Habitat Diversity and Small Mammal Populations in Canaan Valley, West Virginia

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Abstract: Small mammals were trapped annually in Canaan Valley, West Virginia, from 1978 to 1993. Canaan Valley is located at 1,000 m elevation in the Appalachian Mountains and contains an unusual interspersion of ecological communities. Snap-trapping was conducted for 4 consecutive nights each September in each of 11 habitat types: alder, aspen, conifer, grassland, grassland/ecotone, hayfield, young hardwoods, mature hardwoods, muskeg, shrub/ecotone, and spiraea. The most abundant species captured were deer mice (*Peromyscus maniculatus,* 2.0 captures/100 trapnights), short-tailed shrew (*Blarina brevicauda,* 1.6), meadow vole (*Microtus pennsylvanicus,* 1.1), masked shrew (*Sorex cinereus,* 0.8), and red-backed vole (*Clethrionomys gapperi,* 0.3). Mean annual trap success for all sites combined varied significantly within years, ranging from 1.7 to 10.6 captures/100 trapnights in the 16-year period. Mean annual trap success within habitat types for all species combined ranged from 2.8 (shrub/ecotone) to 8.3 captures/100 trapnights (aspen). Significant differences in captures occurred among community types within years, ranging from no captures to 22.0 captures/100 trapnights. Standard deviation of annual means was less in the total Canaan Valley (all communities combined) than in any single community, with the exception of hayfield and shrub/ecotone. Trapping data indicated year-to-year small mammal populations were more stable in the existing complex of communities than if a single community type had dominated the Valley.

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To manage ecosystems we must understand all associated communities along with the various wildlife populations comprising these communities. Small mammals are an important component of most ecological communities and their population fluctuations have a major impact on ecosystem stability. One management strategy used to maintain stable and healthy ecosystems is to promote and/or maintain the greatest possible habitat diversity (Hunter 1990). However, the impact of habitat diversity on population fluctuations within the associated ecosystem is not understood.

Population fluctuations of small mammals have been studied extensively, but few studies have examined the relationship between habitat diversity and these fluctuations. Habitat diversity may be related to vertical diversity as reflected in the structural diversity of a forest community, or to the horizontal diversity resulting from the juxtaposition of distinct ecological communities and their ecotonal areas (Hunter 1990).

Higher population densities usually result from an interspersion of communities. The "edge effect," as proposed by Leopold (1933), proposes that more community edges result in more food and cover resources and thus higher species abundance and richness. Most studies documenting the existence of an edge effect have involved birds (Guljas 1975, Gates and Gysel 1978, Strell and Dickson 1980, Kroodsma 1984). However, creation (or preservation) of edge also appears beneficial to many kinds of wildlife (Robinson and Bolen 1989).

Small mammal populations are an important component of the trophic structure in most terrestrial communities. The various niches associated with a diversity of small mammals impact community diversity and ultimately community stability. Small mammals may be herbivorous, granivorous, fructivorous, insectivorous, or carnivorous and simultaneously provide a source of food for many other wildlife species, including snakes, birds, and larger mammals. Population fluctuations of prey-level mammals are usually associated with corresponding fluctuations of predator-level mammals and birds (Robinson and Bolen 1989).

One management goal for eastern forests has been to provide the greatest possible diversity (of both habitats and species). Although this goal has been accepted by much of the general public and many resource managers, there is little scientific data to justify its overall value. Odum (1975:55) wrote: "Diversity in systems in general is undeniably a good thing. But as with most 'good things' in the real world there can be too much of it as well as too little." Too much diversity impacts those forest interior species that are impacted by fragmentation. Robinson and Bolen (1989:42) stated that ". . . the logic behind the theory that diversity produces stability seems compelling." A knowledge of the association between habitat diversity and population stability would benefit many wildlife managers.

This study examined annual fluctuations of small mammals within an ecosystem comprised of numerous, interspersed ecological communities. The objective was to determine if year-to-year populations of small mammals were more stable in a complex of communities than in any single community type.

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Methods

Canaan Valley is a raised-anticline valley located in Tucker County near Davis, West Virginia. The valley floor lies at 975 m elevation and the surrounding mountains reach 1,280 m. The Blackwater River and its major tributaries drain the Canaan Valley watershed, which is 14,165 ha. Climate is similar to that of southeastern Canada, with a growing season of 92–93 days (Weedfall and Dickerson 1965). Mean average daily temperature for the last 10 years was 8 C, ranging from −6 C in January to 18 C in July. Mean annual precipitation for the last 10 years was 137 cm, with total snowfall averaging 356 cm per year.

Sides of the mountains surrounding Canaan Valley are covered with northern hardwoods, while the valley floor contains interspersed upland and wetland communities. A total of 2,626 cover stands having distinct boundaries and representing distinct habitat types were present in Canaan Valley (Environ. Protection Agency 1992). Mean size of individual stands was 5.1 ha, ranging from a mean of 0.7 ha for all conifer stands to a mean of 49.6 ha for hardwood stands.

A description of each major habitat type where trapping occurred follows:

(1) Alder — thickets found in low-lying areas, mainly along streams and rivers. Speckled alder (*Alnus serrulata*) was the dominant overstory vegetation and grew to heights of 2–4 m. Various forbs, grasses, and sedges were present in the understory.

(2) Aspen — groves of mature aspen (*Populus grandidentata* and *P. tremuloides*) which generally occurred on the lower mountain slopes and elevated areas of the valley. The understory was dominated by blueberry (*Vaccinium* spp.), aster (*Aster* spp.), and club mosses (*Lycopodium* spp).

(3) Conifer — scattered stands of red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), and hemlock (*Tsuga canadensis*) located on poorly-drained soils. Yellow birch (*Betula allegheniensis*), speckled alder, rhododendron (*Rhododendron maximum*), and mountain holly (*Ilex montana*) made up the understory. Only a few herbaceous species were present.

(4) Grassland — areas located between woodlands and lowlands. Soils were moderately well-drained. Vegetation consisted of old-field species of grasses and forbs, mainly poverty grass (*Danthonia spicata*), goldenrod (*Solidago* spp.), and aster, and scattered shrubs such as hawthorne (*Crataegus* spp.) and viburnum (*Viburnum* spp.).

(5) Grassland/ecotone — the edge areas which occurred between hardwoods and grassland, dominated by herbaceous plants.

(6) Hardwoods — extensive areas of northern hardwoods located on mountain slopes surrounding the valley floor and on a few elevated, well-drained sites within the valley. Beech (*Fagus americana*) and sugar maple (*Acer saccharum*) were dominant and were often mixed with black cherry (*Prunus serotina*) and red maple (*A. rubrum*). The understory was quite limited and consisted of reproduction from the dominant overstory species and some striped maple (*A. pennsylvanicum*) and serviceberry (*Amelanchier* spp.). Grasses and forbs adapted to low light conditions occurred in low densities on the forest floor. Young hardwoods had a stand age of <25 years and mature hardwoods had a stand age of >75 years.

(7) Hayfield — agricultural fields that were mowed annually. Vegetation

consisted primarily of native grasses such as *Glyceria* spp., rice cutgrass (*Leersia oryzoides*), oat-grasses (*Danthonia* spp.), and bromegrass (*Bromus* spp.).

(8) Muskeg — extensive bog-like habitat which occurred extensively over the valley floor. Dominant plants were polytrichum moss (*Polytrichum* spp.) and sphagnum moss (*Sphagnum* spp.). Goldenrod and cotton grass (*Eriophorum virginicum*) grew on hummocks which were often surrounded by small pools of standing water. A few scattered shrubs of viburnum were present.

(9) Shrub/ecotone — the edge areas between hardwoods and grasslands dominated by shrubs (mainly hawthorne and viburnum).

(10) Spiraea — dense thickets of spiraea (*Spiraea* spp.) approximately 2 m high, that were present in poorly-drained sites. Very little vegetation occurred in the understory except occasional grasses, sedges, and forbs.

Successional changes throughout the 16-year study were insignificant due to an overpopulation of white-tailed deer (*Odocoileus virginianus*), a short growing season, and the frost-pocket effect created by the mountains surrounding the valley floor. These factors slowed the rate of ecological succession by reducing the invasion of woody plants into communities dominated by non-woody vegetation.

Sizes of the individual stands where trapping occurred were: alder, 2.9 ha; aspen, 2.1 ha; conifer, 1.2 ha; grassland, 17.7 ha; grassland/ecotone, 1.8 ha; mature hardwood, 69.5 ha; young hardwood, 15.4 ha; hayfield, 9.3 ha; muskeg, 18.7; shrub/ecotone, 1.2 ha; and spiraea, 2.2 ha. Trap stations were located near the center of each community in which trapping occurred.

Small mammal populations were surveyed by use of Museum Special snap traps baited with a peanut butter-rolled oats mixture. During 1982–1993, 60 traps were set in the 11 habitat types, with 3 traps at each of 20 stations. Traps were set in 10 habitat types during 1979–1981, and in 8 habitat types during 1978 (Tables 1, 2). Stations were arranged in 2 parallel rows of 10 stations each, with rows 25 m apart and stations 10 m apart. Trapping was conducted for 4 consecutive nights during the 2nd and 3rd week of September for a total of 2,640 trapnights during 1982–1993, 2,400 during 1979–1981, and 1,920 during 1978 (Tables 1, 2). The 20 stations in each habitat type were permanently marked and trapping was conducted at the same sites each year.

Results

Thirteen species of small mammals were trapped during 1978–1993 (Table 1). Total number of captures for each species were: deer mice, 827; short-tailed shrew, 646; meadow vole, 438; masked shrew, 303; red-backed vole, 126; meadow jumping mouse (*Zapus hudsonius*), 26; southern bog lemming (*Synaptomys cooperi*), 12; woodland jumping mouse (*Napaeozapus insignis*), 12; smoky shrew (*Sorex fumeus*), 5; rock vole (*Microtus chrotorrhinus*), 3; eastern chipmunk (*Tamias striatus*), 1; star-nosed mole (*Condylura cristata*), 1; and northern water shrew (*Sorex palustris*), 1. Five species comprised 96% of the captures: deer

Table 1. Relative abundance of small mammals in Canaan Valley, West Virginia.

Species	1978[a]	1979[b]	1980[b]	1981[b]	1982[c]	1983[c]	1984[c]	1985[c]	1986[c]	1987[c]	1988[c]	1989[c]	1990[c]	1991[c]	1992[c]	1993[c]	Mean	SD
	N captured / captures/100 trap nights																	
Deer	5	68	76	29	76	12	96	67	46	19	12	32	71	122	42	54	51.7	
mouse	0.26	2.85	3.17	1.2	2.88	0.45	3.64	2.54	1.74	0.72	0.45	1.21	2.69	4.62	1.59	2.04	2	1.23
Short-	64	103	31	9	32	33	53	42	26	34	25	21	92	26	12	1.63	40.4	
tailed shrew	3.33	4.29	1.29	0.38	1.21	1.25	2.01	1.59	0.98	1.29	0.95	0.79	3.48	0.98	0.45	1.61	1.58	1.09
Meadow	43	38	36	21	13	16	41	35	25	31	7	7	51	57	12	5	27.4	
vole	2.24	1.58	1.5	0.87	0.49	0.6	1.56	1.33	0.95	1.17	0.27	0.27	1.92	2.16	0.45	0.19	1.09	0.67
Masked	83	29	21	45	15	14	9	17	12	6	0	3	10	32	4	3	18.9	
shrew	4.32	1.21	0.88	1.87	0.57	0.53	0.34	0.64	0.45	0.23	0	0.11	0.38	1.21	0.15	0.11	0.81	1.03
Red-	0	12	11	13	12	0	2	16	11	5	0	2	16	13	6	7	7.9	
backed vole	0	0.5	0.46	0.54	0.45	0	0.08	0.61	0.42	0.19	0	0.08	0.61	0.49	0.23	0.26	0.3	0.22
Other	5	5	7	1	2	2	11	1	2	8	1	3	9	0	1	3	3.8	
	0.26	0.2	0.29	0.04	0.08	0.08	0.42	0.04	0.08	0.3	0.04	0.11	0.34	0	0.04	0.11	0.15	0.14
Total	200	255	182	118	150	77	212	178	122	103	45	68	249	250	77	115	150	
	10.4	10.6	7.6	4.9	5.7	2.9	8	6.7	4.6	3.9	1.7	2.6	9.4	9.5	2.9	4.3	6	2.9

[a]Total of 1,920 trapnights. [b]Total of 2,400 trapnights. [c]Total of 2,640 trapnights.

mice (2.00 captures/100 trap nights), short-tailed shrews (1.58), meadow voles (1.09), masked shrews (0.81), and red-backed voles (0.30). The combined capture rate of all other species of small mammals was 0.15/100 trap nights.

Deer mice had the highest capture rate in 10 of the 16 years, short-tailed shrews in 5 years, and masked shrews in 1 year (Fig. 1). Deer mice had the highest standard deviation of mean annual capture rates (1.23) during the 16 years, followed by short-tailed shrews (1.09), masked shrews (1.03), meadow voles (0.67), and red-backed voles (0.22).

Mean total capture rates for the 16 years were highest in the aspen habitat type (8.3 captures/100 trapnights) and lowest in shrub/ecotone habitat (2.8 captures/100 trapnights) (Table 2). When comparing all habitat types, highest capture rates occurred in aspen in 4 of the 16 years and in conifer habitats in 4 of the 16 years, followed by alder (3 years), grassland/ecotone (3 years), mature hardwoods (1 year), and spiraea (1 year).

Alder had the highest standard deviation of mean annual capture rates during the 16 years (6.0), followed by grassland/ecotone (5.1), aspen (4.9), and conifer (4.6). Shrub/ecotone had the lowest variance (2.0), followed by hayfield (2.6).

Highest annual capture rates occurred in 1978 (10.4/100 trapnights), 1979 (10.6), 1991 (9.5), 1990 (9.4), and 1984 (8.0). Lowest annual capture rates were in 1983 and 1992 (2.9) and 1988 (1.7).

The 5 species with the highest capture rates each attained its highest relative abundance in a different habitat type. Deer mice were most abundant in mature hardwoods (23.8% of total captures), meadow voles in alder (24.0%), short-tailed shrews in spiraea (17.8%), masked shrews in muskeg (19.8%), and red-backed voles in conifer (39.3%) (Table 3). The lowest percentage of captures of deer mice was in hayfield (0.1%), meadow voles in mature hardwoods (0%) and young hardwoods (0%), short-tailed shrews in muskeg (0.2%), masked shrews in mature hardwoods (0%), and red-backed voles in muskeg (0%), shrub/ecotone (0%), and hayfield (0%). The rarer small mammals may be of greater interest than the more ubiquitous species, but the number of captures is in-

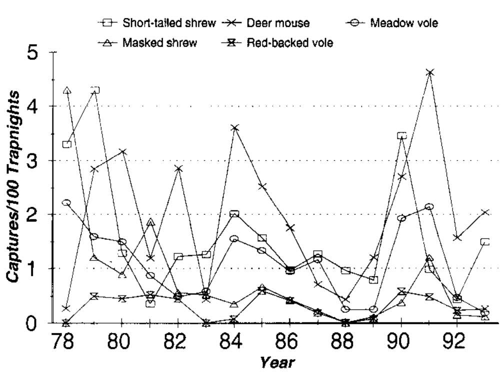

Fig. 1. Annual fluctuations in relative abundance of 5 small mammal species, Canaan Valley, West Virginia.

Table 2. Relative abundance of small mammals in various habitats in Canaan Valley, West Virginia.

	Captures/100 trap nights																	
Habitat type	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Mean	SD
Aspen	20	12	9.5	9.7	8.4	5.7	6.6	5.8	3.2	6.2	3.3	1.6	15.4	12.8	2.5	9.9	8.3	4.9
Spiraea	11.1	11.3	6	2.9	7.5	4.5	14.2	7.5	9.1	8.2	1.7	1.7	9.9	9.1	4.9	5.8	7.2	3.5
Conifer	18.9	5	4.6	12.4	6.7	3.3	9.5	10.8	11.2	3.2	0.8	6.6	8.7	5.8	4.1	1.2	7.1	4.6
Mature hardwoods	5.5	15	8.7	3.6	11.3	2	10.6	9.5	5.4	3.3	2	1.2	9.1	10	5.8	7	6.9	3.8
Grassland/ ecotone	1.1	20.5	9.3	1.3	12.2	2	9.2	6.6	7.1	2.5	2.9	4.1	5	14.1	4.9	5.8	6.8	5.1
Alder	4.4	8	10.7	2	6.7	2.1	5.1	2.8	2.9	3.7	1.6	3.6	22	19.6	2	3.3	6.3	6
Young hardwoods	a	15	9.1	5.6	2.6	3.7	13.4	10.4	1.2	4.1	0.8	2.1	5.3	8.7	4.2	4.2	6	4.2
Grassland	4.4	7	7	2.7	2.4	1.2	6.4	5.4	0.4	5.3	2.4	1.6	12	10	1.2	6.6	4.8	3.2
Muskeg	17.8	7.5	6	6.3	0.4	2.9	1.6	4.1	3.7	3.3	0.4	0.4	1.6	7.5	1.6	0.4	4.1	4.3
Hayfield	a	a	a	a	3.4	1.6	8.4	6.6	4.6	2.5	1.6	2.9	7.8	2.5	0	1.2	3.5	2.6
Shrub/ ecotone	a	5.5	5	2.3	0.8	2.8	2.8	4.7	2	0	1.2	2.1	6.6	4.5	0.8	0.8	2.8	2
Mean	10.4	10.6	7.6	4.9	5.7	2.9	8	6.7	4.6	3.9	1.7	2.6	9.4	9.5	2.9	4.3	6	2.9

[a]Habitat type not sampled.

Table 3. Frequency of occurrence of 5 small mammal species in 11 habitat types in Canaan Valley, West Virginia (total number captures = 2,401).

	Percentage of total				
	Deer mouse	Meadow vole	Short-tailed shrew	Masked shrew	Red-backed vole
Aspen	13.2	5.9	16.0	16.1	9.8
Spiraea	2.0	23.1	17.8	8.3	0.9
Conifer	11.1	4.0	9.0	14.6	39.3
Mature hardwoods	23.8	0	5.4	0	7.1
Grassland/ecotone	20.2	0.3	10.2	1.0	0.9
Alder	3.6	24.0	13.3	18.8	8.9
Young hardwoods	16.0	0	2.0	0.5	32.1
Grassland	4.2	11.4	12.4	9.9	0.9
Muskeg	0.4	17.8	0.2	19.8	0
Hayfield	0.1	5.8	10.2	7.8	0
Shrub/ecotone	5.2	7.7	3.4	3.1	0
Total	99.8	100.0	99.9	99.9	99.9

sufficient to reach any conclusions regarding habitat selection or population fluctuations.

Capture rate increases or decreases did not occur uniformly among all species. During several specific years, ≥1 species exhibited an increase in capture rates while other species exhibited decreases. Deer mice captures increased 11% while short-tailed shrew captures decreased 70% from 1979 to 1980 (Fig. 1, Table 1). In contrast, deer mice captures decreased 62% from 1980 to 1981 while masked shrew captures increased 110%.

Discussion

Small mammal capture rates fluctuated widely during the 1978–1993 period. Reasons for these fluctuations are unknown, but are probably due to annual variations in natality, mortality, weather, food supply, and trappability. Year-to-year fluctuations differed among habitat types and among species, indicating that the factors responsible for the annual fluctuations did not affect all species equally.

Weather may have had both a direct and indirect effect on trapping results. Directly, it may have affected the trappability while indirectly it affected the food resource and population densities. No significant correlations between weather and trapping results were detected. The 5 species with the highest capture rates have different food habits and different habitat requirements, thus they would not all respond similarly to changes in weather and food supply. Deer mice are primarily granivores, meadow voles and red-backed voles are grazers, and masked shrews and short-tailed shrews are carnivores. An increase or decrease in the mast supply (primarily black cherry in Canaan Valley) would impact deer mice more than voles (Jameson 1955). An extremely dry or wet year would impact voles more than deer mice because of their food habits and shrews more than deer mice because of their trappability. Extended periods of deep snow theoretically benefit those species which feed under the snow, but are detrimental to those which feed on top of the snow.

Diversity of habitat types within Canaan Valley apparently resulted in a more stable population of small mammals than would have occurred if the area had been dominated by a single habitat type. The standard deviation of annual means for all habitat types was exceeded by the individual variance for each habitat type except shrub/ecotone and hayfield. Had alder, aspen, or conifer habitat types dominated Canaan Valley, small mammal populations would have fluctuated significantly more than actually occurred.

If the management goal for an area is to sustain relatively stable populations of small mammals or the predators which prey upon them then a diversity of habitat types should be maintained. A diversity of habitats would also result in a greater diversity of small mammal species, and probably a greater diversity of predators. Fragmentation of large stands of 1 uniform habitat type into smaller stands of different habitat types would increase the diversity of small mammals and the overall biodiversity of the ecosystem involved.

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