91.0% of the variability. The second canonical variable had a correlation of 0.2784 and accounted for 9.0% of the variability.

The first canonical variable (Can1) had a high positive loading for herbaceous cover and high negative loadings for canopy closure and tree density (Table 4). The second canonical variable (Can2) had no well-defined interpretation but had the highest positive loadings for canopy closure, moss, hummock, and hollow. In a plot of the discriminant analysis, Can1 separated the three groups along the x-axis, but Can2 provided little separation along the y-axis (Figure 1).

Discussion

In general, the species richness in this fen was similar to that reported in eastern Tennessee upland forests (Dueser and Shugart, 1978; Kitchings and Levy, 1981), but greater than that reported in a Tennessee cedar glade (Seagle, 1985a). However, our study no doubt underestimated the faunal richness at the site, because we did not use pitfall traps or snap traps.

Zapus was the most notable species encountered in our study. It is currently listed on the North Carolina Animal Watch List (LeGrand, 1995) and is relatively rare or uncommon throughout the southern Appalachian mountains (Webster et al., 1985). It forages among weeds and grasses for insects, berries, seeds and fungi (Webster et al., 1985). The three individuals encountered during this study were captured in relatively wet plots with extensive herbaceous cover (x = 73.3%) and few or no canopy trees. This sort of habitat is consistent with what is reported for this species (Webster et al., 1985).

Four *Blarina* were captured in three plots. This species is one of the most abundant small mammals in the southern Appalachians (Webster et al., 1985). It is a semi-fossorial insectivore that occurs in many types of habitats, especially those with a thick layer of leaf litter (Webster et al., 1985). The small number of

Table 3. Means (± SD) of microhabitat variables in a western North Carolina fen for three types of plots: those where *Peromyscus* were captured (P), those where *Ochrotomys* were captured (O), and those where neither species was captured (N).

Variable	Plot type		
	P	O	N
Sample size (N)	15	23	20
Herbaceous cover (%)	65.7 ± 9.3b	70.1 ± 12.4b	82.5 ± 9.6a
Shrub thickness (%)	33.3 ± 12.4	35.5 ± 11.8	37.4 ± 18.0
Overstory cover (%)	92.7 ± 3.5a	73.0 ± 28.5a	48.1 ± 26.4b
Woody debris (m)	10.8 ± 12.6	7.7 ± 12.1	2.0 ± 3.4
Flat (%)	22.0 ± 14.2	22.6 ± 17.1	21.5 ± 19.0
Hollow (%)	8.7 ± 8.3	7.8 ± 8.0	12.0 ± 12.0
Hummock (%)	69.3 ± 12.8	65.2 ± 21.7	66.5 ± 19.8
Moss (%)	41.3 ± 21.3	41.7 ± 22.7	58.0 ± 19.4
Shrub density (no./100m^2)	30.0 ± 30.5	27.5 ± 29.4	38.8 ± 57.6
Tree density (no./100m^2)	4.8 ± 3.1a	3.2 ± 3.9ab	0.7 ± 1.6b

Note: Values followed by the same or no letter are not significantly different across rows at $P > 0.003$.

Table 4. Canonical coefficients for microhabitat variables in a western North Carolina fen.

Variable	Can1	Can2
Herbaceous cover	0.7072	0.1607
Shrub thickness	0.1421	–0.1625
Canopy closure	–0.8076	0.3437
Woody debris	–0.3601	–0.0312
Flat	0.0077	–0.1477
Hollow	0.1824	0.3090
Hummock	–0.0635	0.3183
Moss	0.3380	0.4558
Shrub density	0.1195	0.1776
Tree density	–0.5941	0.1246

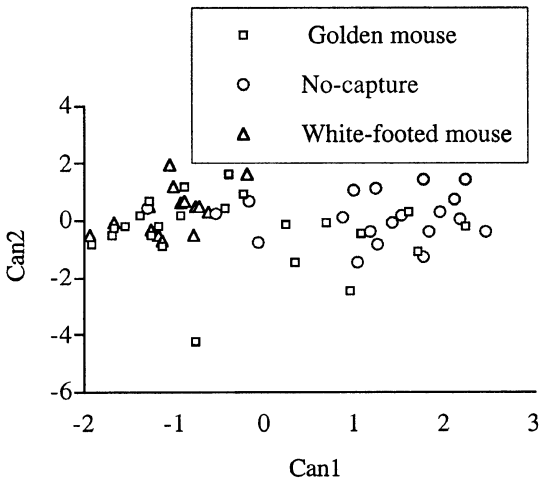

Figure 1. Discriminant analysis of the 10 microhabitat variables for sample plots where either: *Peromyscus* were captured, *Ochrotomys* were captured, or neither species was captured. Can1, from left to right, is a gradient from high canopy closure and tree density, to high herbaceous cover. Can2, from bottom to top, represents a combination of variables, including shrub thickness and microtopography, to herbaceous cover and canopy closure.

Blarina captured may not accurately reflect the relative abundance of this species in the wetland, because insectivores are difficult to capture in live traps (Rose et al., 1990). The plots in which *Blarina* were captured were characterized by dense canopy closure (> 88%), consistent with Kitchings and Levy (1981), who reported routine captures of *Blarina* under a dense upland overstory in Tennessee.

Peromyscus and *Ochrotomys* accounted for 91% of all captures at our study site. These species were also reported as the most abundant small mammals in the Great Dismal Swamp in Virginia and North Carolina (Rose et al., 1990). In our study, *Peromyscus* and *Ochrotomys* both occurred in plots with moderate herbaceous cover (x = 66% and 70%) and relatively high canopy closure (x = 93% and 73%) (Table 3). No *Peromyscus* were captured in open areas of the fen. Other studies also have reported that *Peromyscus* selected wooded rather than open areas (Getz, 1961; M'CLoskey and LaJoie, 1975; Kitchings and

Levy, 1981; Kaufman et al., 1983), possibly to avoid predators (Kaufman et al., 1983; Barnum et al., 1992).

We found that microhabitat variables such as understory density and thickness, moss cover, microtopography, and total length of logs had no significant influence on plot selection by either species of mouse. These results differ from those of Kaufman et al. (1983) who reported that a well-developed shrub layer played a major role in habitat use by *Peromyscus*. They also differ from Seagle (1985a), who reported that fallen logs were an important cover component for both *Peromyscus* and *Ochrotomys*.

In deciduous forests, *Peromyscus* are considered habitat generalists (King, 1968), while *Ochrotomys* are considered greater specialists (Linzey and Packard, 1977). These patterns of habitat use are supported by other studies in deciduous forests (Dueser and Shugart, 1978; Kitchings and Levy, 1981; Seagle, 1985a). In a structurally complex cedar glade, however, Seagle (1985a) found that *Peromyscus* were habitat specialists, selecting areas with greater tree densities, while *Ochrotomys* were greater generalists. A similar pattern occurred in our study, where *Peromyscus* were more selective than *Ochrotomys*, tending to occur in areas with greater canopy closure and higher tree densities (Figure 1).

Possible explanations for the different microhabitat preferences of *Peromyscus* and *Ochrotomys* include competition between the two species (Seagle, 1985b), the occurrence of predators within the wetland, or the distribution of food items preferred by each species. Knuth and Barrett (1984) reported that the diets of *Ochrotomys* were more general than those of *Peromyscus*. They attributed this in part to the larger cheek pouches of *Ochrotomys*, which they suggested may allow *Ochrotomys* to forage farther from nests or feeding platforms. *Ochrotomys* feed primarily on seeds and invertebrates (Linzey, 1968; Linzey and Packard, 1977), whereas *Peromyscus* feed largely on seeds, nuts, and acorns, but few invertebrates (Getz, 1961).

The results of this study may help guide conservation and restoration efforts in southern mountain wetlands by showing how two species have utilized the variety of habitats available in a structurally complex system. In managing this type of wetland, it would be important to maintain a dense overhead canopy for *Ochrotomys* and *Peromyscus*, as well as open herbaceous areas for the small population of *Zapus* found at the site.

Acknowledgments

We thank K. Hining, F. Mauney, and K. Riddle for field assistance. S. Seagle and four anonymous reviewers provided helpful comments on this manuscript. This research was funded by the Center for Transportation and the Environment.

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