71-23,229

REILLY, Raymond E., 1928-
FACTORS INFLUENCING HABITAT SELECTION BY THE
LEAST CHIPMUNK IN UPPER MICHIGAN.

Michigan State University, Ph.D., 1971
Ecology

University Microfilms, A XEROX Company, Ann Arbor, Michigan

FACTORS INFLUENCING HABITAT SELECTION BY THE LEAST CHIPMUNK IN UPPER MICHIGAN

By

Raymond E. Reilly

A Thesis

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Fisheries and Wildlife

1970

ABSTRACT

Habitat selection by the least chipmunk (Eutamius minimus) in Upper Michigan was evaluated by field observation and experimental tests of visual factors. Each of four, 5-acre experimental areas was subdivided into approximately 250 sq. ft. units and analyzed in detail in the field for the habitat factors: brushpile and woody ground cover distribution and density, distribution and degree of horizontal visibility, density of overhead cover and light intensity. These habitat characteristics were ranked on a three point scale system.

Habitats with good horizontal visibility, medium to dense brush piles and open canopies with correspondingly higher light intensities were occupied significantly more than other habitats. The extent of low, woody ground vegetation appeared to have no significance.

Eleven chipmunks were tested in an enclosure 10 ft. in diameter for their preference of: restricted vertical and horizontal visibility and two different perch heights. Pens restricting horizontal visibility were used significantly less than pens with unrestricted vision, unless the pens had high perches in them, which were used more than pens with low perches. Restricted vertical visibility was not a significant factor.

I conclude that habitats selected for good horizontal visibility and high brush pile density provided protective cover as well as the opportunity for visual social communication and spacing of the population. Certain types of vocalizations were also noted.

ACKNOWLEDGEMENTS

I wish to thank Dr. Leslie Gysel, Professor of Wildlife Management, for his technical advice during the course of this study. I also wish to thank Drs. Rollin Baker, John King, John Cantlon and Stephenson for serving on my graduate committee. I am indebted to the many people who assisted me with the design of the miniature transmitter, especially Harold Meirs, Michigan Bell Telephone, Harvey Ball, U. S. Corps of Engineers, and William Cochran, Illinois Natural History Survey. I am also grateful to Lake Superior State College and the Michigan State University Agricultural Experiment Station for some financial assistance. Special thanks are necessary for Dr. David Behmer, Lake Superior State College, for his invaluable advice concerning the statistical analysis of the data. I wish to recognize the efforts of Steven and Brian Reilly who spent many hours assisting me in the field. Without their aid this project would not have been possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

Many authors have noted that animals are not distributed at random but are found in certain habitats more frequently than in others. Some investigators have correlated animal density and distribution, with vegetational types (Dice, 1931; Grange, 1948; Leopold, 1948). Applied ecologists have attempted to create an optimal stage of vegetational succession for the management of squirrels (Allen, 1943); grouse (Ammann, 1957); hares (Grange, 1949) and other game animals.

The interrelationship between the physical factors of the environment and habitat selection by mammals have been considered experimentally by a few early workers. Chenoweth (1917) attempted to relate mammal distributio in a habitat to the evaporation quality of the air. Moody (1929) and Kalabukhow (1938) studied the influence of light intensity. More recently, Chew (1951) worked with the significance of water in the environment. Pruitt, (1953 and 1959) found a correlation between the moisture in the soil, physiological water loss (of the short-tail shrew (*Blarina brevicauda*) and its distribution in various soil and plant types. Hardy (1945) noted that the soil texture and structure may affect burrowing species from digging their ground burrows. The significance of environmental temperatures has been examined experimentally by Stinson and Fisher (1953) and more recently by Ogilvie and Stinson (1966). The latter workers correlated the spatial distribution of the white-footed mouse (*Peromyscus leucopus*) deer mouse (*P. maniculatus*) and the house mouse (Mus musculus) to microtemperature variations within their environments. Banasiak (1964), Behrend (1966) and Verme (1968) have attempted to explain the selection by white-tailed deer (*Odocoileus virginiana*) of certain conifer woodlands during the winter season based on the degree of physical comfort afforded by their habitat.

Another facet which has been reported to influence the selection of habitat is competitive exclusion. Odum (1959) states that where there is competition between ecologically similar species, the range of habitat conditions which each of the species occupies becomes restricted to the optimum. An illustration of this point can be taken from those periods when a species is more abundant and widely distributed and is inhabiting a portion of the habitat whose quality would be less that optimum. This implies (Evans, 1942) that an animal's occurrence may reflect habitat occupation rather than habitat selection. Whitaker (1967) and Sheppe (1967) described coaction effects between *Peromyscus leucopus* and *Mus musculus*. Whitaker implied that the latter species would inhabit the environment in which he found the former except for competitive exclusion. Sheppard (1965) describes a similar coaction phenomenon between *Eutamias amoenus* and *E. minimus*. Sheppe's work (1967) with *Peromyscus* demonstrated that *P. maniculatus* was being excluded from a habitat by *P. oreas*. Calhoun (1963) described the dominance relationship between *Clethrionomys* and *Peromyscus*. He suggested expansion of the home range of *Peromyscus* was inhibited by the presence of *Clethrionomys*; whose presence was communicated through vocal behavior.

Walker's (1964) experiments with 3 genera of woodland mice, utilized soil-vegetation units from two forest types translocated to the lab. He concluded that Clethrionomys and Napeozapus tended to choose the units in which they reach their greatest abundance. Tevis (1956) has considered the effects of ground vegetation on habitat selection by certain rodents.

Lack (1949) stated that a bird's selection of its habitat is accomplished by utilizing environmental recognition features which are not necessarily those directly essential to their existence. He classified the important environmental "cues" as proximate as opposed to ultimate; the former serving as "guidelines" which will orient the animal to a habitat which should provide the physiologically important necessities for survival. He believed that the choice of the ultimate factors are innate and set through natural selection. Tinbergen (1948) suggested that the habitat recognition "mechanism" or releaser mechanism involves the individual's response to the "sum effect" of several different stimuli in the environment. Once the total stimuli from a number of factors reaches a particular threshold level peculiar to the individual's habitat recognition, then selection is possible.

Wecker (1963) tested the influence of learning on habitat selection. Using the field subspecies of Peromyscus maniculatus, he concluded that both heredity and experience can play a role in determining the preference of P.m. bairdi for the field.

Few studies have been conducted to evaluate what these important cues are for an animal's selection of habitat. Harris (1952) conducted an experiment designed to uncover selection cues important to two races of Peromyscus maniculatus. The precise characteristics of the objects were not ascertained in these experiments, but his results indicated that visual cues were important.

Inheritance of the behavior of habitat selection has also been investigated by Klopfer (1965), Sheppard et al. (1968), and discussed by

Thorpe (1945), Howard (1965), Mayr (1963), King (1967), and others. This idea is more understandable if one remembers that the animals are polygenic for many characteristics, including behavior, many of which have not yet been defined. Thorpe (1945) points out that genetic change may reinforce existing differences in habitat preference through natural selection. Thus the habitat of *Eutamias minimus oreocetes* would be expected to be somewhat different than that of *E.m. consubrinus* or *E.m. neglectus.* The evolution of the latter subspecies appears to have been facilitated by an eastward extension of the species' range. Its subspecific differences are probably reflected in its behavior as well as its morphology. Therefore it is possible that its habitat preferences are also due in part to genetic inheritance.

Habitat of *E. minimus*

The habitat of *E. minimus** has been reviewed by Sheppard (1965) and Larrison (1947). Ten subspecies of *E. minimus* are characterized by living in dry sagebrush habitats; three subspecies live in alpine regions. The subspecies, *E.m. borealis*, *caniceps*, *hudsonius* and *neglectus* all occur in forested areas similar to those occupied by *E. amoenus luteiventris* (whose preferred habitat is generally semi-open or contains many openings in the forest). In general, *E. minimus* occupies the widest range of habitats of any North American chipmunk. In areas where it is the only species of *Eutamias* it occurs in forested as well as open regions. In areas of potential competition with other *Eutamias* species, *E. minimus* is restricted to alpine or dry sagebrush. Neither of these latter habitats are characteristic for the genus as a whole except for *E.m. consubrinus*

---

*Taxonomy is based on the work of Hall and Kelson (1959).

and *E.m.* *operaruis* which occupy a wide range of habitats from sagebrush to alpine including forest edges, but generally more open habitat.

Martinsen (1965) concluded that in Montana, *E.* *minimus* was more abundant on cut-over areas older than three years. The forested area was occupied by *E.* *amoenus*. Sheppard (1965) attempted to quantify the habitats of *E.* *amoenus* *luteiventris* and *E.* *minimus* *oreocetes* in Alberta. *E.* *minimus* predominated in open (unforested) areas which were supplied with a plentiful cover of rocks and stumps. He concluded, however, that *E.* *amoenus* was inhibiting *E.* *minimus* from using habitats containing more woody growth and in general, *E.* *minimus* is more tolerant of varied habitat types.

The habitat of *E.m.* *neglectus* has been described by several authors. Jackson (1961) cites McAllister as stating that in northern Wisconsin it was found in coniferous, mixed coniferous and hardwood forests, particularly if the ground cover contains various types of woody or rock debris and woody shrubs or combinations of these. Rarely did it occur in low wet wooded areas. Manville (1949) describes its general habitat in northern Michigan as occurring in dense upland forests, conifer swamps, and along shorelines; recently burned or cut-over areas, rocky mountaintops, cleared lands and openings in the forest containing shrubby ground cover. Forbes (1964) did not find this species in spruce-fir or northern hardwood forests in northern Minnesota. Disturbed areas within the forest supported the greatest number. He concluded that an open forest margin with rock, brush, or slash piles interspersed with bramble thickets, was a favorable habitat at least during the summer, and that *E.* *minimus* seemed to avoid dense cover. I was impressed with the observations that certain very "open" habitats, containing dense stands of bracken fern (Pteridium aquilinum) or woody ground cover or both adjacent to pine stands, held few if any chipmunks. Conversely, relatively small contiguous clearings in cut-over forests were occupied by the species in fair numbers. It suggested to me that the degree of visibility and ground cover within the different kinds of "open" habitats needed to be evaluated.

This led to two types of investigations:

1) An evaluation of the pattern of habitat use by this species in relation to the composition of the available habitat within a study area.

2) An experimental phase in which the effects of environmental parameters similar to those investigated in the field, were tested and evaluated.

This work was an attempt to clarify the significance of the habitat factors investigated on the selection of habitat by Eutamias minimus neglectus in the Upper Peninsula of Michigan.

FIELD STUDIES

Introduction

The objectives of the field work were an attempt to: (1) estimate the home ranges and movements of individual chipmunks in the study areas via a system of capture, mark, recapture, sightings and telemetry; (2) obtain information regarding the composition and density of the population; (3) compare the composition of the habitat within the home range with that of the total area; (4) attempt to determine the significance of certain features of the habitat in terms of their role in habitat selection by the chipmunk.

Description and location of areas

Experimental Areas I and II were chosen by reference to habitat descriptions reported in the literature (Jackson, 1961; Manville, 1949; Larrison, 1947; Sheppard, 1965; Forbes, 1964 and Martinsen, 1965 and the results of trial trapping periods. The areas were composed of diverse elements within their boundaries which would serve as "test" units.

New experimental areas were established in 1967 and 1968 because of a change in my residency from Escanaba to Sault Ste. Marie. This relocation was an opportunity to test the process of predicting chipmunk habitat selection based on previous field and experimental work conducted in 1965 and 1966.

All areas were located in Michigan's Upper Peninsula. Areas I and II were situated about seven miles southwest of Escanaba; Areas III through V approximately 30 miles southwest of Sault Ste. Marie near the settlement of Raco.

The summers are mild, the July temperatures averaging about 66 degrees F. near Escanaba and 62 degrees near Sault Ste. Marie; the January averages are 12 degrees F. and 10 degrees F. respectively. The Escanaba area receives about 35 inches of precipitation annually which includes approximately 55 inches of snow. The area near the Sault receives about 32 inches annually including 90 inches of snow.

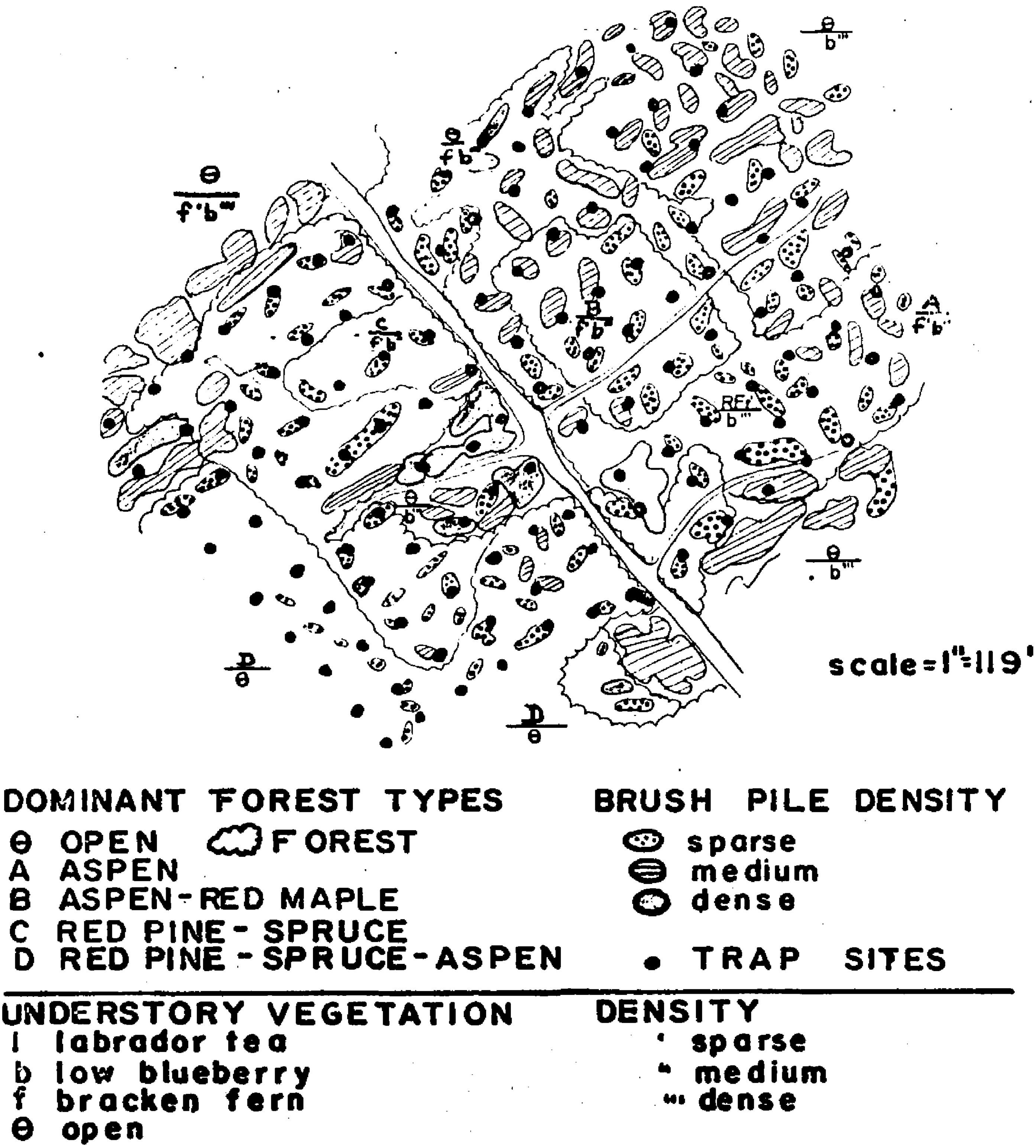
Most of the 40-year old forest on Area I was cut-over in 1961. The uncut forest and remaining trees consisted of primarily red pine (Pinus resinosa), aspen (Populus tremuloides) and black spruce (Picea mariana) plus a scattering of white pine (Pinus strobus) and balsam fir (Abies balsamifera) (Figure I and Table I).

The soil (Kinross mucky sand) had a ground water table within one to three feet of the surface. Associated with the more xerophytic conditions were various species of mosses, wintergreen (Gaultheria procumbens) and blueberry (Vaccinium sp.). Labrador tea (Ledum groenlanaicum) and sphagnum moss (Sphagnum sp.) grew in the scattered moist depressions under a partially open canopy. Bracken fern was sparsely scattered under the denser portions of the forest; it was of medium density and intermittent distribution under tree cover of medium density and among tree reproduction; and it formed a tall dense, continuous layer in the open, northeast portion of the study area. The brush pile ratings were established on a subjective basis described later.

The periphery of Area II consisted of almost pure hemlock (Tsuga canadensis) of varying ages growing on Kalkaska sand (Figure 2 and Table I). The study area had been cut-over at different times; most recently in 1960 and 1961. After earlier cuttings about 55 years ago, red maple

Figure 1

Cover map of Area I



Θ/b'''
Θ/f b
Θ/f'b'''
B/f'b"
C/f'b
A/f'b'
RFr/b'''
Θ/b
Θ/b'''
D/Θ
D/Θ
scale=1"=119'
DOMINANT FOREST TYPES
Θ OPEN
FOREST
A ASPEN
B ASPEN-RED MAPLE
C RED PINE-SPRUCE
D RED PINE-SPRUCE-ASPEN
BRUSH PILE DENSITY
sparse
medium
dense
• TRAP SITES
UNDERSTORY VEGETATION
l labrador tea
b low blueberry
f bracken fern
Θ open
DENSITY
' sparse
" medium
''' dense

Table 1

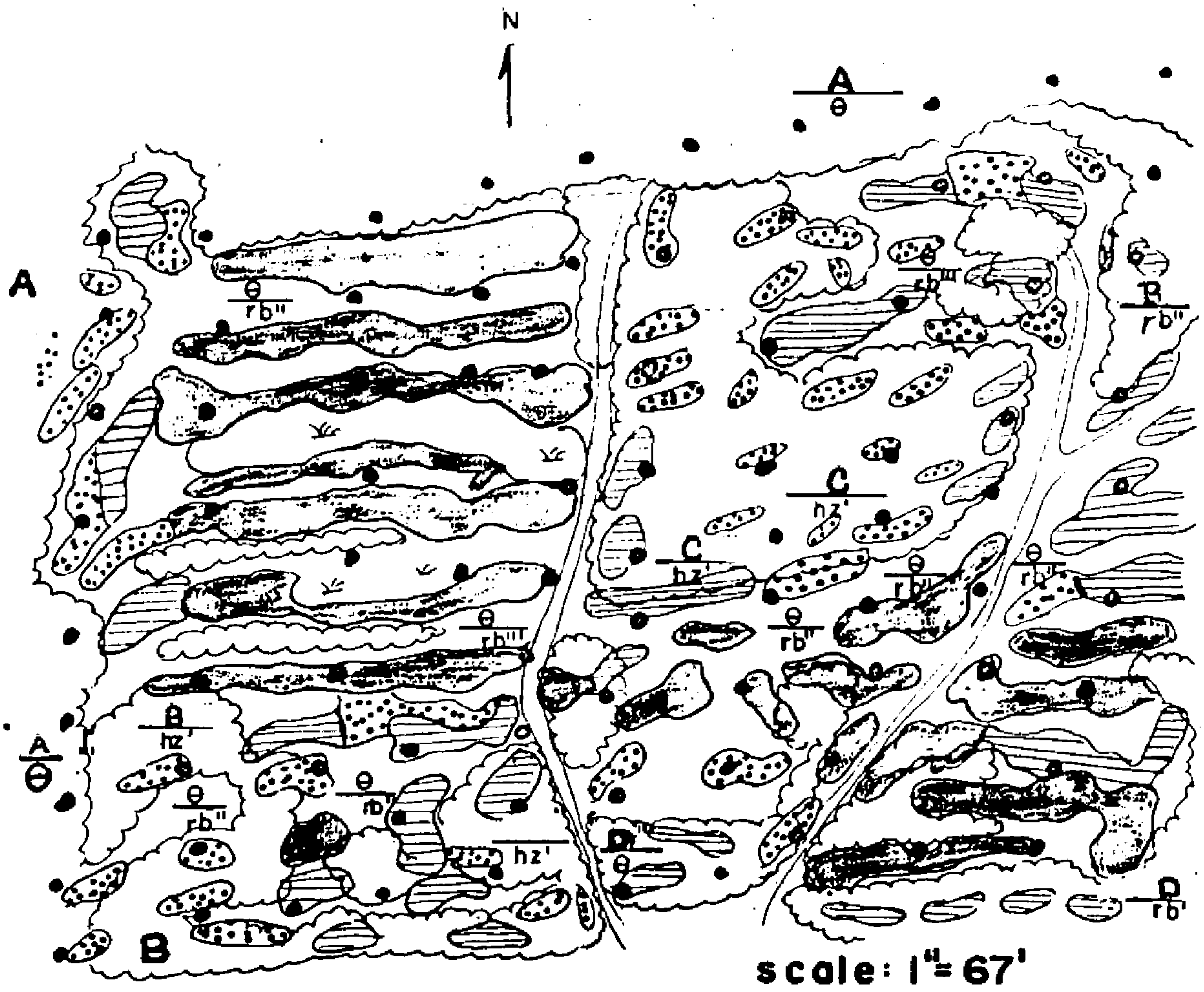
A summary of tree densities for each Area's forest types. Measurements indicate basal area in square feet/acre, stem count/acre and the distribution of the stems per size class (in per cent).

	AREA I				AREA II				AREA III				AREA IV	
	Forest Types*				Forest Types*				Forest Types*				Forest Types	
Species	A	B	C	D	A	B	C	D	A	B	C	D	A	B
	Basal Area-square feet				Basal Area-square feet				Basal Area-square feet				Basal Area-sq.ft.	
Red Pine	1.6	-	32.1	37.4	4.5	-	-	-	3.9	1.0	10.8	1.9	-	4.6
White Pine	-	-	-	15.5	3.8	4.7	22.9	-	-	-	1.5	-	-	-
Jack Pine	-	-	-	-	-	-	-	-	7.0	1.2	1.9	69.7	2.6	0.7
Hemlock	-	-	-	6.7	115.4	55.1	55.1	0.4	-	-	-	-	-	-
Spruce	1.0	-	15.5	30.2	0.8	-	-	-	-	-	-	-	-	-
White Cedar	-	-	-	-	-	-	2.3	-	-	-	-	-	-	-
Fir	0.2	0.4	1.2	8.9	0.4	9.1	2.3	0.5	-	-	-	-	-	-
Yellow Birch	-	-	-	-	0.8	28.9	2.1	-	-	-	-	-	-	-
White Birch	-	-	-	-	5.6	3.1	-	-	22.7	-	6.3	9.4	6.0	7.0
Aspen	10.0	1.7	2.3	29.3	-	-	-	-	11.3	3.5	6.3	10.6	1.6	14.7
Red Maple	0.5	4.3	0.5	10.4	5.2	43.3	136.7	28.7	-	-	0.9	-	2.3	0.4
Totals	13.3	6.4	51.6	138.4	136.5	144.2	221.4	39.6	44.9	5.7	27.7	91.6	12.5	27.4
Stems/Acre	38	112	192	521	452	750	460	680	284	43	132	186	160	117
DBH Class														
1 - 4"	72%	90%	33%	53%	42%	67%	-	100%	69%	75%	61%	31%	90%	49%
5 - 10"	28%	10%	63%	42%	48%	29%	89%	-	30%	23%	33%	69%	10%	50%
11- 15"	-	-	2%	3%	10%	3%	7%	-	1%	2%	6%	-	-	-
16- 20"	-	-	2%	2%	-	1%	4%	-	-	-	-	-	-	1%

*Refer to individual cover maps for a description of the forest type categories A, B, C and D.

Figure 2

Cover map of Area II



DOMINANT FOREST TYPE

θ OPEN ☁ FOREST
A HEMLOCK
B HEMLOCK-YELLOW BIRCH-RED MAPLE
C RED MAPLE-HEMLOCK-WHITE PINE
D RED MAPLE

BRUSH PILE DENSITY

◌ sparse
⊜ medium
⬬ dense

● TRAP SITES

UNDERSTORY VEGETATION
hz hazelnut
rb red raspberry
sedge

DENSITY
' sparse
'' medium
''' dense

(*Acer rubrum*) and yellow birch (*Betula alleghaniensis*) became established along with the previously mentioned conifer. They comprised the relatively more mature trees in the center of the area. Hazel nut (*Corylus sp.*) was the dominant shrub of a sparse, tall-shrub layer with these hardwoods. Since the 1962 cuttings, young red maple sprouts and saplings as well as conifer reproduction, have become interspersed throughout the cut-over area. Red raspberry (*Rubus idaeus*) was very abundant in the more open areas.

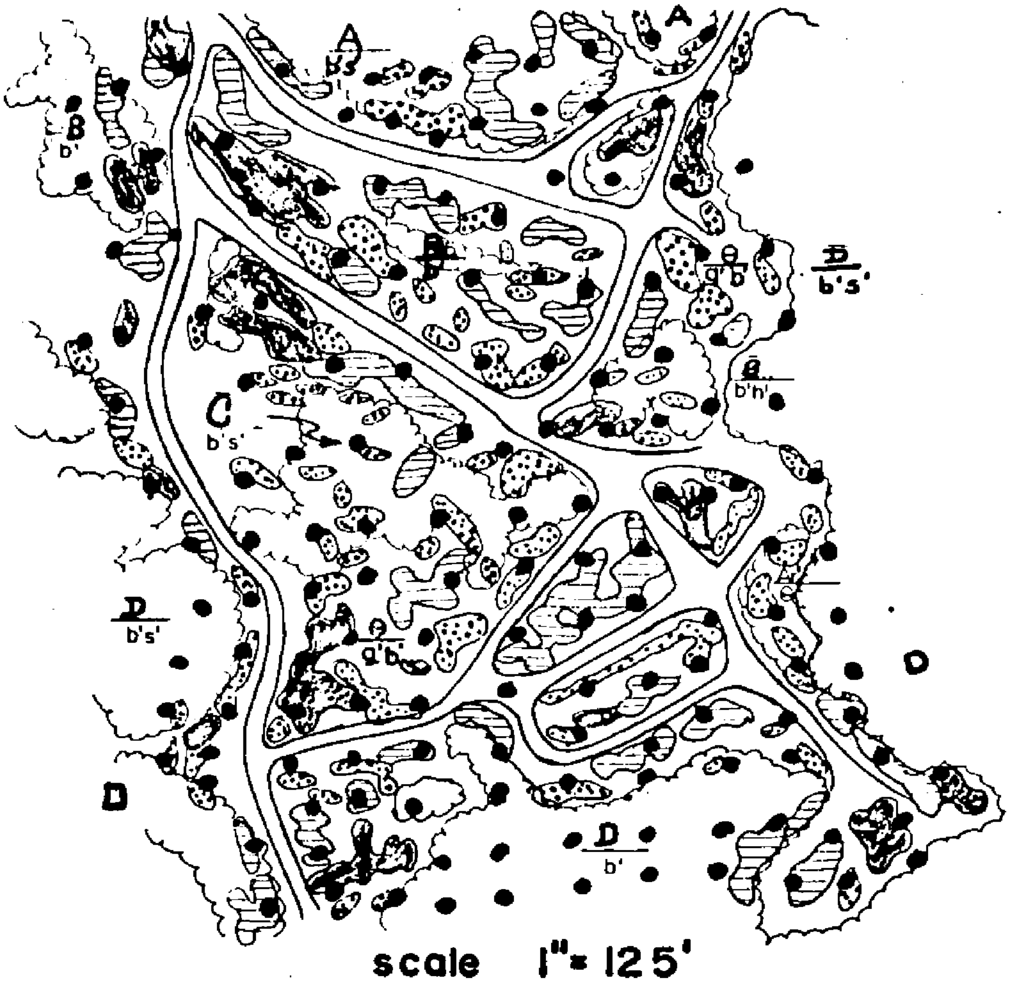
The composition of the low, woody vegetation under the forest canopy was primarily wintergreen, bunchberry (*Cornus canadensis*) and bristly dewberry (*Rubus hispidus*). The most common fern in the hardwoods was the woods spinulosa (*Dryopteris spinulosa*). Staghorn (*Lycopodium clavatum*) and stiff (*Lycopodium annotinum*) clubmosses, as well as the pipsessewa (*Chimaphila umbellata*) were common. Bracken fern was sparsely scattered throughout the open and semi-open portions.

The maps for Areas I and II were constructed from aerial photos taken at a height of about 200 feet by a private photographer, and cover mapping on the ground.

Areas III and IV are in a relatively flat region. Rubicon sand supported a forest of jackpine (*Pinus banksiana*), red maple, red pine, aspen and white birch (*Betula papyrifera*)(Figures 3, 4 and Table 1). The tall shrub layer was very sparse consisting of an occasional juneberry (*Amelanchier sp.*). The woody ground vegetation was typified by bearberry (*Arctostaphylos uva-arsi*), wintergreen, sweetfern (Comptonia peregrina), blueberry and bush honeysuckle (*Diervilla lonicera*). The latter three species were the most common and of varying densities. Other common plants

Figure 3

Cover map of Area III



DOMINANT FOREST TYPES
ϴ OPEN ⬭ FOREST
A ASPEN-WHITE BIRCH
B ASPEN-JACK and RED PINE
C ASPEN-RED PINE-WHITE BIRCH
D JACK PINE-ASPEN

BRUSH PILE DENSITY
⬭ sparse
⬭ medium
⬬ dense

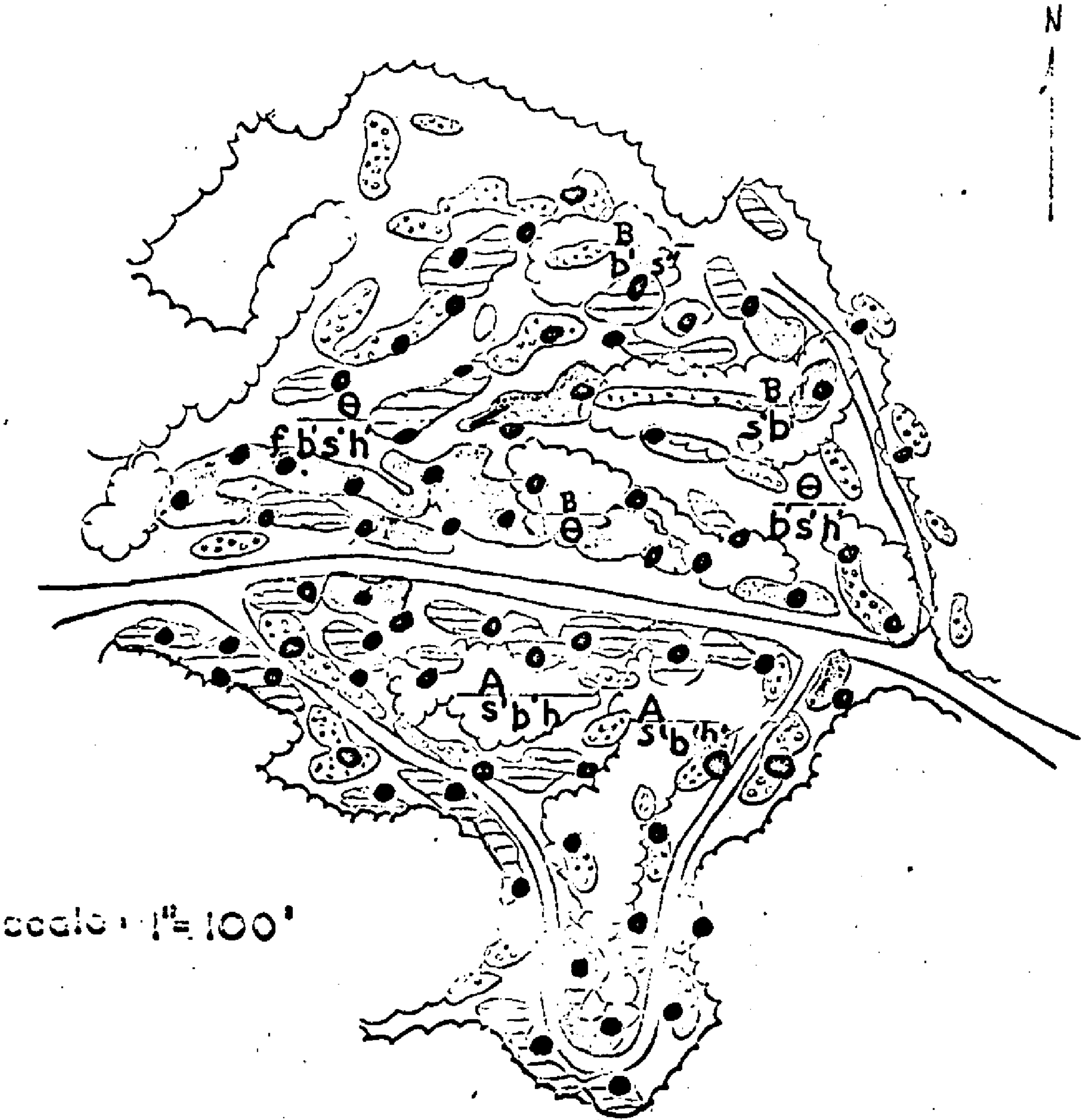
● TRAP SITES

UNDERSTORY VEGETATION
b low blueberry
h bush honeysuckle
s sweetfern
g grass
f bracken fern

DENSITY
' sparse
" medium
"' dense

Figure 4

Cover map of Area IV



DOMINANT FOREST TYPE
θ OPEN
FOREST
A JACK PINE - REDMAPLE WHITE BIRCH
B WHITE BIRCH - RED PINE - ASPEN

BRUSH PILE DENSITY
sparse
medium
dense

● TRAP SITES

UNDERSTORY VEGETATION
b low blueberry
h bush honeysuckle
s sweetfern
f bracken fern

DENSITY
' sparse
'' medium
''' dense

were reindeer moss (Cladonia sp.) and bracken fern (Pteridium aquilinum). The fern's density was medium to dense and its distribution was interwoven between brush piles throughout the area.

With the exception of a few small, scattered jackpine and red maple trees, Area V was treeless and lacked tall shrubs. The ground cover was similar to that in Areas III and IV but less dense. Bracken fern was of sparse to medium density and scattered around the brush piles. Relatively wide grassy areas separated the rows of brush piles (Figure 5).

The Areas III, IV and V were mapped from greatly enlarged USDA aerial photos and cover mapping on the ground. Plates I through V illustrate the Areas.

One other site worthy of note was trapped. This was a 4-acre commercial cedar post yard about six miles west of Escanaba (Plate VI). No detailed records were kept, but at least 10 chipmunks were trapped. They were still reported to be "plentiful" after this trapping was completed.

Plate I

Figure 1. North corner of Area I

Figure 2. North central portion of Area I

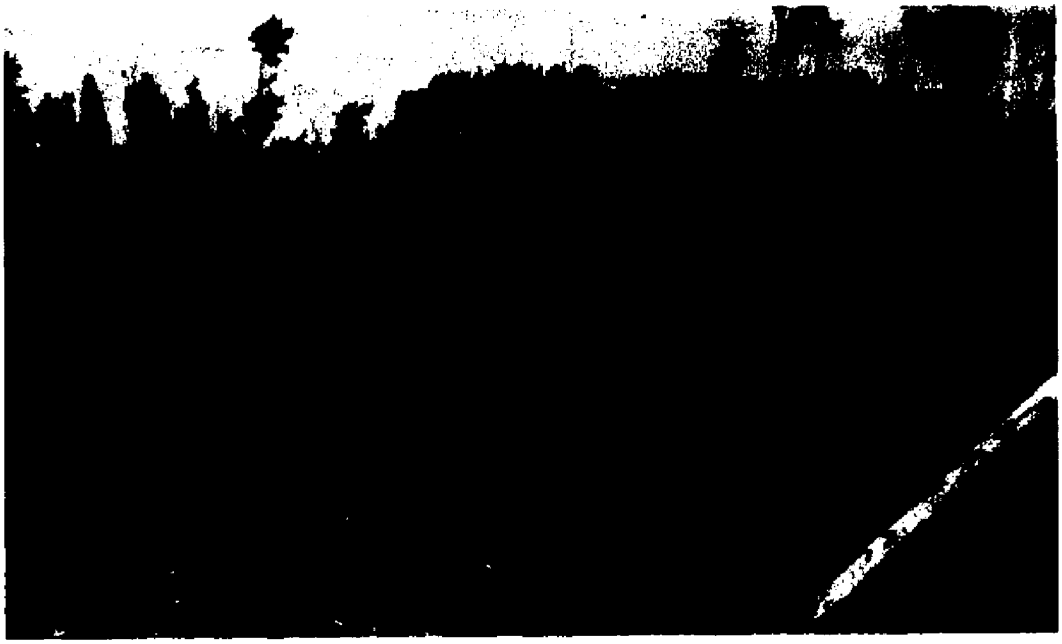


Plate II

Figure 3. South central portion of Area II

Figure 4. South east portion of Area II

Plate III

Figure 5. North west portion of Area III

Figure 6. South central portion of Area III

Plate IV

Figure 7. Central portion along trial, Area IV

Figure 8. South west portion of Area IV

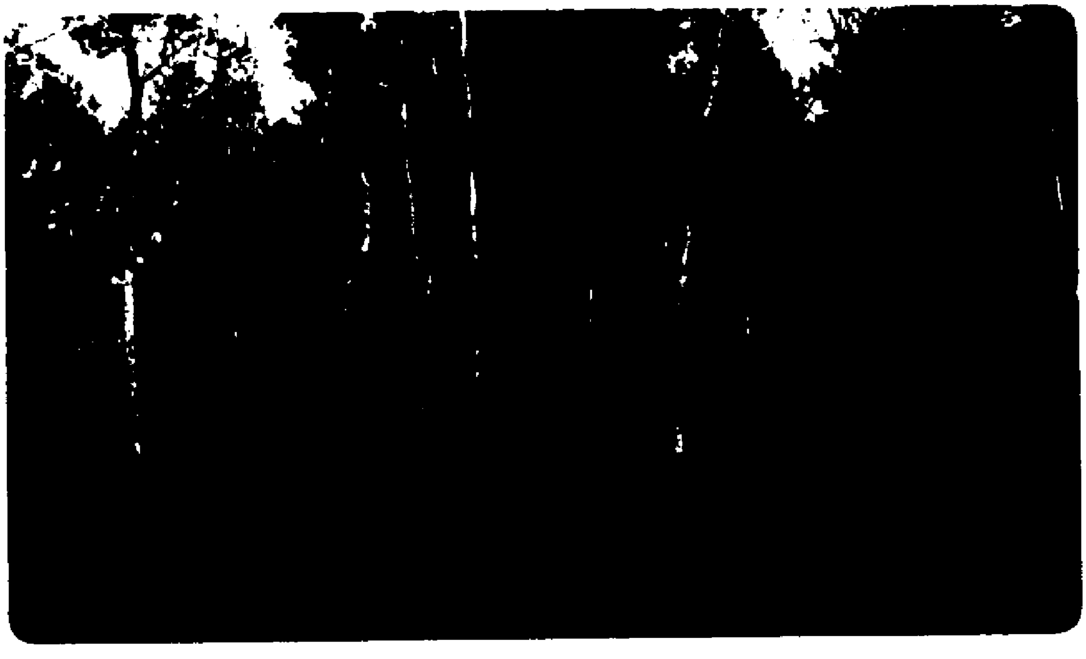


Plate V

Figure 9. Looking west from northeast corner of

Figure 10. Looking south from northeast corner of

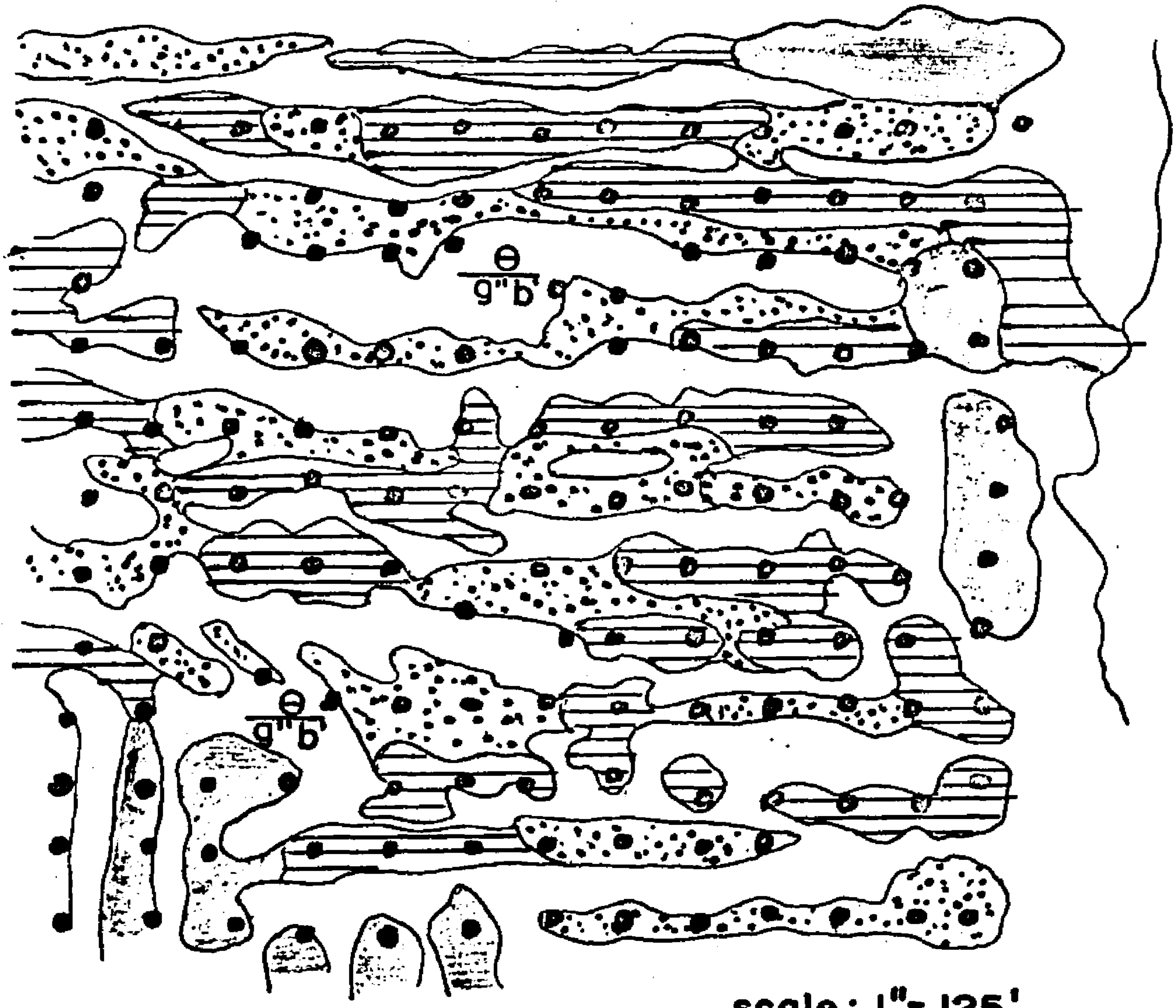
Area V

Plate VI

Figure 11. A trial trapping location having a high density of chipmunks

Figure 5

Cover map of Area V



scale : 1" = 125'

COVER TYPES

θ OPEN
g grasses
b low blueberry

BRUSH PILE DENSITY

⊕ sparse
Ø medium
◉ dense

● TRAP SITES

MATERIALS AND METHODS

Trapping

There is no one acceptable method of arranging traps that has been agreed upon by all workers for use with even one species. I used the grid system: (1) its validity seemed to be supported by many workers, (Tevis, 1956; Tanaka, 1963; Wolfe, 1968; Blair, 1941). (2) Use of a grid system would facilitate analysis of the estimated home range of the animal's habitat. (3) Sheppard (1965) and Martinsen (1965) used the grid system to study E. minimus, and my data would be comparable to theirs.

All areas were measured using a compass and tape. The trap sites formed a grid pattern. No traps were placed in the open, instead their location was shifted 3 or 4 feet to a brush pile or similar dense woody ground cover. Trap sites were marked with a numbered stake to facilitate finding the traps and add uniformity to the trapping regimen. The stakes were about 3 feet above ground level. Only one trap was set per site.

The trap, which was 3 inches by 12 inches, was constructed of 1/4 inch hardware cloth (Plate VII). It was operated by a treadle having attached to it a prop holding up a trap door which dropped by gravity when the treadle was tripped. The trap was staked down to prevent overturning, and partially covered by a small piece of burlap. A 2-inch metal sheath was soldered to the inside of the door. Into this was placed a 3 inch wire, hooked on one end. When the door dropped, the wire slid down through the metal sheath, through the wire mesh on the bottom of the trap thus locking the door down.

PLATE VII

Figure 12. The live trap used

The bait, a mixture of rolled oats and peanut butter, was placed on a small rectangular piece of metal suspended 1 inch below the top of the trap by a wire. Thus, the animal could see the bait even when looking into the trap through the entrance door. This method lessened loss of bait to insects.

Traps set overnight on Areas I and II caught too many nocturnal mammals. Therefore, they were set about dawn and checked around mid-day and early evening. Overnight sets were made on other areas.

Not all sites in Area I were trapped simultaneously because I lacked traps during 1965. Approximately one-half of the area was trapped first, then the traps were transferred to the untrapped portion of the area. No traps were set on rainy mornings. However, this did not delay the trapping schedule more than one day. Three-day trapping periods reduced the effect of weather variables and the possibility of interference with the habitat and animal activity by the investigator. All traps were removed after the trapping period was terminated. This was done to help prevent a "loss of interest" which was described by Tropan and Wofciechowska (1967). It was speculated that this "absence" would maintain a level of curiosity in the animals for the traps when they were re-introduced into the area.

The trapped chipmunks were transferred to a wire cone. This was done by inserting the open trap into a black hood which had a wire cone attached to it. The animal ran through the hood and into the cone. While restrained, it was toe-clipped, marked with Nyanzol*, weighed, sexed and

---

*The six animals from Area III fitted with transmitters and animals captured from Area V were not marked with Nyanzol.

its age estimated.

The dye marking system used was similar to that described by Martinsen (1965). The toe-clipping followed the pattern described by Blair (1941). Since pelage moult appeared to begin shortly after cessation of breeding, adults had to be dyed again upon recapture.

Chipmunks in Area V were tagged with different colored polyvinyl strips. A strip was attached to two collars; one was put around the animal's neck and the other around its abdomen. The animals were located with the aid of 7 x 50 binoculars. Once an animal was sighted it was usually followed visually. Each time it reappeared, its location was classified as a new detection point. An animal moving 50 feet in continuous view had one detection point; if it disappeared and reappeared three times, it had four detection points.

Habitat analysis

An Area was subdivided into habitat units by assigning the stake at each trap site as a corner of a unit. Since the trap sites weren't laid out in a perfectly square grid, the shape of each unit varied. This had little effect on the results since within each unit the evaluation was on a relative basis. This partitioning facilitated detailed analysis of the total habitat, one unit at a time.

The habitat factors used for evaluating the environment were: (1) brush pile density; (2) the distribution of woody ground vegetation; (3) horizontal visibility; (4) density of the overhead tall tree and shrub canopy; (5) light intensity. Cover maps provided the bases for the description of the five habitat factors. Their variability was then subjectively ranked (Table 3). The numbers of units in each area are listed in Table 2. Factor one was rated in the spring; factors two, four and five during the summer. Factor three was determined at two seasons; spring, prior to the emergence of the broadleaf vegetation, and summer. Further explanation is required for factors three and four. The horizontal visibility was rated by an observer located at a trap site as he faced the sites located diagonally* from his position. If there were no appreciable obstructions at about 2 feet of height between him and the diagonally located trap stake, it was rated 0; a scattering of trees, shrubs or bracken fern gave a rating of 1; many dense clumps of vegetation between the two sites rated a 2; if the distance between the two trap sites was almost completely closed in with a high growth of vegetation, it was rated a 3. Two observations were made from each trap site stake (Figure 6) and averaged together for a unit rating. If a unit's average rating was 2.5 it was rounded off to 3.0.

Subjective ratings used in biology have been shown to be fairly reliable if: (1) the observer is experienced; (2) only one person does the evaluating; (3) the same predetermined standards are used throughout the survey. These three criteria were met. Conclusions based on these and other methods are presented as being reliable as the techniques used.

The light intensity for Areas I, II and III was measured and evaluated using a modification of a method described by Friend (1961). I used small, clear glassed, screw-capped jars into which one stack of 14 ozalid papers were faced through the side of the bottle; another stack faced up through the bottom of the overturned jar. Two jars were attached to a selected trap at dusk, one at ground level and the other at the top of the stake.

---

*Frontal direction was used at the first and last row sites.

Table 2

Descriptions of the criteria used to evaluate habitat factors on a unit basis within and between study areas.

1. Brush Pile Density	Rating
No brush piles	0
Most of the ground visible under the brush pile--sparse	1
About 50% of the ground visible under the brush pile--medium dense	2
Little of the ground visible under the brush pile--dense	3

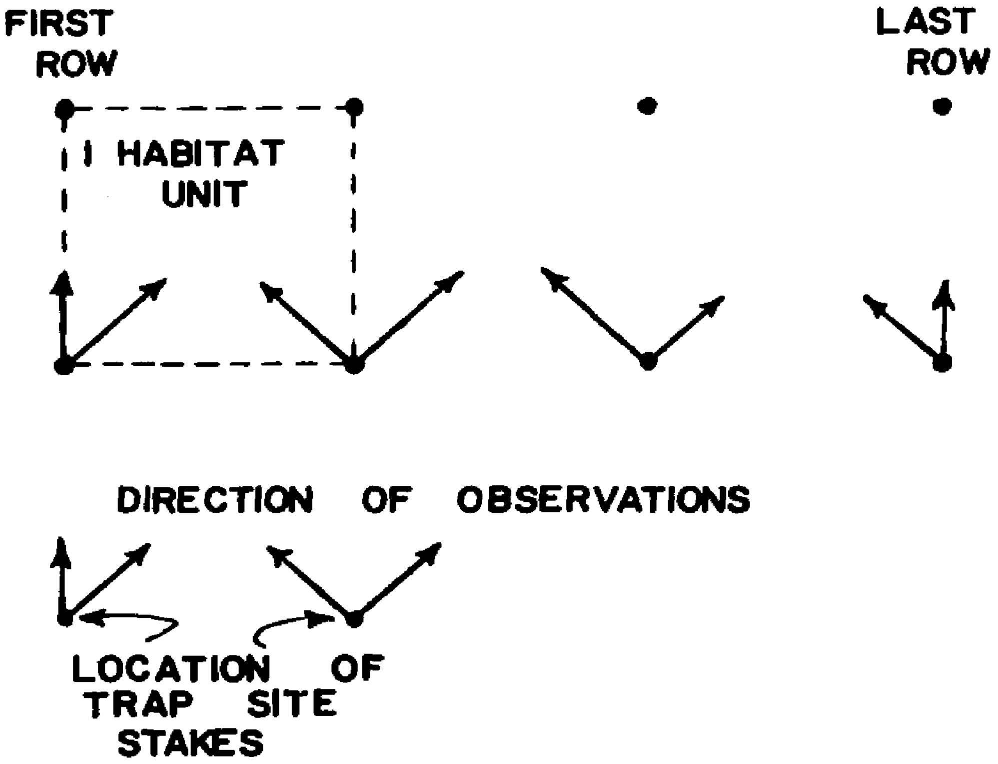
2. Distribution of Woody Ground Vegetation (less than three feet in height)	Rating
No low woody cover	0
Less than 1/3 of the ground covered by woody cover	1
Between 1/3 and 2/3 of the ground covered by woody cover	2
Over 2/3 of the ground covered by woody cover	3

3. Horizontal Visibility--evaluated at brush pile height of 2 feet above ground level	Rating
Few visual obstructions or none at all--almost all of stake visible	0
Scattered clumps or individual trees between the two points--at least 2/3 of the stake visible	1
Many dense clumps between the two points--less than 1/3 of the stake visible	2
Widespread dense arrangement of obstructing objects--stake not visible	3

4. Light Intensity and Canopy Condition (Rated when foliage present)	Rating
Six or less ozalid papers exposed--less than 1/4 canopy open	0
6-8 papers exposed--canopy 1/4 open	1
8-10 papers exposed--canopy 3/4 open	2
Over 10 papers exposed--open--no canopy	3

Figure 6

The procedure used for evaluating the horizontal visibility of a habitat unit


FIRST
ROW
LAST
ROW
HABITAT
UNIT
DIRECTION OF OBSERVATIONS
LOCATION OF
TRAP SITE
STAKES

They were exposed for one full, almost cloudless day. The number of papers exposed provided a measure of light intensity. The selection of the stakes was on a random basis for each of the four canopy closure categories, 10 stakes within a category. Areas I and II were each sampled with 80 jars. Since Area V was virtually without a forest canopy, no measurements were taken.

The individual habitat factor ratings for a particular unit were not averaged together because this would obscure their difference.

The observed use of the habitat, as determined from home range data, was compared to the expected random use of the habitat. Only the actual data were used to make comparisons using the Chi Square test. Significant differences were reported at the .05 and .01 level. Quantitative description of the study areas is found in Table 3.

Age and sex criteria

The age classification criteria used by Sheppard (1965) and in part by Forbes (1964) could not be used without sacrificing the animals. Therefore, field techniques, although not as dependable, were used. The criteria were (1) Bodyweight. Based on my observations, no adult male chipmunk trapped prior to July 1 weighed less than 34 gms. Forbes (1964) and later Sheppard (1968) presented data indicating that juveniles which usually emerge after July 1, have a bodyweight which averages less than 30 gms. He noted that the weight of juveniles prior to August 1 averaged approximately 25 gm. Therefore, all male animals weighing 32 gms. or less were considered juveniles. (2) Gonads and secondary sexual structures. Breeding adults were distinguished from sub-adults when captured before July 1 by the swollen testes, evidences of lactation or size of

Table 3

Quantitative description of the study areas: size, number of habitat units, number of trap sites and spacing.

Area	Size (in acres)	Number of Habitat Units*	Number of Trap Sites	Approximate Trap Site Spacing (in feet)
I	5.3	104	126	50
II	4.2	72	90	50
III	6.2	130	154	50
IV	2.5	65	74	25-30**
V	6.6	130	156	50

*See Figure 6, page 29.

**Objective for this area was primarily to estimate population size.

female teats, or both. Thus, animals trapped for the first time prior to July 1 were classified as adult or sub-adult using the appropriate criteria. Once marked, they were not confused upon recapturing. Animals trapped for the first time during July and August were classified using criterion (1). However, after mid-August, the reliability of classifying "new" captures was questionable.

Population estimates

No formal population estimating techniques were employed for the following reasons: (1) Most adults using the area regularly were thought to have been trapped and marked soon after the animals were exposed to the traps. This pattern of capture is similar to that reported by other workers. Some animals were trapped later but they appeared to be transient except for No. 14 in Area I. (2) Recruitment took place in July and few young animals were recaptured after the end of August. New juveniles captured in September were thought to be dispersing from other areas. (3) The basic assumptions to be used before various population estimating techniques can be applied were generally violated by the type of procedures used in this study.

Home range estimates

In an attempt to recognize the influence of the factors mentioned by Stickel (1960), my data were collected on Areas I and II throughout the spring, summer and part of the fall seasons. This insured a wide variation in kind and quantity of food and cover available as well as variations in age, sex and reproductive condition of the animals in the area. The concept of home range used in this paper was based on Blair's (1953) definition.

One of my prime objectives was to utilize the estimated home range and movement data as aids in interpreting the animal's habitat use. Many methods have been suggested for measuring home ranges (Hayne, 1949; Calhoun and Casby, 1958; Stickel, 1954 and 1965; Mohr and Stumpf, 1966; Wolfe, 1968). Brown (1962) and Sanderson (1966) have reviewed the literature. Most methods are related to the procedure used for the determination of animal movement, e.g. trapping, visual observations, radioactive tags and telemetry; the latter two being relatively new innovations. I used a combination of these, excluding the radioactive tags. The minimum method of Martinsen (1965) was used because the data would be more meaningful if the methods used and the results obtained were comparable with his data for the species. Animals with fewer than four detection points were not included in home range estimates or habitat selection analyses.

Telemetry

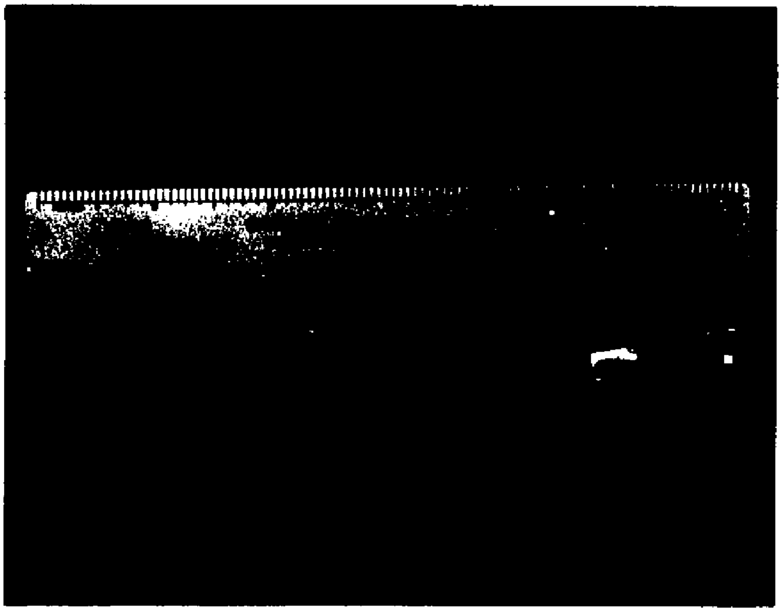
A miniature transmitter was used in 1967 in an attempt to obtain more information about the movements of chipmunks. The trapping and tagging with the transmitter was carried out on August 22 and 23. The basic design is a modification of one developed by Cochran (mimeographed April, 1967) and was assembled according to the instructions given in his report. The modified design enabled me to utilize all crystals designed for frequencies from 148.00 mc to 148.75 mc. (Figure 9, Appendix). The transmitter's antenna was a copper wire loop fitted to the animal's abdomen while the animal was restrained. The loose end of the antenna was soldered with liquid to the transmitter to complete the circuit. The transmitter and battery were potted with a dental acrylic to protect it from shock and water. Both were affixed with a silicone glue to a 2 inch long piece of thin polyvinyl. This strip was then snapped to another strip which served as a fitted neck collar. The completed transmitter formed a back-pack which weighed approximately 7.8 gm. It was prevented from slipping off the animal's back by the relatively snug fit of the collar and antenna. A captive chipmunk was used to test the harness' fit and behavioral effects. No apparent adverse effects were noted. Plate VIII illustrates the complete "package".

Receiver model DC 4603 was a 12-V battery operated 6-transistor car radio. To its circuit was attached an International TRC-5B transistorized converter. It converted the radio to a receiver capable of receiving signals from 148 mc to 149 mc.

The directional antenna used to receive the signals was a 6 element Yagi especially cut according to specifications described in the Radio Amateur's Handbook (39th edition, 1962). A coaxial antenna cable, resonant with the operating frequency, connected the antenna to the receiver. The antenna was to be attached to a 20 feet long pole that could be rotated 360°. Field tests of the transmitter in dense, brushy habitat indicated that 40 yards was about the maximum distance that the signal could be perceived whether the antenna was elevated 20 feet or 6 feet. However, when the chipmunk was sitting in an exposed location, the effective signal distance was as much as 125 yards. No signal could be detected if the animal was in an underground den. Due to these limitations, a harness type, over-the-shoulder sling was constructed for the receiver, converter and 12 V battery. Signals were located while walking slowly down the logging trails which criss-crossed the area. Pausing frequently, the antenna was rotated 360° in an attempt to locate the direction

Plate VIII

Figure 13. Transmitter, uncoated and coated with denture material



of an emitting signal. When one was received, its location was determined by triangulation from two points about 20 yards apart. This procedure was used for each signal that was detected. A moving animal was "tracked" until it settled down to one spot for about five minutes.

Although a "functional" schematic was used, unexpected difficulties were encountered with the transmitter. (1) Not all of the crystals were sensitive enough to oscillate. This necessitated revamping the schematic. (2) To obtain a signal that could be received at a "reasonable" distance, a specifically cut resistor was necessary which increased battery drain and shortened its life. (3) It was necessary to use a high frequency wave length (148 mc) in order to obtain the necessary directional qualities. Working with this frequency placed a premium on the delicate art of construction. Slight alteration in the winding of the L 1 coil resulted in effects varying from no function to the production of a non-oscillating signal.

Telemetry was not used in 1968.

Vocalizations

Another method of locating chipmunks was by noting the location of their vocalizations. If an animal emitted any of the calls associated with fear or warning, the observer was usually quite close to the general location of the animal noted. One type of call, a soft "Qwip" or "Whoit", was frequently heard late in the day. In an open area, and depending upon weather conditions, the call could be heard 100 yards. Records were kept of the number of locations at which this call was heard. On every occasion, the animal was perched in a very conspicuous elevated location. The enumeration of vocalizations was based on the number of different locations at which the call was heard. Thus, the location at which an animal was observed calling, was designated as one call regardless of how many individual calls he emitted per time length at that location. If the animal changed locations and began calling again (which was noted very frequentl it was considered a "new" location.

RESULTS

Home Range Determinations

Adult males had larger home ranges than females, and adult males larger ones than juvenile males (Tables 4 and 5). The juvenile females had larger home ranges than those of the adult females. This latter situation may have been due to: (1) a greater affinity of adult females for the nest site; (2) the restricted movements breeding females had during late pregnancy and lactation; (3) the tendency to capture adults less frequently in late summer than in the spring; (4) the possibility that the "home range" of juveniles may tend to increase as they grow older due to exploration and dispersal. Thus, a reportedly smaller home range for adult females _vs_ juvenile females may be an artifact produced by one or more of the aforementioned set of circumstances.

The estimated home ranges for each area were combined and outlined on individual maps (Figures 13 through 20, Appendix). Included on each map is the outlined area of home ranges for adults only, as well as for all animals combined. A larger home range composite for all animals may be explained by the tendency for juveniles to explore portions of the habitat apparently unused by the adults; this may be preliminary to their dispersal.

Telemetry provided additional detection points in Area III which resulted in a home range map having a considerable clumping of points. As a result, the most frequently used portion of the habitat for this season was more easily discernible. The calculated home range with

Table 4

A summary of home range data for males

Area	No. of Animals	Estimated Age	No. of Months of Observation	Total no. of times seen per visit to area	Total no. of Detection Points (1)	Average Estimated Home Range Minimum Method (in acres)	Average of Farthest Movement Recorded (in feet)
I	5	A	7	6	59	0.65	282
	4	J	7	4	45	0.79	346
II	4	A	3	7	32	0.50	223
	6	J	3	10	33	0.50	275
III	2	A	1	8	78	0.80	419
	3	J	1	7	34	0.75	304
V	4	A	2	17	97	1.15	425
Averages for the:		15 Adults				0.77	332
		13 Juveniles				0.68	309

(1) Includes trap data, daily visual observations and telemetry points.

Table 5

A summary of home range data for females

Area	No. of Animals	Estimated Age	No. of Months of Observation	Total no. of times seen per visit to area	Total no. of Detection Points (1)	Average Estimated Home Range Minimum Method (in acres)	Average of Farthest Movement Recorded (in feet)
I	5	A	7	3	40	0.49	223
	2	J	7	11	18	0.81	301
II	2	A	3	3	12	0.54	225
	3	J	3	4	22	0.62	289
III	1	A	1	6	33	0.86	350
	5	J	1	2	96	0.64	292
V	3	A	2	4	29	0.38	194
Averages for the:		11 Adults				0.57	224
		10 Juveniles				0.69	295

(1) Includes trap data, visual observation points and telemetry points.

telemetry still included some points which appeared to be exploratory sallies. They were more easily detected from the main concentration of points and range use.

Data from Table 6 indicate that the adults trapped in 1966 were the same animals trapped in 1965. The adult male (#7) which died in July, 1965 was replaced that month by a sub-adult (#14). This animal was still present in 1966. The data also suggested that: (1) all the juveniles trapped in Area I had dispersed by the next breeding season; (2) some hierarchial system of behavior may have been affecting the population structure. Certain home ranges contained breeding adults which were residents surviving from the previous season. The juveniles, which probably were of a "lower" hierarchial status, disperse. Other authors have suggested similar behavioral interactions.

Seasonal Behavior of Habitat Selection

Data obtained from evaluating horizontal visibility and light intensity were considered to be most important during the summer based on the following rationale. Most mating appeared to take place prior to the emergence of vegetation (approximately late May or early June). Various workers (Wecker, 1963; Thorpe, 1945; Allee et al., 1949) have suggested that the behavior of habitat selection, which is the basis for establishing a breeding unit within the environment, is in part innate. Based on this premise, it was assumed that young of the year dispersing from the parental home range are biologically capable of selecting a habitat which could serve as a "functional" home range. Of the five habitat factors considered, horizontal visibility, overhead cover and light intensity are the ones most affected by the change of the seasons. This

Table 6

Trapping effort and success for Area I, 1965* and 1966.

CAPTURE DATES

Chipmunk Number and Age		April	May		June		July		Aug.	Sept.	Totals
		28-29	1-6	15-20	1-6	15-20	1-6	15-20	15-20	21-26	
1	A	X	X	X		X		X	X		6
2	A		X	X	X	X	X	X		X	7
3	A		X	X	X			X	X	X	6
4	A	X	X	X				X		X	5
5	A			X	X			X		X	4
6	A		X	XX	X	X	XX			X	8
7	A	X	X		X	X	X	X			6
8	A		X	X	X	X		X		X	6
9	J					XX		XX	XX		6
10	J							XX	XX		4
11	J						XX	XXX	X		6
12	J							XX	X	XX	5
13	J						XX	X	X		4
14	A					X		XX	XX	X	6
15	J							XX	X		3
16	J							XX			2
17	J						X				1
18	J									XX	2
19	J									XX	2

1966**

		1-3	1-3	
1	A	X	X	2
2	A	XX	X	3
3	A	X	X	2
4	A	X	X	2
5	A	X	X	2
6	A	XX	X	3
8	A	XX	XX	4
14	A	XX	X	3

---

* Sixty-three traps set each trapping day except eighteen in April.

** One hundred twenty-six traps set each trap day.

seasonal change is most pronounced in the latter part of September as the vegetation dies back. Few juvenile recaptures were noted in mid-September when food resources waned and baited traps would seem to be even more attractive. The data suggested that the lack of capture could be merely affected by the trapping procedures, or that the juveniles had dispersed seeking their own habitat prior to the onset of hibernation.

Therefore, the selection for the establishment of their home range would have to be based on the condition of the ground vegetation by mid-September. In some areas studied, the vegetation retained the summer aspect but was beginning to show the onset of fall. Those portions of the environment which appeared to provide habitat, as evidenced by occupancy of breeding adults, appeared to have similar habitat ratings for either season. However, ratings for unoccupied portions within an area changed considerably from September to October.

Animal Density and Distribution

The Areas ranked in decreasing order of adult animal density were II, I, V, III, and IV (Table 7). The same ranking order was obtained when comparing the computed density of all animals. Since the vegetation density of the habitats was easily categorized (II, I, IV, III, V in decreasing order of density), it appeared that the denser the habitat, the smaller the home range and the denser the population. Habitability is based on the percentage of the total area used by the adults and also by all animals (Table 8). The Areas ranked by the amount of acreage comprising the estimated adult home ranges, were in decreasing order: V, III, I, II, IV; when all home ranges were considered the order was III, I, II, IV. Since Area V was investigated during the spring and only an

Table 7

Estimated chipmunk densities based on the habitat estimated to have been used by the animals.

Area	Number of sexually active adults	Density of sexually active adults per acre based on the habitat used	Number of Adults	Density of adults per acre based on the habitat used	Total Number of Animals	Density of all animals per acre of used habitat
I	8	3.0	8	3.0	19	5.0
II	6	3.2	7	3.7	17	5.6
III	?	-	5	1.3	15	4.9
IV	1	0.3	2	0.5	2	0.5
V	8	1.9	9	2.1	9	Not Comparable*

*Area investigated in spring when no young of year present.

Table 8

Estimated use of an area's habitat by animals of different age.

Use is determined from home range data.

Area	Total size in acres	Estimated area used by adults	Percentage used by adults	Estimated area used by all animals (in acres)	Percentage used by all animals
I	5.3	2.7	.51	3.8	.72
II	4.2	1.9	.44	3.0	.71
III	6.2	3.9	.63	4.5	.72
IV	2.5	0.3	.12	0.3	.12
V	6.6	4.3	.65	Not Comparable*	

*Area investigated in spring when no young of year present.

adult population was present, it was not comparable for ranking with the latter group. However, assuming some young would be raised, the total area of recorded use would probably be expanded. The data in Tables 9 and 10 were used to test the null hypothesis that the chipmunks were randomly distributed (Table 11).

The validity for this compilation of data collected from individual animals was at first considered to be a problem. If the data were too variable between individual animals it would be heterogeneous and therefor not be comparable. Although the number of habitat units varied with the size of the home range of each individual, the trends of habitat use for individual animals of the same age, sex and area appeared homogeneous.

Statistical analysis

Use of Chi Square requires: (1) that the data not be in percentages and (2) that there should be an expected value of at least five for each class. The first was strictly adhered to; the application of the second varied somewhat partly because of separation of the data into age, sex and area comparisons. Pooling of more of the data would have increased the sample size, but also increased the probability of heterogeneity. Slight variation in the application of the second criterion was thought to be less serious than the "masking" effect from increased heterogeneity.

Four of the six Chi Squre values obtained from juvenile use of brush piles were statistically significant. One value was significant for adult males and one was significant between the .06 and .10 confidence interval. Two of the four values for adult females were significant between the .06 and .10 confidence interval. Examination of Tables 9 and 10 indicates that juveniles and adults used brush piles with the higher density ratings. This may be explained for the juveniles by an initial attachment the young may

Table 9

Percentage of the habitat units in each category for the habitat fact
occurring within the estimated home range of chipmunks for all areas

Area	Age	Sex	Sample Size	Brush Pile Density				Ground Cover				Horizontal Visibility				Overhead Cover			
				HABITAT RATING CATEGORIES															
				0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
I	A	M	4	0	.45	.37	.18	0	.17	.51	.31	.25	.43	.22	.08	.01	.25	.20	.52
	A	F	4	0	.52	.29	.17	0	.10	.57	.32	.26	.45	.25	.05	.05	.29	.21	.44
	J	M	5	0	.46	.38	.16	0	.10	.60	.30	.12	.42	.31	.15	0	.25	.66	.38
	J	F	2	0	.38	.42	.18	0	.04	.38	.57	.19	.57	.23	0	0	.57	0	.47
II	A	M	4	0	.03	.15	.82	0	.06	.61	.33	.76	.15	.09	0	0	.03	.18	.79
	A	F	2	0	.04	.22	.72	0	.18	.50	.31	.04	.13	.13	.04	0	.04	.17	.85
	J	M	5	.02	.06	.41	.51	0	.17	.57	.26	.56	.15	.17	.13	.07	.28	.07	.58
	J	F	3	0	.02	.17	.82	0	.8	.60	.3	.71	.11	.11	.60	.02	0	.22	.75
III	A	M	2	0	.31	.43	.24	0	.38	.43	.18	.50	.24	.08	.18	.01	.06	.19	.72
	A	F	1	0	.32	.63	.05	0	.36	.53	.10	.58	.36	0	.05	0	0	.06	.94
	J	M	2	0	.16	.27	.55	0	.38	.55	.05	.55	.27	.05	.11	0	0	.22	.78
	J	F	5	0	.19	.60	.21	0	.23	.59	.19	.55	.31	.01	.13	.04	.02	.13	.80
V	A	M	4	0	.30	.52	.15	0	.27	.48	.24	.61	.07	.04	.23	1.00			
	A	F	3	0	.31	.59	.10	0	.21	.58	.21	.65	.07	.07	.21	1.00			

Table 10

Percentage composition of the habitat units in each category for each area's habitat factors.

Area	Brush Pile Density				Ground Cover				Horizontal Visibility				Overhead Cover			
	HABITAT RATING CATEGORIES															
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
I	.03	.46	.43	.08	.01	.26	.47	.26	.17	.26	.34	.23	.16	.25	.21	.39
II	.06	.18	.34	.42	.01	.26	.50	.23	.41	.15	.18	.26	.11	.35	.16	.37
III	.02	.32	.43	.22	.02	.44	.42	.12	.43	.19	.08	.30	.10	.07	.18	.64
V	.02	.39	.46	.13	.02	.31	.47	.20	.37	.08	.03	.52				

Table 11

A summary of Chi Square values. These were obtained by comparing the estimated utilization of habitat factors within the habitat units with the habitat composition of the area.

Areas	Sample Size	Age	Sex	Brush Pile Density	Ground Cover	Horizontal Visibility	Overhead Cover
I	4	A	M	5.28	3.07	12.19**	12.64**
	4	A	F	7.51	4.48	8.96*	3.28
	5	J	M	12.84**	15.56**	7.21	36.30**
	2	J	F	3.53	11.76*	8.57*	17.93**
II	4	A	M	15.18**	9.22*	18.44**	30.60**
	2	A	F	6.98	1.46	37.23**	18.26**
	6	J	M	6.10	2.74	6.98	10.33*
	3	J	F	27.62**	7.62*	19.33**	28.75**
III	2	A	M	2.63	4.27	5.84	15.93**
	1	A	M	5.41	.63	12.52**	7.25
	2	J	M	12.50**	1.12	4.50	2.82
	5	J	F	10.52*	15.76*	19.83**	9.36
V	4	A	M	6.27	3.38	49.22**	
	3	A	F	2.25	2.84	27.21**	

*Significant at the .05 to .03 level at 3 df.

**Significant at less than the .03 level at 3 df.

have to the area near the nests. Animals appeared to use different degrees of woody ground vegetation in a random fashion. Ten of the 14 Chi Square visibility values were significant or highly significant (Table 11). These values reflect a significantly greater use of habitat units rated as having high horizontal visibility than would be expected by chance. Conversely, the chipmunks used units with low horizontal visibility ratings less than expected. The significant values for overhead cover stem from greater use of units with high light than low light intensities.

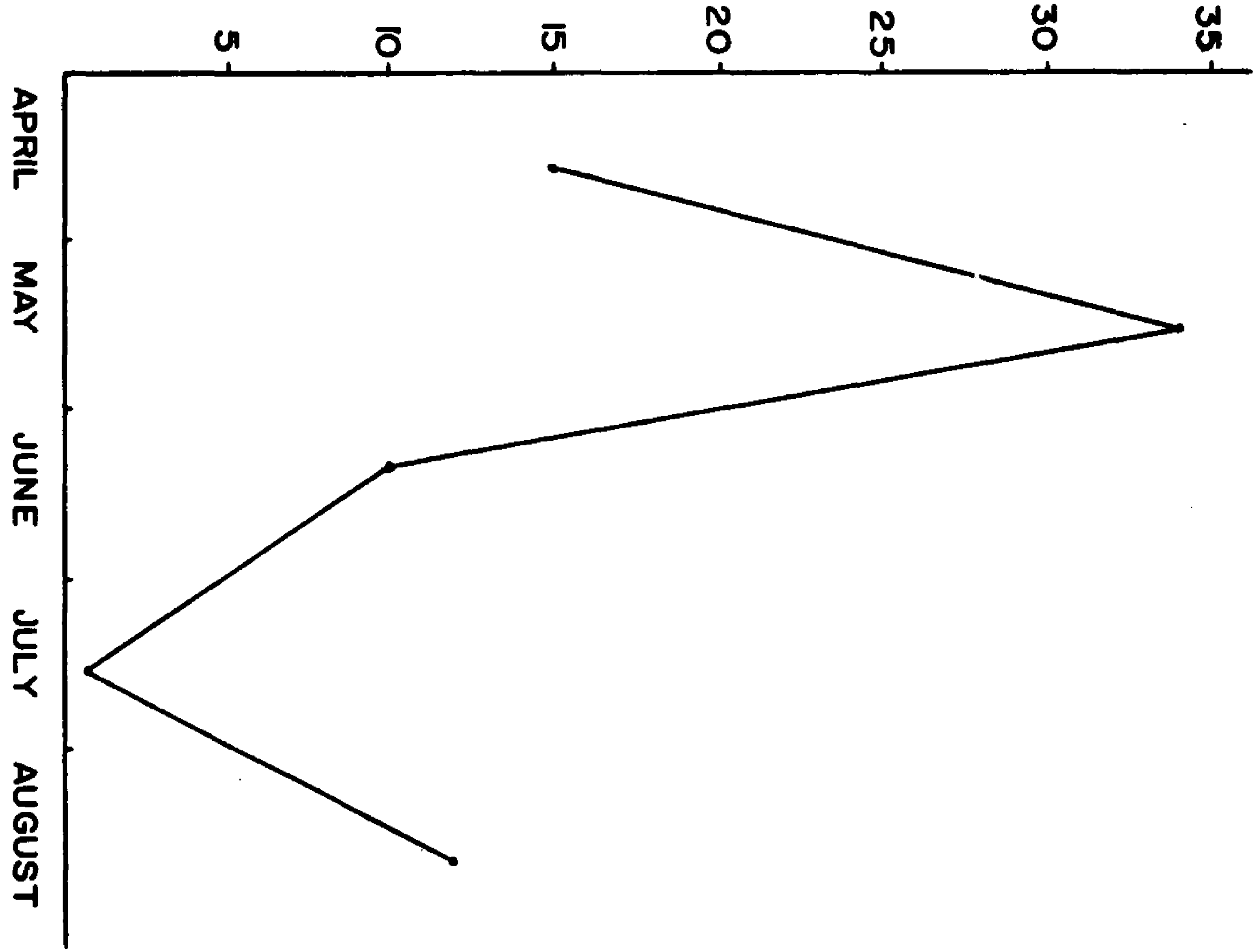
Vocalizations

As mentioned in another section, I made special note of ventriloquistic calls which I described as "Qwip". It was heard most frequently in the spring and late summer and in late afternoon to early evening (Figure 7). Chipmunks used in the experimental enclosure were also heard issuing this call under similar time and conditions as those obtained under field conditions. It will be noted that few calls were heard during July but they were recorded for mid-August and September.

Figure 7

Relation of the number of Qwip calls heard to the month of the year

TOTAL NUMBER of "QWIPS" HEARD per 10 HOURS in THE FIELD FOR ALL AREAS.



DISCUSSION

Evaluation of different areas for chipmunk habitat has been attempted. It is based on the estimated home range in relation to the use of certain elements within the habitat and by the density of the home ranges (those supporting animals in the breeding condition). The literature suggests that E. minimus neglectus is quite varied in its habitat utilization but by-and-large an animal of the forest openings or semi-forested areas. Home range data were necessary to confirm which portions of the habitat were utilized by E. minimus but one or more of the following factors can alter their reliability.

Hayne (1950) found a positive relationship between apparent home range and distance between traps. Stickel (1954) pointed out that a closer spacing of traps produces smaller home range estimates--wider spacing, wider home range estimates. Thus, she considered trap spacing an important element of home range measurements. My traps were every 50 feet, Manville's (1949) every 30 feet. Both Martinsen (1965) and Sheppard (1965) spaced their traps every 100 feet.

The size of the home ranges presented by the latter workers were considerably larger than those presented in Tables 4 and 5. This may be explained by their wider trap spacing and/or the fact that these authors investigated habitats considerably less cluttered with large environmental objects (e.g. brush piles, trees, woody shrubs) allowing for considerable visual "access". An exception to this latter situation was the work of Manville (1949) who trapped in habitats in the Upper Peninsula which were denser than those discussed in this report. Seven adults that he trapped had an average home range of 0.2 acres, compared to 0.7 acres from my data. His method of estimating the home range was somewhat similar to that used by Harvey and Barbour (1965) which would result in smaller home ranges estimates *vs* the minimum method which I used. Jackson (1961) also reported a home range of less than one acre for *E. minimus* in northern Wisconsin. My data indicate substantially smaller home ranges for *E. minimus* in northern Michigan than in the western portion of its range.

The greatest distance traveled between two points is another reflection of the range of this species. Martinsen (1965) reports an average of 512 feet for nine animals. Sheppard's data, although not strictly comparable, indicated that his average animal covered greater distances than did mine. Manville reported an average of 229' for two adult males and 171' for four adult females; a small sample but still similar to my data (Tables 4 and 5).

Jackson (1961) and Martinsen (1965) cited instances where various species of *Eutamias* had moved from one area to another in order to obtain an especially abundant, preferred food. It seems logical that baited traps would have their greatest "appeal" during early spring when food resources are minimal. From the data available, I could not attribute to the lure of the bait any distortion of the animal's movement pattern at any season. Successful trap sites were generally in close proximity to other sites which never had a chipmunk caught at the site. During the summer, the bait had to compete with natural foods which were generally plentiful to very abundant. Juveniles appeared to be more susceptible to trapping during this season than the adults. This may have been due to their inexperience with the traps, naive curiosity, or a greater need for a variety of food due to higher rates of metabolism and growth or some combination of these factors. However, up to mid-August they also confined their movements to certain habitats regardless of the baited traps present in a different habitat fifty feet away. It is concluded, therefore, that in general, distribution of the food resources in the traps had little effect in significantly altering the size of the home range between the spring and summer seasons.

Jorgensen (1968), Quadagno (1968) and Sheppard (1965) stated that competitive exclusion may influence home range size and therefore animal distribution. This interference would most likely come from an animal having about the same size, activity pattern and habitat as *Eutamias*. *Tamias striatus* was the only similar animal in some of the study areas. However, I collected no data to evaluate their interrelationship; the literature (Forbes, 1964) does not contribute enough to make any interpretation of competitive exclusion.

From my data I can neither prove nor disprove that *E. minimus* is territorial. I observed active chasing in the spring on two occasions by unidentified animals. A review of the literature (Sheppard, 1965; Martinsen, 1965; Forbes, 1964; Criddle, 1943; Jackson, 1961; Larrison, 1947) describes some chasing activities, especially in defense of artificial food supplies. However, there is little or no supportive evidence for "true" territorial behavior.

Describing the vocalizations of an animal in phonetic symbols is subjective. Thus, calls described by various workers which may actually be the same, may be phonetically expressed in different word forms. Sheppard (1965), Gordon (1963), Larrison (1947), Broadbooks (1958) and Miller (1944) have attempted to correlate the vocalizations of *E. amoenus* or E. minimus or both with their behavioral reaction. Calls indicating alarm, defense, scolding, escape, hawk, dominance and "territoriality" have been reported. I interpreted the "Qwip" call to be associated with the behavior of social spacing based on the following. It is similar to the "territorial" call described by Larrison and Broadbooks for E. amoenus, and Miller for E. minimus as well as E. amoenus. The call did not appear to be associated with any fear, alarm or agonistic type of environmental stimuli. It was performed from an elevated site in the environment, e.g. shrubs but usually tree stumps or slash piles. These conditions would enhance maximum sound projection which would be expected if sound designated an animal's occupancy of a particular portion of the habitat. The call was heard most frequently during the breeding season and associated with males much more frequently than females. Certain locations within each animal's estimated home range were used consistently giving me the impression that they were "calling" posts. Most of those chipmunks observed calling during late summer were juvenile males. I speculate that with physical maturation the animals expressed a developing inclination toward establishing a space in the habitat for themselves. A similar type of developing behavior has been reported for other animals such as the drumming juvenile ruffed grouse, Bonasa umbellus, (Trippensee, 1948).

My data suggest that chipmunks, regardless of age or sex use a habitat more frequently which provides them good horizontal visibility. At least two explanations are possible. Habitats with elevated perching sites or those with few environmental obstructions may be a pre-requisite to insure adequate dispersal of their "territorial" call. Not enough data were gathered to test this. Some sort of visual contact between animals may be necessary for maintenance of population stability. Thus, in a "good" habitat the animal can perch on brush piles having exposed, elevate branches that provide a reasonably open view of the surrounding habitat and movement of other chipmunks (as well as readily available escape cover). Although this predilection for exposed situations would seem to increase the animal's vulnerability to predation, *E. minimus* can move very quickly and possibly avoid many winged predators. Other authors have also made note of their alacrity (Forbes, 1964; Jackson, 1961).

The data also indicate greater use by juveniles for medium to dense brush piles. No habitats having rock piles, old buildings, and other such cover were investigated in detail, however, I would assume that adequate escape and nesting den cover in any form would suffice. Therefore, brush piles per se are not critically important. The literature makes frequent note to the use of the latter type of cover by *E. minimus*.

The significantly greater use of habitat units with little overhead cover may be interpreted several ways. (1) The overhead cover in the densely stocked conifer stands of Areas I and II had closed canopies, very sparse woody shrub growth at the ground level and no brush piles but did have many tree stems which reduced horizontal visibility in varying degrees. No areas were studied that had much overhead cover and spars tree or tall shrub stem stocking. Because these two conditions were not independent, data from field studies cannot be used to differentiate their independent significance. (2) Increased overhead cover may increase the probability of winged predation. (3) Overhead cover (and therefore reduced light intensity) would be responsible for differences in the ambient temperatures between the shade and the open. If the animal's metabolism was such as to be affected by environmental temperatures, then the degree of shade may produce an avoidance behavior.

The effect of overhead cover (reduced vertical visibility) was tested in the experimental enclosure to be described later and the data presented at that time.

PEN EXPERIMENT

Introduction

The initial field work led to hypotheses that could test the significance of specific environmental elements in habitat selection. The following elements were investigated: (1) use of pens having different vertical and horizontal visibility; (2) use of perches with two different heights; (3) individual difference between chipmunks. These variables were found to be testable from preliminary work. The variables, light intensity, solar radiation and relative humidity were also tested in earlier experiments but were not found to be worthy of further investigation.

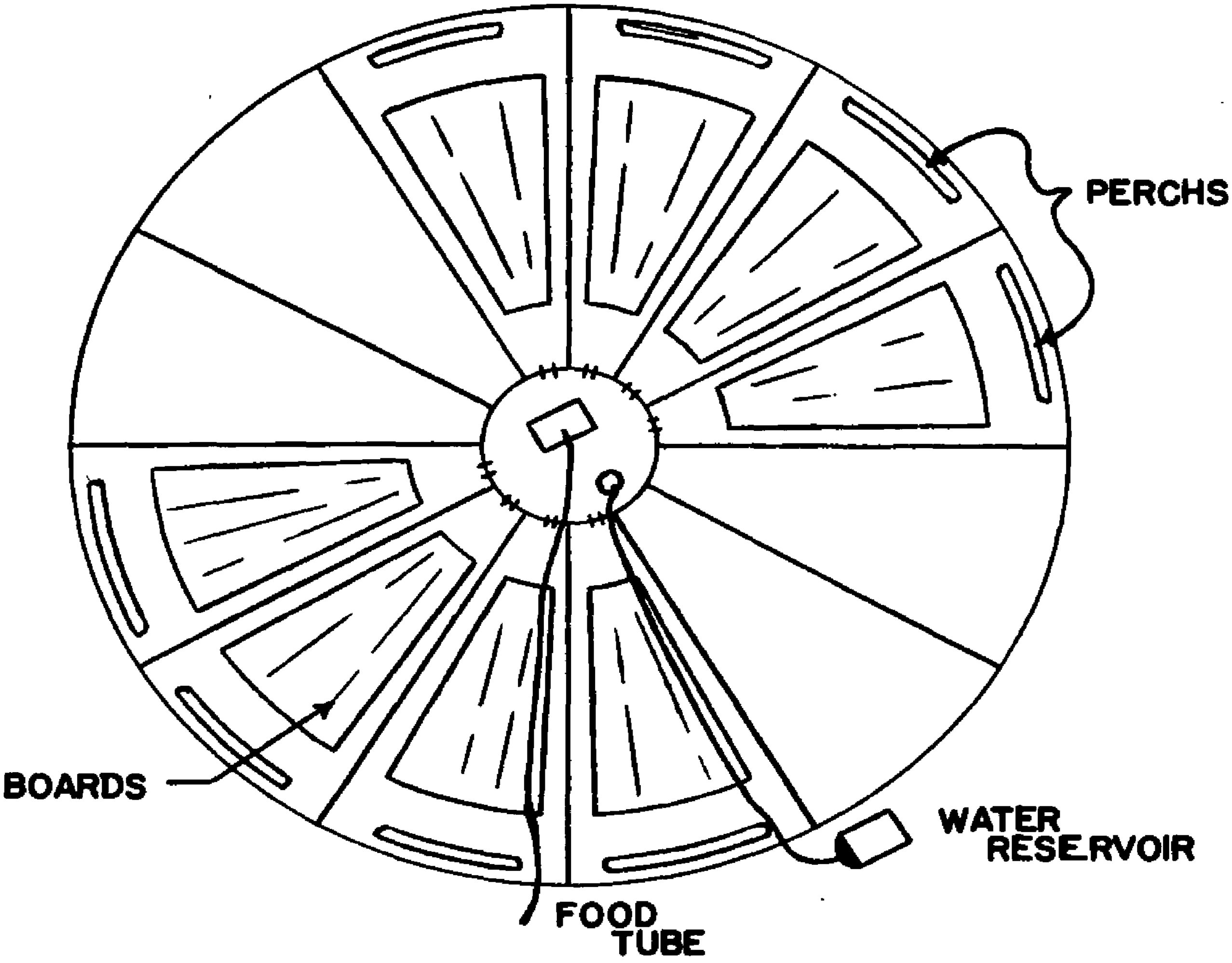
MATERIALS AND METHODS

Apparatus

The test apparatus consisted of a multiple choice enclosure (Figure 8) The structure was located on the edge of an abandoned field in an area containing very short grass (Plate IX). Food was passed through a long tube into a #10 can located in the center of the enclosure. Water was provided from a reservoir through a hose to a dish near the can. The food and water were supplied to maintain an excess. A mixture of sunflower, corn and rye seeds was used for food. Two layers of similarly arranged boards provided uniform escape cover at the ground level in each pen. Each chipmunk had free access to any of the eight pens. Each pen had only one opening which was guarded by two micro-switches to ensure a recor

Figure 8

The construction details of
the experimental enclosure



DIMENSIONS

DIAMETER - 10'
LENGTH OF INSIDE SIDE WALLS - 4'
PERIMETER LENGTH OF OUTSIDE WALLS OF INDIVIDUAL PENS - 2.5'
PERIMETER LENGTH OF INSIDE END OF PENS - 7"

COVER

EACH PEN CONTAINED 2 TIERS OF BOARDS. EACH TIER SEPARATED BY 2" SPACERS.

Plate IX

Figure 14. Experimental enclosure

of ingress and egress. Electrical contact of one or both of the switches activated one of 16 electromagnets in a common return, Esterline-Angus 20 pen recorder. This moved an inked recording pen which marked the event in one of the paper's 16 columns which turned on a motor driven chart. All perches were wired to the recorder to detect their use by an animal. They were designed to convert to a 16" or 24" height. Horizontal visibility was restricted by suspending double thicknesses of burlap at the appropriate height on the outside periphery of the desired pen. A double thickness of burlap laid on top of the enclosure restricted vertical visibility.

Experimental design

The three treatments, horizontal, vertical visibility and perch height were applied in a random fashion to each of the eight pens. One chipmunk had all eight differently treated pens available to him at one time. This exposure lasted for 24 hours*, which was considered one trial. Four trials (with four different chipmunks) comprised one replication. The entire experiment using the same four chipmunks was replicated four times, therefore a total of 16 trials were conducted. The order, sex and age in which a chipmunk was selected for use was also random. The experimental design was basically a split-plot (Snedecor, 1956). The treatments consisted of:

(1) an open pen; no treatment; control
(V) vertical visual restrictions for a pen with a 16" perch
(H) horizontal visual restrictions for a pen with a 16" perch
(VH) a combination of restrictions applied to a pen with a 16" perch
(VP) restricted vertical vision to a pen with a 24" perch

---

*The chipmunk was introduced into the enclosure during late afternoon.

(HP) restricted horizontal vision to a pen with a 24" perch

(P) an open pen having a 24" perch

(VHP) a combination of restrictions applied to a pen with a 24" perch

RESULTS

Pen utilization

Assumption of randomness was met by the nature of the experimental design. A normal distribution was obtained by adding one to all numbers and the data were transformed to logs. Homogeneity of variance was examined by the analysis of the data for interactions. The data were treated by analysis of variance working with four factors. Some trials failed to produce data because of various equipment failures. These missing data were treated accordingly to Anderson's (1946) missing plot technique. The F test was used for estimating the probability of obtaining the results reported by chance (Table 12).

The highly significant values for the combined treatments or perch height-horizontal visibility (HP) and vertical visibility-horizontal visibility (VH) indicate interactions exist. The F values for main effects - different perch heights in the pens, restricted horizontal visibility and restricted vertical visibility were highly significant (Table 12). The separate effects were tested and examined but since they are not orthogonal they are interpreted conservatively (Tables 13 through 15).

The test data from Table 13 indicate a highly significant F value for the main effect and horizontal treatment in all cases except one. This suggests a reduced use of pens treated with restricted horizontal visibility. The two highly significant F values from Table 12 for separate effects indicate that restricted vertical visibility appeared to result in a significant reduction of pen use even if those pens had no

Table 12

The final results of statistical treatment of one phase of the experimental design. These data were compiled from measurements of minutes spent by each of the four chipmunks in the eight pens exposed to different treatments.

Source	S Sq	df	ms	F
Whole Plots	40.01	15	2.67	
Chips	11.02	3	3.67	4.65
Reps	21.92	3	7.31	
Error	7.07	9	.79	
Treatments				
P	2.99	1	2.99	2.58
H	73.10	1	73.10	63.02**
V	16.67	1	16.67	14.37**
PH	10.80	1	10.80	9.31**
PV	1.14	1	1.14	.98
HV	14.66	1	14.66	12.64**
PC	5.43	3	1.81	1.56
HC	3.03	3	1.01	.87
VC	2.33	3	.78	.67
PHV	.52	1	.52	.45
PHC	8.46	3	2.82	2.43
HVC	2.20	3	.73	.63
CVP	1.54	3	.51	.44
PVCH	4.98	3	1.66	1.43
Error b	88.27	76	1.16	
Totals	287.33	119		

**Significant at .01 level

Tables 13 through 15

Analysis of the interaction data, PH, HV and PV for the separate effects of horizontal, vertical and perch height treatments. The values reflect the minutes spent by all chipmunks in a pen.

Table 13

Analysis for the separate effect - Horizontal treatment.

	No Horizontal Restrictions	Horizontal Restrictions	Difference	F Values
No Vertical Restrictions	75.84	31.26	44.58	50.077**
16" Perch				
Vertical Restrictions	55.79	35.44	20.35	11.896**
No Vertical Restrictions	72.95	49.65	23.30	15.60**
24" Perch				
Vertical Restrictions	49.66	44.36	5.30	.806

Table 14

Analysis for the separate effect, Vertical treatment.

		No Vertical Restriction	Vertical Restriction	Difference	F Values
No Horizontal Restrictions	16" Perch	75.84	55.79	20.05	11.550**
	24" Perch	72.95	49.66	23.29	15.586**
Horizontal Restrictions	16" Perch	31.36	35.44	4.18	.501
	24" Perch	49.65	44.36	5.29	.803

Table 15

Analysis for the separate effect, the influence of different perch heights on pen use.

		16" Perch	24" Perch	Difference	F Values
No Horizontal Restrictions	No Vertical Restrictions	75.84	72.95	2.89	.240
	Vertical Restrictions	55.79	49.66	6.13	1.079
Horizontal Restrictions	No Vertical Restrictions	31.26	49.65	18.39	9.718**
	Vertical Restrictions	35.44	44.36	8.92	2.286

horizontal restrictions and regardless of what height perches are in the pens. In pens having horizontal restrictions and vertical restriction, just the presence of the burlap (visibility restrictions) may produce some type of avoidance behavior. This could also hold true for reduced use of pens with horizontal restrictions. The overall pen use was much less for pens with horizontal treatment than for pens without horizontal treatment. The presence of horizontal restrictions depress pen use about the same regardless of the application of vertical treatments. This suggests that horizontal treatment "over-rides" any effect of the vertical one.

Perch utilization

Pens having a higher perch were used significantly more when they were treated with a horizontal restriction but no vertical restriction (Table 15). There was no significant difference between the use of pens having either of the two perch heights and both types of visibility restrictions.

The data indicate that animals used pens with horizontal visibility restrictions significantly less. Pens having both high perches and horizontal visibility restrictions were used more than those pens with just horizontal restrictions; even more if there were no vertical restrictions on the pens with horizontal restrictions and high perches.

No interactions between chipmunks and treatments were noted, which indicates that all chipmunks behaved similarly to all the treatments. This would be expected if any innate behavioral mechanism was influencing their habitat selection.

The. data obtained from the perch use by the different animals are summarized in Table 16. No statistical tests were considered necessary because the results can be interpreted by inspection. In the control

Table 16

A summary of perch use data for the four chipmunks used in the 1968 experiment enclosure. Data represent the number of times the chipmunks used the elevated perch in a pen.

Treatments	Low Perch	High Perch
Open Pens Control	36.97	31.33
Horizontal Restrictions	17.15	44.18
Vertical Restrictions	28.27	27.60

pens and those having vertical restrictions, chipmunks generally used the low and high perches about an equal amount. The high perches in those pens having horizontal restrictions were used considerably more than the low perches in these treated pens. These data indicate a preference by the chipmunks for access to good horizontal visibility. Data obtained from preliminary experimental work agreed with these results.

DISCUSSION AND CONCLUSIONS

In recent years considerable evidence has been presented and reviewed to support the concept that inter and intraspecific social interaction has a regulatory effect on population size and the physical condition of the individual animals (Calhoun, 1963; Terman, 1963; Wynne-Edwards, 1962). Various authors (Crowcraft and Rowe, 1962; Healey, 1967; Lorenz, 1966; Tinbergen, 1959) have presented data which implicates aggression and social structure with dispersal and individual spatial distribution of animals, as part of a complex, interacting system. The means by which the social contact is implemented varies from species to species. In birds it is generally conceded that sound and visual stimuli provide the method of contact between members of a population. These methods are also suggested for various non-human primates. Other mammals make use of various types of body secretions. The function of these and other types of stimuli are discussed by Marler and Hamilton (1966).

It is suggested that social communication would eventually initiate some type of psychophysiological mechanism which would set limits to the size of the home range and therefore, also population levels. Bronson (1961) demonstrated experimentally and in the field that the visual signal system was the stimulus regulating the agonistic behavior of woodchucks (Marmota monax). This behavior in turn affected the spatial distribution of the members of the woodchuck population. He also postulated some interacting physiological mechanism associated with the adreno-cortical system which resulted in some type of stress factor. Christian (1959, 1960, 1961) has described many experiments implicating this system. Thiessen (1964) reviewed the literature concerning the association of the endocrine system to social and reproductive behavior. Welch (1965) reviewed certain theoretical aspects involving the hypothalamic-reticular system and what he called the Mean Level of Environmental Stimulation. In summary, there appears to be ample evidence from the literature to support the theory that social contact mediated at various levels of the nervous system could have a significant influence on the neurological, endocrine, behavioral and physiological (*e.g.* gamete production, vigor of parents and juveniles or both) responses.

The level of tolerance to social encounters varies considerably from those animals who are definitely territorial to those who tolerate widely overlapping home ranges. Here again the tolerance level will vary with the season, age, sex and social position of the animal. Jenkins (1961 a) reported that the spatial distribution of partridge *Perdix perdix*, was correlated with the degree of visual interaction, population density and the density of ground cover. Increasing amounts of interaction as a result of poor cover (extensive horizontal visibility) and higher animal densities or both, resulted in home ranges which were larger and overlapping. Birds in good cover had less visual interaction with each other even at a high population density. In a latter paper (Jenkins, 1961 b) he associated a high degree of interaction (as well as the quality of other visual cues) with a lowered degree of physiological resistance to environmental hazards in parental birds and their offspring.

My data and that of other authors (Sheppard, 1965; Martinsen, 1965) indicate that the adult chipmunk, with some exceptions, generally maintains the same home range and that it is usually separate from that of other adults. Exceptions to this could be temporary congregations at preferred food locations. A separate home range implies a method exists which can function to disperse and space the individuals, especially the breeding pairs. Visual communication is considered a form of advertised occupancy of a home range. It could serve as a way by which the habitat is partitioned through social interaction for a more effective use of social space (Wynne-Edwards, 1962). A void in a formerly active portion of the communication system could be the signal for a juvenile or neighboring adult to explore the vacancy. Here factors such as access, social dominance, aggression and population density, may determine which, if any, animal fills the vacancy. A home range and a method by which it can be advertised, especially during the breeding season, are behavioral features and therefore should have selective value. The data suggest that poor horizontal visibility would offer few opportunities for visual social encounters. Thus, home ranges with this type of visibility may be inadequate to attract and hold a mate or provide the necessary visual stimulation to initiate or enhance reproductive behavior or both. These home ranges would be marginal to sub-marginal and would not provide a consistent breeding population. Juvenile and sub-adult animals would probably occupy this type of habitat. They would provide the reserve for filling optimal home ranges vacated by adults due to death or other factors. Marginal home ranges might be occupied when unusually good reproductive survival resulted in dispersal from high population densities in optimum habitats. The field and experimental data supported the significance of horizontal visibility to habitat selection by the animal. The species' widespread distribution implies an ecologically adaptable animal. Regardless of the apparently diverse habitats it occupies, all species within the genus* are found in open areas which could offer adequate horizontal visibility. This adds further credibility to the hypothesis that this is a basic characteristic of the genus' habitat selection. Field data also implicate brush pile density as being important.

It appears that in an environment with a favorable supply of resources, where the possibility of visual assessment for "intruding" adults is readily available but that actual visual contact is minimal, the home range tends to be smaller and population density greater. Areas I and II approach this situation most closely. For the latter area only 44% of the total portion was inhabited but it had the highest adult density (3.7 animals per acre). This habitat was typified by the "open" area having good horizontal visibility. However, one small portion with medium horizontal visibility did not support an adult home range. This may have been due to inadequate habitat factors not measured or recognized, its visual isolation from the rest of the population or both. Conversely, a habitat with less restrictive horizontal visibility may provide too many visual social encounters and thus result in a polarizing effect on neighboring animals. This situation would favor larger home ranges which would result in greater dispersal. Thus, breeding season encounters would be reduced to a "tolerable" level (Areas III and V). In Area V, adult animals were so spaced that 65% of the area was being occupied but by a relatively less dense population (2.1 adults per acre). This area provided relatively unimpeded vision from those locations where the horizontal visibility was adequate. Thus, distribution of sound and sight stimuli

---

*The exception is *E. townsendii*.

would be transmitted maximally. If only subminimal opportunities for visual assessment in the environment prevail, very low or no breeding pairs may be present. This situation may have been present in Area IV which apparently did not have a breeding pair in 1967 or 1968. This may also explain why Manville (1949) only trapped 46 E. minimus (including recaptures) over a three year period (705 trap-days) on four, 2 acre plots* of what I would consider atypical habitat. In comparison, for Area I only (5.3 acres), I captured 19 animals a total of 90 times during 522 trap-days. His data suggest that the habitats sampled were not optimum. Some areas on which I conducted preliminary trapping were similar to those studied by Manville, however, I captured no chipmunks.

Greatly restricted horizontal visibility could not afford a chipmunk an opportunity to visually evaluate the number and social status of its neighbors and thus, the likelihood of more direct confrontations (chasing and other acts of agonistic behavior) would increase. If these social contacts reached a certain level per unit of time, changes in the nervous and endocrine systems may be forthcoming. These could initiate animal dispersal and individual spacing as an alternate to more drastic physiological changes associated with a high mean level of visual interaction. E. minimus being a social animal, may require a certain minimal level of social encounters. Lack of them could result in sensory deprivation. Welch (1964) proposed that stress with decreased adrenal function was a result of a social animal's isolation. Stress with increased adrenal function resulted from sensory overloading and overpopulation. Habitats providing a balance of visual interaction would be considered optimum. Therefore, a maximum breeding population density could be assumed to

---

*SAF types 6, 12, 24, 23.

develop in habitats where (1) the sum total of resources including all visual cues, indicated to an animal that the habitat is "habitable". (2) the number of social encounters is adequate to maintain communication but not so frequent or dominating as to produce a stressful situation which would result in dispersal or such a restricted home range that it wasn't a functional breeding unit. Since natural selection normally favors higher levels of organization, psychophysiological mechanisms could be serving as a feedback for population dispersal and stability. These assumptions would not preclude an animal's utilization of special food supplies temporarily in areas of very low or very high horizontal visibility.

I have concluded from field and/or experimental data that horizontal visibility and brush pile density are significant environmental factors associated with habitat selection of *E. minimus neglectus*. I have also suggested their significance to the spacing and density of the animals.

LITERATURE CITED

Allee, W. C., A. E. Emerson, O. Park, T. Park and K. P. Schmidt. 1949. Principles of animal ecology. W. B. Saunders, Philadelphia. 837 pp.

Allen, Durwood L. 1943. Michigan Fox Squirrel management. Mich. Cons. Dept., Game Div. Pub. 100. 404 pp.

Ammann, G. A. 1957. The prairie grouse of Michigan. Mich. Cons. Dept., Game Div. Tech. Bul. 200 pp.

Anderson, R. L. 1946. Missing plot techniques. Biometrics 2:42-47.

Banasiak, C. F. 1964. Deer in Maine. Maine Dept. Inld. Fish Game, Game Div. Bull 6. 163 pp.

Behrend, D. F. 1966. Correlation of white-tailed deer activity, distribution and behavior with climatic and other environmental factors. N. Y. Dept. Cons. Job Completion Rept. P-R proj. W-105-R-7. 123 pp.

Blair, W. F. 1941. Techniques for the study of mammal populations. J. Mammal. 22:148-157.

__________. 1953. Population dynamics of rodents and other small mammals. Advances in Genetics. 5:1-41. Academic Press, Inc. New York.

Broadbooks, H. E. 1958. Life history and ecology of the chipmunk, _Eutamias amolnus_, in eastern Washington. Misc. Publ. Mus. Zool. Univ. of Mich. 103:5-42.

Bronson, F. H. 1961. Some aspects of social pressure in woodchucks. Ph.D. thesis. Pa. State Univ. 107 pp.

Brown, L. E. 1962. Home range in small mammal communities. pp. 131-179. _in_ Surv. Biol. Progr. Academic Press, Vol. 4.

Burt, W. H. 1946. The mammals of Michigan. Univ. of Mich. Press, Ann Arbor, Mich. 288 pp.

Calhoun, John B. 1956. Behavior of house mice with reference to fixed points of orientation. Ecology 37:287-301.

Calhoun, John B. and J. U. Casby. 1958. Calculation of home range and density of small mammals. U. S. Govnt. Printing Off. 1958. Public Health Serv. Pub. 592 pp.

Calhoun, J. B. 1963. Social use of space, pp. 1-187 _in_ W. V. Mayer and R. G. Van Gelder (eds.) Physiological mammalogy. Academic Press, New York. 2 vol.

Chenoweth, H. E. 1917. The reactions of certain moist forest mammals to the air conditions and its bearing on problems of mammalian distribution. Biol. Bull. 32:183-201.

Chew, K. M. 1951. The water exchanges of some small mammals. Ecol. Monographs. 21:215-225.

Criddle, S. 1943. The little northern chipmunks in Southern Manitoba. Can. Field-Nat., 57:81-86.

Christian, J. J. 1959. The role of endocrine and behavioral factors in the growth of mammalian populations. pp. 71-130. In A. Gorbman (ed.) Comp. Endocrin., Wiley, N. Y.

Crowcroft, Peter and F. P. Rowe. 1962. Social organization and territorial behavior in the wild house mouse. Proc. Zool. Soc. London 140:517-531.

Dice, Lee R. 1931. The relation of mammalian distribution to vegetation types. Sc. Month. :312-317.

Evans, F. C. 1942. Studies of a small mammal population in Bagley Wood Berkshire. J. Animal Ecol. 11:182-197.

Forbes, Richard. 1964. Ecological studies of the eastern and least chipmunks. Ph.D. thesis. Univ. Minn. 82 pp. Univ. Microfilms. Ann Arbor, Mich.

Friend, D. T. C. 1961. A simple method of measuring integrated light values in the field. Ecol. 42:577-579.

Gordon, Kenneth. 1943. The natural history and behavior of the western chipmunk and mantled ground squirrel. Oregon State Univ., Corvalis 104 pp.

Grange, Wallace B. 1948. Wisconsin grouse problems. Wisc. Cons. Dept. Game Div. Pub. 328. 318 pp.

_________________. 1949. The way to game abundance. Chas. Scribner & Sons. New York. 356 pp.

Hall, E. R. and K. R. Kelson. 1959. The mammals of North America. Ronald Press. Vol. I 625 pp. New York.

Hardy, Ross. 1945. The influence of types of soil upon the local distribution of some mammals in southwestern Utah. Ecol. Mono. 15:71-108.

Harris, V. T. 1952. An experimental study of habitat selection by prairie and forest races of the deer mouse, Peromyscus maniculatus. Contrib. Lab. Vert. Biol. Univ. Mich. 56:1-53.

Harvey, Michael J. and R. W. Barbour. 1965. Home range of *Microtus ochrogaster* as determined by a modified minimum area method. J. Mammal. 46:398-402.

Hayne, Donald W. 1949. Calculation of size of home range. J. Mammal. 30:1-18.

_______________. 1950. Apparent home range of *Microtus* in relation to distance between traps. J. Mammal. 31:26-39.

Healy, M. C. 1967. Aggression and self regulation of population size in deer mice. Ecology 48:377-392.

Howard, Walter E. 1965. Interaction of behavior ecology and genetics of introduced mammals. pp. 461-480. *In* H. G. Baker and G. L. Stebbins (eds.). The Genetics of Colonizing Species. Academic Press, N. Y.

Jackson, Hartly H. 1961. Mammals of Wisconsin. The Univ. of Wisc. Press Madison, Wisc. 504 pp.

Jenkins, David. 1961 a. Social behaviour in the partridge *Perdix perdix*. The Ibis. 103a:155-191.

_______________. 1961 b. Population control in protected partridges *Perdix perdix*. J. Animal Ecol. 30:235-255.

Jenkins, D. H. and H. Bartlett. 1959. Michigan white tails. Mich. Cons. Dept., Game Div. Lansing, Mich. 80 pp.

Jorgensen, Clive D. 1968. Home range as a measure of probable interactions among populations of small mammals. J. Mammal. 49:104-112.

Kalabukhov, N. I. 1938. On ecological characters of closely related species of rodents. The peculiarities of the reaction of wood mice (*Apodemus sylvaticus* L. and *A. flavicollis* melch) and ground squirrels (*Citellus pygmaeus* Pall. and *C. suslicus* Gueld) to the intensity of illumination. (In Russian, English summary); Zool. Z. hum. 17:521-532.

King, John A. 1967. Behavioral modification of the gene pool. pp. 22-43. *In* Jerry Hirsch (Ed.) Behavioral Genetic Analysis. McGraw-Hill, N. Y.

Klopfer, P. H. 1965. Behavioral aspects of habitat selection: a preliminary report on stereotypy in foliage preferences of birds. Wilson Bull. 77:376-381.

Lack, David. 1949. The significance of ecological isolation. pp. 299-308 *In* Glenn, L. J., G. G. Simpson and Ernest Mayr (ed.) Genetics, paleontology and evolution. Princeton Univ. Press. Princeton, N. J.

Larrison, E. J. 1947. Notes on the chipmunks of west central Washington. The Murrelet 28:23-30.

Leopold, Aldo. 1948. Game management. Chas. Scribner & Sons, N. Y. 481 pp.

Lorenz, Konrad. 1966. On Aggression. Hartcourt, Brace and World, N. Y. 306 pp.

Manville, Richard H. 1949. A study of small mammal populations in northern Michigan. Misc. Publ. Mus. Zoo. Univ. Mich. 73:83.

Marler, Peter and W. J. Hamilton III. 1966. Mechanisms of animal behavior. John Wiley & Sons, New York. 771 pp.

Martinsen, David L. 1965. Seasonal movements and habitats of chipmunks (Eutamias) in Montana. M.S. Thesis. Utah State Univ. 58 pp.

Mayr, E. 1963. Animal species and evolution. Harvard Univ. Press, Cambridge, Mass. 797 pp.

Miller, A. H. 1942. Habitat selection among higher vertebrates and its relation to intraspecific variation. Amer. Naturalist 76:25-35.

Miller, A. H. 1944. Specific differences in the call notes of chipmunks. J. Mammal. 24:87-89.

Mohr, Carl O. and W. A. Stumpf. 1966. Comparison of methods for calculating areas of animal activity. J. Wildl. Mgmt. 30:293-303.

Moody, P. A. 1929. Brightness vision in the deer mouse Permyscus maniculatus gracilis. J. Exptl. Zool. 52:367-405.

Odum, Eugene P. 1959. Fundamentals of ecology. W. B. Saunders Co., Phil. 546 pp.

Ogilvie, D. M. & R. H. Stinson. 1966. Temperature selection in Peromyscus and healthy laboratory mice, Mus. musculus. J. Mammal. 47:655-659.

Pruitt, Wm. O. 1953. An analysis of some physical factors affecting the local distribution of the short tail shrew (Blarima brevicauda) in the northern part of the lower peninsula of Michigan. Misc. Pub. Mus. Zool. Univ. of Mich. 79:39 pp.

Pruitt, Wm. O. 1959. Microclimates and local distribution of small mammals on the George Reserve, Michigan Misc. Pub. Mus. Zool., Univ. of Mich. 109:27 pp.

Quadagno, David M. 1968. Home range size in feral house mice. J. Mammal. 49:149-151.

Sanderson, Glen. 1966. The study of mamal movements - a review. J. Wildl. Mgmt. 30:215-235.

Sheppard, David H. 1965. Ecology of the chipmunks, Eutamias amoenus luteiventris (Allen) and E. minimus oreocetes (Merriam). Ph.D. Thesis. Univ. Sask. Univ. Microfilms. Ann Arbor, Mich. 229 pp.

Sheppard, David H. 1968. Seasonal changes in body and adrenal weights of chipmunks (Eutamias). J. Mammal. 49:463-474.

Sheppard, David H. and P. H. Klopfer and H. Oelke. 1968. Habitat selection: differences in stereotype between insular and continental birds. Wilson Bull. 80:452-457.

Sheppe, Walter. 1967. Habitat restriction by competitive exclusion in the mice Peromyscus and Mus. Can. Field Naturalist. 81:81-98.

Snedecor, G. W. 1956. Statistical Methods. Iowa State Univ. Press, Ames. 534 pp.

Stickel, L. E. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mammal. 35:1-15.

_____________. 1960. Peromyscus ranges at high and low population densities. J. Mammal. 41:433-441.

_____________. 1965. A method for approximating range size of small mammals. J. Mammal. 46:677-679.

Stinson, R. H. and K. C. Fisher. 1953. Temperature selection in deer mice. Can. J. Zool. 31:404-416.

Tanaka, R. 1963. Truthfulness of the delimited area concept of home range in small mammals. Bull. Kochi. Wom. Univ. Ser. Nat. Sci. 11:6-11.

Terman, C. R. 1963. The influence of different early social experience upon spatial distribution within a population of prairie deermice. An. Behav. 11:246-262.

Tevis, L., Jr. 1956. Responses of small mammal populations to logging of Douglas fir. J. Mammal. 37:187-196.

Thiessen, D. D. 1964. Population density and behavior: a review of theoretical & physiological contributions. Texas Rept. on Biol. Med. 22:266-314.

Thorpe, W. H. 1945. The evolutionary significance of habitat selection. An., Ecol. 14:67-70.

Tinbergen, N. 1948. Social releasers and the experimental method required for their study. Wilson Bul. 60:6-51.

___________. 1959. Behavior, systematics and natural selection. Ibis. 101:318-330.

Trippensee, R. E. 1948. Wildlife management. McGraw-Hill Book Co. New York. 479 pp.

Trofan, Przemyslaw and Bozena Wojciecjowska. 1967. The reaction of smal rodents to a new object and estimate of population numbers. Ekologia Polska - S.A. 15:727-736.

Van Valen, Leigh. 1965. Morphological variation and width of ecological niche. Am. Nat. 99:377-390.

Verme, L. J. 1968. An index of winter weather severity for northern deer. J. Wildl. Mgmt. 32:566-574.

Walker, R. E. 1964. An experimental investigation of habitat selection by woodland mice. M. A. Thesis. Univ. of Toronto. 46 pp.

Wecker, Stanley C. 1963. The role of early experience in habitat selection by the prairie deermouse, *Peromyscus maniculatus* bairdi. Ecol. Mono. 33:307-325.

Welch, B. L. 1965. Psychophysiological response to the mean level of environmental stimulation: a theory of environmental integration. pp. 39-99. *In* Symposium on Medical Aspects of Stress in the Military Climate. U. S. Govnt. Prtg. Office. 1965: 778-814.

Whitaker, John O. Jr. 1967. Habitat relationships of four species of mice in Vigo County, Indiana. Ecology. 48:867-872.

Wolfe, James L. 1968. Average distance between successive captures as a home range index for *Peromyscus leucopus*. J. Mammal. 49:342-343.

Wynne-Edwards, V. C. 1962. Animal dispersion in relation to social behavior. Oliver and Boyd, Edinburgh and London. p. 653.

APPENDIX

Figure 9

Schematic of miniaturized transmitter

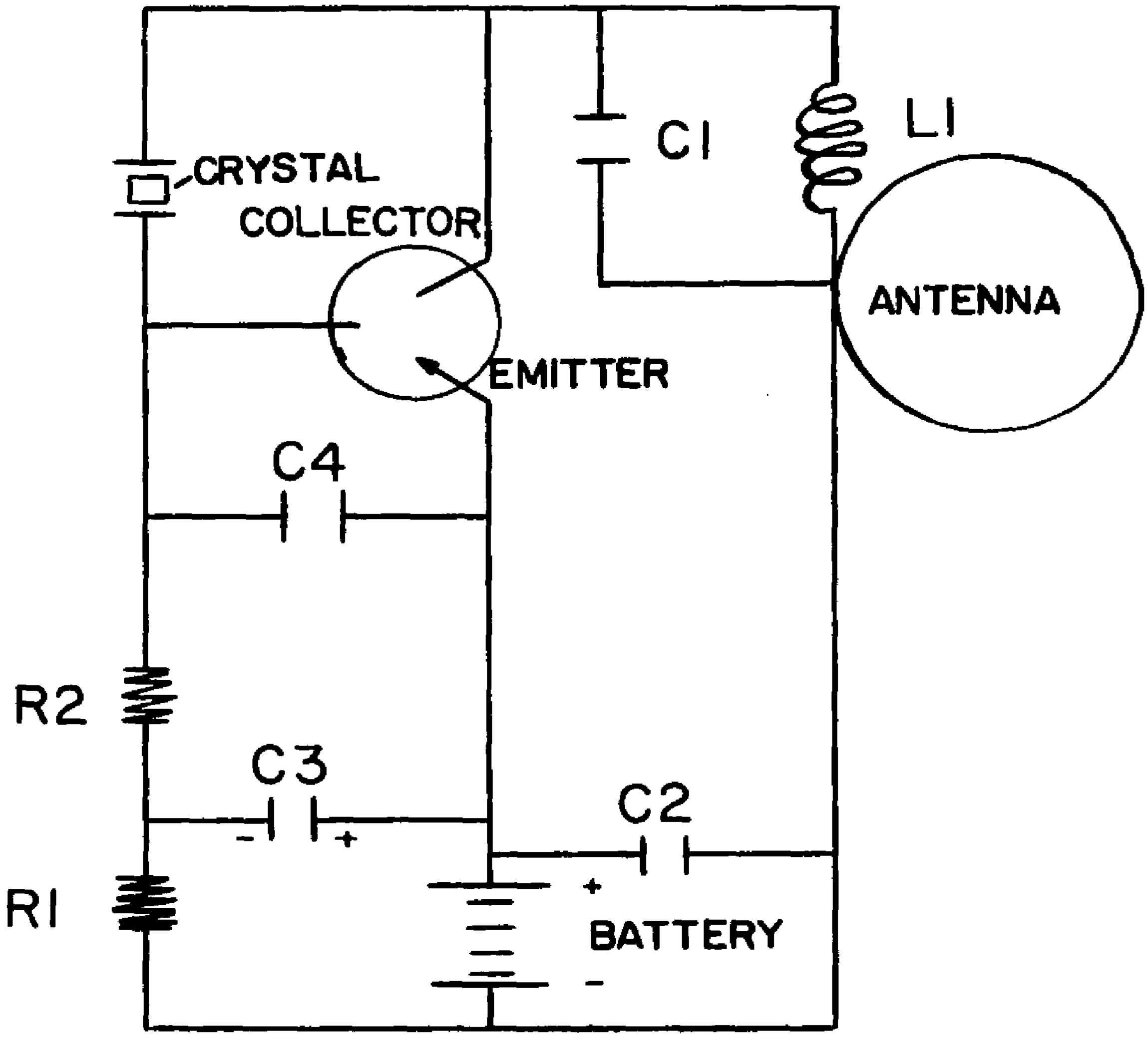

CRYSTAL
COLLECTOR
C1
L1
ANTENNA
EMITTER
C4
R2
C3
-
+
C2
+
BATTERY
-
R1

Table 17. Age, sex and weight data obtained from Area I, 1965 and 1966.

Animal Number	Sex	Estimated Age	Weight in Grams	Reproductive Condition
1	Female	A	40	L
2	Male	A	36	T
3	Female	A	44	E
4	Female	A	42	E
5	Female	A	45	E
6	Male	A	34	T
7	Male	A	38	T (died 7/3/65
8	Male	A	39	T
9	Female	A(sub)	40	Neg
10	Male	J	28	Neg
11	Male	J	29	Neg
12	Female	J	30	Neg
13	Male	J	29	Neg
14	Male	A(sub)	38	Neg*
15	Female	J	31	Neg
16	Male	J	20	Neg
17	Male	J	30	Neg(died 7/19/65
18	Female	J	32	Neg
19	Female	J	31	Neg

E enlarged teats
L lactating
T enlarged testes
* in breeding condition in spring 1966

Table 18. Age, sex and weight data obtained from Area II, 1965.

Animal Number	Sex	Estimated Age	Weight in Grams	Reproductive Condition
1	Male	A	35	T
2	Male	A	38	T
3	Male	A	38	T
4	Male	A(sub)	32	Neg
5	Female	A	41	E
6	Female	A	42	E
7	Male	J	30	Neg
8	Female	A	41	Neg
9	Female	J	31	Neg
10	Female	J	35	Neg
11	Female	J	37	Neg
12	Male	J	29	Neg
13	Male	J	30	Neg
14	Male	J	28	Neg
15	Male	J	32	Neg
16	Male	A	40	Neg
17	Female	J	34	Neg

E enlarged teats
L lactating
T enlarged testes

Table 19. Age, sex and weight data obtained from Area III, 1967.

Animal Number	Sex	Estimated Age	Weight in Grams	Reproductive Condition
1	Female	J	35	Neg
2	Male	J	30	Neg
3	Male	A	39	Neg
4	Female	A	47	E
5	Male	A	41	Neg
6	Female	J	36	Neg
7	Male	A	39	Neg
8	Female	J	35	Neg
9	Male	J	32	Neg
10	Female	J	35	Neg
11	Female	J	36	Neg
12	Female	A	44	E dead in trap
13	Male	J	30	Neg

E enlarged teats

Table 20. Age, sex and weight data obtained from Area V, 1968.

Animal Number	Sex	Estimated Age	Weight in Grams	Reproductive Condition
1	Male	A	38	T
2	Male	A	39	T
3	Female	A	43	E
4	Male	A	38	T
5	Female	A	44	E
6	Male	A	35	T
7	Female	A	44	E
8	Female	A	46	E
9	Male	A	36	Testes Regressing

E enlarged teats
T enlarged testes

Table 21. Trapping effort and success for Area II, 1966.*

CAPTURE DATES

Chipmunk Number and	Age	May	June	July		August		Sept.		Totals
1	A	X	X	X	X	X			X	6
2	A	X X	X	X	X		X		X	7
3	A	X	X	X	X	X			X	6
4			X	X	X		X			4
5	A		XX		X	X			X	5
6	A		X				X			2
7	J			XX	X		X			4
9	J			X	X	X	X			4
10	J			X	X	X			X	4
11	J			X		X	X			3
12	J			X	XX	X	X			5
13	J			X	X	X	X			4
14	J				X	X	X	X		4
15	J				X	X	X		X	4
16	A					X	X			2

* Ninety traps set each trapping day except 20 in May.

Table 22. Trapping effort and success for Area III, 1967*

		CAPTURE DATES						
		August						
Chipmunk Number and	Age	21	27	28	29	30	31	Totals
1	J	X	X					2
2	J	X						1
3	A	X	X	X				3
4	A	X		X				2
5	A	X			X			2
6	J	X		X		X		3
7	A		X					1
8	J		X		X			2
9	J		X			X		2
10	J		X				X	2
11	J			X			X	2
12	A			X				1
13	J				X			1

* Thirty-six traps set Aug. 21, 153 Aug. 29, other days 154.

Table 23. Trapping effort and success for Area IV, 1967 and 1968.

CAPTURE DATES

September, 1967

Chipmunk Number and Age		2	3	4	Totals
1	A	X		X	2
2	A	X			1

June, 1968

		2	3	4	
1		X	X		2

Table 24. Trapping effort and success for Area V, 1968.

CAPTURE DATES

Chipmunk Number and	Age	April*				May*				June*					Totals
		17	19	20	21	3	4	5	6	1	2	3	4	5	
1	A		X			X									2
2	A			X	X		X		X	X	X				6
3	A			X		X			X		X		X		5
4	A				X	X			X	X			X		5
5	A				X	X		X			X				4
6	A				X		X					X		X	4
7	A					X	X			X				X	4
8	A					X				X					2
9	A									X					1

* One hundred and fifty-six traps set.

Table 25. A summary of movement and home range data from 1965 and 1966 for Area I.

Animal Number	Number of Times Trapped	Number of Times Seen per Visit	Home Range Size (in acres)	Farthest Movement Recorded (feet)
1	8	2	.44	178
2	10	1	.96	312
3	8	1	.63	223
4	7	2	.48	267
5	6	1	.41	223
6	11	2	.59	267
7	5	2	.52	235
8	10	2	.74	312
9	4	1	.67	314
10	6	2	.89	310
11	6	-	.55	401
12	5	1	1.14	405
13	7	3	.81	322
14	4	1	.44	309
15	3	-	.63	245
16	3	-	-	356
17	3	2	.89	378
18	2	-	-	200
19	2	-	-	343
Averages	5.7	1.6	.67	295

Table 26. A summary of movement and home range data, 1965, for Area II.

Animal Number	Number of Times Trapped	Number of Times Seen per Visit	Home Range Size (in acres)	Farthest Movement Recorded (feet)
1	6	2	.57	233
2	7	2	.70	250
3	6	2	.42	240
4	4	1	.29	167
5	5	1	.40	208
6	2	2	.67	241
7	4	2	.31	183
8	2	-	-	-
9	5	1	.31	250
10	4	1	.70	333
11	4	2	.86	284
12	4	3	1.40	433
13	4	1	.46	350
14	2	1	.14	217
15	4	2	.41	300
16	3	1	.31	167
17	1	-	-	-
Averages	3.9	1.6	.53	257

Table 27. Movement and home range data for Area III, 1967.

Animal Number	Number of Times Trapped	Number of Times Seen per Visit	Home Range Size (in acres)	Farthest Movement Recorded (feet)
1	2	2	.68	287
2	1	-	1.18	600
3	3	2	1.95	450
4	2	-	.86	350
5	2	2	1.64	387
6	3	3	1.27	338
7	1	1	-	-
8	2	2	.31	225
9	2	2	.31	263
10	2	2	.45	350
11	2	2	.50	262
12	1	1	-	-
13	1	1	-	50
Averages	1.8	1.8	.91	324

Table 28. Movement and home range data for Area V, 1968.

Animal Number	Number of Times Trapped	Number of Times Seen per Visit	Home Range Size (in acres)	Farthest Movement Recorded (feet)
1	2	5	1.14	469
2	5	4	1.20	575
3	5	1	.36	173
4	5	4	1.60	600
5	3	2	.43	250
6	3	3	.64	230
7	3	1	.36	198
8	2	-	-	156
9	1	1	-	250
Averages	3.2	2.6	.81	322

Table 29. Distribution of the new animals captured for each trapping period.* They are categorized into either spring, summer or fall periods to reflect recruitment into the population from natality and/or dispersal.

Season	Trapping periods*			Areas			New animals marked in each period	Accumulati percentage total anima marked
		I	II	III	IV	V		
Spring prior to July 1	1	7	-	-	-	6	16	.22
	2	1	3	-	-	2	7	.32
	3	0	3	-	-	1	5	.39
Summer July 1 to Sept. 10	1	1	7	6	-	-	16	.62
	2	3	2	4	2	-	13	.80
	3	5	1	2	0	-	8	.93
	4	1	0	1	0	-	2	.96
Fall After Sept. 10	1	1	1	-	-	-	2	1.00
Totals		19	17	13	2	9		1.00

---

* A trapping period may be one out of a series of consecutive or nearly consecutive days, or a compilation of nearly consecutive days.

Table 30. A summary of chipmunk densities for all areas.

Area	Total Size in Acres	Known Number of Adults on Area*	Estimated Density of Adult Animals per Acre	Total Number of Animals	Estimated Overall Density per Acre
I	5.3	8	1.5	19	3.6
II	4.2	7	1.7	17	4.0
III	6.2	5	.8	15**	2.4
IV	2.5	2	.8	2	.8
V	6.6	9	1.4	9	1.4

---

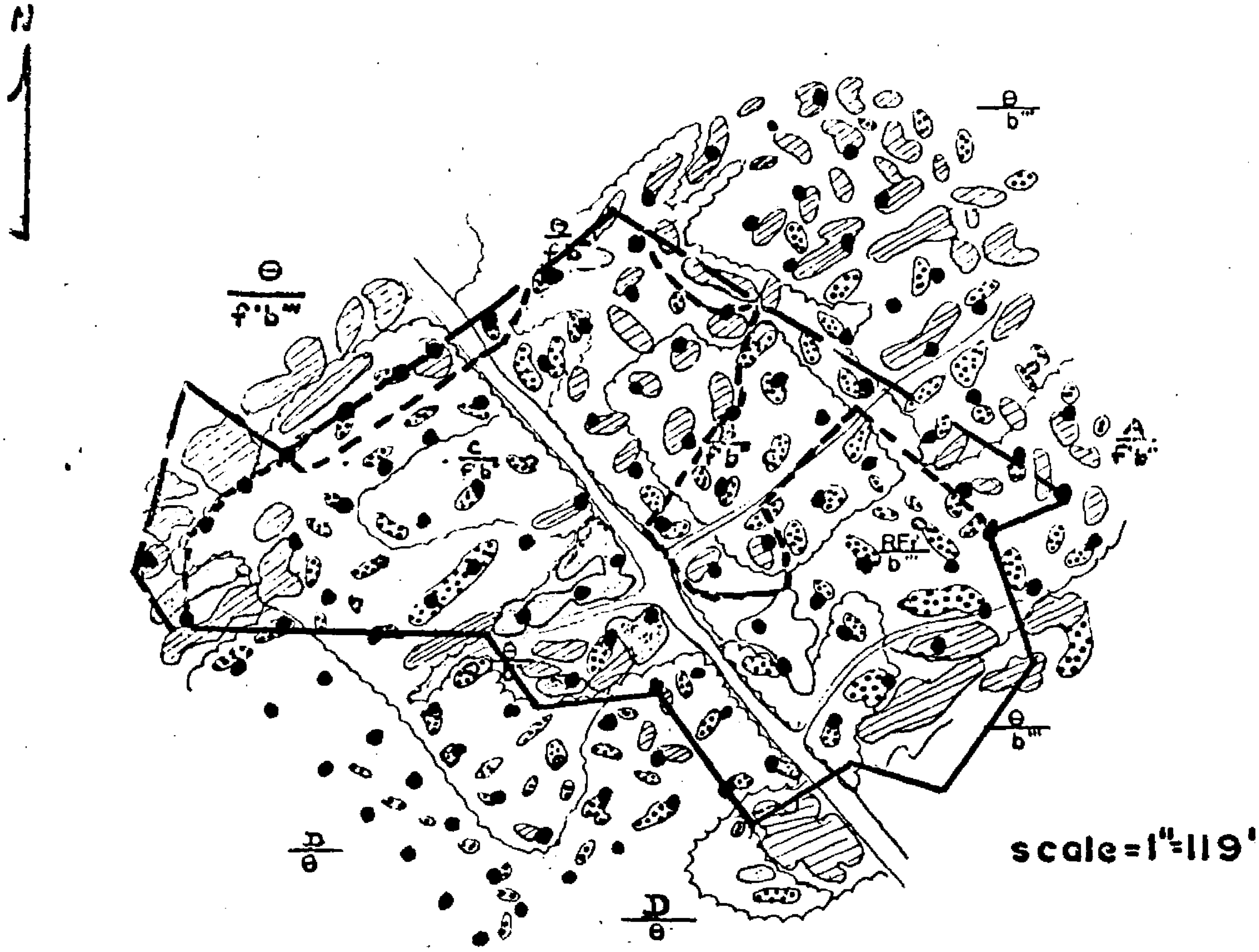
* This includes some animals that may be transient to an area.

** This includes two unmarked animals seen on the area after trapping and marking operations were concluded.

Table 31. Telemetry data for Area III.

Animal Number	Number of location points determined by telemetry	Total distance tracked via telemetry in feet	Life of transmitter
1	26	440	4 days
2	18	540	?
3	33	940	5 days
4	29	560	6 days
5	26	460	5 days
6	29	550	4 days

AREA I

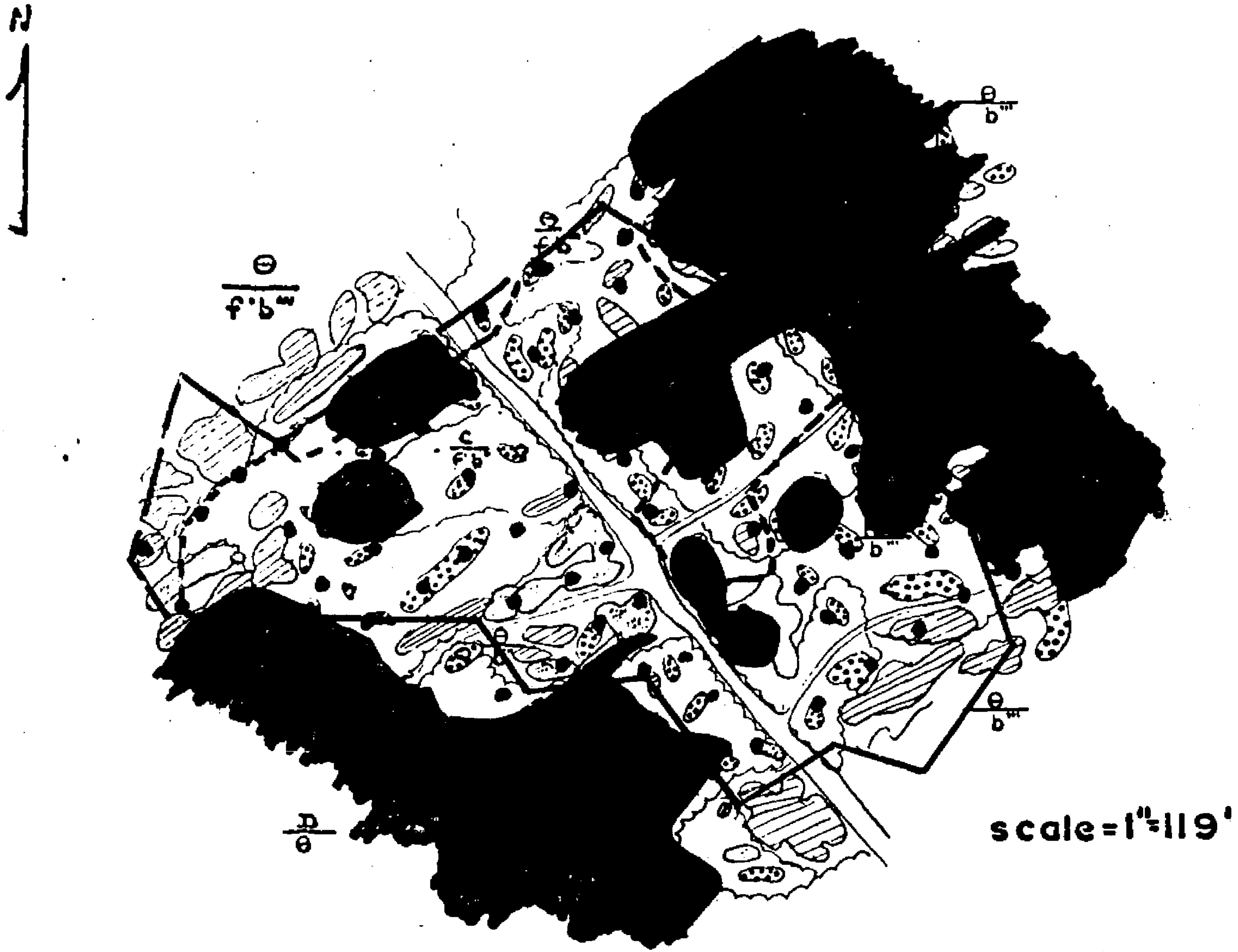


——— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

—— —— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.



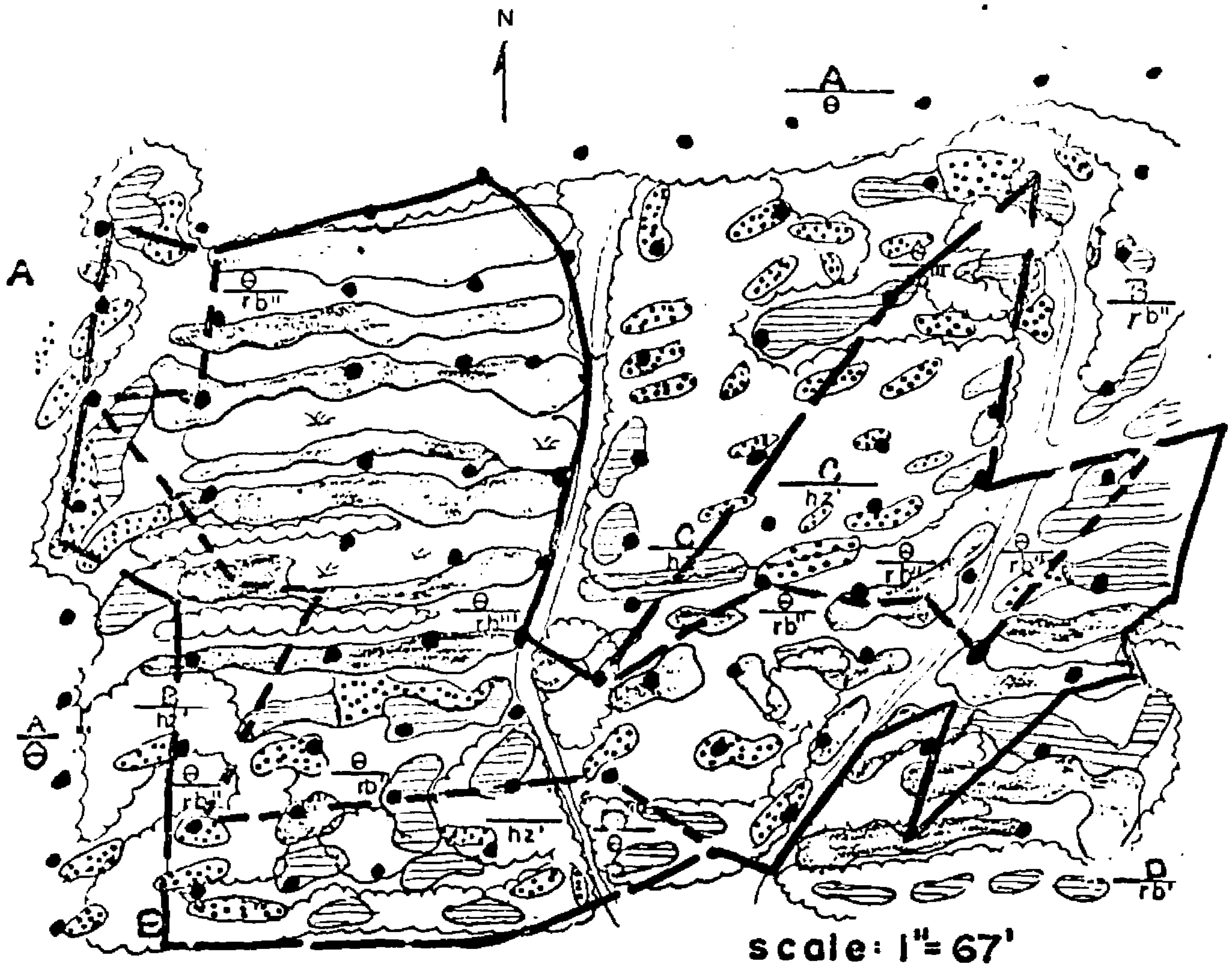
——— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

— — OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.

AREA II



———— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

—— —— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

☐ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.

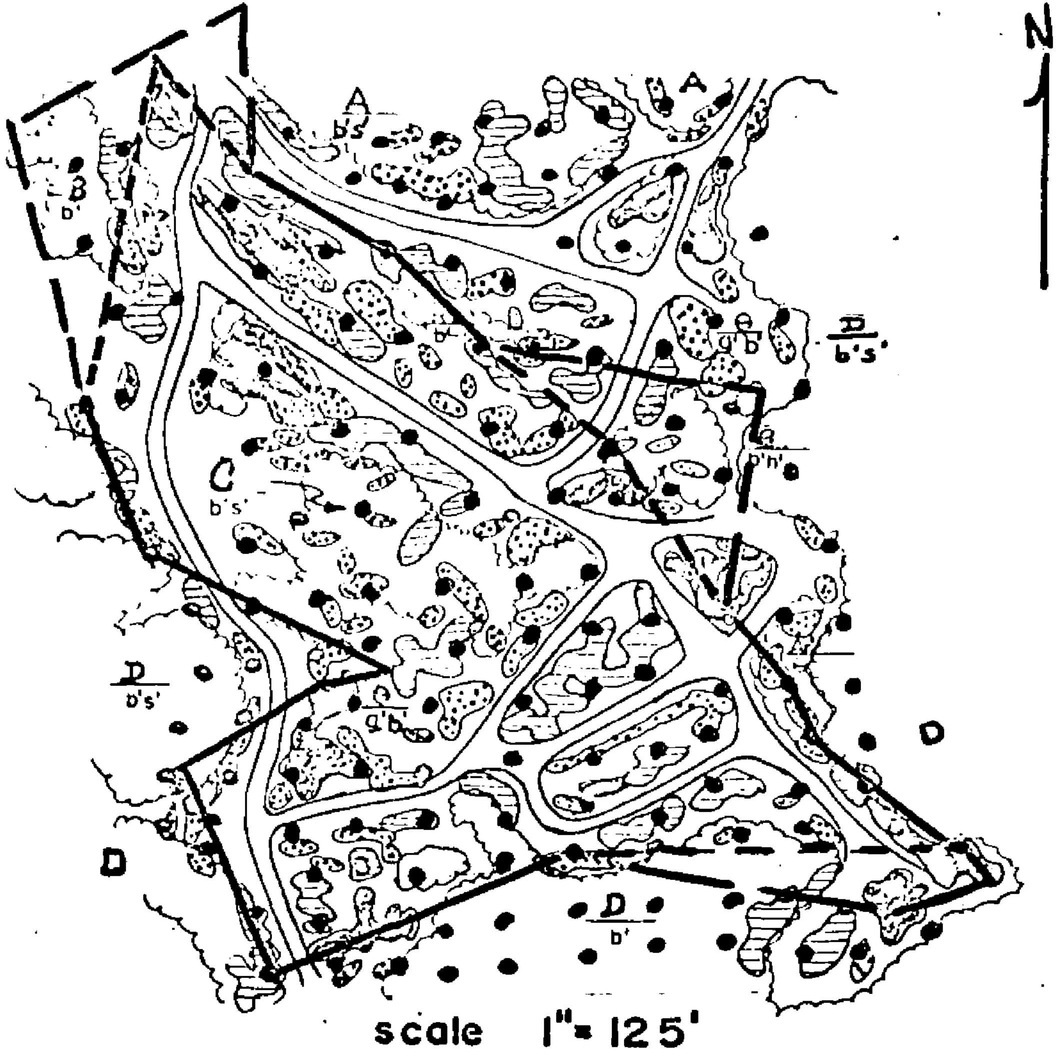
—— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

— — OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.

AREA III

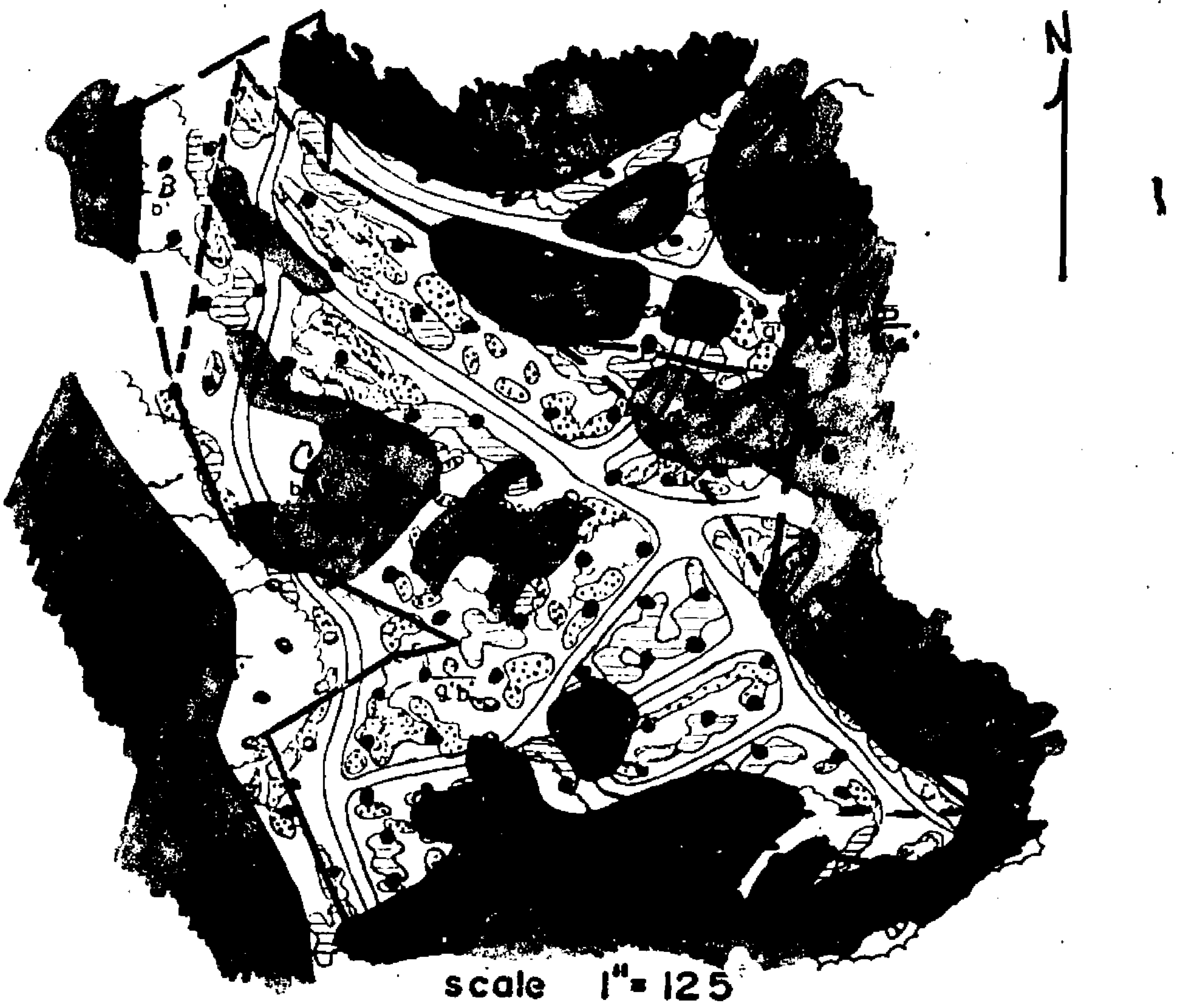


——— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

– – – – – – OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

—— —— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

☐ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.



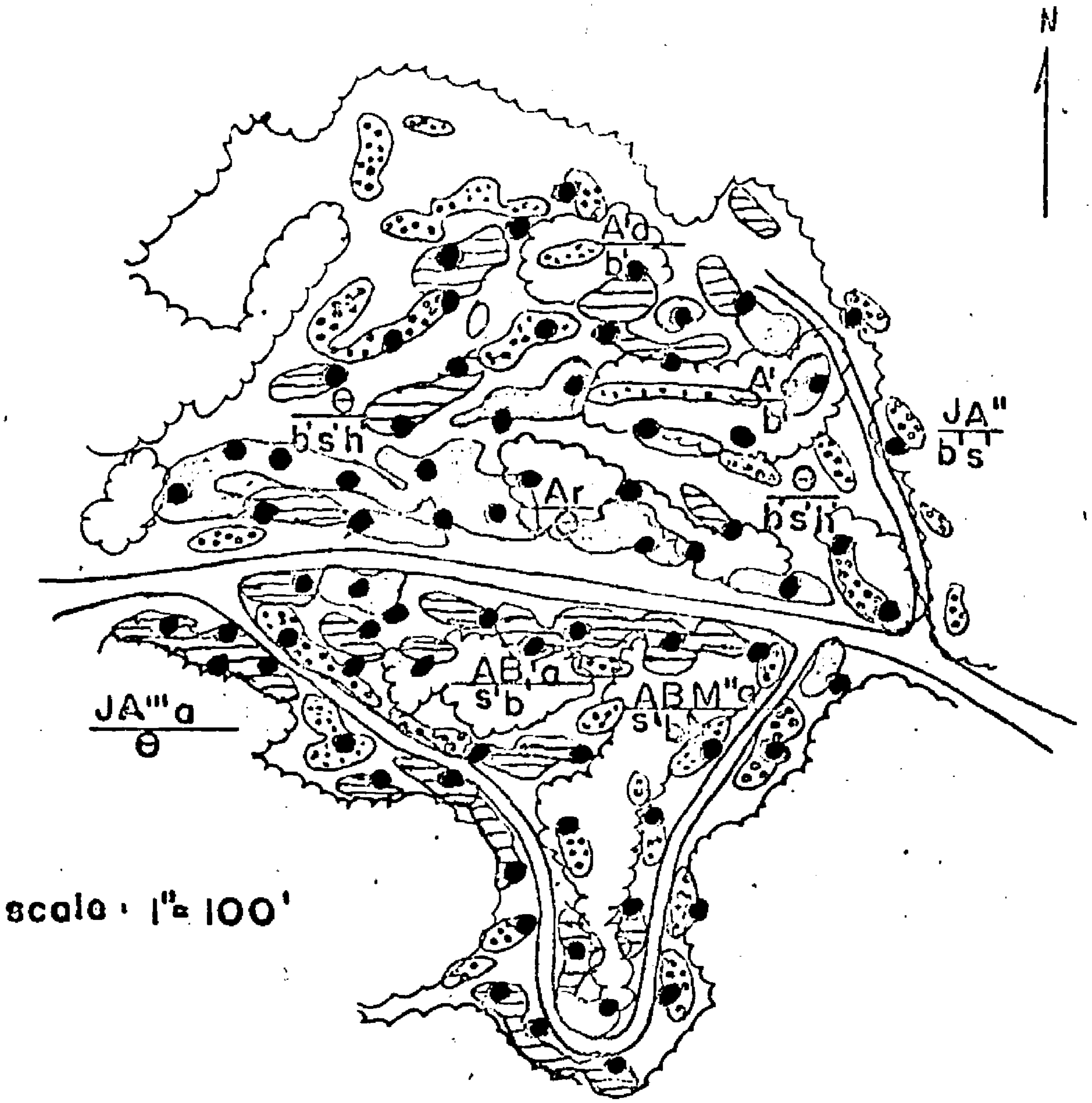
——— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

—— —— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

☐ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.

AREA IV

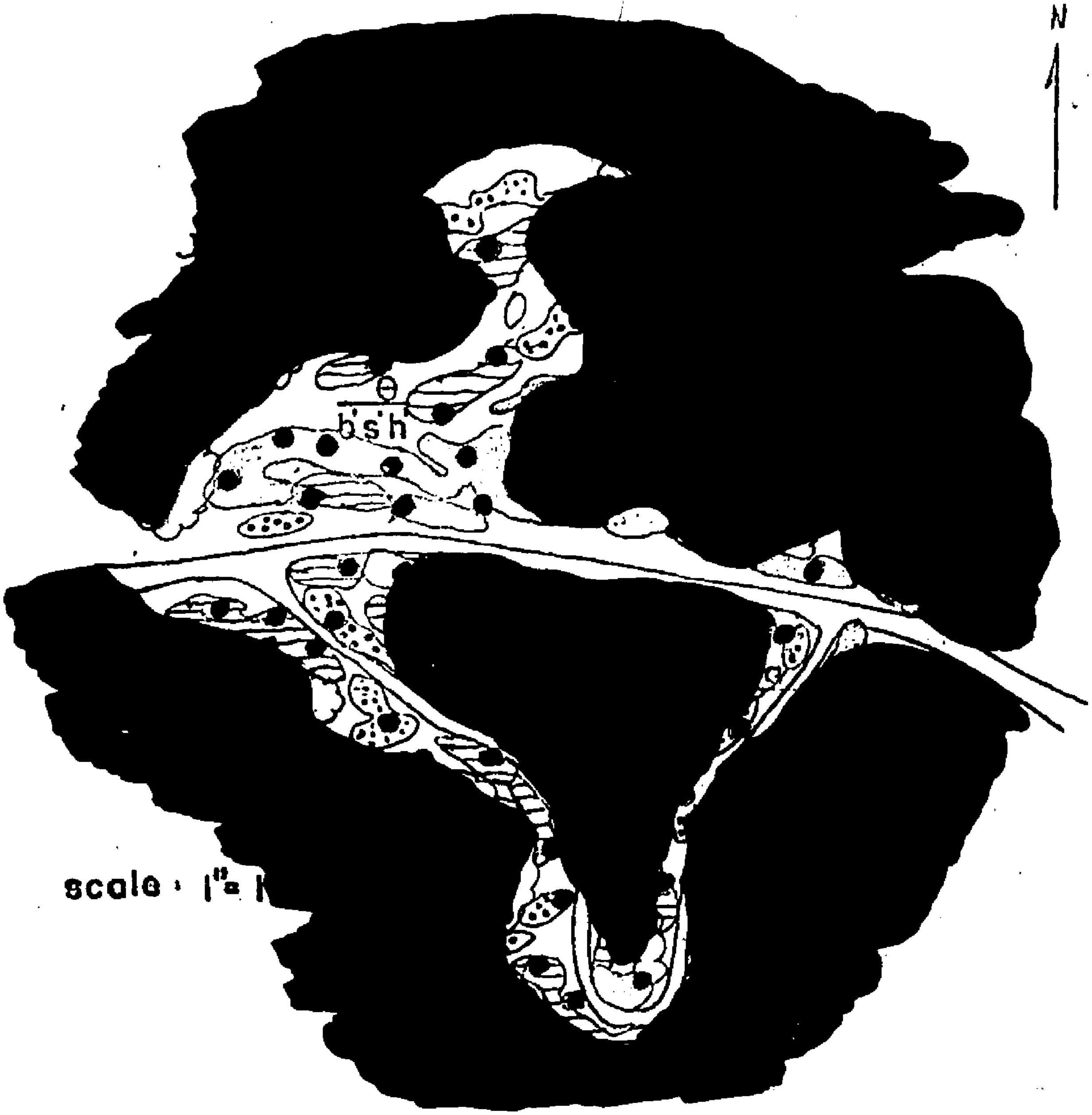


———— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

—— —— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.



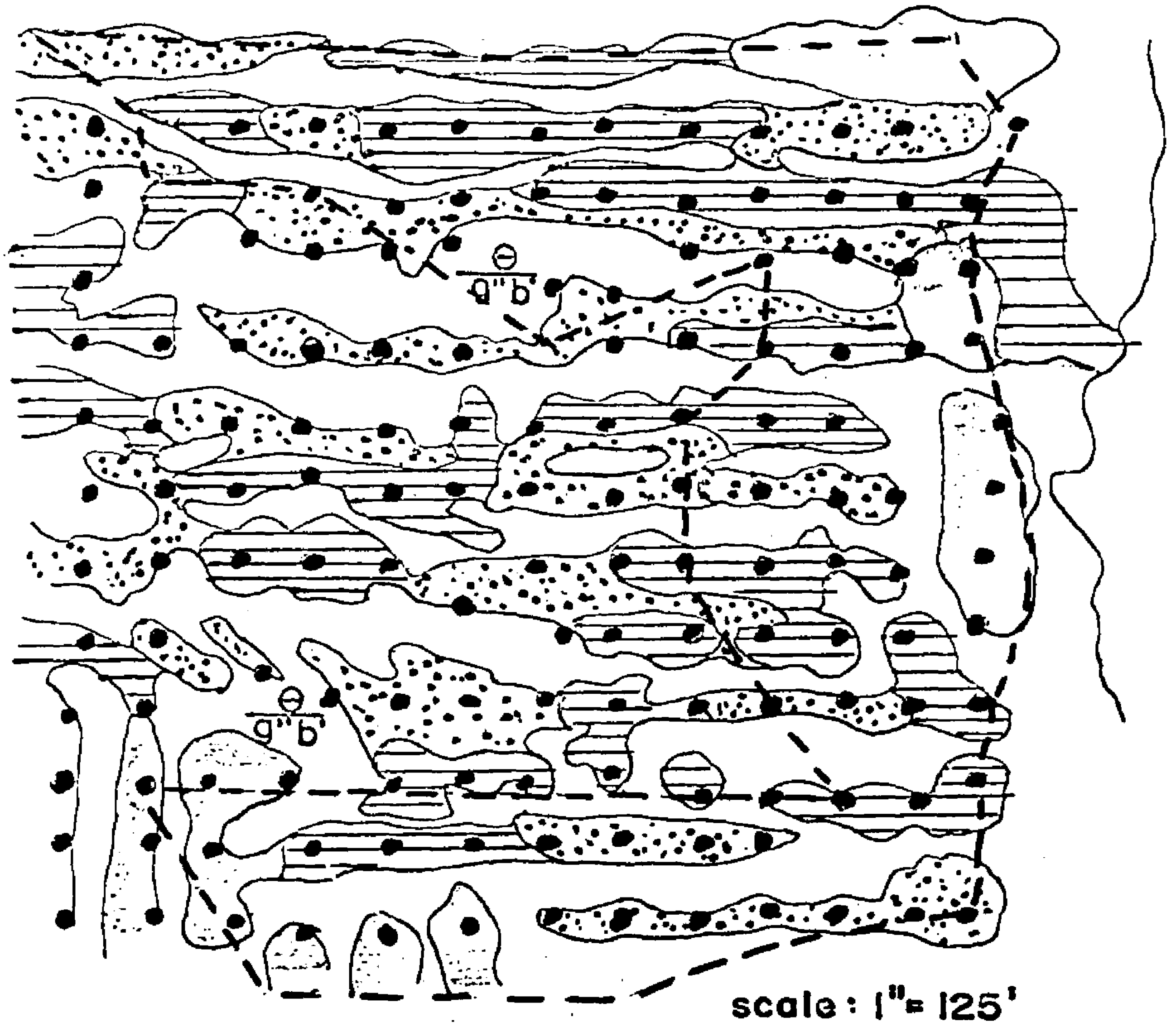
———— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

— — OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.

AREA V

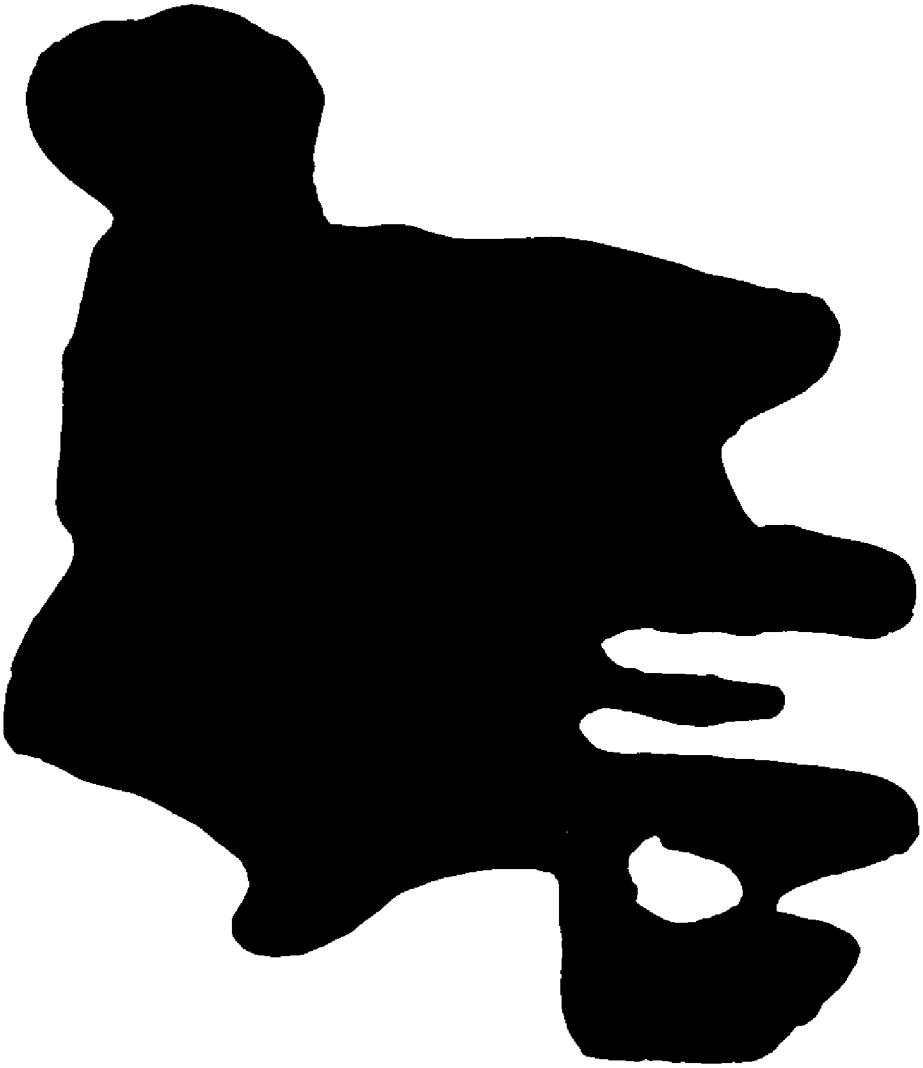


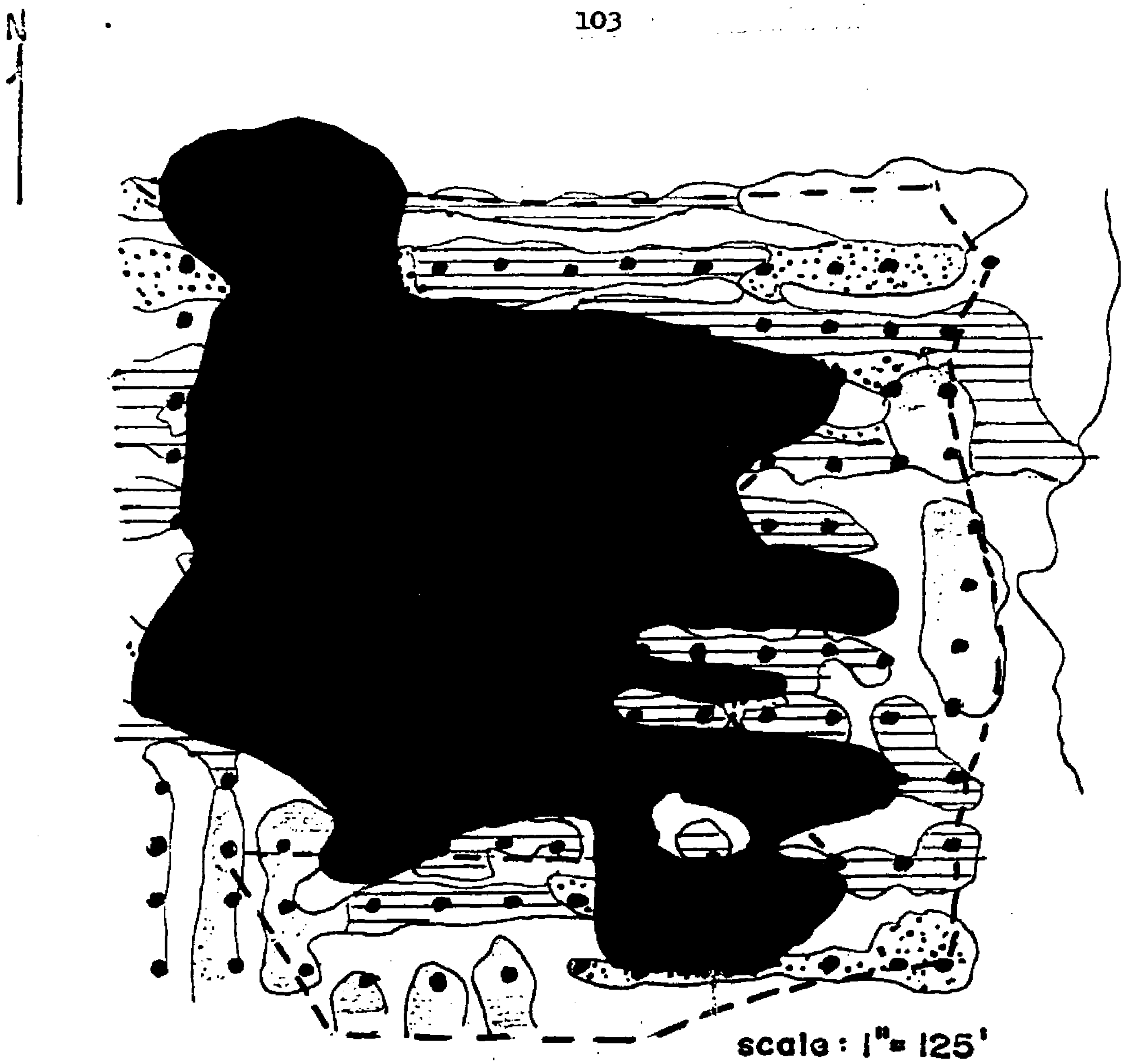
——— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

— — OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.





——— OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ALL ANIMALS.

- - - - - - OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR ADULTS ONLY.

— — OUTLINE OF COMBINED ESTIMATED HOME RANGES FOR JUVENILES.

▭ SHADED PORTIONS OF THE AREA WERE RATED AS HAVING POOR HORIZONTAL VISIBILITY; UNSHADED, MEDIUM TO GOOD.

Tables 32 through 40 summarize, in logarithmic form, the data obtained by measuring the time spent in the various pens exposed to different treatments. The data were collected from the 1968 experimental enclosure.

Table 32. Comparison of the treatments perch height and vertical visibility.

	No Vertical	Vertical	Totals
16" Perch	107.10	91.23	198.33
24" Perch	122.60	94.02	216.62
Totals	229.70	185.25	414.95

Table 33. Comparison of the treatments perch height with chipmunks.

Chipmunk	16" Perch	24" Perch	Totals
2	59.02	65.18	124.20
3	54.21	55.31	109.52
4	35.23	48.26	83.49
5	49.81	47.87	97.74
Totals	198.33	216.62	414.95

Table 34. Comparison of the treatment horizontal visibility with chipmunks.

Chipmunk	No Horizontal	Horizontal	Totals
2	72.98	51.22	124.20
3	66.10	43.42	109.52
4	55.03	28.46	83.49
5	60.13	37.61	97.74
Totals	254.24	160.71	414.95

Table 35. Comparison of the treatment horizontal visibility with chipmunks.

Chipmunk	No Vertical	Vertical	Totals
2	66.01	58.19	124.20
3	62.37	47.15	109.52
4	43.94	39.55	83.49
5	57.38	40.36	97.74
Totals	229.70	185.25	414.95

Table 36. Comparison between the treatments perch height and horizontal visibility with chipmunks.

	16" Perch		24" Perch		
Chipmunk	No Horizontal	Horizontal	No Horizontal	Horizontal	Totals
2	34.18	24.84	38.80	26.38	124.20
3	36.32	17.89	29.78	25.53	109.52
4	28.02	7.21	27.01	21.25	83.49
5	33.11	16.76	27.02	20.85	97.74
Totals	131.63	66.70	121.61	94.01	414.95

Table 37. Comparison between the vertical visibility and horizontal visibility with chipmunks.

	No Vertical		Vertical		
Chipmunk	No Horizontal	Horizontal	No Horizontal	Horizontal	Totals
2	41.60	24.95	31.92	26.27	124.20
3	40.03	22.34	26.07	21.08	109.52
4	29.38	14.56	25.65	13.90	83.49
5	38.32	19.06	21.81	18.55	97.74
Totals	148.79	80.91	105.45	79.80	414.95

Table 38. Comparison between the vertical visibility and perch height with chipmunks.

	16" Perch		24" Perch		
Chipmunk	No Vertical	Vertical	No Vertical	Vertical	Totals
2	31.70	27.32	34.31	30.87	124.20
3	30.34	23.87	32.03	23.28	109.52
4	17.88	17.35	26.06	22.20	83.49
5	27.18	22.69	30.20	17.67	97.74
Totals	107.10	91.23	122.60	185.25	414.95

Table 39. Comparison between the perch height, horizontal visibility and vertical visibility

	No Vertical		Vertical		
	No Horizontal	Horizontal	No Horizontal	Horizontal	Totals
16" Perch	75.84	31.26	55.79	35.44	198.33
24" Perch	72.95	49.65	49.66	44.36	216.62
Totals	148.79	80.91	105.45	79.80	414.95

Table 40. Comparison between the perch height, horizontal and vertical visibility with chipmunks.

	Chipmunk 2	Chipmunk 3	Chipmunk 4	Chipmunk 5	Totals
H	10.99	9.26	2.71	8.30	31.26
V	13.47	15.24	12.85	14.23	55.79
P	20.35	18.95	14.21	19.44	77.95
(1)	20.71	21.08	15.17	18.88	75.84
HV	13.85	8.63	4.50	8.46	35.44
PV	18.45	10.83	12.80	7.58	49.66
PH	13.96	13.08	11.85	10.76	49.65
PHV	12.42	12.45	9.40	10.09	44.36
Totals	506.65	409.83	339.13	338.09	1593.71

Tables 41 and 42 summarize in logarithmic form the data obtained by measuring the time spent in the various pens exposed to different treatments. The data were collected from the 1968 experimental enclosure.

Table 41. Comparison of the treatment vertical visibility with that of horizontal visibility.

	No Vertical	Vertical	Total
No Horizontal	48.79	105.45	254.24
Horizontal	80.91	79.80	160.71
Total	229.70	185.25	414.95

Table 42. Comparison of the treatment perch height with that of horizontal visibility.

	No Horizontal	Horizontal	Total
16" Perch	131.63	66.70	198.33
24" Perch	122.61	94.01	216.62
Total	254.24	160.71	414.95

Tables 43 through 45. The number of times the chipmunks used the elevated perch in a pen. Refer to the text for a description of the experimental treatments. Data obtained from the 1968 experimental enclosure.

Table 43.

Treatment Open.

Chipmunk	16" Perch	24" Perch	Total
2	5.24	7.22	12.46
3	10.12	11.08	21.60
4	9.93	10.09	20.02
5	11.68	2.99	14.67
Total	36.97	31.33	68.40

Table 44.

Treatments Horizontal.

Chipmunk	16" Perch	24" Perch	Total
2	3.94	10.46	14.90
3	6.23	10.07	16.30
4	1.79	12.23	14.02
5	5.19	11.42	16.61
Total	17.15	44.18	61.83

Table 45.

Treatments Vertical.

Chipmunk	16" Perch	24" Perch	Total
2	3.68	3.25	6.93
3	9.46	8.57	18.03
4	6.89	8.97	15.86
5	8.24	6.81	15.05
Total	28.27	27.60	55.87