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MASTER

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A. Introduction

Studies of the effects of environmental perturbation on natural ecosystems are essential to sound environmental planning and reclamation efforts. The extent of natural spatial and temporal variation of ecosystem components must be documented if future human impacts upon the environment are to have a neglible effect on ecosystem stability.

Small mammals are an integral part of temperate forest ecosystems. As consumers of plants and invertebrate animals, they influence mineral cycling, the composition of plant and animal communities, community dynamics, and ultimately, forest succession. Alternatively, small mammals are important as buffer species in the diet of many forest predators, and are consumed when larger game species population levels are dangerously low. Predators of small mammals are diverse, and include snakes, hawks, owls, racoons, weasels, fox, and man himself. Clearly, small mammals contribute to both the structural complexity and the stability of ecosystems.

Population density levels of small mammals are often roughly correlated with local forest productivity. In a highly productive forest the total number of individual small mammals (all species) may exceed 100/hectare. Low productivity forests may harbor few or none at all. Thus, the potential exists for using small mammal populations as indicators of local forest composition and quality. Changes in the density levels of species used for this purpose (indicator species) may so reflect the dynamics of forest structure and productivity. Small mammals are better suited for this than larger mammals because an individual's activity is confined to a smaller area. This means more animals can be examined for study per unit effort, and even more important, that the parameters studied are likely to be indicative of a relatively small, specified area and less affected by factors external to the study area and interests of the investigation.

The white-footed mouse, Peromyscus leucopus, is common in temperate deciduous forests throughout the northeastern United States. Its ubiquitous distribution is a required feature for studying the effects of variation in forest components upon a representative consumer. The goal of this study was to collect baseline data on P. leucopus populations responding to spatial and temporal forest heterogeneity, and so evaluate its potential as an indicator species.

B. Study Areas

The study was conducted within relatively undisturbed tracts of forest located at Brookhaven National Laboratory, Upton, New York. Field work was done is three forest types recognized by the dominant tree species in each: maple (Acer rubra); pine (Pinus rigida); and oaks (Quercus coccinea and Q. alba). Upland forests are dominated by scarlet oak and some white oak. The shrub layer is well developed and consists primarily of blueberries (Vaccinium spp.) and huckleberry (Gaylusaccia spp.). Soils of upland forests are usually Riverhead or Plymouth series, acid, and well-drained. From upland to lowland, distinct plant communities are encountered. Moderate slopes (10-15%) are dominated by pitch pine (P. rigida) and the shrub layer is poorly developed and in some cases absent. Shrubs vary in composition and abundance due to local topography and disturbance history. Frequent and severe fires eventually produce a shrub layer that is almost entirely composed of bear oak. Soil types of pine forests include sandy, well- to excessively-well drained soils such as Carver-plymouth and Wareham types. Below this area the slope is moderate and the forest more mesic than elsewhere. The canopy species are primarily white oak, red oak, and pitch pine in order of abundance. A diverse shrub layer includes sassafras, blueberries, and cat's claw (Smilax sp.), but this stratum is sparse and patchy. The mesic forest grades sharply into lowland forest within an ecotone characterized by a dense shrub layer of Clethra sp. Lowland forests drain to the east and form the headwaters of the Peconic River. The forest consists almost exclusively of Acer rubra and a few, large scattered pines. Sweet pepperbush (Clethra alnifolia) forms dense patches and accounts for most of the shrub layer. Ground water is at or near the surface of the forest floor most of the year. Wind storms result in many treefalls and scattered brush piles. Tip-ups from larger trees form pools of water which are permanent. Lowland soils are generally muck.

C. Methods

Oak, pine, and maple forests were each censused for small (less than 300 g) mammals by four 1 ha 10 by 10 sampling grids (Figure 1). Traps were spaced 10 m apart, set for 6 g sensitivity (to ensure capture of the smallest animals) and baited with a 1:1 mixture of peanut butter and rolled oats. A 10 consecutive day trapping period was routinely employed. Captures were individually marked by a scheme of toe-clipping and ear-notching, and the species identity, age class, sex, reproductive condition, weight to nearest 0.1 g, presence of external parasites, and behavior upon release noted. Sherman live traps and Mc Gill snap traps were used. Snap-trapping was discontinued after the first three days of the spring census to avoid depletion of already low population sizes.

D. Results

Shrews (Sorex cinereus and Blarina brevicauda) were rarely captured but were observed foraging in the field around traps, without entering them. Shrews are probably more abundant than the two recorded captures suggest. Other rarely-trapped small mammals included the eastern chipmunk (Tamias striatus) and the eastern woodrat (Neotoma floridanus). Peromyscus leucopus was the only small mammal encountered regularly in traps. The following results pertain to this species only.

1. Distribution and Abundance. Captures of P. leucopus occurred only in upland oak- and lowland maple- forests from spring to summer. Only one P. leucopus was taken in pine habitat during the entire study. Mesic oak forests surrounding the lowland areas contained no mice from spring to summer. Spring populations were at very low density levels (2 adults/ha). Both upland and lowland populations increased to about 10 individuals (all ages included)

during summer and declined to about 8 individuals by the fall. At this time mesic forests, previously vacant, also supported populations of 8 mice/ha. The population levels of each area are summarized in Table 1.

2. Reproduction and Recruitment. All mice taken during April-May were adults in reproductive condition. Juveniles first appeared in early June. Observations of 10 litters born in the lab to wild caught females housed in isolation during early May suggested these field-caught juveniles to be the first cohort of Spring and to be 30-40 days old. The average number of neonates born was five/litter; of these only 4 were successfully weaned. From May to November mice produced three litters. No differences in the duration or time of reproductive events were noted between habitats.

3. Somatic Condition (Adult Weight). Body weights of adult mice were examined to determine if weight differed significantly between sexes, populations (upland versus lowland), or seasons. Analyses of variance were employed (Table 2). Males and females did not differ significantly in weight (females known to be pregnant were excluded from the study). Similarly, no differences between populations were statistically significant. A habitat by season comparison revealed no differences that were significant between habitats or seasons for a particular habitat, but the season x habitat interaction was significant ($p = .05$).

4. Interhabitat Movements. Colonization of unoccupied forest has already been mentioned. The origin of these mice is undetermined. During the course of the Fall trapping period, two adults were observed to make extensive movements from lowland to mesic forest types. Since they were not recaptured after this time, the nature of these movements (exploratory, dispersal, etc.) remains ambiguous.

E. Discussion

This study was based upon mark-recapture methods and accordingly hampered by the low population density levels encountered. Several of the findings are nevertheless significant, and treated in order. The distribution and abundance of mice has changed dramatically over the past few years. This change appears correlated with the degree to which productivity of mast has occurred. Deciduous forests at BNL experienced a mast crop rated good in Fall 1976 and a poor crop in upland oak forest near the North Boundary in Fall 1977. Most areas on site experienced crop failure since 1977. Since that time mouse density has declined, and distribution has shifted. The upland and lowland areas occupied in Spring may represent survival habitats during periods of mast crop failure. Upland areas present good yields of fruits for small mammals from June to early September. Lowland areas provide green shoots and insects in Spring, *Clethra* in July, and an annual supply of maple seed in the Spring. The two habitats appear to be roughly equivalent in their ability to support populations of *Peromyscus* during years when no acorns are produced.

The apparent redistribution and colonization of formerly unoccupied oak (mesic) forest occurred after a moderate crop of bear oak, red oak, and white oak acorns was produced during September and October of this year (1979). Areas with unsuitable shrub cover may suddenly become suitable for occupation in the fall and winter when acorns are available.

Food supply has long been recognized as a key factor determining the abundance of small mammals, including P. leucopus.[1] These findings suggest that changes in mast productivity have about a tenfold effect on absolute density of mice in survival habitat, and further result in expansion and contraction of local mouse populations following and preceeding each mast crop.

The results further suggest the potential importance of dispersal by mice between habitats as a mechanism of opportunistic resource exploitation. This is not only significant from an ecological perspective, but an evolutionary one as well. Upland and lowland populations of P. leucopus,previously suggested by some to be distinct breeding units,[2] may in fact be periodically linked by gene flow across colonization habitats. Thus, gene frequencies may change not only as a function of locality or habitat but episodically in time as forest productivity fluctuates.

F. Conclusions

Peromyscus leucopus was the most abundant small mammal captured by live-trapping in temperate forests at Brookhaven National Laboratory. Maple forests and oak forests with good cover of fruiting shrubs permanently support populations of P. leucopus which increase from low levels in spring and reach a peak of two to three times the spring density in the late summer. Production of mast crop is correlated with colonization of areas normally unsuited for mice because of poor food supply. Population density in oak forests the summer following a good mast crop may be as much as 10 times greater than in years intervening mast crops. Mouse populations after this period crash sharply over the following winter by a factor of 10. The third summer after a mast crop only oak forests with adequate shrub cover still support mice. Other populations either are extinct, or at such low levels that conventional methods of censusing are unable to detect them.

This study qualitively suggest the overriding importance of considering spatial and temporal forest heterogeneity when contemplating the use of a forest consumer as a model indicator species. Colonization from nearby patches of different forest types may bias results in studies using small mammals as subjects assumed to reflect local productivity in a strict sense.

G. Future Work

Studies of habitat utilization and dispersal of P. leucopus are in progress. Radiotelemetry is being used to make more definitive measurements of these aspects of white-footed mouse life history than possible with live-trapping mark-recapture methods alone. Such methods of telemetering location and activity generate large data bases even at extremely low density levels.

REFERENCES

1. J.F. Bendell, Can. J. Zool. 37, p. 173-209 (1959).
2. D.H. Miller and L.L. Getz, J. Mamm. 58, p. 1-16 (1977).

Table 1
Area Population Densities for *P. leucopus* as a Function of Time

Sample Location		Spring 1977	Spring 1978	Spring 1979	Summer 1979	Fall 1979
Oak						
upland	1	NR[a]	NR	2	8	6
	2	20[b]	10	4	12	10
mesic	3	NR	3	0	0	6
	4	NR	NR	0	0	8
Maple	1	NR	6	3	10	8
	2	NR	NR	0	3	5
	3	NR	5	1	7	6
	4	NR	NR	2	8	7
Pine	1	NR	0	0	0	0
	2	NR	0	0	0	0
	3	6	0	0	0	0
	4	8	0	1	0	0

[a] NR = not recorded.

[b] Numbers are minimum number of individuals known to be alive.

Table 2
Analyses of Variance of Adult *P. leucopus* Bodyweights

	df	ss	ms	F_s
Sex vs. Habitat				
Source of Variation				
Subgroups	3	28.49	9.50	
S (sex)	1	16.47	16.47	2.98 ns
H (habitat)	1	4.45	4.45	0.80 ns
interaction (S x H)	1	7.56	7.56	1.37 ns
Within subgroups (error)	10	55.34	5.53	
			$F_{.05}[1,13] = 4.67$	
Habitat vs. Season				
Source of Variation				
Subgroups	3	41.12	13.71	
S (season)	1	2.04	2.03	0.333 ns
H (habitat)	1	0.77	0.77	0.125 ns
interaction (S x H)	1	38.32	38.32	6.27 *
Within subgroups (error)	12	73.32	6.11	
			$F_{.05}[1,12] = 4.75$	

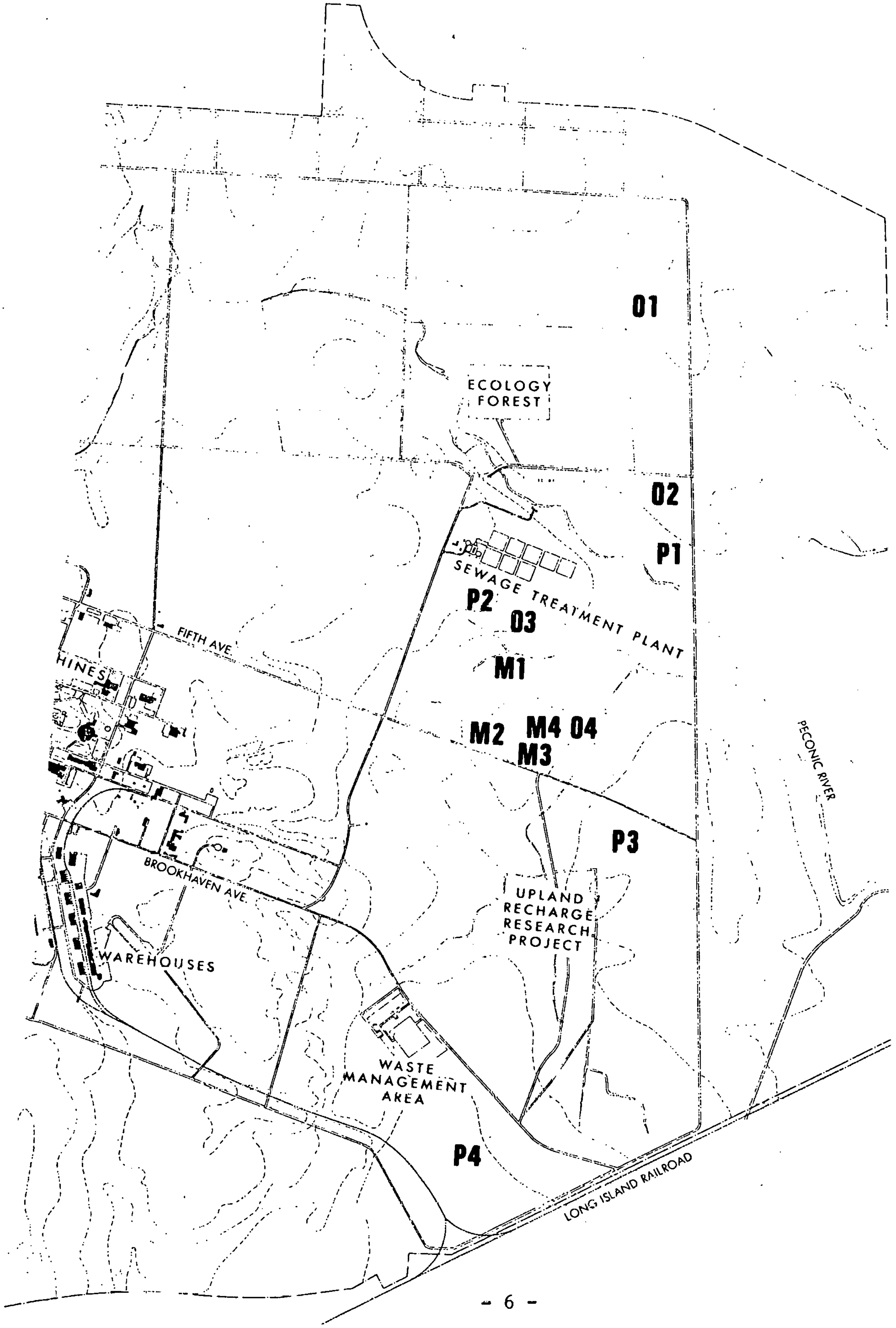

Figure 1. Locations of the twelve 1-ha small mammal study grids. Alphanumeric symbols denote forest type and grid number. O = oak; P = pine; M = maple.