Small Mammal Survey of the Vermont Ecosystem Management Project Plots, Stevensville Brook Research Area, Mount Mansfield State Forest

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Abstract: A survey of small mammals was conducted on the experimental treatment units of the Vermont Forest Ecosystem Management Demonstration Project on Mount Mansfield in the summer of 2002. A total of nine species of small terrestrial mammals, including two shrews and seven rodents, were documented from this northern hardwood habitat. Four species, including the short-tailed shrew (*Blarina brevicauda*), the Eastern chipmunk (*Tamias striatus*), the deer mouse (*Peromyscus maniculatus*) and the woodland jumping mouse (*Napaeozapus insignis*), were abundant and widely distributed. These four species accounted for 87.4 % of the total captures. Specimens of the southern bog lemming (*Synaptomys cooperi*) and southern flying squirrel (*Glaucomys volans*) represent the first records of these two taxa from this area and brings the total known species of terrestrial small mammals from Mt. Mansfield to 16. Red-backed voles (*Clethrionomys gapperi*) were found at very low population densities, likely resulting in an underestimation of the typical species richness and diversity of terrestrial small mammals in this habitat. However, the mean species richness (4.71) and estimates of mean species diversity (D=0.340; 1-D=0.660; H'=1.85) compare well with other estimates from northern hardwood forest of the Green Mountains. The limited variation in species richness and diversity across experimental treatment units, suggests that these unit are of sufficient size to allow examination of various management treatments on small mall diversity.

Introduction

The Vermont Forest Ecosystem Management Demonstration Project (FEMDP) is designed to bring together researchers to examine the effect of traditional and experimental forest management on the northern hardwood ecosystem. Five study plots have been established within each of eight experimental treatment units at the Stevensville Brook Research Area in the Mount Mansfield State Forest (Keeton, 2001). Two of these treatment units will serve as controls while the plots in the other five units will be subjected to a spectrum of silviculture treatments in the winter of 2002-2003 (Keeton, 2001).

Twenty-seven species of terrestrial small mammals (i.e., weighing less than 500 g) are known from Vermont. Five of these species (long-tailed shrew, pygmy shrew, southern bog lemming, rock vole, and pine vole) are considered rare (i.e., know from fewer than 50 specimens collected in Vermont). A total of 14 species of small mammals are known from Mount Mansfield (Osgood, 1938; Chipman, 1994, Zadock Thompson Natural History Collection of the University of Vermont) and Trombulak (1995) identified 15 species of mammals from the west slope of Mt. Mansfield, including nine species of small mammals.

A pretreatment survey of terrestrial small mammals was conducted in the summer of 2002 on established study plots of seven of the experimental treatment units of the Vermont Forest Ecosystem Management Demonstration Project. The objective of this work was to estimate the diversity and relative abundance of small mammals on experimental treatment units prior to the initiation of silviculture treatments.

Materials and Methods

Between 15 July and 30 August 2002 small mammals were collected with Sherman live traps (7.7 cm x 9.0 cm x 23.0 cm) from seven experimental treatment units. Within each unit, three 0.1 ha plots were sampled with traps set in a 6 X 6 grid (traps approximately 7 meters apart). Traps were baited with rolled oats and were set in the evening and checked in the early morning. All plots were trapped for three nights and most for three consecutive nights. Plots sampled within each unit were selected at random from among the five established plots. Five pit traps with a drift fence were established on each unit sampled and checked for 5 days. The pit traps were placed on the unit but not on an established plot to reduce the habitat alteration of the study plots.

The species of each mammal captured was identified and recorded with position on the grid where captured. Salivary samples were collected from mice of the genus *Peromyscus* to allow unambiguously identification to species using the genetic markers at the salivary amylase locus following the methods of Aquadro and Patton (1980) with the modifications of Kilpatrick et al. (1994). Most mammals were marked by ear punching and released at the site of capture. Voucher specimens (n=32) of animals which died in traps (Appendix 1) were prepared as museum skins and skulls and are deposited in the Zadock Thompson Natural History Collections of the University of Vermont.

In order to assess habitat diversity not solely based on species richness (number of species) but also on the abundance of each species (species eveness) the following

diversity indices, which account for heterogeneity in species eveness, were calculated. Simpson's index (Krebs, 1989) was calculated by:

$$D = \sum pi^2$$

where D is Simpson's index and pi is the proportion of species i in the community. This diversity index predicts the probability of collecting two organisms that are the same species. More commonly used is its complement, 1 - D, which is the probability of collecting two organisms that are different species. The Shannon-Wiener index is derived from information theory and was calculated by the following:

$$H' = -\sum(pi)(\log_2 pi)$$

where H' is the Shannon-Wiener index of species diversity and pi is the proportion of the sample comprised of the ith species. This index is a measure of the amount of uncertainty in predicting the species of an individual chosen at random.

Results

During the summer of 2002 a total of nine species of small mammals (Table 1) were documented on the experimental treatment units of the Vermont Ecosystem Management Project, Stevensville Brook Research Area, Mount Mansfield State Forest. Three species, short-tailed shrews (*Blarina brevicauda*), deer mice (*Peromyscus maniculatus*) and woodland jumping mice (*Napaeozapus insignis*), were widespread and abundant. Short-tailed shrews and woodland jumping mice were captured on every unit and accounted for 28.8% and 32.2 % of the total captures respectively (Table 1). Deer mice were captured on six of the seven units sampled and accounted for 21.2% of the total small mammals captured (Table 1). These three species account for 82% of the total captures.

Pit traps produced only 6 specimens of the same two species of shrews (short-tailed shrew and masked shrew) as captured with Sherman live traps. The number of specimens captured per experimental treatment unit ranged from zero to two, with a mean of less than one capture (0.86). The results from the pit traps were not included in the calculations of trap success or species diversity.

Small Mammal Diversity

A total of 2268 trap nights were spent surveying 21 plots (three plots on each of seven experimental treatment units) with an average trap success of 5.2 % (Table 2). The effort of sampling on each unit was 324 trap nights and the success varied from 3.40 % to 6.48 % (Table 2). The number of species captured on each unit ranged from three to six with a mean of 4.71 (Table 2). The number of species captured on each plot ranged from one to five and only three of the 21 plots sampled produced all of the species detected on the unit.

Simpson's index (D) of species diversity (Krebs, 1989) indicated a mean probability of 34 % of two specimens sampled from a unit being identical and thus a 66 % probability (1-D) that the two specimens would represent different species (Table 2). These indices varied from a D of 0.222 to 0.487 and a 1-D of 0.513 to 0.778 across units

(Table 2). The mean Shannon-Wiener index (H') of species diversity or uncertainty of predicting the species of a specimen captured on a unit was 1.85 with variation ranging from 1.27 to 2.33 across units (Table 2).

Small Mammal Distributions and Abundance

Shrews. Shrews accounted for 31.3 % of the total captures, however, only two of the six species of shrews known from Vermont were taken during this survey. The short-tailed shrew (*Blarina brevicauda*) accounted for 92 % of the shrew captures and was taken on every unit sampled (Table 1). Only three specimens of the masked shrew (*Sorex cinereus*) were captured with each coming from a different unit (Table 1).

Rodents. Seven species of rodents were captured during this survey (Table 1) and represent 68.7 % of the total captures. The woodland jumping mouse (*Napaeozapus insignis*) was the most abundant species captured, representing 32.2 % of the total captures (Table 1). This taxon was captured on all units sampled (Table 1) and accounted for 15 to 65 % of the animals captured on each unit.

Mice of the genus *Peromyscus* represented 24.6 % of the captures. Nearly all specimens captured (86.2 %) were deer mice (*P. maniculatus*) whereas only four specimens were white-footed mice (*P. leucopus*). Deer mice were taken from six of the seven units sampled whereas white-footed mouse were only captured from a single unit (Table 1).

Voles (subfamily Arvicolinae) made up only 3.4 % of the captures and were represented by two species, the red-backed vole (*Clethrionomys gapperi*) and the southern bog lemming (*Synaptomys cooperi*). Red-backed voles accounted for only 2.5 % of the total captures and were taken on only two of the seven units samples (Table 1). A single specimen of the rare southern bog lemming was captured at the base of a large rock on unit 4.

Although chipmunks (*Tamias striatus*) accounted for only 6.8 % of the total captures and were taken from four of the seven units sampled (Table 1), this species is more abundant and more widely distributed than reflected in this trapping results. Although the Sherman live traps used in this survey will capture chipmunks, this trap is not designed to capture this taxon thus resulting in many chipmunks that enter traps escaping without being captured. Chipmunks were observed on all units and nearly all of the plots sampled.

Southern flying squirrels (*Glaucomys volans*) were taken on two units (Table 1). This survey clearly reflects an underestimation of the abundance and distribution of this taxon as sampling methods were not designed specifically to sample this species.

Discussion

Nine species (Table 1), including two shrews and seven rodents, were captured in this survey. Specimens of the southern bog lemming (*Synaptomys cooperi*) and the southern flying squirrel (*Glaucomys volans*) represent the first records of these two taxa from Mt. Mansfield and bring the total known species of terrestrial small mammals from

Mt. Mansfield to 16 (Appendix 2). Four species, including the short-tailed shrew, the Eastern chipmunk, the deer mouse, and the woodland jumping mouse were found to be abundant and widely distributed across the experimental treatment units. These four species accounted for 87.4 % of the small mammal captures.

Small Mammal Distributions and Abundance

Only two of the five shrews known from Mt. Mansfield (Appendix 2) were taken in this survey. Two rare shrews, the long-tailed shrew and the pygmy shrew, were not taken in this survey or the earlier survey by Trombulak (1995) but both were collected in a 1988-1989 survey by Chipman (1994). Chipman (1994) surveyed small mammals in the krumholtz and rocky areas on Mt. Mansfield at an elevation above 1100 m. The long-tailed shrew, *Sorex dispar*, is known from relatively few habitats primarily among rocks, especially along talus slopes, adjacent to cool mountain streams and in clear-cuts (Kirkland et al., 1976; Kirkland, 1977; Kirkland, 1981; French and Crowell, 1985). Thus, suitable habitat for long-tailed shrews was not observed among the treatment units sampled. The pygmy shrew, *Sorex hoyi*, is difficult to capture by conventional methods, however, pit traps have been effective elsewhere Prince, 1941). This species was not captured in the limited pit trapping used in this survey and was not reported in the preliminary results of pit trapping conducted by Trombulak (1995), however, it is not clear if subsequent examination of skull from pit trapped shrews by Trombulak has confirmed the presence of pygmy shrews from lower elevations on Mt. Mansfield.

More surprising is the apparent absence of the smokey shrew, *Sorex fumeus*, in both this survey and that conducted by Trombulak (1995). Although it is likely with the low numbers (n=5) of shrews of the genus *Sorex* obtained in this survey that the smokey shrew might have been missed, Trombulak (1995) listed the masked shrew (*S. cinereus*) as abundant and reported no captures of smokey shrews. Chipman (1994) reported the capture of eight masked shrews and only a single smokey shrew. Brannon (2000) found that the smokey shrew had a greater niche breadth than the masked shrew in the southern Appalachian mountains, however, the masked shrew often appears to be more abundant than the smokey shrew in some (Kilpatrick, 2001) but not all sites (Decher and Kilpatrick, 2001) in Vermont. Additional worked is needed to understand the niche breadth and habitat requirements of shrews of the genus *Sorex* in the northern Appalachian mountains.

The short-tailed shrew (*Blarina brevicauda*) is one of the most abundant small mammals of New England and occurs in a wide variety of habitats (Godin (1977). In the Green Mountains, this species accounts for 17 to 29 % of the small mammals captured (Decher and Kilpatrick, 2001; this study), however, it is much less abundant in other areas of the state (Kilpatrick, 2001)

Of the 11 species of rodents classified as small mammals known to occur on Mt. Mansfield (Appendix 2), seven were found on the experimental treatment plots (Table 1). Two, deer mice and woodland jumping mice, were abundant and widespread (Table 1) whereas a third, the Eastern chipmunk, was more abundant than widespread than the trapping results indicated. Each of these three species was classified as abundant in the survey by Trombulak (1995).

Four additional species (white-footed mice, red-backed voles, meadow voles, and meadow jumping mice) were characterized as abundant on the west slopes of Mt. Mansfield by Trombulak (1995). Two of these, meadow voles (*Microtus pennsylvanicus*) and meadow jumping mice (*Zapus hudsonicus*), are grassland species (Godin, 1977) and were found only at lower elevations (1200 and 2200 feet) in the survey by Trombulak (1995). Although the experimental treatment units were located between 1500 to 1800 feet in elevation, no grassland habitat was observed in any of the treatment units. Thus, suitable habitat for either meadow voles or meadow jumping mice was absent from the survey area.

Trombulak (1995) differentiated deer mice (*Peromyscus maniculatus*) from white-footed mice (*P. leucopus*) by the depth of their cheek pouches. As indicated by Trombulak (1995) this technique is not completely reliable on living animals. In this survey, mice of the genus *Peromyscus* were identified to species by genetic markers, an approach that provides unambiguous identification to species (Aquadro and Patton, 1980; Kilpatrick et al., 1994). This survey found that the deer mouse was abundant and widely distributed whereas the white-footed mouse was less abundant. Similar results in relative abundance were reported by Chipman (1994) who also identified mice of the genus *Peromyscus* to species by salivary amylase genetic markers.

In addition to differences in accuracy in species identification between this survey and that conducted by Trombulak (1995), differences in microhabitats sampled may also account for the differences in abundance of the white-footed mice reported. This survey found white-footed mice to occur on only one treatment unit, near a ski trail. In a survey of small mammals in the Killington area, deer mice were found on all mountains surveyed, whereas white-footed mice were only found on mountains with roads or ski trails (unpublished data). Deer mice prefer habitats associated with coniferous or northern hardwood forest (Godin, 1977) and appear to prefer habitats with larger diameter trees with less ground cover than habitats preferred by white-footed mice (Klein, 1960; Parren and Capen, 1985). I hypothesized that white-footed mice were able to move into habitats above a 1000 feet in elevation by colonizing the shrubby vegetation along roads and ski trails, a hypothesis that need to be examined in more detail.

Other small mammal surveys conducted on Mt. Mansfield have reported the red-back vole (*Clethrionomys gapperi*) as abundant (Trombulak, 1995) or as the most abundant (44 % of the captures) small mammal collected (Chipman, 1994). The red-backed vole was only taken on two treatment units and accounted for only 2.5 % of the captures, clearly not abundant during the summer of 2002. In Vermont, population densities have been reported to range between 0 and 37 per ha and populations have been reported to display periodic peaks in abundance (Miller and Getz, 1972; 1977). Clearly population densities of red-backed voles were at a low on the experimental treatment units during the summer of 2002.

Small Mammal Diversity

Relatively little variation was observed in the number of species captured on each unit (3 to 6, with mean of 4.71) as compared to the variation among plots of 1 to 5. This suggest that the units are of sufficient size to allow the evaluation of experimental

treatments on the biodiversity of small mammals. However, it is likely that future sampling will occur at times when red-back vole densities are higher and thus provide a slightly higher estimate of species richness.

Estimates of species eveness demonstrated similar ranges of variation across units as the estimates of species richness (Table 2). The mean Simpson's index of 34 % and variation observed across units (Table 2) are similar to other northern hardwood sites in the Green Mountains (mean D = 38.8 % with a range of 29 % to 60 %) (Decher and Kilpatrick, 2001; 2002; 2003). The Shannon-Wiener index of species diversity observed (mean = 1.85, range 1.27 to 2.33), however, is slightly higher than that observed at other northern hardwood sites in the Green Mountains (mean = 1.55, range 1.02 to 2.01) (Decher and Kilpatrick, 2001; 2002; 2003).

Conclusions

The pretreatment survey of seven experimental treatment units of the Vermont Forest Ecosystem Management Demonstration Project provides the baseline data of estimates of species richness and species diversity of terrestrial small mammals. The estimates of species richness and species diversity compare well with other northern hardwood sites in the Green Mountains. However, the baseline data obtained in the summer of 2002 may represent an underestimation of species richness and diversity due to the apparent low density and abundance of red-backed voles. Control sites should be monitored regularly (see proposed future work) to provide a better mean estimate of species richness and diversity as the red-back vole population size increases.

Although Trombulak (1995) found that pit traps were an effective method for surveying small mammals, this survey had rather limited success with pit traps. If future work is to include pit traps then long-term establishment of pit traps and drift fences are needed. Initial habitat modification associated with placing pit traps and drift fences may have a negative effect on success. Although these could also be used to survey herptiles and some insects in addition to small mammals, they may remove a substantial part of the fauna from an area. The Sherman live traps used in this survey resulted in 27 % trap mortality, primarily of shrews, and 73 % of the small mammals captured were released.

Proposed Future Work

1. An acoustical bat survey will be conducted in the summer of 2003 on both of the control units and representative treatment units. This survey will be conducted with an Anabat II using the passive system described by O'Farrell (1998).
2. Live traps will be used to survey three plots on each of the two control units to provide a better estimate of species richness and diversity with the expected increase in red-backed voles. No additional funds, are requested for either the acoustical survey or the live trapping of the two control units.
3. If additional funds are available, surveys of small mammals richness and diversity on the experimental treatment units should be conducted every three to five years to monitor the effects of management treatments on small mammals.

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Table 1.-- Small mammals collected in the summer of 2002 on seven experimental treatment units of the Vermont Ecosystem Management Project, Stevensville Brook Research Area, Mount Mansfield State Forest.

	Number of Individuals Captured in Each Unit								Percentage	Units of
Species	**1**	**2**	**3**	**4**	**5**	**7**	**8**	**Total**	**of Captures**	**Occurrence***
Sorex cinereus	**1**	**1**				**1**		**3**	**2.5%**	**3**
Blarina brevicauda	**2**	**4**	**3**	**4**	**5**	**12**	**4**	**34**	**28.8%**	**7**
Tamias striatus		**2**	**1**	**4**			**1**	**8**	**6.8%**	**4**
Glaucomys volans		**1**				**1**		**2**	**1.7%**	**2**
Peromyscus maniculatus	2	5		2	6	3	7	25	21.2%	6
Peromyscus leucopus							4	4	3.4%	1
Clethrionomys gapperi	**2**			**1**				**3**	**2.5%**	**2**
Synaptomys cooperi				**1**				**1**	**0.8%**	**1**
Napaeozapus insignis	**13**	**5**	**7**	**2**	**4**	**3**	**4**	**38**	**32.2%**	**7**
Total	**20**	**18**	**11**	**13**	**15**	**20**	**21**	**118**		

Table 2.—Species diversity of seven experimental treatment units of the Vermont Ecosystem Management Project, Stevensville Brook Research Area, Mount Mansfield State Forest.

Unit	Number of Captures	Trap Success	Number of Species	D*	1-D**	H'***
1	20	6.17 %	5	0.455	0.545	1.62
2	18	5.56 %	6	0.222	0.778	2.33
3	11	3.40 %	3	0.487	0.513	1.27
4	13	4.01 %	5	0.243	0.757	2.16
5	15	4.63 %	3	0.342	0.658	1.57
7	20	6.17 %	5	0.410	0.590	1.70
8	21	6.48 %	6	0.224	0.776	2.32
Mean	16.86	5.20 %	4.71	0.340	0.660	1.85

* Simpson's Index = probability of picking two organisms that are the same species.

** 1-D = probability of picking two organisms that are different species.

*** Shannon-Wiener H' = average degree of uncertainly in predicting the species of an individual chosen at random.

Appendix 1. Voucher specimens of mammals collected from the Vermont Ecosystem Management Project plots in 2002, Stevensville Brook Research Area, Mount Mansfield State Forest.

Species	Sex	Measurements				Field Number
		Total Length	Tail Length	Hind Foot	Ear Height	
Blarina brevicauda	M	101	22	13	3	SDB 1
Blarina brevicauda	?	110	25	15	2	SDB 2
Blarina brevicauda	?	111	24	11	2	SDB 3
Blarina brevicauda	?	100	23	14	3	SDB 4
Blarina brevicauda	?	103	26	16	6	SB 2
Blarina brevicauda	?	90	21	13	4	SB 3
Blarina brevicauda	?	119	24	12	3	SB 4
Blarina brevicauda	?	120	27	14	0	CRC 2
Blarina brevicauda	F	114	29	16	4	JC 2
Blarina brevicauda	F	116	27	14	3	JC 3
Blarina brevicauda	M	98	21	17	5	NED 3
Blarina brevicauda	?	109	30	14	0	PEF 1
Blarina brevicauda	F	104	13	13	3	JF 3
Blarina brevicauda	?	100	25	10	1	CG 2
Blarina brevicauda	?	111	50	13	5	MRH 4
Blarina brevicauda	?	97	22	15	4	PTH 1
Blarina brevicauda	?	90	25	12	5	ACK 2
Blarina brevicauda	?	110	25	14	7	ACK 3
Blarina brevicauda	M	122	21	14	0	EJM 2
Blarina brevicauda	?	117	20	15	0	EJM 3
Blarina brevicauda	M	91	18	15	5	DGS 2
Blarina brevicauda	?	114	31	15	0	JLS 2
Blarina brevicauda	?	109	24	10	0	JLS 3
Blarina brevicauda	?	115	23	13	0	JW 1
Blarina brevicauda	?	107	30	13	7	CZ 1
Blarina brevicauda	?	114	27	13	8	CZ 2
Blarina brevicauda	?	126	33	15	7	CZ 3
Sorex cinereus	F	105	39	11	4	PTH 3
Sorex cinereus	F	96	41	11	3	CRM 2
Synaptomys cooperi	F	98	21	17	8	CRC 1
Napaeozapus insignis	F	230	148	30	16	CRM 3
Napaeozapus insignis	M	216	140	29	13	AR 2

Appendix 2.--Terrestrial species of small mammals known from Mount Mansfield, Vermont.

Common name	Scientific name	Reference or Source
Masked shrew	*Sorex cinereus*	Chipman, 1994; Trombulak, 1995; this survey
Smokey shrew	*Sorex fumeus*	Osgood, 1938; Chipman, 1994
Long-tailed shrew	*Sorex dispar*	Chipman, 1994
Pygmy shrew	*Sorex hoyi*	Chipman, 1994
Short-tailed shrew	*Blarina brevicauda*	Chipman, 1994; Trombulak, 1995; this survey
Eastern chipmunk	*Tamias striatus*	Trombulak, 1995; this survey
Red squirrel	*Tamiasciurus hudsonicus*	ZTNH
Southern flying squirrel	*Glaucomys volans*	this survey
Deer mouse	*Peromyscus maniculatus*	Chipman, 1994; Trombulak, 1995; this survey
White-footed mouse	*Peromyscus leucopus*	Chipman, 1994; Trombulak, 1995; this survey
Red-backed vole	*Clethrionomys gapperi*	Chipman, 1994; Trombulak, 1995; this survey
Meadow vole	*Microtus pennsylvanicus*	Trombulak, 1995
Rock vole	*Microtus chrotorrhinus*	ZTNH
Southern bog lemming	*Synaptomys cooperi*	this survey
Meadow jumping mouse	*Zapus hudsonicus*	Trombulak, 1995
Woodland jumping mouse	*Napaeozapus insignis*	Chipman, 1994; Trombulak, 1995; this survey

ZTNH = Zadock Thompson Natural History Collection, University of Vermont