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TREE COMMUNITIES, MICROHABITAT CHARACTERISTICS, AND SMALL MAMMALS ASSOCIATED WITH THE ENDANGERED ROCK VOLE, *MICROTUS CHROTORRHINUS*, IN VIRGINIA

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ABSTRACT - We located the endangered rock vole, *Microtus chrotorrhinus*, at 3 of 59 sites in mixed mesophytic forests in the southern Appalachians. Rock voles were always found within mixed mesophytic habitats characterized by yellow birch, *Betula alleghaniensis*, rather than mixed mesophytic habitats dominated by other tree species. We compared the tree communities, microhabitat features, and small mammals found within three groups of habitats: sites where *M. chrotorrhinus* was found, yellow birch habitats where *M. chrotorrhinus* was not found, and other mixed mesophytic habitats where *M. chrotorrhinus* was not found. Sites occupied by *M. chrotorrhinus* had greater amounts of large, rocky substrate, greater incidence of moss, and a more northwest aspect than yellow birch and other mixed mesophytic sites without *M. chrotorrhinus*. Moreover, sites with rock voles had larger trees and were significantly older than sites without *M. chrotorrhinus*. Red-backed voles, *Clethrionomys gapperi*, are readily sampled by live-trap methods and were significantly more abundant at sites with *M. chrotorrhinus*, and may thus be a promising indicator species. Our results suggest that mixed mesophytic forests, especially older stands dominated by yellow birch and rocky substrate, should be managed with care to preserve *M. chrotorrhinus* habitat.

INTRODUCTION

The rock vole, *Microtus chrotorrhinus*, is an endangered species in Virginia (Roble 2001). *Microtus chrotorrhinus* is a boreal rodent whose geographic distribution extends from eastern Canada south along the Appalachians to North Carolina and Tennessee (Kirkland and Jannett 1982). Populations of *M. chrotorrhinus* may be adversely affected by natural and anthropogenic habitat fragmentation and destruction (Pagels 1990), which may be further compounded by relatively low reproductive output (Kirkland and Jannett 1982). Thus, identifying and conserving existing *M. chrotorrhinus* in Virginia is a critical component of successful conservation of this species (Pagels et al. 2002).

In his overview of trends in distribution and diversity of Virginia mammals, Handley (1992) described *M. chrotorrhinus* as a high- to

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medium-boreal species that occurs in isolated, relict populations and in danger of extirpation. Despite many years of sampling in Virginia's mountains (Handley 1992, Handley and Pagels 1991, Kalko and Handley 1993, Mitchell et al. 1997, Pagels et al. 1994), the known distribution of the rock vole in Virginia is limited to three localities (Orrock et al. 1999, Pagels 1990). We use data collected during a large-scale small mammal sampling study (Orrock et al. 2000) to evaluate the characteristics of *M. chrotorrhinus* habitat in the southern Appalachians of Virginia. We complement previous accounts (Orrock et al. 1999, Pagels 1990, Pagels et al. 2002) by providing quantitative comparisons of the tree communities and small mammal communities associated with *M. chrotorrhinus*. Moreover, we build upon previous accounts by examining the microhabitat components associated with *M. chrotorrhinus*, providing a more complete picture of *M. chrotorrhinus* habitat requirements to aid location and conservation of existing habitat.

Because mixed mesophytic habitats are readily separated from other forest types in the southern Appalachians based upon tree species (Eyre 1980, Orrock et al. 2000), we did not compare microhabitat features between mixed mesophytic and other forest types. Rather, we compared microhabitat and small mammal communities within specific subsets of mixed mesophytic habitats. Orrock et al. (2000) further divided mixed mesophytic habitats into six different habitat types based upon tree species. Of these six types, *M. chrotorrhinus* has only been found in one type: habitats dominated by yellow birch, *Betula alleghaniensis*. As such, we compared three groups of habitats: sites where *M. chrotorrhinus* was found (hereafter called rock vole sites), yellow birch habitats, and the remaining five mixed mesophytic forest types (hereafter called mixed mesophytic sites). Our aim was to identify the habitats and small mammals that are indicative of *M. chrotorrhinus* habitat to provide the information necessary to identify and conserve habitat for the endangered rock vole in Virginia.

Our study had two objectives: 1) describe the habitat of the endangered rock vole using the most thorough data set available; and 2) evaluate the characteristics of habitats where the rock vole was found to determine if specific habitat characteristics and small mammal species are indicative of rock vole habitat.

METHODS

Between May and September in 1996 and 1997, we sampled small mammals in a 160 km^2 portion of the George Washington and Jefferson National Forests in the southern Appalachian Mountains between 38°28'–38°02'N and 79°40'–79°50'W, near Mountain Grove and Monterey, Virginia. This sampling was part of a larger project that sampled 349 sites (see Orrock et al. 2000). Because rock voles were only found within mixed mesophytic habitats (Orrock et al. 1999), we restrict our analysis to the 59 mixed mesophytic sites. All sites were at least 250 m apart and at least 20 m from the edge of the given habitat type.

In May 1999, we revisited several of these sites, and captured an additional *M. chrotorrhinus* at one site where none had previously been caught during our 1996–1997 effort. The new site was approximately 300 m from one of two localities where we had previously captured *M. chrotorrhinus* (Orrock et al. 1999). In all analyses, we consider this site to be classified as rock vole habitat, although one *M. chrotorrhinus* was not detected during the time when the tree, microhabitat, and small mammal data were collected (1996–1997).

Each site was a circular area, 22 m in diameter, with trap stations established within the site at each cardinal direction. Two 8 x 9 x 23 cm Sherman live traps (H.B. Sherman Traps, Inc., Tallahassee, FL) were placed at likely capture spots within a 2 m radius extending from the site perimeter towards the center. A single 21 x 21 x 62 cm Tomahawk live trap (Tomahawk Live Trap Company, Tomahawk, WI) was placed within each site. Sherman live traps were baited with whole oats covered with either peanut butter or peanut oil. Tomahawk traps were baited with sunflower seeds. Synthetic bedding material was placed in all traps, and traps were covered with a roofing shingle or leaf litter to provide shelter. A pitfall array was installed within each sample site consisting of a center pitfall surrounded by three other pitfalls spaced 1 m from the center (Type 1B of Handley and Kalko 1993). Each 0.5-liter pitfall was connected to the center pitfall by a drift fence made of a 0.3 m high aluminum screening. Pitfalls were filled with approximately 5 cm of water during trapping and were closed after use.

A seven-day trap session was conducted at each site; a typical session included 30 sites of various habitat types. Pitfall traps were open for seven consecutive days; live traps were pre-baited for two days and then opened for five consecutive days. All traps were checked daily for captures and live traps rebaited as necessary. Specimens were marked with a No.1 monel ear-tag (National Band and Tag Co., Lexington, KY), and species, sex, age, and weight recorded before release. Dead specimens were injected with 10% formalin solution and deposited in the Virginia Commonwealth University Mammal Collection.

Quantification of Habitat Characteristics

At each site, slope was determined using a Suunto PM-51360 clinometer, and aspect determined with a compass by estimating the direction water would flow from the center of a site (Table 1). Diameter at breast height (dbh) was recorded for all trees, defined as woody plants with a dbh greater than 0.04 m and height greater than 1 m. We identified and counted all shrubs (woody plants not classified as trees) within each site (Table 1). Canopy openness, ground cover, and substrate composition were determined using the line-transect method of Canfield (1941). Along two transects within each site, we tallied observations in the following categories by looking through an ocular tube: herbaceous material, leaf litter, bare soil, rock, woody debris, moss, lichen, and whether the canopy was open or closed (Table 1). One sample point along a transect could yield several tallies, e.g., if a moss-covered rock was shaded by herbaceous vegetation. We considered woody debris to be any portion of a woody stem or trunk regardless of size. We counted all downed logs with a diameter greater than 10 cm within each site. Site elevations were derived from digital elevation models (DEMs) using a geographic information system (GIS). GIS was also used to calculate the distance of each site from the nearest stream (Table 1). Measures of stand age were obtained from US Forest Service Continuous Inventory of Stand Condition (CISC) data (Table 1).

Soil was sampled at each site by taking soil to a depth of 0.1m at four random locations; all samples were frozen until laboratory analysis. Prior to analysis, soil samples (excluding humus layer) were pooled for each site. Field capacity (moisture-holding ability) was determined as in

Table 1.Variables used to quantify habitat characteristics at 59 mixed mesophytic study sites in the southern Appalachian Mountains. Variables transformed as described in text.

Data type	Name	Description
Temporal	Age	Age of habitat (number of years since last harvest)
Physiognomy	Aspect	Aspect transformed to value between 0 and 2
	Strmdis	Distance to nearest stream (5-m resolution)
	Elev	Elevation (m) as determined by GPS data
	Slope	Slope of site taken along aspect
Microhabitat	FC	Field capacity (Soil moisture-holding ability)
	Canopy	% Canopy coverage
	Herb	% Incidence of herbaceous vegetation
	Leaf	% Incidence of leaf
	Moss	% Incidence of moss
	Rock1	% Incidence of rock < 20 cm wide
	Rock2	% Incidence of rock 20 - 40 cm wide
	Rock3	% Incidence of rock 40 - 80 cm wide
	Rock4	% Incidence of rock > 80 cm wide
	Soil	% Incidence of bare soil
	Wdydeb	% Incidence of woody debris
	Logs	Count of downed logs diameter > 10 cm
	Wdsum	Sum of estimated diameter of woody debris > 10 cm
Small mammal		Abundance (M_{t+1}) of 10 small mammal species
Tree		5 tree species with greatest mean importance value
	Avgdbh	Average size (dbh) of all trees in cm
	Avgshb	Average number of woody shrubs (dbh < 4cm, height < 1m)

Salter and Williams (1967), where a known amount of soil was saturated and weighed, then dried for 24 hours at 105 °C and weighed again. Field capacity was then expressed as the ratio between saturated weight and dried weight for a constant volume of soil.

Comparison of Habitats

We compared three habitat types: mixed mesophytic forests without rock voles, yellow birch habitats without rock voles, and habitats with rock voles. We extend previous descriptions of tree species found in our three habitat types (e.g., French and Crowell 1985, Kirkland and Jannett 1982, Orrock et al. 1999, Orrock et al. 2000, Pagels 1990) to note the frequency of the five most common tree species in each habitat because tree communities can be valuable indicators of habitat for small mammals in the Appalachians (Orrock et al. 2000). We also noted the average size of all tree species in each habitat (based on dbh). We used importance values to describe the relative abundance and relative basal area of tree species at each site (Orrock et al. 2000). For example, if 21 of the 35 trees at a site were sugar maple, and sugar maples were 520 cm^2 of the 1300 cm^2 total dbh at a site, then sugar maple had an importance value of $21/35 + 520/1300 = 0.6 + 0.4 = 1.0$ at that site. As such, the sum of all importance values at a site always equaled 2.

Because variables at each site were not necessarily independent, we performed a global analysis using multivariate analysis of variance (MANOVA; Scheiner 2001) for all microhabitat data and for all small mammal abundance data (Table 1). We followed these global analyses with separate, univariate ANOVAs for each variable. Using global MANOVAs for each group of site-derived data also protects against inflated Type I error rates when performing multiple univariate ANOVAs on a single data set (called protected ANOVAs, Scheiner 2001). Other variables (e.g., elevation and age; Table 1) were examined using ANOVA. When significant differences among habitats were found using ANOVA, we performed pairwise comparisons using Tukey's post-hoc procedure.

Prior to analyses, aspect data were transformed as outlined in Beers et al. (1966), where a linear score between 0 (southeast aspect) and 2 (northwest aspect) was used to represent the original circular aspect data. We used the number of individual small mammals captured as our estimate of small mammal abundance at each site (M_{t+1} sensu Slade and Blair 2000). Analyses were conducted using SAS software version 8.1 (SAS Institute 2000).

RESULTS

Relative to yellow birch and rock vole habitats, other mixed mesophytic habitats were dominated by sugar maple, *Acer saccharum*, northern red oak, *Quercus rubra*, and black locust, *Robinia pseudoacacia* (Table 2). Mountain maple, *A. spicatum*, standing dead trees (snags), green ash, *Fraxinus pennsylvanica*, and yellow birch, *Betula alleghaniensis*, were more important in yellow birch habitats (Table 2). American basswood, *Tilia americana*, yellow birch, and snags were most important in habitats where *M. chrotorrhinus* was captured (Table 2). The average dbh of trees was greater in mixed mesophytic and rock vole sites than in yellow birch sites, whereas there was no significant difference in the mean number of shrubs among habitat types (Table 3).

Sites where *M. chrotorrhinus* was found were significantly older, in terms of last harvesting event, than either yellow birch or mixed mesophytic sites (Table 3). Aspect was also significantly different, with yellow birch and rock vole sites oriented northwest, while other mixed mesophytic sites more approximated southeastern orientation (Table 3). Although only marginally significant, trends suggest that rock vole sites were closer to riparian habitats, and that rock vole and yellow birch sites were more steeply sloped and at higher elevation than other mixed mesophytic sites (Table 3). Microhabitats were significantly different among the three habitat types (MANOVA, $F_{32,84} = 3.15$, $P < 0.001$). These differences were largely due to greater field capacity and large rock in rock vole sites, as well as greater incidence of moss and less leaf litter in yellow birch and rock vole sites compared to other mixed mesophytic sites (Table 3).

Overall, small mammal abundance was significantly different among rock vole, yellow birch, and other mixed mesophytic sites (MANOVA, $F_{20,96} = 2.20$, $P = 0.006$). These differences were largely due to significantly greater numbers of rock shrews, *Sorex dispar*, and red-backed voles, *Clethrionomys gapperi*, in sites with rock voles (Table 3). Pygmy shrews, *S. hoyi*, were more abundant in rock vole and yellow birch habitats compared to other mixed mesophytic sites (Table 3).

Table 2. Relative importance of tree species at 59 mixed mesophytic habitats in the southern Appalachians. Tree species are listed in order of decreasing importance (importance values described in text). Note that habitats are nested, i.e. yellow birch habitats are a kind of mixed mesophytic habitat, and all rock vole habitats are yellow birch habitats where rock voles were found. Standing dead trees are labeled snags. Number of sites in each group indicated in parentheses.

	Habitat Type	
Mixed Mesophytic (N = 52)	Yellow Birch (N = 4)	Rock Vole (N = 3)
Snag	*Acer spicatum*	*Tilia americana*
Acer saccharum	Snag	*Betula alleghaniensis*
Quercus rubra	*Fraxinus pennsylvanica*	Snag
Tilia americana	*Betula alleghaniensis*	*Acer spicatum*
Robinia pseudoacacia	*Tilia americana*	*Acer saccharum*

DISCUSSION

Conservation of *M. chrotorrhinus* habitat should begin by assessing impacts of forest management on mixed mesophytic forests. Within mixed mesophytic forests, habitats dominated by *B. alleghaniensis* and *Tilia americana* were most likely to represent high-quality rock vole habitat in our study (Table 2). Although the dominant tree species differed between mixed mesophytic forests, yellow birch habitats, and rock vole habitats, the similarity between them may make discrimina-

Table 3. Summary of differences in tree communities in mixed mesophytic, yellow birch, and rock vole habitats in the southern Appalachians. Means are presented ± S.E., and P-values are from one-way ANOVA. Variables that were significantly different by ANOVA are evaluated using Tukey's post-hoc procedure. Values with different superscripts are different at P < 0.05.

	Habitat type			
Variable	Mixed mesophytic	Yellow birch	Rock vole	P-value
Temporal				
Age (years)	75.92 ± 5.82[a]	34.50 ± 20.56[a]	138.67 ± 23.75[b]	< 0.01
Physiognomy				
Aspect	0.56 ± 0.08[a]	1.40 ± 0.30[b]	1.57 ± 0.34[b]	< 0.01
Strmdis (m)	147.79 ± 25.18	353.75 ± 90.78	36.67 ± 104.82	0.05
Elev (m)	977.94 ± 23.07	1175.75 ± 83.17	1050.33 ± 96.04	0.07
Slope	20.52 ± 1.34	29.25 ± 4.85	30.00 ± 5.60	0.08
Microhabitat				
FC	80.43 ± 7.43[a]	193.60 ± 26.77[b]	344.69 ± 30.92[c]	< 0.01
Canopy	33.44 ± 0.61[ab]	26.25 ± 2.21[b]	34.00 ± 2.56[a]	0.01
Herb	0.17 ± 0.02	0.11 ± 0.05	0.14 ± 0.06	0.53
Leaf	0.45 ± 0.02[a]	0.31 ± 0.07[b]	0.25 ± 0.08[b]	< 0.01
Moss	0.05 ± 0.01[a]	0.21 ± 0.02[b]	0.21 ± 0.03[b]	<0.01
Rock1	0.08 ± 0.01	0.06 ± 0.05	0.07 ± 0.06	0.97
Rock2	0.05 ± 0.01	0.08 ± 0.04	0.06 ± 0.04	0.82
Rock3	0.02 ± 0.01[a]	0.04 ± 0.02[ab]	0.08 ± 0.02[b]	< 0.05
Rock4	0.02 ± 0.01[a]	0.04 ± 0.01[a]	0.08 ± 0.04[b]	< 0.01
Soil	0.03 ± 0.01	0.02 ± 0.02	0.01 ± 0.02	0.38
Wdydeb	0.13 ± 0.01	0.16 ± 0.03	0.10 ± 0.04	0.42
Logs	11.04 ± 0.81	9.25 ± 2.92	11.00 ± 3.37	0.84
Wdsum (cm)	23.50 ± 4.22	40.25 ± 15.23	11.67 ± 17.58	0.44
Small mammal				
Blarina brevicauda	1.13 ± 0.22	0.75 ± 0.80	1.67 ± 0.92	0.75
Sorex cinereus	0.63 ± 0.16	0.00 ± 0.69	1.67 ± 0.80	0.29
S. dispar	0.02 ± 0.02[a]	0.00 ± 0.09[a]	0.33 ± 0.10[b]	< 0.01
S. fumeus	0.87 ± 0.36	2.25 ± 1.31	2.33 ± 1.51	0.41
S. hoyi	0.02 ± 0.03[a]	0.50 ± 0.11[b]	0.33 ± 0.13[b]	< 0.01
Clethrionomys gapperi	1.71 ± 0.39[a]	6.25 ± 1.41[b]	12.00 ± 1.63[c]	< 0.01
Napaeozapus insignis	0.85 ± 0.24	0.50 ± 0.88	0.67 ± 1.02	0.92
Peromyscus leucopus	1.98 ± 0.29	3.25 ± 1.05	1.67 ± 1.21	0.48
P. maniculatus	2.69 ± 0.31	4.75 ± 1.12	4.33 ± 1.30	0.12
Tamias striatus	1.40 ± 0.25	0.00 ± 0.92	3.00 ± 1.06	0.11
Tree				
Avgdbh (cm)	14.45 ± 0.59[a]	8.83 ± 2.13[b]	19.39 ± 2.46[a]	< 0.01
Avgshb	32.27 ± 3.60	32.50 ± 12.97	46.33 ± 14.97	0.42

tion difficult in practice (Table 2). Rather, ranking a mixed mesophytic habitat to determine its suitability for *M. chrotorrhinus* may require quantifying substrate characteristics as well as sampling the small mammal community (Table 3). In general, managers interested in conserving *M. chrotorrhinus* habitat should seek to conserve older, northwest-facing mixed mesophytic stands that are adjacent to riparian areas and characterized by rocky substrates. Conservation of mixed mesophytic forests for *M. chrotorrhinus* may yield community-wide benefits, as mesic forests contain greater small mammal diversity than other forest types in our study area (McShea et al. 2003).

Trees associated with *M. chrotorrhinus* in our study (Table 2) were similar to tree species associated with *M. chrotorrhinus* in other areas. In West Virginia, red maple, *A. rubrum*, northern red oak, *Quercus rubra*, American beech, *Fagus grandifolia*, yellow poplar, *Liriodendron tulipifera*, and black cherry, *Prunus serotina* (Kirkland 1977a) were also found in association with *M. chrotorrhinus*. No conifers were present at our Virginia sites, but *M. chrotorrhinus* occurs in nearby in West Virginia in red spruce forests, mixed red spruce-northern hardwood forests and in northern hardwood forests (Kirkland 1977a, b).

Our finding that rock vole sites were typically older than yellow birch or mixed mesophytic sites suggests that older forest stands may be critical habitat components for *M. chrotorrhinus* in the study area. These findings are contradictory to Healy and Brooks (1987), who found that *M. chrotorrhinus* was equally abundant in four forest age classes in West Virginia that varied from 8–9 to > 100 years since management. However, we explored a wide range of ages in the mixed mesophytic habitats we sampled (mean age = 76.32 years, range 12–187 years), and only found rock voles at the oldest sites. Although recent clearcuts may be inhabited by *M. chrotorrhinus*, clearcut-mediated increases in abundance rapidly decline (Kirkland 1977b), and clearcuts may also be actively avoided (Martell and Radvanyi 1977). As such, even if recent clearcuts are used, they are poor choices for long-term maintenance of viable *M. chrotorrhinus* populations.

The importance of rocky substrate for *M. chrotorrhinus* is supported by the significantly greater amounts of large rock found in sites with rock voles compared to other mixed mesophytic habitat (Table 3). These findings concur with other studies that stress the ubiquity of rocks in *M. chrotorrhinus* habitat (e.g., Kirkland and Jannett 1982). Our data also suggest that cool, mesic conditions are critical components of *M. chrotorrhinus* habitat, as evidenced by the importance of field capacity in rock vole habitats and aspect in yellow birch and rock vole sites (Table 3). Increased moss cover in yellow birch and rock vole sites also reflects the cool, moist microclimate, and may also serve as an important food resource (Kirkland

and Jannett 1982). The influence of canopy on microclimate may explain why some yellow birch habitats were occupied by *M. chrotorrhinus*, but some were not occupied (Table 3).

Although many microhabitat features were not significantly different among rock vole, yellow birch, and other mixed mesophytic sites, this should be interpreted with caution. That is, if a threshold amount is important for rock vole habitat, and all mixed mesophytic sites exceed this threshold, we would not detect a significant difference, but the value would still be important. This is an important consideration because mixed mesophytic forests differ from other forest types in several ways that may be important to rock voles, but may not have been detected with our analysis, because the components may be homogeneous among yellow birch, rock vole, and mixed mesophytic habitats. For example, compared to other forest types in our study area (290 sites), mixed mesophytic forests have less leaf litter (t-test, $t = 3.55$, 347 d.f., $P < 0.001$), less bare soil (t-test, $t = 2.05$, 347 d.f., $P = 0.04$), more herbaceous vegetation (t-test, $t = 3.14$, 347 d.f., $P = 0.002$), and more large rock (Rock2, Rock3, Rock4, Table 3; t-test, all $t > 3.23$, 347 d.f., all $P < 0.002$). Mixed mesophytic habitats also contained more downed logs (t-test, $t = 2.33$, 347 d.f., $P = 0.02$), greater field capacity (t-test, $t = 5.48$, 347 d.f., $P < 0.001$), and smaller average dbh (t-test, $t = 2.19$, 347 d.f., $P = 0.03$). Clearly, mixed mesophytic forests are different from other forests (McShea et al. 2003, Orrock et al. 2000), and these differences may also be important components of *M. chrotorrhinus* habitat as well.

All of the small mammal species examined (Table 3) are known to be associates of *M. chrotorrhinus* in some capacity (Kirkland and Jannett 1982). However, we found that three species were consistently more abundant in rock vole sites: red-backed voles, *Clethrionomys gapperi*, pygmy shrews, *Sorex hoyi*, and rock shrews, *S. dispar*. Red-backed voles have been noted as a consistent associate of *M. chrotorrhinus* in other areas (Kirkland and Jannett 1982), and our results also suggest that *C. gapperi* is the most useful indicator of *M. chrotorrhinus* in our study area. Red-backed voles are readily captured in Sherman live traps that can also be used to sample for *M. chrotorrhinus*. Sampling habitats for *Sorex* spp. requires the use of pitfall arrays that are less likely to yield captures of *M. chrotorrhinus* and also require additional effort to establish. Moreover, the habitat features associated with the presence and abundance of *C. gapperi* in the study area are available (Orrock et al. 2000) and can provide guidance for locating habitats where *C. gapperi* is abundant and thus where *M. chotorrhinus* is likely to occur.

Our data suggest that standard small mammal monitoring protocols may fail to detect *M. chrotorrhinus*, even if it may be present, because we only detected *M. chrotorrhinus* at one of our sites during a follow-up visit. This is in agreement with other work suggesting that *M. chrotorrhinus* abundance is often low, even in apparently suitable habitat (French and Crowell 1985, Kirkland and Jannett 1982). Habitat features, and the presence and abundance of other, more common small mammals are critical criteria for designating habitats for conservation, even if *M. chrotorrhinus* is not detected during a sampling period.

Mixed mesophytic forests are unique forest types in the Appalachians that provide important habitat for *M. chrotorrhinus* as well as other species (McShea et al. 2003, Orrock et al. 2000). Within mixed mesophytic forests, high-quality *M. chrotorrhinus* habitat may be identified using tree species, microhabitat conditions, and the abundance of more common small mammals. However, we cannot conclude that rock vole sites and yellow birch habitats are the only important types of mixed mesophytic forest for *M. chrotorrhinus*. For example, other types of mixed mesophytic forest (e.g., mixed mesophytic dominated by black birch, Orrock et al. 2000) may serve as important movement corridors that connect patches of suitable habitat. Indeed, it is possible that some mixed mesophytic patches are suitable for *M. chrotorrhinus*, but are not colonized because of low vagility, as suggested by our finding of *M. chrotorrhinus* in 3 yellow birch sites, but not in the remaining 4 yellow birch sites. Until more is known about the habitat requirements and movement ability of *M. chrotorrhinus* in the highly fragmented forests of the southern Appalachians, conservation of this species will hinge upon the identification and protection of mixed mesophytic forests.

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