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Small Mammal Diversity in Forested and Clearcut Habitats in the Virginia Piedmont

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ABSTRACT

A total of 754 small mammals representing 17 species was captured in clearcut/old field and mixed forest habitats in Cumberland County, Virginia. Species richness and diversity (H') were highest in clearcuts, and overall captures were twice as great in this habitat. Habitat generalists and edge/old field species represented 65% and 32%, respectively, of the total captures in the forested habitats. In the clearcuts, however, nearly the opposite was found: 59% were edge/old field forms, and 40% were generalists. Certain edge/old field forms, among them *Cryptotis parva*, *Reithrodontomys humulis* and *Microtus pennsylvanicus*, although captured in greater numbers in the clearcuts, were also captured in the forested habitats, indicating their ability to inhabit or disperse through atypical environments when corridors of preferred habitat are not present.

Key Words: Mammals, diversity, deforestation, Virginia Piedmont

INTRODUCTION

Thirty-three species of mammals have been reported from the central Piedmont of Virginia exclusive of bats and introduced murine rodents (Handley and Patton, 1947; Pagels, 1977; Handley and Pagels, 1991). Twelve of the 33 are considered habitat generalists. Seven species occupy habitats near water, and 6 species are associated with woodlands. Many of the latter are squirrels. The remaining 8 species are colonizing or pioneer species associated with edge and old field habitats.

Because of current and historic landuse practices, Virginia's modern day landscape is a mosaic of habitat types (Silver, 1990). These include agricultural fields, old fields, mixed pine-hardwoods, pine monocultures, mixed hardwoods, riparian corridors, wetlands, and the interfaces among these habitats. Corridors connecting habitats allow colonization of new areas as old ones become unsuitable. Presumably, the precolonial landscape was also a mosaic of forest and isolated, temporary clearings resulting from windstorms, fire, and native American activities. There was certainly less nonforested land than there is today, and it was considerably more disjunct. Because certain small mammals have been found in greater numbers in early successional habitats than in older habitats (Kirkland, 1990), they have apparently benefitted from the clearing of closed canopy forests and the proliferation of old fields.

Due to the mixture of habitat generalists and specialists, small mammal community composition and diversity should vary among major habitat types. We examined these aspects of small mammal ecology in 2 highly contrasting habitats, old field and forest, in the central Piedmont of Virginia. Our objectives were to (1) compare species richness and diversity of small mammal communities in the 2 habitats, and (2) evaluate the impacts of tree removal (clearcutting) on forest communities in the Virginia Piedmont. We also use these results and insights to speculate on habitat use and relative population size of colonizing species before European settlers cleared large tracts of forest.

METHODS AND MATERIALS

Four study sites were located in northern Cumberland County, Virginia, 3-6 km SW of Columbia, Goochland County. The sites were approximately 65 km W of the Fall Line. Two clearcuts, herein designated clearcut north (CCN) and clearcut south (CCS), were 3 and 6 years of age, respectively. Total ground level vegetation, e.g. grasses, forbs, vines, shrubs and seedlings, was similar at CCN and CCS. Numbers of seedlings were greater at CCS, and the younger CCN was characterized by greater numbers of vines. The nearest forest to either clearcut sampling array was approximately 185 m. The 2 forest sites, herein designated forest north (FRN) and forest south (FRS) were both approximately 40 years old. The most abundant trees at FRN with a dbh ≥ 10 cm were red maple (*Acer rubra*, 22.1% of total), shortleaf pine (*Pinus echinata*, 18.6%), tulip poplar (*Liriodendron tulipifera*, 15.7%), white oak (*Quercus alba*, 10.7%) and American beech (*Fagus grandifolia*, 10.7%). At FRS the most abundant trees were sweet gum (*Liquidambar styraciflua*, 19.7%), tulip poplar (*Liriodendron tulipifera*, 16.7%), red maple (*Acer rubra*, 15.2%), white oak (*Quercus alba*, 12.1%), short leaf pine (*Pinus echinata*, 9.1%) and sycamore (*Platanus occidentalis*, 9.1%). Mean canopy openness, 14% at FRN and 25% at FRS, was reflected in greater numbers of vines and deciduous seedlings at the latter site. Small perennial streams were within 5 m of sampling arrays at the forested sites. The nearest clearcut to either forest site sampling array was approximately 165 m.

We sampled all sites with pitfall arrays based on a method modified from Campbell and Christman (1982). Each array consisted of 3 arms that radiated from a central point; the triad was open at the center and each arm was 5 m away from the center point. An arm consisted of a 5-m-long by 61-cm-high aluminum flashing drift fence with a 40 l bucket buried in the ground at each end. Pitfalls were open from September 1989 through September 1990; trapping effort totaled 2190 days in the combined clearcuts and 2346 days in the combined forested sites. We assumed that trappability of small mammals did not differ between the 2 habitat types, and that numbers captured reflected their actual relative abundance. A chi-square goodness of fit test was used to determine if differences existed in captures between habitat types; numbers of captures from a given habitat type were combined for the analyses. The Shannon Index (H') was used to calculate diversity. For further comparisons between habitat types, we classified each of the species captured into 1 of 4 categories: semi-aquatic (A), forest (F), old field/edge (O), and generalist (G) (Table 1). These categories were based on the habitat with which the species are typically associated as noted in the literature and in our

TABLE 1. Numbers of small mammals captured in pitfall-drift fence arrays in 2 mixed forest (FRN, FRS), and 2 clearcut/old field (CCN, CCS) habitats in Cumberland County, Virginia. See text for explanation of letters in parentheses.

Species		Sites				
		CCN	CCS	FRN	FRS	Total
Didelphis virginiana	(G)	0	1	0	0	1
Scalopus aquaticus	(G)	0	1	0	0	1
Condylura cristata	(A)	0	0	2	1	3
Sorex longirostris	(G)	26	37	5	18	86
Sorex hoyi	(G)	1	9	11	9	30
Blarina brevicauda	(G)	12	11	20	22	65
Cryptotis parva	(O)	64	23	4	6	97
Glaucomys volans	(F)	0	0	1	0	1
Reithrodontomys humulis	(O)	38	39	2	9	88
Peromyscus leucopus	(G)	41	56	39	27	163
Ochrotomys nuttalli	(G)	0	10	0	0	10
Oryzomys palustris	(A)	2	4	2	1	9
Sigmodon hispidus	(O)	4	19	0	0	23
Microtus pennsylvanicus	(O)	21	18	3	4	46
Microtus pinetorum	(G)	1	0	3	1	5
Zapus hudsonius	(O)	40	34	30	17	121
Sylvilaqus floridanus	(O)	0	5	0	0	5
Total		250	267	122	115	754
Richness		11	14	12	11	17
Diversity (H′)		2.83	3.16	2.73	2.91	3.21
Evenness (H′)		0.82	0.91	0.76	0.84	0.79

experiences. Specimens were deposited in the Virginia Commonwealth University Mammal Collection.

RESULTS

Diversity and numbers of mammals captured were highest in the clearcuts; nearly 70% of 754 mammals were captured in this habitat type (Table 1). The total number and species composition of mammals captured within a given habitat type were similar (Table 1). Species richness was slightly higher in clearcut than in forested habitats. *Ochrotomys nuttalli* and *Sigmodon hispidus* were captured only in the clearcut habitat, along with the incidental captures of juvenile *Didelphis virginiana*, *Sylvilagus floridanus*, and a single *Scalopus aquaticus*. *Condylura cristata* and *Glaucomys volans* were trapped only in the forested habitats. Approximately 32% of 237 forest captures were species we classified as edge or old field forms; whereas, 59% of 517 clearcut captures were old field forms (Table 2). Chi-square analysis indicated that of the 10 species captured in both habitats, 7 were captured in significantly different numbers between habitat types ($p < 0.05$). *Sorex longirostris*, *Cryptotis parva*, *Reithrodontomys humulis*, *Peromyscus leucopus*, *Microtus pennsylvanicus*, and *Zapus hudsonius* were captured in greater numbers

Table 2. Habitat associations of small mammals in the central Virginia Piedmont. Within each category for typical habitat association, the number of species (no. spec.), captures (no. caps.) and percent of those captures (% of caps.) in each habitat type are given.

Typical		Forests			Clearcuts		
Habitat Association		No. Spec.	No. Caps.	% of Caps.	No. Spec.	No. Caps.	% of Caps.
Generalist	(G)	5	155	65.4	8	206	39.8
Edge/Field	(O)	4	75	31.7	6	305	59.0
Semi-aquatic	(A)	2	6	2.5	1	6	1.2
Forest	(F)	1	1	0.4	--	--	--
Totals		12	237	100	15	517	100

in the clearcuts than in the forests, and *Blarina brevicauda* was captured in greater numbers in the forested habitats.

DISCUSSION

Results of this study increased our knowledge of the distribution of Virginia mammals. Our captures of the uncommon star-nosed mole (*Condylura cristata*) substantially increased the meager number of records for Virginia (Handley and Pagels, 1991). The rice rat (*Oryzomys palustris*), a semi-aquatic species common in coastal marshes, was taken in both habitat types. Our records in Cumberland County are the westernmost for *O. palustris* in Virginia (Webster et al., 1985).

Handley and Patton (1947) commented on the habitats of the few sites where *Zapus hudsonius* had been collected in the eastern half of Virginia. Later, Pagels (1980), who used snapback traps, noted that he had collected *Zapus* at only 1 site in 10 years of small mammal trapping in central Virginia. *Zapus* represented 16% of our 754 captures. Shrew captures accounted for approximately 37% of the total number of mammals taken. Our captures of *S. longirostris* equaled all known statewide captures as recently as 1989 (Pagels and Handley, 1989). Clearly, some of what we know about modern day diversity and abundance of Virginia mammals reflect years of sampling effort. Perhaps we encountered high population levels for certain species, e.g., *Zapus*; however, the numbers of captures of some species, e.g., shrews in general, also reflected the efficacy of pitfall trapping with drift fences.

Our results agree with those of numerous studies (see Kirkland, 1990) that found an increase in relative abundance of certain small mammals after clearcutting, with at least a portion of the increase being attributable to exploitation of the site by non-forest small mammals. Only *Sorex hoyi* and *Blarina brevicauda*, species that we categorized as generalists (Table 1), were taken in lower numbers in the clearcuts than in the forests. *Sigmodon hispidus,* a species categorized as an edge/old field form, was captured only in clearcut habitats, as was *Ochrotomys nuttalli,* a habitat generalist. Many of the differences in small mammal abundance between habitat types resulted from more captures of edge or old field forms in the clearcut habitat than in the forest habitat (Table 2). Generalists comprised a much greater percentage of the overall captures in the forest.

Because of the captures of old field forms in nearby forest habitats, we can suggest that their presence in clearcut habitats, as manifested both in species richness and abundance, was the result of both exploitation or colonization from nearby old fields and the "buried seed strategy" (Marks, 1974). The latter would be demonstrated by old field forms that existed in low numbers in the forests but that increased in numbers following the development of suitable habitat through clearing.

At the first symposium on threatened and endangered biota of Virginia, Pagels (1980) observed that although certain Virginia mammals had been extirpated or had diminished ranges, other species were now more common and widespread than several hundred years ago. Our data support Pagels' contention that such species are those associated with edge and old field situations. Concomittantly, small mammals characteristic of special habitat types are becoming increasingly rare. Because the area we studied lacks specialized habitats, e.g. caves or spruce forests, we found no species now considered threatened or endangered in Virginia. We predict that with continued clearing of closed canopy forests and landscape alterations due to urban development, species at home in edge/old field situations will continue to flourish, and that the "specialist forms", i.e. forest and semi-aquatic species, will decrease in numbers, if not disappear completely. What type of habitat mosaic will characterize our landscape in the future, and what species will dominate the mammal fauna? Inventories of selected urban communities could provide insight into these questions and lead to management options that may help to insure the long term survival of all of Virginia's small mammals.

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The data presented in this paper are from only 2 small mammal populations, both in CRC, which were monitored from 1986 through 1990. The number of small mammals which consume mast that were captured was multiplied by the estimated daily mast requirements for each species (*Peromyscus*, 2 acorns/day, Verme, 1957; *Tamias,* 4 acorns/day, Verme, 1957, Elliot, 1978; *Glaucomys*, 4 acorns/day, Weigel, 1978; *Sciurus*, 8 acorns/day, Nixon and Hansen, 1987); the sum was considered the estimated daily mast needs for the mast-dependent community within the study areas.

The avian understory community was sampled with mist-nets during June 1990. On each grid nets were placed every 50 m (5 lines of 5 nets), so as to cover the entire site. Each captive was aged, sexed, weighed, checked for molt and subcutaneous fat reserves, and banded with a U.S. Fish and Wildlife Service band. Two sites were netted during each 1 week period of the breeding season (June 1 - July 1) for a total of 1,500 net hours (12 hours x 25 nets x 5 days) at each site. We monitored all bird populations, but focused our efforts on species which nest and/or forage within 2 m of the forest floor (Table 1). The abundance of this particular guild of birds should closely reflect understory composition.

As a preliminary measure of activity of deer on the grids, in November 1990 we established a series of remote tripcameras on 2 grids with markedly different understory densities (Elk and Range grids). The 35 mm auto-focus camera, with wide angle lens and built-in flash, is connected to an infrared sensor which detects changes in "heat profile" (CAM-TRAKKER, Dan Stoneburner, Athens GA). Three trip-cameras were placed 60 m apart on each grid and set for 1 week. If a camera ceased functioning during the week, a day/time stamp placed on each photograph determined the last day the camera monitored an area and allowed a calculation of "camera days" for each grid (sum of cameras operating on each day of sample; maximum n for each grid = 21). The cameras also possess a 3-minute delay between photos to reduce repeated photos of a single animal. The trip-cameras cannot differentiate between individuals and hence cannot be used to determine density, but they give an estimate of animal activity within each study area. The amount of deer activity in an area was expressed as number of deer photographed per "camera day".

Habitat variation was sampled within three 576-m^2 (24 X 24 m) plots at each site, and emphasized the density and diversity of forest understory and ground cover. The specific protocol was developed by SNP officials, and is presently used as part of their long-term environmental monitoring program (SNP 1990). Measurements of understory within each plot included counting and identifying all woody stems, estimating density through use of a "cover board" (Nudds, 1977), and counting and identifying all woody seedlings in 12 1-m plots within each larger plot. The coverboard was a 2-m board with 100 squares equally divided into 4 quadrats. For each 24 x 24 m plot observers recorded the number of squares which contained vegetation when sighted from the center of the plot to each of the corners. For understory density, we used the mean number of cells covered by vegetation for the portion of the board between 0.5 and 1.5-m in height. The relationship between understory density and bird populations, and between small mammal populations and mast crop, was tested with Pearson product-moment correlation coefficients, where significance was considered $P < 0.05$.

TABLE 1. Bird species that nest and/or forage within 2 m of forest floor within the central-Atlantic region of North America (Ehrlich et al., 1988; Terre, 1980).

Kentucky Warbler	*Oporornis formosus*
Louisiana Waterthrush	*Seiurus motacilla*
Ovenbird	*Seiurus aurocapillus*
Veery	*Catharus fuscescens*
Worm-eating Warbler	*Helmitheros vermivorus*
Hooded Warbler	*Wilsonia citrina*
Wood Thrush	*Hylocichla mustelina*
Rufous-sided Towhee*	*Pipilo erythrophthalmus*
Northern Cardinal*	*Cardinalis cardinalis*
Gray Catbird*	*Dumetella carolinensis*

* species which also occur in early successional forests, but are expected to respond to increased understory density.

RESULTS

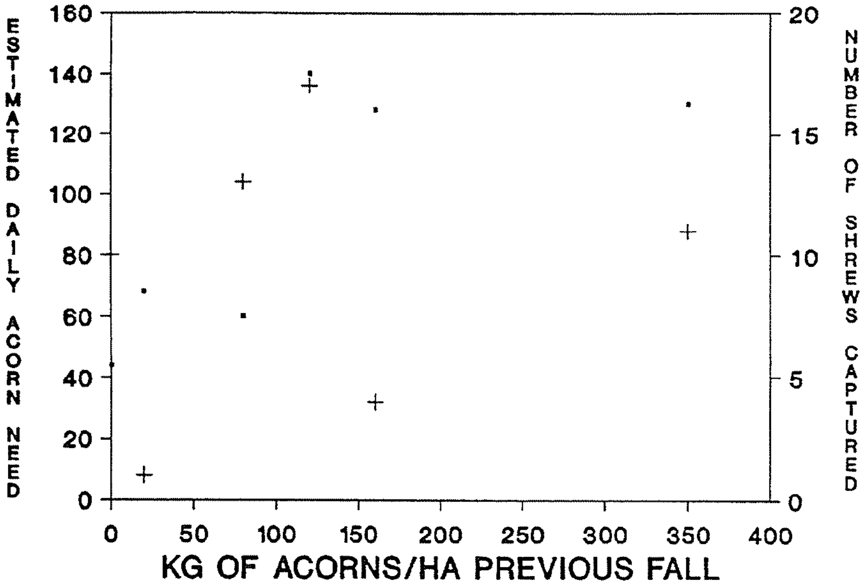
Small Mammals: The density of the mast-dependent small mammal community in the spring was positively correlated with the mast crop production during the previous autumn ($r = 0.76$, $n = 6$, $P < 0.05$), but mast production beyond 150 kg/ha does not appear to have a significant impact on small mammal densities (Figure 1). As a test for possible correlation between mast production and severity of winter, mammals that do not consume mast (*Blarina* and *Sorex*) showed no significant correlation between spring densities and mast production the previous autumn ($r = 0.12$. $n = 6$, $P > 0.10$).

Bird Community: There was a significant positive correlation between the understory density, as measured by the coverboard, and both the number of individuals and the number of species captured (Table 2). Within the guild of understory birds there was also a significant increase in the number of species captured with increasing understory density, as measured by both the coverboard and the number of woody stems (Table 2).

Deer Density: There were almost twice as many deer photographed on the low-density understory grid, as on the high-density understory grid (1.29 deer photographed/camera day and 0.70 deer photographed/camera day, respectively; 17 and 20 cameras days, respectively).

DISCUSSION

Estimates of mast crop requirements for wildlife range from 100 to 200 kg/ha (Goodrum et al., 1971; French, 1980; Johnson et al., 1989). For this study, at densities below 150 kg acorns/ha there was a positive correlation between mast crop size and the overwintering population of mast-consuming small mammals. The lack of a significant correlation between mast crop and nonmast-consuming small mammals indicates that severity of winter, or some other environmental factor correlated with mast crop, was probably not responsible for the results. Above acorn densities of 150 kg/ha, it is not known whether mast is no longer limiting, or small mammals cannot effectively exploit the large mast crop before the deer. Deer



FIIGURE 1. The relationship between spring densities of small mammals and the size of the acorn crop the previous autum. Two groups of small mammals are shown, those rodents which consume acorns (●) and small insectivorous shrews which do not consume acorns (+). Individuals within the acorn-consuming small mammal population are weighted by the amount of acorns each species was estimated to consume each day (see methods).

TABLE 2. Understory and bird community characteristics of each study grid during summer 1990. The correlation coefficients (r) between bird community measures, and number of woody stems (r1) and coverboard measures (r2) are given at bottom of table.

Grid	Number of Species	Number of Individuals	Understory Bird Guild[2]	Number of Woody Stems	Coverboard[1]
Elk	13	35	2	101	3.8
Dump	13	30	3	52	4.1
Posey	12	47	3	222	4.3
Hilltop	18	45	2	146	6.2
Bear	12	45	3	330	9.7
Range	23	103	7	296	14.2
Keyser	18	67	6	3 86	15.8
AT	22	68	6	804	16.9
r1	0.59	0.50	0.65*		
r2	0.78**	0.78**	0.90**		

[1] see TABLE 1
[2] mean number of squares covered by vegetation
* $P < 0.05$

consume acorns at a rate of approximately 1 acorn/minute (McShea and Schwede, 1992). Slower search and handling times for sciurids and mice (Verme, 1957; Elliot, 1978) may limit their ability to store more mast within the period before the mast crop is eaten by deer.

The bird community was larger with increased understory density. This was particularly evident for the guild of birds that nest or forage within the understory. Deer do shape the composition and density of the understory (Hough, 1965; Alverson et al., 1988). The higher density of deer within the grid with the low density of understory supports the hypothesis that deer may have an indirect impact on bird communities within deciduous forests.

This paper presents preliminary evidence for the impact of deer on forest vertebrate communities, but the data only suggest an impact through correlation. Manipulation of deer density within the study areas must be made to test the correlations. We are presently constructing deer exclosures around 4 study grids, with 4 grids left as controls. It may take several years to detect any changes which might occur within the exclosures; however, at the conclusion of the project we will be able to quantify the effect of reduced deer density on our 2 study groups.

The densities of deer within these study areas are high. There is no evidence that the deer population will soon "crash" because of these densities, or that any other form of natural regulation will reduce deer densities during the immediate future. There is nothing inherently wrong with high deer densities, the question for land managers is how compatible these high densities are with other conservation goals. We do not identify white-tailed deer as a negative factor within forest communities, but as a keystone component within their community, which should be viewed as an integral part of any land management. Decisions to increase or decrease populations of specific species within the vertebrate community (e. g. neotropical migrant birds) must consider the role of white-tailed deer in their ecology.

The challenge of land management in Virginia will be to increase populations of endangered and endemic species, while preserving what are essentially our success stories of abundant wildlife species.

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