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VOLE MANAGEMENT STUDIES-1978

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Earlier studies at the Cary Arboretum (McAninch, 1978) have described mowing and general cultural management practices as key elements in vole management programs. During the 1978 growing season, studies were initiated to quantify several soil parameters and vegetative elements in fruit orchards and correlate these characteristics to the distribution and abundance of vole populations. Although a great deal of additional orchard-vole data has been generated, only the associations described above will be discussed in this paper.

METHODS AND MATERIALS

Fifteen orchards, three in Dutchess County, and 12 in Ulster County were selected as collecting sites for this study. Orchard ground cover was inconsistent across all orchards but generally included orchard grass (Dactylis glomerata), fescue grasses (Festuca spp), bromegrasses (Bromus spp), bluegrasses (Poa spp), timothy (Phleum pratense), clover, (Trifolium spp), foxtail (Setaria spp), goldenrod (Solidago spp), poison ivy (Rhus radicans), dandelion (Taraxacum spp), sheep sorrel and dock (Rumex spp), and plantain (Plantago spp). The blocks varied in age from 3 to 60 years and in density from 30 to 150 trees per acre. One, a 45 year old abandoned block was included in the study.

Vole trapping was conducted in October and November using Sherman live traps (5X5X18cm) and Victor snap traps with peanut butter as bait. One live and one snap trap was located at fruit trees chosen as data stations. All data stations were established at 12m intervals within a 7X7(49 station) grid network. A 25m border strip surrounded each grid resulting in a 1.75ha. sampling area. Traps were checked daily over a five day period. In this study relative abundances were determined using the index of trapability of Pucek (1969) with the correction for sprung traps of Nelson and Clark (1973).

All animals collected were identified in the field, weighed, sexed and aged (juvenile or adult). At the laboratory several physical measurements including total length, tail length, length of the hind foot, and ear length, were taken. Skulls were removed, cleaned, and examined to verify all field identifications. Females were examined for obvious signs of pregnancy. In addition uteri were removed and the presence of placental scars, embryos or feti was noted. Only the species composition of the vole populations encountered will be discussed in this paper.

Quantitative soil and vegetation information was collected or recorded on four locations at each data station. All locations were one meter from the tree base and at 90° angles from each adjacent location around the tree. Soil and vegetative values for each data station represented the average of the four locations around each tree.

Soil compaction was measured with a soil penetrometer (Soiltest Inc., Model CL-700) and soil samples were collected with an Oakfield Soil Sampler. The four soil samples from each data station were thoroughly mixed and totaled approximately 30cc in volume. Subsamples of approximately 10g were used to determine soil moisture and soil organic matter (Wilde et al., 1972).

Ground litter (thatch) depth was found using a centimeter ruler and vegetation density at 0-25cm and 0-1m was measured with density boards (Birch, 1977; McAninch, 1978). Light intensity 1 m above the ground was recorded in foot-candles with a light meter. Readings at each location were divided by the value of a reading taken in an open location. This proportion represented the quantity of light penetrating the tree canopy.

Any habitat alterations including mowing and herbicide applications were noted. In addition, rodenticide applications, principally zinc phosphide and endrin were monitored.

RESULTS

The degree of variation in site characteristics was analyzed by comparison of the seven soil and vegetative parameters measured in each block. The ANOVA for each parameter across all blocks indicated there were significant differences between blocks (Table 1). Factor level contrasts (Fig. 1) were computed using the Tukey method (Neter and Wasserman, 1974) and a family confidence coefficient of .95. Blocks G, I, J, K, L, and S were not included in the contrasts. The early application of rodenticides in these blocks likely changed vole population size and structure and therefore would have biased any correlations of vole populations with orchard characteristics.

The seven factors presented in Fig. 1 indicated blocks presented voles with a variety of significantly different habitat types. Only light intensity failed to discriminate markedly among blocks. The abandoned block (M) demonstrated low soil compaction, high soil moisture and organic matter, moderate thatch depth, and high vegetative cover at both density levels. The combination of characteristics observed were indicative of the lack of management activities (machinery, spraying, mowing, etc.) in the block. Block H, with low values for every parameter, was well mowed with little residual thatch, had each tree base cleared and in general exhibited excellent cultural management practices. The remaining blocks had variable combinations of the seven characteristics measured which reflected the variety of ground cover types, mowing and herbicide practices, and tree care techniques utilized in each respective location. The number of significant differences found among the maintained orchards implied that cultural management of an orchard was a key factor in the resultant soil and vegetative characteristics of a particular block.

Table 1. ANOVA for each soil and vegetative parameter for all orchards sampled during October and November, 1978.

Parameter	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Statistical Significance
	Between blocks	14	28.16	2.01		
Soil	Within Blocks	718	74.30	.10	19.53	p=.001
Compaction	Total	732	102.46			
Soil	Between blocks	14	2.45	.18		
Moisture	Within blocks	718	2.11	.003	58.33	p=.001
	Total	732	4.56			

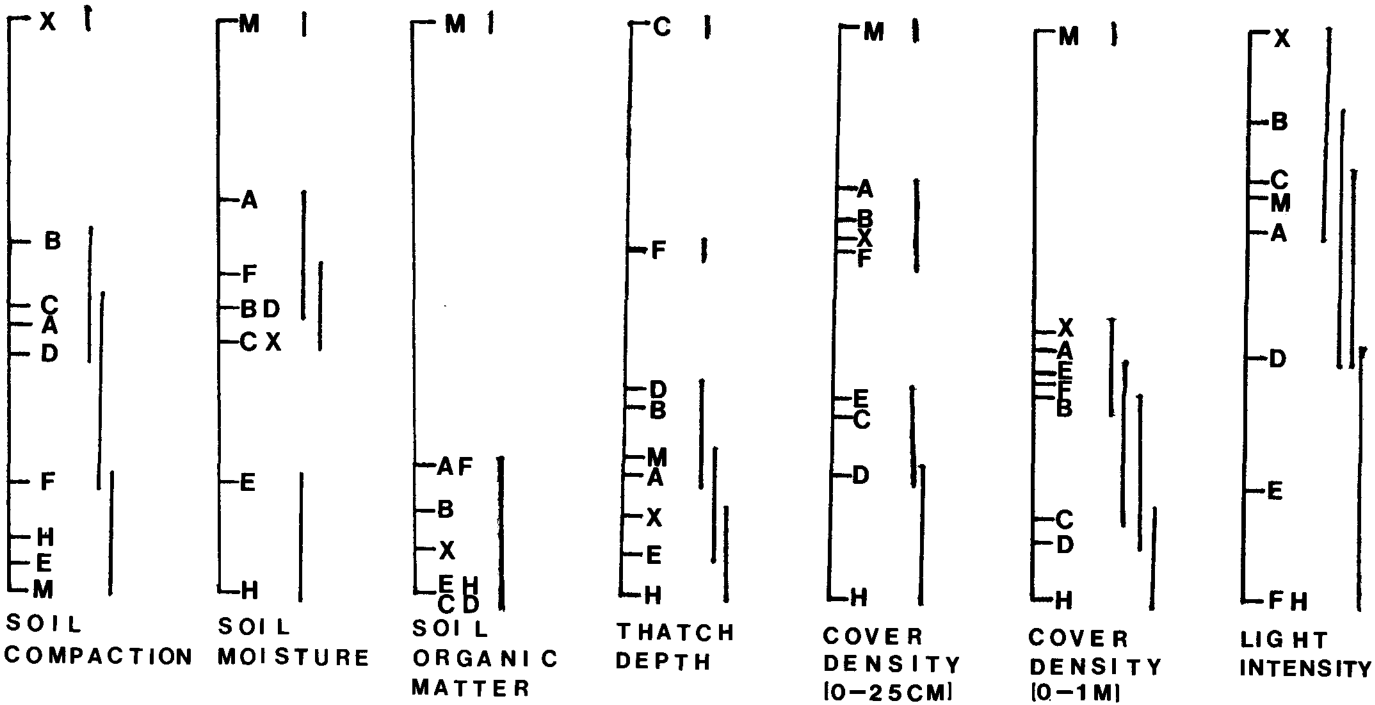

Fig. 1. Contrasts of factor level means for nine selected blocks using a confidence coefficient of .95. All brackets indicate non-overlapping groups. Large values appear at the top and small values at the bottom of each scale.

Table 1. (continued)

Soil Organic Matter	Between blocks	14	.96	.07		
	Within Blocks	689	1.05	.002	35.00	p=.001
	Total	703	2.01			
Thatch Depth	Between blocks	14	847.21	60.52		
	Within blocks	718	896.11	1.25	48.40	p=.001
	Total	732	1743.32			
Cover Density (0-25cm)	Between blocks	14	152,275.83	10,876.85		
	Within blocks	718	273,690.63	381.18	28.53	p=.001
	Total	732	425,966.46			
Cover Density (0-1m)	Between blocks	14	42,693.70			
	Within blocks	718	107,759.52	150.08	20.30	p=.001
	Total	732	150,453.22			
Light Intensity	Between blocks	14	21.56	1.54		
	Within blocks	718	76.14	.11	14.00	p=.001
	Total	732	97.70			

To facilitate comparisons of vole populations and orchard habitat characteristics, vole abundances were summarized for the eight maintained blocks (Table 2). In addition to the six blocks excluded due to early rodenticide applications, the unmanaged, abandoned block (M), a significantly different orchard habitat, was not included in the analysis.

Table 2. A summary of meadow and pine vole densities for eight maintained blocks sampled during October and November, 1978.

Block	Meadow Vole (RA)[a]	Pine Vole (RA)	Total Voles (RA)
A	4.64	0	4.64
B	8.86	0	8.86
C	9.62	.21	9.83
D	7.89	0	7.81
E	2.74	0	2.74
F	1.07	4.49	5.56
H	.88	0	.88
X	3.63	0	3.63

a - RA=Relative abundance or captures per 100 trap nights.

Meadow vole home ranges have not been well described for orchard habitats. Byers (1978) suspected meadow voles ranged over a much larger area than pine voles. Field observations from this study indicated meadow voles ranged within the dripline of several trees within rows as well as across two or three tree rows. Based on the above evidence, meadow vole abundance was summed over each block, and was then regressed upon the soil and vegetative characteristics of each block (Table 3).

Weak relationships were observed between soil compaction, soil moisture, thatch depth and meadow vole abundances. The relationship between soil compaction and meadow vole abundance suggested a quadratic function in the form of a parabola. Specifically, this observation indicated meadow voles preferred moderate soil compaction conditions. Soil moisutre and thatch depth demonstrated direct linear relationships with meadow vole abundances. Light intensity also displayed a weak relationship with meadow vole abundance. Light intensity was less than 60% of the full light intensity in all blocks and the recorded values were confounded by variations in pruning practices and tree age. Regardless, values for light intensity increased with meadow vole abundance.

Table 3. Regression of meadow vole abundance on soil and vegetation characteristics in eight blocks, October and November, 1978.

Variable	Intercept	Slope	R^2	Statistical Significance
Soil Compaction	-2.09	6.55	.20	p=.15
Soil Moisture	-3.87	47.47	.22	p=.15
Soil Organic Matter	9.003	44.79	.03	p=.40
Thatch Depth	2.94	1.34	.29	p=.13
Cover Density (0-25cm)	3.78	.02	.01	p=.45
Cover Density (0-1m)	6.47	-.09	.02	p=.40
Light Intensity	.83	11.15	.44	p=.10

Although one pine vole was recovered from block C, block F was the only site where a thriving pine vole population was located. Pine vole captures were adjusted for each data station (tree) to facilitate the analysis. Total pine vole captures (after the five day collection period) for trees where pine voles were caught were increased by one and trees within a row that were adjacent to a tree where pine voles were captured were assigned a pine vole capture frequency of one. All other trees where pine vole captures were not recorded retained a capture frequency of zero. This adjustment was based on the home range and movement information of Fitch (1958), Paul (1970), and Sullivan (1977) that found pine voles seldom moved between rows and generally were active under two or three trees within a row. Specifically, the adjustment in pine vole capture frequencies was an attempt to divide trees into two groups; trees with pine vole activity and trees without pine vole activity.

Initial comparisons of the presence or absence of pine voles based on the above criteria indicated soil compaction, thatch depth, and light intensity were significantly different (Table 4). Soil compaction was higher and the thatch deepr in areas harboring pine voles. While higher values for light intensity were associated with pine vole presence, the importance of this relationship is reduced since values over the entire block were less than 20% of full light intensity. Cover density (0-1m) was weakly significantly different between sites with pine voles selecting for slightly less dense cover.

The regression of adjusted pine vole captures on soil and vegetation characteristics indicated thatch depth accounted for 89% of the variation in capture frequencies (Table 5). The high degree of significance of this relationship implied thatch depth was a key cultural management practice for pine vole control. Soil compaction accounted for a small amount of the variation in pine vole capture frequencies yet indicated a significant relationship was present. Additional data in future studies from more blocks with pine vole populations will be needed to further substantiate

Table 4. Comparative analysis of soil and vegetation characteristics of pine vole capture sites (P) versus sites where pine voles were not captured (A). Data were collected from block F during October and November, 1978.

Variable	Site Group	Average	Standard Deviation	Test Statistic	Statistical Significance
Soil Compaction	A	.82	.26	3.33	p=.005
	P	.99	.24		
Soil Moisture	A	.21	.04		
	P	.21	.03	0	0
Soil Organic Matter	A	.11	.02		
	P	.11	.02	0	0
Thatch Depth	A	2.31	1.30		
	P	3.08	1.17	3.08	p=.005
Cover Density (0-25cm)	A	56.80	20.10		
	P	55.80	14.50	.28	p=.40
Cover Density (0-1m)	A	20.70	12.40		
	P	18.00	7.00	1.33	p=.10
Light Intensity	A	.08	.03		
	P	.15	.19	2.55	p=.01

Table 5. Regression of pine vole capture frequency on soil and vegetation characteristics at 49 trap sites in block F, October and November, 1978.

Variable	Intercept	Slope	R^2	Statistical Significance
Soil Compaction	-.72	1.81	.16	p=.01
Soil Moisture	1.48	-2.81	.01	p=.35
Soil Organic Matter	1.85	-8.68	.03	p=.15
Thatch Depth	-1.38	.86	.89	p=.001
Cover Density (0-25cm)	1.28	-.01	.01	p=.25
Cover Density (0-1m)	1.02	-.01	.003	p=.30
Light Intensity	.80	.87	.01	p=.30

the significance of the factors described here.

CONCLUSIONS

The variation in soil and vegetation characteristics reflected basic differences in ground cover and ground cover control practices. Brome and bluegrass habitats tended to exhibit denser growth and deeper thatch than other ground covers. Red fescue, in particular, created a low cover density (0-25cm) that was hardly altered by mowing practices. Herbicide techniques unless applied when vegetation was less than approximately 30cm created similar dense cover situations. Only when grasses were at least partially invaded by substantial numbers of low-growing forbs was herbiciding acceptable on growth over 30cm. The type of cover provided by poorly maintained orchard vegetation was similar to cover in the abandoned orchard where thatch depth was minimal and vegetation density was high at both levels measured.

When pine and meadow vole abundances were correlated to soil and vegetative parameters, cover, primarily thatch depth, was a key element in determining population levels. Surprisingly, thatch depth was almost singularly responsible for the fluctuations in pine vole capture frequencies in block F.

The potential effects of reduced cover on vole populations have been discussed by McAninch (1978). Documentation of the mortality patterns of pine and meadow vole populations would be essential to the complete understanding of the effects of vegetative cover destruction on population levels. In addition, well maintained orchards may inadvertently induce vole populations to persist in edge habitats and thereby retain an ever-present damage and invasion potential for border blocks.

A great number of elements vital to the intelligent management of voles in orchard habitats remain to be described. An important foundation for vole control programs based on the interrelation of voles and soil and vegetative factors in orchards has been provided by this study. The strength of this foundation is dependent upon an understanding by growers that they are the managers of a complex ecosystem that heretofore has provided meadow and pine vole populations with optimal habitats.

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