MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Services des thèses canadiennes

Ottawa, Canada
K1A 0N4

CANADIAN THESES

THÈSES CANADIENNES

NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

Reproduction in full or in part of this film is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30.

**THIS DISSERTATION
HAS BEEN MICROFILMED
EXACTLY AS RECEIVED**

AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

La reproduction, même partielle, de ce microfilm est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30.

**LA THÈSE A ÉTÉ
MICROFILMÉE TELLE QUE
NOUS L'AVONS REÇUE**

Canada

PEROMYSCUS LEUCOPUS IN EXPERIMENTAL FENCEZOWS

by

William Osborne Morrison, B.Sc.

A thesis submitted to the Faculty of Graduate Studies
and Research in partial fulfillment of the requirements
for the degree of Master of Science.

Department of Biology, Carleton University

Ottawa, Canada

© April 1986

4
Permission has been granted to the National Library of Canada to microfilm this thesis and to lend or sell copies of the film.

L'autorisation a été accordée à la Bibliothèque nationale du Canada de microfilmer cette thèse et de prêter ou de vendre des exemplaires du film.

The author (copyright owner) has reserved other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without his/her written permission.

L'auteur (titulaire du droit d'auteur) se réserve les autres droits de publication; ni la thèse ni des longs extraits de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation écrite.

ISBN 0-315-29896-0

The undersigned hereby recommend to the Faculty of
Graduate Studies and Research acceptance of this thesis,
submitted by William Osborne Morrison, B.Sc., in partial
fulfillment of the requirements for the degree of
Master of Science.

.....
Chairman, Department of Biology

.....
Supervisor

Carleton University

April 1986

ABSTRACT

To determine the relationship between use of fencerows as movement corridors by Peromyscus leucopus and fencerow structure, I constructed experimental fencerows, released mice in these and measured their movement. The use of fencerows by mice increased with the number of structural elements present in the fencerow. Fencerows were most likely to be used by mice if they provided protective cover at two levels: above-ground and at ground level, possibly corresponding to protection from aerial and terrestrial predators.

To determine whether mice in natural populations would recognize this artificial fencerow as a functional analogue to a natural fencerow corridor, I constructed another fencerow next to a woodlot and trapped animals in the vicinity. Mice were trapped in this fencerow and in a natural fencerow but never in the surrounding field.

The recognition of functional heterogeneity of fencerow corridors indicates that the concept of 'connectivity' between habitat patches should be modified.

ACKNOWLEDGEMENTS

Many people have shown patience and guidance through the duration of this project. I would like to thank my advisory committee, Drs. C.A. Barlow and M.B. Fenton and my thesis supervisor, Dr. H.S. Merriam. I received financial assistance from the Carleton University Faculty of Graduate Studies, the Ontario Graduate Scholarship Program and Dr. Merriam. For their encouragement throughout the course of my studies, I would like to dedicate this thesis to my parents.

TABLE OF CONTENTS

	Page
Abstract	iii
Acknowledgements	iv
Table of Contents	v
List of Tables	vii
List of Figures	viii
List of Appendices	ix
Introduction	1
Methods	6
Release Experiments	7
Mice	7
Fencerow Complexity	8
Structural Element Function	12
Analysis	15
Natural Experiment	15
Results	17
Release Experiments	17
Fencerow Complexity	17
Structural Element Function	19
Natural Experiment	21
Discussion	23
Fencerow Complexity	23
Structural Element Function	25
Some Methodological Considerations	26

Discussion (cont.)	Page
Mice and Fencerows	30
Mice and Landscapes	34
Conclusions	38
Tables	39
Figures	44
Appendices	52
Literature Cited	55

LIST OF TABLES

	Page
1. Sex/age classes of mice released in fencerow complexity experiment.	39
2. Sex/age classes of mice released in structural element function experiment.	40
3. Chi-squared analysis of responses in fencerow complexity experiment.	41
4. Chi-squared analysis of responses in structural element function experiment.	42
5. Small mammal captures in natural experiment.	43

LIST OF FIGURES

Page

1. Recognizable footprints of released mice.	44
2. Example of results from tracking tube.	45
3. Placement of fencerows at release site.	46
4. Diagram of various fencerows.	47
5. Placement of fencerows and traps at natural experiment site.	48
6. Comparison of distances travelled by mice in fencerow complexity experiment.	49
7. Frequency distribution of mouse detection.	50
8. Comparison of distances travelled by mice in structural element function experiment.	51

LIST OF APPENDICES

	Page
1. Location of home woodlots of mice used in structural element function experiment.	52
2. Logit analysis of fencerow complexity experiment data.	53
3. Significance tests of variables in Logit model.	54

INTRODUCTION

In recent years the fact that all ecosystems are heterogeneous at some scale has led some ecologists to view heterogeneous systems as wholes and to emphasize the study of interactions among, rather than within, ecosystem components (Wiens 1976, Southwood 1977, Whittaker and Levin 1977, Hansson 1979). These interactions may involve the movement of organisms or other matter. When they occur among components traditionally considered to be discrete entities (e.g. forests and lakes) we may speak of ecosystem coupling or flux (Risser et al. 1984). These processes are important to the study of landscape ecology where landscape is defined as "a kilometers-wide area where a cluster of interacting stands...is repeated in similar form" (Forman and Godron 1981). One such landscape is found in much of northeastern North America where forest patches or woodlots are scattered throughout primarily agricultural areas.

Since the formulation of the equilibrium theory of island biogeography (MacArthur and Wilson 1963, 1967) it has been popular to view woodlots as islands for forest organisms in seas of agricultural land (Gottfried 1979, Burgess and Sharpe 1981). However, application of the theory to terrestrial systems has received some serious criticism (Simberloff 1974, Gilbert 1980, McCoy 1983) involving both conceptual difficulties and problems with

empirical verification.

An alternative approach involves the use of patch-dynamic models which consider woodlots as patches of suitable breeding habitat for small, local populations which are separated by unsuitable habitat (the matrix) and examine movement between these patches. These patch networks support regional populations or Levins' (1970) "metapopulations". Local populations may go extinct and become recolonized from other local populations. Models have been developed to describe evolutionarily stable strategies of dispersal among such local populations (Hamilton and May 1977, Comins et al. 1980). These models emphasize the importance of dispersal for the long-term persistence of metapopulations. Inter-patch movement may be facilitated by movement corridors which, by definition, reduce interpatch mortality (vis-à-vis the surrounding matrix). This mortality is an extremely important variable in the models mentioned above and has proven difficult to study in the field (Merriam 1984). For animals, the probability of use for a particular corridor may depend on a) pressures to leave the home patch, b) the perceived unsuitability of the matrix and/or c) the suitability of that corridor relative to the matrix or to other available potential corridors. I wished to determine whether there was a relationship between the structural characteristics of a corridor and the perceived suitability of these corridors.

Fahrig et al. (1983) have simulated the population

dynamics of mice in small woodlots with a patch-dynamics model. In this model, fencerows act as corridors between woodlot patches through the agricultural matrix. The probability of a mouse using any specific corridor (fencerow) is assumed to be equal. This assumption is intuitively suspect when one considers the diversity of fencerow structures in natural landscapes. Included in the description 'fencerow' are such differing linear landscape elements as wire fences and metres-wide, treed shelterbelts. These structural differences seem likely to influence the suitability of these structures as corridors for dispersing mice. It should be noted that fencerows differ from European 'hedgerows' by being composed primarily of vegetation which has not been introduced intentionally or managed by man and which may outlast the original fence. It is not known whether these differences are reflected in functional differences pertaining to animal movement.

Few studies have dealt specifically with fencerows and hedgerows. These have demonstrated that species number increases with fencerow structural complexity for breeding bird communities (Gromadski 1970, Arnold 1983, Best 1983, Osborne 1984) and small mammals (Asher and Thomas 1985). In these studies, structural complexity has included such elements as the size and density of constituent trees and shrubs, and the height and width of the fencerow. Not surprisingly, the number of woodland species increases

4

with the density of trees in a fencerow. If the suitability of a fencerow to a woodland animal is predicted by its structural complexity then we may hypothesize that there will be a threshold complexity above which a fencerow will be perceived as a suitable habitat structure by these animals. Hence there should be a point at which a relatively small increase in definable structural complexity of a fencerow produces a significant increase in its use by a forest animal.

The white-footed mouse (*Peromyscus leucopus* (Rafinesque, 1818)) is widely considered to be a predominantly forest-dwelling animal (Baker 1968, Adler et al. 1984). These mice are often found in small woodlots and have correspondingly small population sizes, especially in early spring (Hansen and Batzli 1978, Taylor 1978, Middleton and Merriam 1981, Gottfried 1982). One consequence of small population size is a high probability of local extinction. However, woodlots in which local extinctions have occurred are normally recolonized within a single breeding season (Middleton and Merriam 1981, Gottfried 1982). Furthermore, *P. leucopus* is commonly found in fencerows (Wegner and Merriam 1979, Dickson 1982, Fleharty and Navo 1983, Asher and Thomas 1984). Fahrig and Merriam (1985) have demonstrated a positive relationship between woodlot connectivity (i.e. number of adjoining fencerow corridors) and mouse population growth within woodlots. This evidence strongly suggests that *P. leucopus* uses fencerows as movement corridors between

areas of good breeding habitat, i.e. fencerows act as corridors between woodlot patches.

The habitat associations of *P. leucopus* have been extensively studied but remain unclear (Baker 1968, M'Closkey 1975a, M'Closkey and Lajoie 1975, Miller and Getz 1977, Morris 1979, Adler et al. 1984). When *P. leucopus* is trapped in fencerows often enough to be considered a resident, the fencerows are invariably well-treed, relatively complex structures (Dickson 1982, Yahnner 1983). In woodland habitat, these mice are attracted to areas with considerable debris (logs, rocks etc.) which suggests that protective cover may be an important component of the mouse environment (Beer 1961, Bendell 1961, Stickel 1968, M'Closkey 1975a, 1975b, Barry and Franq 1980). The relative importance of vertical and horizontal elements is unclear (M'Closkey 1976, Barry and Franq 1982). Thus it may be at the level of protective cover that we should look for important structural variables in a fencerow.

The purpose of this study was to examine the influence of fencerow structural complexity on movement in fencerows by *P. leucopus*. To do this I constructed fencerows with different structural attributes and measured the movement of released mice along them. In addition I wished to determine whether easily constructed artificial fencerows would be recognized by mice in natural populations as possible dispersal corridors.

METHODS

To test for a possible relationship between fencerow structure and fencerow use by mice, I constructed different experimental or artificial (i.e. no natural vegetation) fencerows. I released mice inside these fencerows and measured their movements. This set of 'release experiments' was done in two parts. First I hoped to determine whether a stepwise addition of structural elements to an experimental fencerow, which I equate with increasing its structural complexity, would lead to an increase in fencerow use by mice. I refer to this part as the 'fencerow complexity' experiment. Subsequently I hoped to determine the specific functions that different elements filled in influencing mouse behaviour. This is the 'structural element function' experiment.

To determine whether mice in natural populations would recognize an experimental fencerow as a functional analogue to a natural fencerow, I constructed a fencerow

in an old field abutting the edge of a woodlot in which *P. leucopus* was known to be present. To measure response I trapped small mammals a) in the artificial fencerow, b) in a nearby structurally complex natural fencerow and c) in the surrounding old field. I call this the 'natural experiment'.

Release Experiments

Mice

Peromyscus leucopus noveboracensis (Fischer, 1829)

were captured in live-traps from 15 July to 28 September, 1984 in a 12.2 ha beech-maple woodlot ("Nepean Woods" N45° 16', W75° 43') 16.5 km south of Ottawa, Canada. This woodlot is 18 km away from the area where the mice were released. This minimized the possibility that homing behaviour would influence the movements of the released mice. The mice were sexed, weighed to the nearest 0.5 g and identified as juvenile, sub-adult or adult depending on pelage colour. Pregnant and lactating females and juveniles weighing less than 12 g were released immediately. Mice were held individually in the laboratory for not more than 48 h and given food and water *ad libitum*. These mice were used for the fence-row complexity tests. From 18 June to 21 August, 1985 I collected mice for the structural element function experiment in a variety of woodlots, (see Appendix I for locations). All are situated at least 6 km from the release area. Some mice were kept in the laboratory for more than 48 h.

As I wished to record the movements of individual mice, I used a variation of the 'smoked paper' tracking method (Justice 1961, Sheppe 1965, Fahrig and Merriam 1985). Into a 30 cm long piece of 5 cm diameter black polyethylene tubing (a 'tracking tube'), I placed a 8 cm x 28 cm piece of white bond paper with a 6 cm x 8 cm piece of wax paper stapled to the middle. I covered the wax

paper with a mixture of paraffin oil and carbon black (100 ml oil : 20 g carbon black) so that a mouse passing through the tube, in either direction, would leave footprints on the white bond paper. Mice were individually marked by gluing not more than two toes together with ZAP(r) cyanoacrylic glue. As only the four largest toes on the hind feet were suitable for this procedure, 12 different footprint patterns were possible (Fig. 1). More patterns could be produced by gluing more than two toes together (i.e. using more than one foot) but were not required in this study. In the laboratory, I found that this technique was effective for identifying the footprints of a mouse for 3-8 days after which the mouse usually chewed through the glue to free its toes. In this way, I was able to detect the movement of individual released mice (Fig. 2). This method has one advantage over other methods such as radio-tracking in that it allows one to know precisely where a particular animal has been (e.g. in a fencerow vs. beside the fencerow).

Fencerow Complexity

In 1984, I constructed three experimental fencerows on the reclaimed Ottawa Dump site, which is north of Walkley Rd., 5 km east of Ottawa (N45°24', W75°35'). The dump was covered with crushed shale and clay in 1973. The vegetation at the site was mostly grasses with some vetch (Vicia spp.), birdsfoot trefoil (Lotus corniculatus), St. John's wort (Hypericum perforatum), red clover (Trifolium

repens) and red and white sweet clover (Melilotus spp.).

There were numerous patches of bare ground. This site resembles pasture and I believe that it was poor P. leucopus habitat. This is supported by preliminary live-trapping which showed that, in the summer, P. leucopus were extremely uncommon at this site.

The configuration of the fencerows at the site is shown in Fig. 3a. Each fencerow was 80 m long (12 x 6.7 m similar sections) and at least 90 m away from another fencerow. Each fencerow was at least 50 m from, and parallel to, a wooded area to the north (Fig. 3a). This parallel configuration was chosen because I suspected non-random movement of released mice toward the wooded area, as preliminary work showed that 67% (10 out of 15) mice released at the site were recaptured in live traps situated directly between the release point and this wooded area. As such, any detected movement in the fencerows could be considered the result of an active decision to stay in the fencerow. I labelled the fencerow sites, from west to east, A, B and C (Fig. 3a).

I used different combinations of four structural elements in the experimental fencerows:

Tubes - In each section of each fencerow, there were 6 tracking tubes (see above). These were evenly spaced in two staggered rows of 3 tubes, 1 m apart. The primary function of the tubes was to detect the presence of mice however their possible function as structural elements at ground level must be recognized.

Posts- In some fencerows, 2 m steel posts were placed at the boundary of each section. The posts may have introduced some above-ground structure to the fencerow but their main function was to support snow fences (see below).

Snow fence- In some fencerows, two 80 m lengths of snow fence were leaned against the posts so that the bases of the fences were 1 m apart and their tops met 1 m above the ground. Snow fences are made of wooden slats (120 cm x 3.5 cm x 1 cm) wired together, 7 cm apart. With the snow fences I hoped to introduce a significant above-ground element to the fencerow, i.e. something that the mice could move under.

Leaf litter- In some fencerows, a 1 m wide by 15 cm thick layer of leaf litter was placed on the ground, running the full length of the fencerow. The leaf litter was collected 10-11 July and 25 August from the woodlot in which the mice were collected. The litter consisted primarily of decomposing beech (*Fagus*) and maple (*Acer*)

leaves and branches. Pieces of wood greater than 3 cm in diameter and/or longer than 30 cm were excluded. I collected the litter by raking all the leaves and humic material into plastic garbage bags. Inorganic soil material and rocks were excluded as much as possible. The litter was generally quite moist when collected but dried out within a few days. The addition of leaf litter was meant to increase the structural heterogeneity of the

mouse environment at ground level.

With these different structural elements I constructed three experimental fencerows. These are summarized diagrammatically in Figure 4a and described as follows:

S0- This fencerow was placed at position A from 17-30 September. It consisted only of tubes and small flagging stakes to mark the section boundaries. This contained the minimum number of structural elements (i.e. only the detection mechanism) and I hoped to associate the results from this fencerow with a 'control' situation. However it is not a true control as observed differences might be explained by possible temporal effects (i.e. the timing of releases for S0 did not coincide exactly with those at S1 and S2) or a possible spatial effect (i.e. S0 was in place only at position A).

S1- This fencerow was placed at C from 14 July-26 August and at B from 27 August-30 September. It consisted of tubes, posts and snow fence.

~~S2- This fencerow was placed at B from 14 July-26 August~~
and at C from 27 August-30 September. It was identical to S1 except that it also contained leaf litter.

A comparison of response differences between S1 and S2 is valid as possible temporal and spatial effects are controlled for, but are of limited generality due to lack of fencerow replicates.

Twenty-one mice were released at S0 and 46 at each of S1 and S2. The sex ratios and age class ratios were

approximately equal for mice released at each of the fencerows (Table 1).

I released mice at the midpoint of these fencerows one hour after sunset. The mice were released passively, i.e. the tops were removed from their cages and the mice allowed to leave as they wished, to reduce the possibility of escape behaviour influencing their movements. After releasing a mouse with a specific foot pattern at a specific fencerow, I waited 4-8 days to release another mouse there with the same pattern. On the morning after a release, all tubes were checked for the presence of mouse footprints. If recognizable prints were found, I recorded the distance from release point, direction of movement and identity of the mouse. I calculated the maximum distance moved in the fencerow as being the distance from the release point to the furthest point of unambiguous detection or, if the mouse was detected on both sides of the release point, the distance between the two furthest detection points.

Structural Element Function

In general, the methodology used for this experiment was the same as that for the fencerow complexity experiment. However there are some important differences.

Six 47 m (7 x 6.7 m sections) fencerows were constructed. They were at least 25 m apart from each other. Their placement at the Ottawa Dump release site is shown in Fig. 3b. I labelled the fencerow sites, from

west to east, U, V, W, X, Y and Z.

As well as the four structural elements discussed previously, I also used camouflage net in some fencerows. The net was 2 m wide and had a mesh size of 10 cm. The mesh was covered with irregular pieces of green and brown plastic. I hoped that the net would fill a similar function as the snow fence in the fencerow.

All six fencerows were used from 14 June to 20 August, 1985. They are summarized diagrammatically in Figure 4b and described as follows:

SOL- This fencerow was the same as S0 but contained, in addition, a layer of leaf litter covered by 2.5 cm mesh garden netting. The netting was used to prevent the wind from blowing the litter away. This fencerow was placed at position X. This fencerow was designed to test the effect on mouse movement of leaf litter in the absence of any above-ground structural elements.

S1- The structure of this fencerow is described above. It was placed at position Z.

~~S2- The structure of this fencerow is described above. It~~
was placed at position U. The leaf litter used for S2 and SOL came from the same woodlot as previously described.

Fencerows S1 and S2 were used to provide a basis of comparison with the previous experiment.

The following three fencerows all contained the same elements: tubes, posts and camouflage net.

C1- On this fencerow, the net was hung on wire between the posts, 1 m above the ground and tied together at the

bottom, forming a vertical double 'sheet' which ran the length of the fencerow. This fencerow was placed at position W.

C2- On this fencerow, the net was hung 0.7 m above the ground. The two sides of the net were pegged to the ground, about 1 m apart, to form a long tent-like structure (A-shaped in cross-section). This fencerow was placed at position Y.

C3- On this fencerow, the net was hung 1 m above the ground. A 50 cm cord was tied onto the sides of the net every 2 m. These cords were pegged to the ground so that the sides of the netting were at least 30 cm above the ground, and about 1.5 m apart. If we consider C2 to be tent-like, then C3 resembled a marquee. This fencerow was placed at position U.

Note that for C1, C2 and C3, the amount and kind of structural elements are the same, and it is only the positioning of the camouflage net that changes. In C1, the net touches the ground and offers a clear linear

structure which the mouse might choose to follow but provides little aerial coverage. In C2, with the tent-like structure, there is structure both overhead and close to the ground where the sides of the net are pegged.

Fencerow C3 provides structure above ground but not at ground level. Note also that C2 is similar to S1 except that camouflage net replaces snow fence. A possible temporal effect to explain response differences here is

controlled for but a spatial effect is not. Again there are no fencerow replicates.

Twenty five mice were released at each of the six fencerows. Their sex and age class ratios are shown in Table 2.

Analysis

To analyse the results of the release experiments, I used two methods of detecting response differences of mice in the different fencerows. First, I classified the responses into two categories; 'RUN' if the released mouse was detected anywhere in the fencerow and 'NO RUN' if it was not. Then proportions of released mice detected in the different fencerows were then compared with contingency table analysis. When the expected cell frequencies were too low to allow chi-squared tests to be valid, I used the Fisher exact test to analyze two-way 2×2 tables. Second, the mean distances of mouse movement in the various fencerows were compared using standard significance tests to determine whether mice moved further in some fencerows than in others.

Natural Experiment

On 15 July, 1984 I constructed a 30 m S2 fencerow (Figure 4a) abutting and perpendicular to a maple woodlot immediately north of Timm Dr. in Nepean, Ontario. The fencerow ran west into an old field composed primarily of grasses, with some goldenrod (*Solidago* spp.), St. John's wort and milkweeds (*Asclepias* spp.). The leaf litter used

in this fence came from the Nepean Woods, where mice were trapped for the fencerow complexity experiments. The outer or field end of this fencerow was designated trap station A' (120 m north of the road) (Fig. 5). Station B' was located in the field, 35 m south of A'. Station S' was located in a natural 2-m-wide, 1 m-high stone wall fencerow. This fencerow had some trees and shrubs growing in and beside it. Station S' was 30 m west of the woodlot and 35 m north of A' (Fig. 5). From 15 July-18 September, two Sherman live-traps and four snap-traps were open each night at each of A', B' and S'. Animals captured in live-traps were removed from the area.

To control for a possible site effect between A' and B', I moved the fencerow 35 m south on 29 August. At this time, old leaf litter was removed from the old site and freshly-gathered litter was placed in the new fencerow. Thus for the first half of the experiment A' represented a 'fencerow' trapping station and B' was a 'field' trapping station. For the second half of the experiment these roles were reversed.

The results of this experiment are presented in tabular form and discussed.

RESULTS

Release Experiments

Fencerow Complexity

The frequencies of detection (number of mice detected divided by number of mice released) for the different fencerows are: S0 4.8%, S1 23.9% and S2 43.5% (Table 3). The binary response variable RUN was conservative in estimating the number of mice which used any given fencerow. Any mouse which was detected was a definite fencerow-user but it is likely that some mice moved in the fencerow but were not detected. This indicates that the overall response of mice to some of the fencerows was quite high (e.g. S2 43.5%) which supports the idea that some of these structures are perceived by the mice as analogous to natural habitat features.

The χ^2 value for the results in Table 3 is highly significant ($\chi^2=11.39$, $df=2$, $p<.005$) which indicates different patterns of response among the different fencerows. Following Fienberg (1980) I partitioned the 2×3 table into two separate 2×2 tables. Analyses of these shows a significant difference between S2 and S1 ($\chi^2=3.94$, $df=1$, $p=.045$) and a marginally significant difference between S1 and S0 (Fisher exact test, $p=.052$). In summary, there was significantly higher frequency of response by mice released in S2 than in S1 and a somewhat higher response in S1 than in S0.

Before examining a possible relationship between

mouse responses and fencerows, it was necessary to determine that the observed responses were not significantly influenced by the age or sex of the mice used and that there were no significant interactions between these variables. To do this I used the hierarchical Logit model of SPSS-X (Norusis 1983) to examine a 4-way contingency table with RUN as a binary response variable and AGE, SEX and FENCEROW as predictor variables. I found that a model using only FENCEROW as a predictor variable gave an extremely good fit ($G^2=10.34$, $df=15$, $p=.798$), and that FENCEROW was a significant variable ($\Delta G^2=7.27$, $df=2$, $p<.05$). The variable AGE by itself did not give a good fit to the model ($G^2=17.48$, $df=15$, $p=.291$) nor was its addition to the model significant ($\Delta G^2=0.13$, $df=2$, $P>.95$). The same pattern was observed with the variable SEX ($G^2=15.36$, $df=16$, $p=.499$; $\Delta G^2=2.25$, $df=1$, $p>.05$). None of the higher-order interactions terms significantly improved the fit of the model (more detailed analyses are found in Appendices II and III). These results indicated that AGE and SEX were not significant predictor variables and that I was justified in collapsing the 4-way table into a 2-way table (Table 3) with RUN and FENCEROW as variables of interest (Fienberg 1980). This is not surprising as the overall frequencies of detection for juveniles, subadults and adults were 21%, 30% and 29% respectively. The overall frequencies for males and females were 25% and 35%.

The detected distances of mouse travel in the

fencerows showed high variability (Fig. 6). The mean distance mice travelled in the fencerows was 24.2 m. There was no significant difference between the mean distances travelled in S1 and S2 ($t=1.68$, $df=11$, $p>.10$). It was not possible to compare these distances with the one individual detected in S0.

Mice were usually detected at only one tracking tube, however 45% (5/11) of the detected mice in S1 and 25% (5/20) in S2 were detected in two or more tubes. One mouse in S2 used 11 tubes and one in S1 used 10 tubes. Six mice (3 in S1, 3 in S2) were found in tubes on both sides of the release point, indicating travel in both directions and that some parts of the fencerow were visited at least twice. In S1, two mice were detected 2-4 days after release, while in S2, two mice were detected 2-5 days after release. One mouse was released at S1 and detected in S2 while one mouse moved in the opposite direction.

There is no readily apparent pattern of capture frequency relative to the season (Figure 7a). Note that the releases were not evenly distributed over the season.

Structural Element Function

The frequencies of response for the different fencerows are as follows: C1 4%, C2 44%, C3 20%, S0 12%, S1 36% and S2 48%. These results are shown in Table 4.

These data were analyzed with a 2-way 2 x 6 contingency table with RUN and FENCEROW as variables of interest. The

overall χ^2 for Table 4 is 20.31 which is highly significant ($df=5$, $p<.005$) indicating strong tendencies of non-random fencerow use by the mice. The most apparent distinction between the fencerows seems to be between a 'low-use' group including C1, C3 and S0L (percent use=4-20%) and a 'high-use' group which includes C2, S1 and S2 (percent use=36-48%). I lumped the data into low-use and high-use categories and performed a χ^2 analysis on the resulting 2×2 table which gave $\chi^2=17.75$ which is highly significant ($df=1$, $p<.001$). Within these two groups, no significant differences were discovered (i.e. C1 vs C3: Fisher exact test, $p=.095$; S1 vs S2: $\chi^2=0.74$, $p>.25$). Also, there was no significant difference between the highest member of the low-use group (C3) and the lowest member of the high-use group (S1), ($\chi^2=1.58$, $p>.10$) which indicates that the distinction between the two groups is more gradual than is first apparent. Within the 'camouflage net' group of fencerows, we see a highly significant difference between C1+C3 vs C2 ($\chi^2=9.72$, $p<.005$) but that the difference between C3 alone and C2 is not significant ($\chi^2=3.31$, $p=.068$). A Logit model analysis was not performed on these data.

Again, the distances travelled by mice in the fencerows were found to show high variability (Fig. 8). The mean distance travelled in the fencerows was 11.9 m. A one-way analysis of variance on distance travelled showed no differences among the various fencerows ($F=0.35$, $df=4$, $p>.95$). Fencerow C1 was not included in this

analysis as only one mouse was detected there.

Seventy-three percent (27/37) of mice detected were found in two or more tubes. By fencerow, they were distributed as follows: C1 0/1, C2 8/11, C3 3/5, SOL 2/3, S1 5/9 and S2 9/12. Twelve mice were found in the fencerow on both sides of the release point. They were distributed as follows: C1 0, C2 5, C3 1, SOL 1, S1 4 and S2 1. One mouse was found in S1 two days after release. One mouse moved from C1 to SOL and one mouse moved from SOL to C1.

The frequency distribution of captures during the trapping period is shown in Figure 7b. Again no obvious pattern of captures relative to season is apparent.

Natural Experiment

The cumulative captures over the trapping period are presented in Table 5. There were 390 trap-nights at each trapping station (65 nights x 6 traps). P. leucopus was trapped in the stone fence and in the experimental fencerow but never in the field. Note that Peromyscus were caught in experimental fencerows at both A' and B'. They were trapped when the fencerow had been in place for 14-38 days. This suggests that none of these animals were residents near the trap sites. Low capture frequencies (which prohibit statistical comparisons) and lack of fencerow replicates limit the conclusions which may be drawn from these results. However it is likely that the Peromyscus captured in the experimental fencerow moved

there from the woodlot and thus these results are consistent with the idea that the S2 fencerow has sufficient structural complexity to be recognized by P. leucopus in natural populations as a habitat structure which is preferable to an old field, and hence is a potential movement corridor.

Four other species of small mammals were captured in the stone fence: Mustela erminea, Blarina brevicauda, Sorex cinereus, and Tamias striatus. Two field species, Zapus hudsonius and Microtus pennsylvanicus, were found in field traps and in the experimental fencerow. The Zapus was captured in the experimental fencerow 6 days after construction of the fencerow. The Microtus was trapped in the experimental fencerow 24 days after construction of the fencerow.

DISCUSSION

Fencerow Complexity

These results are consistent with the hypothesis that there is a positive relationship between the structural complexity of a fencerow and use of that fencerow by mice.

The frequency of detection increased with number of fencerow structural elements. I observed a significant response difference between S2 and S1 and marginally significant difference between S1 and S0. While the second comparison is made cautiously, it is clear that the released mice showed no a priori tendency to move along an east-west axis and, in fact, moved north toward the woody area in the absence of other habitat features or when they left the fencerows. This is supported by the extremely low incidence of movement by mice in an east-west direction between different fencerows (even in the second experiment when these fencerows were only 25 m apart). As such I believe that the difference observed between S0 and S1 is real. The comparison between S2 and S1 is valid as both site and temporal effects were controlled for.

The difference in response between S1 and S0 is best explained by the addition of the snow fence to S1. The snow fence may have influenced the behaviour of mice in at least two ways. It may have provided a linear structure which, in a habitat which lacked significant vertical elements, gave the mice something to follow, i.e. the mice

may have some sort of inherent propensity to follow linear structures. Alternatively, the snow fence may have been perceived as protective cover by the mice. Metzgar (1967) showed that mice in unfamiliar habitats are highly susceptible to predation and are likely to search out cover objects.

The difference observed between S2 and S1 is explained by the addition of leaf litter to S2. This made the fencerow more attractive to the mice than the addition of snow fence alone. Again, the perception by mice of the role of the leaf litter in the fencerow is not clear. Unfortunately the litter was gathered from the same woodlot that the mice were captured in and the possibility that the litter acted as some sort of homing cue cannot be rejected. Similarly, the smell of the litter may, in some way, have made the fencerow attractive to the mice, although this seems unlikely as Barry (1984) has shown in laboratory tests that *P. leucopus* does not prefer the smell of leaf litter over grass. It is possible that the litter contained mouse food, however the mice had been given food *ad libitum* prior to release so it is unlikely that this factor should have influenced movement. The leaf litter may have initially influenced the microclimate at ground level, which in turn may have affected mouse movements, but if this effect was significant, we would expect a decrease in the response of the mice over time as the litter dried out. As seen in Figure 7a, this did not occur. The addition of leaf litter undoubtedly increased

the protective cover at ground level and this may have increased the attractiveness of the fencerow to the mice.

Therefore, from this experiment, we see that fencerow use by mice increased as different structural elements were added to the fencerow. Why this is, and the functions that specific elements perform in the fencerow, is examined below.

Structural Element Function

The main result from this experiment is that there was a high-use and low-use group of fencerows (S1, S2, C2 vs C1, C3, SOL). These groups of fencerows correspond to those structures which provide high and low amounts of protective cover respectively.

In the high-use group, it is interesting to note that the previously observed response difference between S1 and S2 was not significant here although the trend is the same. This is probably a result of lower sample sizes (25 releases per fencerow in 1985 vs 46 in 1984). However, there may have been a lower response to S2 in 1985 because the leaf litter used did not come from the home woodlots of the mice used. This seems unlikely however as a slightly higher percentage of positive responses to S2 was observed in 1985 (1984 - 42%; 1985 - 48%). As such, I do not believe that the response of mice to leaf litter in the 1984 S2 fencerow was a result of homing behaviour.

The relative similarity of response between C2 and S1 suggests that the mice perceive the camouflage net to have

the same function as the snow fence in the fencerows.

All the high-use fencerows share two characteristics. They provide two levels of protective cover to the mice with a significant element of above-ground cover, where the two fences met or where the net hung down, and an area of cover at ground level, where the fences or net made contact with the ground. The distinction between above-ground and ground-level cover is somewhat arbitrary. None of the fencerows in the low-use group have both these characteristics. The relatively low use of fencerow C3 indicates that although above-ground cover is important, it alone is not sufficient to provide a high-use corridor. Similarly, the low use of fencerow S01 indicates that although ground-level cover is significant (note comparison between S2 and S1), it too is not sufficient. The fencerow with the lowest use of all was the one which provided neither types of cover (C1). Mice appear not to follow linear structures which do not provide cover. It is possible that the effects of above-ground and ground-level cover may be additive.

Some Methodological Considerations

I have assumed that the proportion of undetected fencerow-users relative to detected mice remained constant for all fencerows. This assumes further that the behavioural response of the mice to the tracking tubes did not change in the different fencerows. For my purposes the tubes were detection mechanisms but the fact that mice enter these tubes indicates that the tubes are a non-

trivial part of the mouse environment and may be viewed as part of the 'habitat'. An animal's perception of, and relationship to, a habitat structure can change as the surrounding habitat changes. For instance, a bird's relationship to a dead elm tree is likely to be different depending on whether the tree stands in the forest or in the middle of a pasture. Similarly, it may not be valid to assume that the mice responded to tracking tubes equally in S0, where there were few other habitat features nearby, as in S2 which offered a much more structurally complex environment. However, if the assumption of equal behavioural response is not valid, it is likely that mice would have been most inclined to enter tubes when there were fewer alternative cover objects available (i.e. in the lower complexity fencerows). This would have minimized the observed differences among fencerows. Thus I believe that this assumption is conservative and that detected differences represent real differences in response by mice to different fencerows.

While I have emphasized the role of protective cover in determining mouse use of the different fencerows, it is possible that other uncontrolled factors may have had an effect as well. The presence of conspecifics in the fencerow might affect the response of a released mouse. However, it is unclear whether this would attract or repel the mouse as this response would depend on the sex, age and social status of both mice involved. This is not

likely to have affected any of the fencerow comparisons as the continued presence of *Peromyscus* in the fencerows for more than one night was not common. Moonlight and weather, and their interactions, may have affected tube and fencerow use by mice. It is possible that the use of cover objects, and hence of fencerows, varies with light level. Clarke (1983) has shown that *P. maniculatus* decreases activity levels with increasing levels of illumination and concentrates activity near cover objects. Clarke correlated this behaviour with increased hunting efficiency by owls under increased light levels. While the influence of illumination may be significant, it is unlikely to have influenced fencerow comparisons as outlined above. It is possible that weather may have influenced the tube and fencerow use by mice. Bider (1968) found that small mammals utilized his covered sand transects most on rainy nights, perhaps to avoid getting wet. I did not notice any consistent patterns between fencerow use and weather but, if they existed, they would not affect comparisons of response among fencerows as mice were usually released at all fencerows on all release nights, thus controlling for a possible weather effect.

These uncontrolled possible influences on mouse behaviour may explain the very high variability of distance travelled in fencerows. I would have expected that mice in high-use fencerows would, on average, have travelled further from the release point in these fencerows than in low-use fencerows. While there is a

trend in this direction from the fencerow complexity experiment (Fig. 6), no such relationship is seen in the structural element function experiment (Fig. 8). The overall mean distances travelled by mice in the fencerows were approximately one quarter the length of the fencerow in both years (1984 - 24.2 m; 1985 - 11.9 m). These distances are comparable to the mean distance travelled nightly in natural southern Ontario fencerows by resident small mammals reported by Asher and Thomas (1985) of 28 m. I assumed linear travel paths of the mice in the fencerows. This is supported by the cases in which mice used many (i.e. >5) tubes, and their travel path could be estimated fairly accurately and by the cases in which mice were detected on both sides of the release point.

The impetus to perform the Logit analysis came from ideas which suggest that different sex and age classes of *Peromyscus* mice display different dispersal characteristics. Briefly, sub-adult males are most likely to be classified as dispersers (and hence to be found in fencerows) and adult females are least likely (Harland et al. 1979, Haigh 1983, Krohne et al. 1984, Krohne and Miner 1985). Clearly though, habitat patches in which local extinctions have occurred must be recolonized by females at some point. The purpose of the Logit analysis then was to determine whether mice of different sex and age classes responded differently to different fencerows. The inability of the variables SEX and AGE to improve the

overall fit of the Logit model indicates that these variables are not important for understanding how *P. leucopus* respond to fencerows as habitat. This is not surprising as there does not appear to be any clear separation by sex or age of mice in their normal breeding habitats (Seagle 1985). Also differences in dispersal behaviour are likely to derive from different motivational states or social pressures to disperse among different ages and sexes of mice (Healey 1967, Fairbairn 1978, Nadeau et al. 1981) and these would not have been a factor in these experiments where a) the mice were captured in woodlots where they were likely residents and hence less likely to disperse and b) the mice were forced to choose their proximate habitat. Finally, the fact that I distributed mice of the various sex and age classes evenly among the different fencerows makes it unlikely that these factors could have explained the observed response differences.

Mice and Fencerows

Based on these observations I believe that the responses by mice were determined by the fencerow structures and that fencerows are most likely to be perceived as viable movement corridors by *Peromyscus* if they are able to provide protective cover at two levels. These levels are what I've referred to as 'above-ground' cover; which is something a mouse can move under for a significant distance, and 'ground-level' cover which provides something that the mouse can squeeze into or

under. This idea is consistent with traditional ideas about *P. leucopus* habitat relations. At a gross habitat scale, *P. leucopus* is found most commonly in woodland, often in shrubby or forest edge habitat and rarely in open areas (Baker 1968, Dueser and Shugart 1978, Adler et al. 1984, Adler 1985). It seems therefore that the mice have a predisposition to move under a canopy of some sort. At a finer-scale level of habitat, it has been shown repeatedly that *P. leucopus* movements are often closely associated with tree stumps, fallen logs, rocks and similar habitat features (Beer 1961, McCloskey 1975a, Barry and Franq 1980, Seagle 1985). These represent structures which mice can squeeze into or get under. I suggest that these habitat relations have evolved as predator-avoidance measures. Mortality in populations of *Peromyscus* is known to be extremely high with few individuals surviving more than one year (Ierman 1968). Predation is an important component of this mortality. The major predators on *Peromyscus* mice are likely to be owls and mammalian predators such as weasels, foxes and skunks. Above-ground structure provides protection from aerial predators and structure at ground level provides some protection from larger mammalian predators. It is interesting to compare these results with the work of Thompson (1982) who was able to alter the composition of a desert small mammal community by adding small cardboard shelters to the habitat. Among the species which increased in abundance

were two Peromyscus species. Thompson (1982) attributed his results to the mammals' perception of cover from aerial predators, which thus influenced their use of foraging areas.

Experimental fencerow use by mice is related to the structural complexity of the fencerows and I have suggested that this association is best explained by the mouse's perception of the amount of protective cover provided by the various structural elements. It must be noted, however, that the mice in these experiments were not natural dispersers and that the experimental system is somewhat artificial. As such, it is necessary to compare these results with a natural system to determine whether the spectrum of fencerow complexity which I used in my experiments falls within the bounds of mouse-defined movement corridors.

The results from the natural experiment indicate that at least one of the experimental fencerows (S2) is a functional analogue to natural fencerows. *P. leucopus* were captured in the natural stone fence and in the experimental fence (at both sites) but never in the adjacent field. Thus, I am confident in relating the patterns observed in my release experiments to the behaviour of naturally dispersing mice.

The experimental fencerows which I have used in this study appear to have bounded a threshold level of complexity which determines whether a fencerow is unsuitable (S0, C1) or suitable (S1, S2, C2) as a movement

corridor. This threshold is ill-defined however as it is difficult to determine when the use of a fencerow is significantly greater than zero. As such, I hesitate to classify SOL and C3. This indicates further that the threshold complexity for *P. leucopus* is quite low as the experimental structures used here have quite low apparent structural complexity compared to most natural fencerows. I suggest further that there is a second threshold which determines whether a mouse perceives a fencerow as suitable breeding habitat. This threshold is likely to be considerably higher than the complexity of the structures used in this study, and is likely to involve factors other than amount of protective cover (e.g. nest site availability, resource availability). In some intensively-cultivated landscapes, fencerows above this second threshold may provide refuges of habitat for woodland organisms (Pollard and Relton 1970, Fleharty and Nave 1983).

It may be possible to apply some of these ideas about mice and fencerows to other woodland organisms. The elements which determine a viable corridor are likely to be different for different kinds of organisms. For instance a useful corridor for a forest dwelling slug would probably incorporate specific microclimatic characteristics while a corridor for a woodland bird might consist of appropriately spaced trees. Returning to small mammals, it is clear that while the important elements

(i.e. protective cover) may be similar for different species, the perceived threshold complexity may differ among species. Henderson et al. (1985) have shown that eastern chipmunks (*Tamias striatus*) follow extremely simple fencerow structures, indicating a low threshold. Conversely, flying squirrels (*Glaucomys* spp.) would probably require a significant tree component in their corridors, indicating quite a high threshold complexity.

The relationship that I have proposed between fencerow use by mice and fencerow structure has ramifications for understanding the population dynamics of regional populations or metapopulations of mice and possibly other woodland species. The probability of long term persistence of the populations is increased if the rate of flow between the component local populations is increased (Levins 1970, Comins et al. 1980). Thus the persistence of mice in a network of woodlots may be increased if we can encourage the flow of mice between woodlots. The results of this study indicate that this might be accomplished by encouraging the development and preservation of structurally complex fencerow connections between these woodlots.

Mice and Landscapes

These results indicate that fencerows can show a great deal of heterogeneity in their function as corridors for movement between woodlot patches. Although this idea is not too surprising, it has been ignored, largely for the sake of developing general models pertaining to

landscapes (Fahrig et al. 1983, Forman and Godron 1986) but also because, to date, there has been no data to support this claim.

The model of Fahrig et al. (1983) could be modified. It might be possible to estimate movement rates by mice in different fencerows and incorporate these into the model for increased predictive ability. Alternatively, it might be possible to insert 'standard' fencerows such as mine into a landscape to test whether fencerow heterogeneity has a significant effect on overall mouse movement.

Forman and Godron (1986) emphasize the dynamic nature of populations in a heterogeneous landscape. However when they mention connectivity in the woodlot-hedgerow-agriculture landscape, they refer only to the number of hedgerow connections to a woodlot and assume that all corridors function equally. Surely a definition of connectivity which emphasizes the functional value of the particular corridors is more appropriate for understanding populations than a purely structural definition. For example, it is likely that a woodlot with five short, dead-end fencerows attached to it will have lower immigration by mice (and therefore lower connectivity) than a woodlot with one fencerow which is attached to another woodlot.

This functional re-definition of connectivity, which is determined only by organism movement, may in turn be affected by structural characteristics. I have emphasized

the role that fencerow structure can potentially have on influencing the amount of movement by mice in fencerows. However in the "woodlot/'patch' - fencerow/'corridor' - field/'matrix'" system for P. leucopus there are likely to be other important factors determining mouse movement. The nature of the field or 'matrix' will probably influence fencerow use and hence connectivity. As the structural complexity of the field increases (e.g. an advanced stage old field vs. a grazed pasture) the difference in structure between the matrix and the corridor will become smaller and hence the incentive to use the fencerow will be smaller. Thus I hypothesize an inverse relationship between matrix complexity and corridor use. With standard fencerows such as my experimental structures, this idea could easily be tested. There is also likely to be a seasonal effect on fencerow use by mice which could operate in two ways. First, the structure of the matrix is likely to change through the season (e.g. hay fields grow and are cut) and this could affect fencerow use as outlined above. Second, mouse populations will increase during the summer and autumn which increases the number of potential dispersers, and hence of fencerow use by mice. Conversely, increased population pressure may actually reduce the probability of fencerow use as mice use a broader range of habitats. Adler (1985) has shown that habitat discrimination by P. leucopus decreases as population density increases. Thus I hypothesize that, during the course of the breeding

season, fence-row use by mice will increase numerically as the population increases but that the proportion of fence-row-users to mice in other non-woodland habitat will decrease. This prediction is more difficult to test as it is often difficult to detect mice in non-woodland habitats.

Throughout this discussion, much emphasis has been placed on movement and flow in corridors, presumably between local populations which have traditionally been considered 'isolated'. This illustrates why the principles derived from the equilibrium theory of island biogeography are not as useful to the study of animals in forest fragments as MacArthur and Wilson (1967) had originally thought. In its original formulation, the theory assumed that immigration to islands was a rare event, i.e. that the organisms perceived the islands as isolated. With a non-lethal matrix and potential movement corridors, this assumption is violated. Also, in agricultural landscapes, there are usually no well defined large source populations. Colonization of islands originates from a group of other small populations. Clearly a landscape perspective, which emphasizes the movement of animals through habitats of differing suitability, is more useful than the theory of island biogeography for understanding the population dynamics of many organisms which inhabit terrestrial habitat mosaics.

CONCLUSIONS

1. The use of experimental fencerows by *Peromyscus leucopus* increased as structural elements were added to the fencerow.
2. The use of these fencerows was highest in the fencerows that included structural elements both at ground level and above the ground.
3. The structure of a fencerow is likely to affect its suitability to mice as a movement corridor and thus a definition of habitat patch connectivity incorporating only number of connections is incomplete..

Table 1. Number of mice of various sex and age classes released at different experimental fencerows in fencerow complexity experiment. A=adult, SA=subadult, J=juvenile. Fencerow descriptions in text.

Fencerow S0					Fencerow S1				
	A	SA	J	Total		A	SA	J	Total
Male	5	8	2	15	Male	19	8	2	29
Female	5	1	0	6	Female	8	5	4	17
Total	10	9	2	21	Total	27	13	6	46

Fencerow S2				
	A	SA	J	Total
Male	17	10	2	29
Female	5	8	4	17
Total	22	18	6	46

Table 2. Number of mice of various sex and age classes released at different experimental fencerows in structural element function experiment. A=adult, SA=subadult, J=juvenile. Fencerow descriptions in text.

Fencerow S0L					Fencerow S1				
	A	SA	J	Total		A	SA	J	Total
Male	12	3	1	16	Male	10	4	2	16
Female	5	3	1	9	Female	7	1	1	9
Total	17	6	2	25	Total	17	5	3	25

Fencerow S2					Fencerow C1				
	A	SA	J	Total		A	SA	J	Total
Male	10	6	1	17	Male	11	5	1	17
Female	6	1	1	8	Female	4	2	2	8
Total	16	7	2	25	Total	15	7	3	25

Fencerow C2					Fencerow C3				
	A	SA	J	Total		A	SA	J	Total
Male	11	4	2	17	Male	10	4	2	16
Female	5	2	1	8	Female	4	3	2	9
Total	16	6	3	25	Total	14	7	4	25

Table 3. Chi-squared analysis of responses by mice released in various experimental fencerows during fencerow complexity experiment. Fencerow descriptions in text. RUN=mouse detected in fencerow, NO RUN=mouse not detected. Expected values given in brackets.

	Fencerow			Total
	S0	S1	S2	
RUN	1 (5.95)	11 (13.03)	20 (13.03)	32
NO RUN	20 (15.05)	35 (32.97)	26 (32.97)	81
Total	21	46	46	113

$$\chi^2 = 11.39$$

$$\chi^2 (2, .005) = 10.60$$

Table 4. Chi-squared analysis of responses by mice released in various experimental fencerows during structural element function experiment. Fencerow descriptions in text. RUN=mouse detected in fencerow, NO RUN=mouse not detected. Expected values given in brackets.

	Fencerow						Total
	SOL	S1	S2	C1	C2	C3	
RUN	3 (6.83)	9 (6.83)	12 (6.83)	1 (6.83)	11 (6.83)	5 (6.83)	41
NO RUN	22 (18.17)	16 (18.17)	13 (18.17)	24 (18.17)	14 (18.17)	20 (18.17)	109
Total	25	25	25	25	25	25	150

$$\chi^2 = 20.31$$

$$\chi^2 (5, .005) = 16.75$$

Table 5. Numbers of captures of small mammals in natural experiment at different habitats and trapping stations.

Species	Habitat	Stone Fencerow	Experimental Fencerow		Field	
	Trapping station	S'	A'	B'	A'	B'
<i>Mustela erminea</i>		2	0	0	0	0
<i>Blarina brevicauda</i>		4	0	0	0	0
<i>Sorex cinereus</i>		2	0	0	0	0
<i>Tamias striatus</i>		3	0	0	0	0
<i>Peromyscus leucopus</i>		4	2	1	0	0
<i>Zapus hudsonius</i>		0	0	1	4	0
<i>Microtus pennsylvanicus</i>		0	1	0	1	0

Figure 1.

Possible configurations of glued toes for recognizing
footprints of released mice.

GLUED TOES

Right fore

Right hind

Left fore

Left hind

Figure 2.

Example of marked paper from tracking tube
showing recognizable footprints.

Figure 3.

Placement of experimental fencerows at Ottawa Dump
release site for A) fencerow complexity experiment
(1984) and B) structural element function
experiment (1985).

A) 1984

B) 1985

Figure 4.

Summary of elements in experimental fencerows for
 A) fencerow complexity experiment (1984) and B)
 structural element function experiment. One 6.7 m
 section is drawn for each fencerow. T=tubes,
 P=posts, SF=snow fence, LL=leaf litter,
 CN=camouflage net (a-tied in vertical 'sheet', b
 'tent-like', pegged at ground; c-raised 'canopy',
 all parts >30 cm above ground).

A) 1984

B) 1985

Figure 5.

Placement of experimental fencerow and trapping stations
for natural experiment.

✓
R

Figure 6.

Distances ($\bar{x} - 1$ s.d.) travelled by mice released in various fencerows during fencerow complexity experiment.

Figure 7.

Frequency distribution of mouse detections in various fencerows during release experiments in 1984 and 1985. Fencerow descriptions in text. Open bars represent nights when mice were released at various fencerows, solid bars represent detections. Arrows indicate date of addition of leaf litter to some fencerows.

A) 1984

B) 1985

September

August

July

June

Figure 8.

Distances ($\bar{x} \pm 1$ s.d.) travelled by mice in various fencerows during structural element function experiment.

Appendix I. Name, location and distance from release site of home woodlots for mice used in structural element function experiment.

Woodlot	Location	Distance (km)
Hemlock Woods	N 45°22', W 75°32'	6
Hall Rd.	N 45°20', W 75°30'	9.5
Dozois Rd.	N 45°13', W 75°37'	20
Farmer's Way	N 45°22', W 75°29'	9.5
Timm Dr.	N 45°19', W 75°52'	23.5
Goulbourn	N 45°20', W 75°56'	29
L. Clear	N 45°30', W 77°12'	90
N. Gower	N 45°09', W 75°44'	31
Louiseize	N 45°21', W 75°36'	6
Richardson	N 45°19', W 75°56'	29.5

Appendix II. Results of Logit analysis on fencerow complexity experiment data. 'Design' is the design model which incorporates the different variables listed, R=Run, F=Fencerow, A=Age, S=Sex. Combinations of these variables within brackets represent interaction terms in the model. G^2 is the maximum likelihood statistic and P represents overall goodness of fit of the data to the specified design model, i.e. for saturated model (design 19), $P=1.00$.

Design	df	G^2	P
1. [R]	17	17.61	.414
2. [R][RF]	15	10.34	.798
3. [R][RA]	15	17.48	.291
4. [R][RS]	16	15.36	.499
5. [R][RF][RA]	13	10.24	.674
6. [R][RA][RS]	14	14.97	.380
7. [R][RF][RS]	14	8.21	.878
8. [R][RF][RS][RA]	12	7.80	.800
9. [R][RF][RA][RFA]	9	8.85	.451
10. [R][RF][RS][RFS]	12	6.40	.895
11. [R][RA][RS][RAS]	12	13.88	.308
12. [R][RF][RA][RS][RFS]	10	5.95	.820
13. [R][RF][RA][RS][RFA]	8	6.12	.634
14. [R][RF][RA][RS][RAS]	10	6.14	.803
15. [R][RF][RA][RS] [RFS][RFA]	6	3.79	.705
16. [R][RF][RA][RS] [RFA][RAS]	6	5.15	.524
17. [R][RF][RA][RS] [RFS][RAS]	8	4.16	.824
18. [R][RF][RA][RS] [RFS][RFA][RAS]	4	2.78	.595
19. [R][RF][RA][RS] [RFS][RFA][RAS][RFAS]	0	0	1.00

Appendix III. Significance tests for addition of various variables to Logit model performed on data from fencerow complexity experiment. 'Design comparison' refers to various model designs presented in Appendix II. Here $p < .05$ represents a significant addition to the model.

Variable of interest	Design comparison	ΔG^2	df	p
Fencerow [RF]	2 vs 1	7.27	2	< .05
Age [RA]	3 vs 1	0.13	2	> .95
Sex [RS]	4 vs 1	2.25	1	> .05
Fencerow x Age [RFA]	9 vs 5	1.39	4	> .75
Fencerow x Sex [RFS]	10 vs 7	1.81	2	> .25
Age x Sex [RAS]	11 vs 6	1.09	2	> .50
Fencerow x Age x Sex [RFAS]	19 vs 18	2.78	4	> .50

LITERATURE CITED

- Adler G.H. 1985. Habitat selection and species interactions: an experimental analysis with small populations. *Oikos* 45:380-390.
- Adler G.H., L.M. Reich and R.H. Tamarin. 1984. Characteristics of white-footed mice in woodland and grassland in eastern Massachusetts. *Acta Theriol.* 29:57-62.
- Arnold G.W. 1983. The influence of ditch and hedgerow structure, length of hedgerows, and area of woodland and garden on bird numbers on farmland. *J. Appl. Ecol.* 20:731-750.
- Asher S.C. and U.G. Thomas. 1985. Analysis of temporal variation in the diversity of a small mammal community. *Can. J. Zool.* 63:1106-1110.
- Baker R.H. 1968. Habitats and Distribution, pp. 98-126 In: King J.A. (ed.), *Biology of Peromyscus (Rodentia)*. Spec. Publ. no. 2, The American Society of Mammalogists.
- Barry R.E. 1984. Effects of early experience on cue preferences of *Peromyscus leucopus*. *Am. Midl. Nat.* 111:234-241.
- Barry R.E. and E.N. Franq. 1980. Orientation to landmarks within the preferred habitat by *Peromyscus leucopus*. *J. Mammal.* 61:292-303.
- Barry R.E. and E.N. Franq. 1982. Illumination preference and visual orientation of wild-reared mice, *Peromyscus leucopus*. *Anim. Behav.* 30:339-344.
- Beer J.R. 1961. Winter home ranges of the red-backed mouse and the white-footed mouse. *J. Mammal.* 42:174-180.
- Bendell J.F. 1961. Some factors affecting the habitat selection of the white footed mouse. *Can. Field Nat.* 75:244-255.
- Best L.B. 1983. Bird use of fencerows: implications of contemporary fencerow management practices. *Wildl. Soc. Bull.* 11:343-347.
- Bider, J.R. 1968. Animal activity in uncontrolled terrestrial communities as determined by a sand transect technique. *Ecol. Monog.* 38:269-308.
- Burgess R.L. and D.M. Sharpe. 1981. Forest island dynamics in man-dominated landscapes. Springer-Verlag, New York.
- Clarke J.A. 1983. Moonlight's influence on predator/prey interactions between short-eared owls (*Asio flammeus*) and deer mice (*Peromyscus maniculatus*). *Behav. Ecol. Sociobiol.* 13:205-209.

- Comins H.N., W.D. Hamilton and R.M. May. 1980. Evolutionarily stable dispersal strategies. *J. theor. Biol.* 82:205-230.
- Dueser, R.D. and H.H. Shugart. 1978. Microhabitats in a forest-floor small mammal fauna. *Ecology* 59:89-98.
- Dickson K.M. 1982. Factors influencing perception of fencerow width by deer mice (*Peromyscus maniculatus*). M.Sc. Thesis, University of Guelph.
- Fahrig L., L.P. Lefkovitch and G. Merriam. 1983. Population stability in a patchy environment. pp. 61-67 In: Lauenroth, W.K., G.U. Skogerboe and M. Flug, (eds.). *Analysis of ecological systems: State-of-the-art in ecological modelling*. Elsevier, New York.
- Fahrig L. and G. Merriam. 1985. Habitat patch connectivity and population survival. *Ecology* 66:1762-1768.
- Fairbairn D.J. 1978. Behaviour of dispersing deer mice (*Peromyscus maniculatus*). *Behav. Ecol. Sociobiol.* 3:265-282.
- Fienberg S. 1980. *The analysis of cross-classified categorical data*. 2nd ed. MIT Press, Cambridge.
- Fleharty E.D. and K.W. Navo. 1983. Irrigated cornfields as habitat for small mammals in the Sandsage Prairie region of western Kansas. *J. Mammal.* 64:367-379.
- Forman R.T.T. and M. Godron. 1981. Patches and structural components for landscape ecology. *Bioscience* 31:733-740.
- Forman R.T.T. and M. Godron. 1986. *Landscape ecology*. John Wiley & Sons, New York.
- Gilbert F.S. 1980. The equilibrium theory of island biogeography: Fact or fiction? *J. Biogeog.* 7:209-235.
- Gottfried B.M. 1979. Small mammal populations in woodlot islands. *Am. Midl. Nat.* 102:105-112.
- Gottfried B.M. 1982. A seasonal analysis of small mammal populations on woodlot islands. *Can. J. Zool.* 60:1660-1664.
- Gromadski M. 1970. Breeding communities of birds in mid-field afforested areas. *Ekologia Polska* 18:307-350.
- Haigh G.R. 1983. Effects of inbreeding and social factors on the reproduction of young female *Peromyscus maniculatus bairdii*. *J. Mammal.* 64:48-54.
- Hamilton W.D. and R.M. May. 1977. Dispersal in stable habitats. *Nature* 269:578-581.

- Harland R.M., P.J. Blancher and J.S. Millar. 1979. Demography of a population of *Peromyscus leucopus*. Can. J. Zool. 57:323-328.
- Healey M.C. 1967. Aggression and self-regulation of population size in deermice. Ecology 48:377-392..
- Henderson M.T., G. Merriam and J. Wegner. 1985. Patchy environments and species survival: chipmunks in an agricultural mosaic. Biol. Cons. 31:95-105.
- Hansen L. and S.O. Batzli. 1978. The influence of food availability on the white-footed mouse: populations in isolated woodlots. Can. J. Zool. 56:2530-2541.
- Hansson L. 1979. On the importance of landscape heterogeneity in northern regions for the breeding population densities of homeotherms: a general hypothesis. Oikos 33:182-189.
- Justice K.E. 1961. A new method for measuring home ranges of small mammals. J. Mammal. 42:462-470.
- Krohne D.T., B.A. Dubbs and R. Baccus. 1984. An analysis of dispersal in an unmanipulated population of *Peromyscus leucopus*. Am. Midl. Nat. 112:146-156.
- Krohne D.T. and M.S. Miner. 1985. Removal trapping studies of dispersal in *Peromyscus leucopus*. Can. J. Zool. 63:71-75.
- Levins R. 1970. Extinction. pp. 77-107 In: Gerstenhaber, M. (ed.) Some mathematical questions in biology. Vol.2. Amer. Math. Soc., Providence.
- MacArthur R.H. and E.O. Wilson. 1963. An equilibrium theory of insular zoogeography. Evolution 17:373-387.
- MacArthur R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton.
- McCoy E.D. 1983. The application of island-biogeographic theory to forest tracts: problems in the determination of turnover rates. Biol. Cons. 22:217-227.
- McCloskey R.T. 1975a. Habitat dimensions of white-footed mice, *Peromyscus leucopus*. Am. Midl. Nat. 93:158-167.
- McCloskey R.T. 1975b. Habitat succession and rodent distribution. J. Mammal. 56:950-954.
- McCloskey R.T. 1976. Use of artificial microhabitats by white-footed mice, *Peromyscus leucopus*. Am. Midl. Nat. 96:467-470.
- McCloskey R.T. and D.T. Lajoie. 1975. Determinants of local distribution and abundance in white-footed mice. Ecology

56:467-472.

- Merriam G. 1984. Connectivity: a fundamental ecological characteristic of landscape pattern. pp.5-15 in Brandt, J. and P. Agger (eds.), Proceedings of the First International Seminar on Methodology in Landscape Ecological Research and Planning (Vol. 1). Roskilde Universitetsforlag GeoRuc., Roskilde, Denmark.
- Metzgar L.H. 1967. An experimental comparison of screech owl predation on resident and transient white-footed mice (*Peromyscus leucopus*). J. Mammal. 48:387-391.
- Middleton J.D. and G. Merriam. 1981. Woodland mice in a farmland mosaic. J. Appl. Ecol. 18:703-710.
- Miller D.H. and L.L. Gatz. 1979. Factors influencing local distribution and species diversity of forest small mammals in New England. Can. J. Zool. 55:806-814.
- Morris D.W. 1979. Microhabitat utilization and species distribution of sympatric small mammals in southwestern Ontario. Am. Midl. Nat. 101:373-384.
- Nadeau J.H., R.T. Lombardi and R.H. Tamarin. 1981. Population structure and dispersal of *Peromyscus leucopus* on Muskeget Island. Can. J. Zool. 59:793-799.
- Norusis M.J. 1983. SPSS-X Introductory statistics guide. McGraw-Hill, Toronto.
- Osborne P. 1984. Bird numbers and habitat characteristics in farmland hedgerows. J. appl. Ecol. 21:63-82.
- Pickett S.T.A. and J.N. Thompson. 1978. Patch dynamics and the design of nature reserves. Biol. Cons. 13:27-37.
- Pollard E. and J. Relton. 1970. Hedges. V. A study of small mammals in hedges and cultivated fields. J. appl. Ecol. 7: 549-557.
- Risser P.G., J.R. Karr and R.T.T. Forman. 1984. Landscape ecology: directions and approaches. Ill. Nat. Hist. Surv. Spec. Publ. no. 2.
- Seagle S.W. 1985. Patterns of small mammal microhabitat utilization of cedar glade and deciduous forest habitat. J. Mammal. 66:22-35.
- Sheppe W.A. 1965. Characteristics and uses of *Peromyscus* tracking data. Ecology, 46:630-634.
- Simberloff D.S. 1974. Equilibrium theory of island biogeography and ecology. Ann. Rev. Ecol. Syst. 5:161-179.

Southwood T.R.E. 1977. Habitat, the templet for ecological strategies? J. anim. Ecol. 46:337-365.

Stickel L.F. 1968. Home range and travels, pp. 373-411. In King J.A. (ed.) Biology of Peromyscus (Rodentia). Spec. Publ. no. 2. The American Society of Mammalogists.

Taylor D.G. 1978. The population biology of white footed mice in an isolated and a non-isolated woodlot in southeastern Ontario. M.Sc. thesis. Carleton University, Ottawa.

Wegner J. and G. Merriam. 1979. Movements by birds and small mammals between a wood and adjoining farmland habitats. J. appl. Ecol. 16:349-357.

Wiens J.A. 1977. On competition and variable environments. Am. Sci. 65:590-596.

Whittaker R.H. and S.A. Levin. 1977. The role of mosaic phenomena in natural communities. Theor. Popul. Biol. 12:117-139.

Yahner R.H. 1983. Population dynamics of small mammals in farmstead shelterbelts. J. Mammal. 64:380-386.

END

FIN

3

04

87