

HABITAT OF WOODRATS (NEOTOMA) IN THE NEEDLES DISTRICT, CANYONLANDS NATIONAL PARK,
UTAH: VEGETATION

ABSTRACT.--Three species of woodrats (Neotoma mexicana, N. albigula, N. cinerea) are sympatric at middle elevations (5000 to 5040 ft.) in the Needles District, Canyonlands National Park, San Juan Co., Utah. All den among rocks of the Permian Cutler Formation. Vegetational composition and structure were considered among a number of characteristics of possible importance in establishing complementarity of realized niches and allowing coexistence. Vegetation was sampled at 11 stations on each of 26 semicircular grids (400 sq. m.) centered on woodrat dens, noting density, coverage, and frequency of species within each synusia. Analyses of vegetation considered floristics and physiognomy, species diversity and habitat diversity. Using nonparametric statistical tests, no significant differences were found in vegetation around dens of the three species of woodrats, except that graminoids were more important about unoccupied dens than about dens of N. cinerea, and forbs were more important near dens of N. mexicana than those of N. albigula.

INTRODUCTION.--Some 22 nominal species of the genus Neotoma occur in North America. Woodrats, or "packrats," range from the Appalachians and Alleghenies westward to the Sierra Nevada, and from the Yukon Territory southward to northern Costa Rica. The greatest diversity within the genus centers in southwestern United States and adjacent Mexico. The animals are among the most conspicuous of nocturnal rodents, for their dens and houses are large enough to be prominent features of the landscape.

Geographic ranges of a number of kinds of Neotoma overlap to various degrees. Distributional relationships of 10 rather widespread species are shown in Fig. 1. Neotoma albigula overlaps broadly six other species, and N. cinerea and N. mexicana both overlap five other kinds. Other species generally are of more restricted distribution and are sympatric with three or fewer other kinds of woodrats. Fig. 2 shows superimposed ranges of 10 species of Neotoma. It is obvious that the region of most complex sympatry within the genus lies in the Canyonlands Section of the Colorado Plateau. There five species (represented by eight subspecies) are in close proximity to one another. Describing work in southeastern Utah, Durrant and Dean (1959:92) wrote: "To the field mammalogist, the collecting of wood rats in Glen Canyon is a somewhat fabulous experience."

In the light of modern niche theory, the sympatry of congeneric species is of both ecological and evolutionary interest: how do such patterns arise, and how are they maintained? In a review of the competitive process, Miller (1957:22) remarked: "Populations which appear to be sympatric in their geographic distributions may diverge ecologically so that they are effectively allopatric in their local distributions We know that closely related species frequently coexist in the same habitats, but there is usually some level of spatial distribution at which they are separate. What is required is a critical comparison between the two supposed competitors and the amount of intersection of their fundamental niches." The purpose of the present research has been to begin to answer these questions: at what level of distribution are populations of woodrats separate, and to what extent do their niches overlap? Field work has considered vegetation, physical situation, and mammalian associates; laboratory studies of food habits, food preferences, and inter- and intraspecific behavioral interactions are planned.

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Several studies of sympatric species of woodrats have been reported in recent years. Finley (1958) presented a monumental study of Coloradan woodrats, emphasizing ecological distribution. Cameron (1971) discussed relationships between N. fuscipes and N. lepida in the Mojave Desert of southern California. Wright (1973) analyzed habitats of N. albigula and N. micropus in southern New Mexico, and Wood (1969) studied ecological distribution and food habits of the two species at a nearby locality. Birney (1973) commented on ecological attributes of N. micropus and N. floridana along a zone of contact between the two species. Most recent studies point out that differences in habitat preferences, denning behavior, or food habits preclude direct competition between species and allow coexistence.

Mammalian faunal reconnaissance was begun in Canyonlands National Park in 1972 (see Armstrong, 1973). That work suggested that relationships among sympatric species of woodrats in the Park were not so clear-cut as described elsewhere. In fact, cursory observation suggested no differences whatever in preferred habitat or den construction. It was such observations that led to initiation of this study.

In describing habitats of animal populations, the feature of most immediate interest usually is vegetation. Vegetation is a complex indicator of the character of a site. Plant life not only provides food for primary consumers; it also lends structure to a site, providing cover and increasing the number of exploitable dimensions. In the present study, several site qualities of possible ecological significance have been "controlled" by working in a small, relatively homogeneous area--physiography and geological substrate, elevation, soils, and climate vary negligibly. Differential character of the study grids was almost solely a function of vegetation. Thus, vegetation should not be construed as mere trophic resource, but as a "comprehensively sensitive" indicator of site qualities and successional history.

METHODS. Study Area.---All observations reported herein were made in the Needles District, Canyonlands National Park, San Juan Co., Utah (sec. 25, T. 30 S., R. 19 E, and secs. 29 and 30, T. 30 S, R. 20 E), in June and July, 1973. Elevations in the study area ranged from 5000 to 5040 ft. (read from topographic maps, U. S. Geological Survey, 15-minute series). All localities are in the Squaw Creek drainage, within about 2 miles of District Headquarters.

Physiographically, the area consists of a series of broad flats upheld by the Elephant Canyon Formation. Breaking the surfaces of the flats are numerous sandy washes and a variety of sandstone prominences--fins, buttes, "toadstools," and needles. The curious array of sandstone "sculptures" owes its origin to the complex depositional history of the Permian Cutler Formation. According to Baars (1971:36): "The Permian System of the Canyonlands is a stratigrapher's nightmare of interfingering and gradational facies." The Cedar Mesa member of the Cutler Formation is an eolian dune or beach deposit consisting of well-sorted, cross-stratified white sands derived from a source area to the northwest. The Cedar Mesa forms resistant white shelves and caps. The undifferentiated Cutler Formation is a fluviatile, arkosic redbed deposit. It is considerably less resistant to erosion than is the Cedar Mesa, and forms the weathered "stipes" of "toadstools" that are capped with Cedar Mesa sandstone. All dens investigated were in rocks of the Cutler Formation.

Habitat of woodrats was described in the field on the basis of physical situation, vegetation, and mammalian associates. Virtually all dens encountered were in cracks and hollows in cliffs or among rubble in massive colluvial rock piles. Preliminary observations of stored forage, midden deposits, and clipped and pruned vegetation suggested that woodrats tended to forage "in front" of the den--on the flat or among colluvium below the cliff or rockpile. A sampling scheme was designed with that in mind, in an attempt to gain a "rat's eye view" of the habitat.

Grid.--A semi-circular pattern of sampling stations was set up (using tape and compass methods) with an apparently active woodrat den at its center. Fig. 3 shows the arrangement of the grid. Stations were marked with a survey stake. Stations on arcs B and C each had one Sherman livetrapp (approximately 8 x 9 x 23.5 cm.). Four traps were set within 1 m. of station A. Stations on arc D were set with heavy Victor snaptraps, a line to assess possible movement on and off the grid. All traps were baited with rolled oats. Except at station A, traps were roughly 5 m. apart. Total area circumscribed by arc D was about 400 sq. m.; total area of the livetrapp grid was about 190 sq. m.

Small Mammals.--Each grid was run continually for four days; they were set at dusk on day one and picked up early on the morning of day four. Animals livetrapped on days one through three were marked (by toeclipping) and released. All animals obtained on day four (and all animals taken in livetraps) were preserved as standard museum specimens. Active grids were checked at dusk, dawn and noon; most days were sufficiently warm that grids also were checked mid-morning and mid-afternoon. Association of a given species of *Neotoma* with a den was established by capturing an individual twice on the same grid in the four-day cycle. Dens not thus associated with a species were considered to be "unoccupied" in the remarks to follow.

Vegetation.--At each station, the stake was used to locate sampling quadrats for vegetation. Sampling was separate for each synusia of the vegetation: deciduous trees, needleleaved evergreens, broadleaved shrubs, aphyllous shrubs, rosettes, stem succulents, forbs, and graminoids. No ferns were encountered on the grids, and non-vascular plants were ignored, although mosses and soil lichens are common and prominent in the flora. Trees and shrubs were tabulated from quadrats 4 m. square (16 sq. m.) located as shown by dashed lines in Fig. 3. Other synusiae were tabulated in quadrats 1 m. square located at the inner corner of the larger quadrat. (except for those quadrats located on the midline of a given arc, in which case the smaller quadrat was centered on the base of the larger).

Raw density was recorded as the number of individuals per quadrat. Coverage-- "...percentage of ground surface included in a vertical projection of a polygon; drawn about the undisturbed foliage of a plant" (Daubermire, 1970:2)--was estimated by eye and tabulated by classes as follows: 1 = 0 to 5 per cent coverage; 2 = 5 to 25 per cent; 3 = 25 to 50 per cent; 4 = 50 to 75 per cent; 5 = 75 to 95 per cent; 6 = 95 to 100 per cent. Frequency was defined as the number of quadrats on the grid including any coverage of a species. Species occurring on the grid but not sampled on any quadrat were recorded as "incidentals." Botanical nomenclature follows Welsh and Moore (1973) wherever possible; Harrington (1954) was useful in identifying plants. Voucher specimens obtained will be deposited in herbaria of the University of Colorado Museum and Canyonlands National Park. Statistical methods follow Sokal and Rohlf (1969) and Rohlf and Sokal (1969).

RESULTS. Distribution of rodents.--Of the 26 dens surveyed, 12 were occupied by Neotoma mexicana, four by N. albigula, and four by N. cinerea; one den was associated with both N. cinerea and N. albigula, and another with both N. mexicana and N. albigula. These dens with apparent plural occupancy (or serial occupancy) were attributed to both species in the following analyses. Eight dens were categorized as unoccupied. In addition to woodrats, 87 rodents of 11 other species were recorded on the grids. Their distribution will be detailed in a subsequent paper.

Floristic Analysis.--Floristic analysis of each grid was carried out in an effort to estimate the importance of a given species within its synusia. An importance index (roughly comparable to the importance value of Curtis and McIntosh, 1951) was calculated for each species. The index is the sum of three percentages: (1) relative frequency--the number of quadrats upon which a species was noted divided by the total number of quadrats per grid (11); (2) relative density--the number of individuals of a species divided by the total number of individuals in the synusia; (3) relative coverage--the coverage of a species divided by total coverage of the synusia. Coverage was recorded in the field by classes, but for analytic purposes classes were decoded and given the percentage value of the midpoint of the class. The importance index may vary from 0 to 300. The index was based on floristic composition of a given synusia, so that indices were not comparable between synusiae. Obviously, no index could be calculated for incidental species. Tabular data on floristic composition of the habitat are available from the author.

A total of 90 plant species was recorded on the 26 grids sampled. Of that number, 21 were herbs recorded only as incidentals. Thirty plant species were recorded in association with dens of a single kind of woodrat. Of such exclusive species, 18 (60 per cent) were incidentals; 26 exclusive species (86.7 per cent) were herbs. For non-incidental, exclusive species, average importance values on grids pertinent to a given species of woodrat ranged from 1.1 to 27.7. Exclusive species with average importance values greater than 20 were Celtis reticulata and Rhus trilobata (both associated with N. mexicana), and Populus fremontii, recorded only about abandoned dens.

In only one instance was a plant species found on all grids associated with a given kind of woodrat: Juniperus osteosperma was found on all grids of N. cinerea sampled (average importance value, 190.2). Few species showed mean importance values greater than 100. Strong associates of N. mexicana included Juniperus osteosperma (142.7), Artemisia tridentata (118.5), Bromus tectorum (124.7), and Lepidium montanum (103.7). The prominence of the latter two species almost surely is a matter of seasonal aspect. Important associates of N. albigula included Fraxinus anomalous (110.0), J. osteosperma (150.5), and A. tridentata (115.0). Dens of N. cinerea showed strong association with F. anomalous (109.0), J. osteosperma (190.2), and Ephedra viridis (104.5). No plant species about unoccupied dens rated an importance index greater than 100. Importance indices of species with average values greater than 100 were subjected to the nonparametric Kruskal-Wallis test. Values for none of the species showed significant differences in location among species of woodrats.

Physiognomic Composition.--Structural composition was assessed in two different ways, emphasizing the absolute and relative importance of the several synusiae. First, data on importance values of species were used to calculate an index of synusial importance.

This is simply the sum of mean importance values of species within each synusia. The sums are presented in Table 1, along with the number of grids on which the synusia was represented and the minimum and maximum importance index of the synusia.

Note that three synusia are not very important in association with any of the dens studied: aphyllous shrubs (Ephedra), stem succulents, and rosettes (Yucca). Deciduous trees are of modest importance in the local flora and this is reflected in their total average physiognomic importance. The important synusiae in the vegetation about wood-rat dens are needleleafed evergreens, broadleafed shrubs, graminoids (all of them grasses), and forbs. Needleleafed evergreens are most important about dens of N. cinerea, least so near abandoned dens. Shrubs show great importance about occupied dens (greatest about those of N. mexicana), and are less important near unoccupied dens. Of the herbaceous synusiae, graminoids show their greatest importance about abandoned dens and are least significant near dens of N. cinerea. Forbs, on the other hand, always are highly important, somewhat more so on grids near N. mexicana, less so about those of N. cinerea.

A second assessment of the importance of each synusia is shown in Table 2. This is a compilation of average, relative synusial importance. Here importance was calculated relative to the entire grid. The index is analogous to the species importance value described above; it is the sum of three percentages: relative frequency, relative density, and relative coverage of a given synusia with respect to totals for an entire grid.

As in the tabulation of average absolute importance, three synusiae show low values: aphyllous shrubs, stem succulents, and rosettes. The latter two synusiae were most important about abandoned dens, whereas aphyllous shrubs were most conspicuous near dens of N. cinerea. Deciduous trees averaged moderately important on all classes of grids, being most conspicuous about dens of N. albigula and least so near dens of N. cinerea. Again, evergreen shrubs and herbs are the predominant synusiae. In this analysis, evergreens were most prevalent in association with N. albigula, least so about dens of N. mexicana. Shrubs had their greatest importance in association with N. mexicana, least so about dens of N. albigula. Herbs averaged consistently predominant on all grids, with forbs about four times as important as graminoids.

The data upon which tables 1 and 2 were based (absolute and relative synusial importance values for each grid) were subjected to the nonparametric Kruskal-Wallis test. The only significant differences in location of the indices were in absolute importance of graminoids and herbs (Kruskal-Wallis H-statistic, 10.70 and 10.02, respectively; chi-square $0.05 [3] = 7.85$). Subsets of indices were tested for homogeneity. With respect to graminoids, all combinations were non-significant save unoccupied dens vs. N. cinerea; considering herbs, all subsets were non-significant except N. mexicana vs. N. albigula.

Diversity.--Another vegetational attribute of possible importance in habitat selection is diversity. Diversity is an important feature of biotic communities, one under study by a number of ecologists. As always in the study of vegetation, floristic and physiognomic attributes must be distinguished carefully. Considered were species diversity, based on floristic composition, and habitat diversity, based on synusial structure of the vegetation.

Species diversity is a notion quite distinct from species density, the number of species per unit area. Species density may be of interest on a large, geographic scale (see, e. g., Simpson, 1964, or Armstrong, 1972), but species diversity has greater ecological interest. Species diversity is a complex attribute that considers the numbers of individuals in each species. It is a nascent concept, and at this stage in its evolution, selection among the several indices of diversity is rather arbitrary (see Lloyd *et al.*, 1968). Species diversity was calculated herein first by the index of E. H. Simpson (1949):

$$l = \sum n_i (n_i - 1) / N (N - 1),$$

where n_i is the number of individuals in the i th species, and N is the total number of individuals taken in the sample. The index l is an estimate of the probability that two individuals drawn from a community at random will be of the same species. Possible values of l range from 0 to 1, the higher the index, the lower the diversity. Table 3 indicates values of the index for plant species diversity on each grid.

Also tabulated in Table 3 is the Shannon index, an information-theoretical measure of the uncertainty of encountering a given species. It was calculated after the method of Lloyd *et al.* (1968):

$$H' = -\sum p_i \log p_i, \text{ approximated by } (3.321928/N) (N \log_{10} N - \sum n_i \log_{10} n_i),$$

where n_i is the number of individuals in the i th species, and N is the total number of individuals in the sample. The constant 3.321928 is a scale factor for converting logarithms from base 10 to base 2. Values of the Shannon index thus calculated are "bits per individual," the larger the index, the greater the diversity. As one would expect, the two indices utilized show strong, negative correlation (Spearman rank correlation coefficient, $r_s = -0.6774767$, which is highly significant--Siegel, 1956:284).

Of perhaps greater interest than taxonomic diversity is some estimate of habitat diversity, or spatial heterogeneity. This might be estimated by calculating diversity within synusia. Thus indices of habitat diversity were calculated as described above, except that individuals were grouped by synusia rather than by species. Table 3 indicates values of the indices. Again, strong, negative correlation is to be expected and is, in fact, observed ($r_s = -0.954703$ --highly significant).

Values of the indices in Table 3 all were subjected to the nonparametric Kruskal-Wallis test. Values of the H-statistic are shown at the foot of Table 3. The H-statistic is distributed approximately as chi-square (chi-square_{0.05 [3]} = 7.185). None of the columns of diversity indices shows significant differences in location among grids associated with a given species of woodrat.

DISCUSSION.--The foregoing analyses suggest that vegetation has little to do with distribution of woodrats in the study area. All species occur primarily in habitats dominated by shrubs, with a strong complement of forbs and grasses. Whereas a number of plant species were documented exclusively with given kinds of woodrat dens, no exclusive species was of great importance in its community. Consistently important species showed no significant differences in distribution among den sites.

Considering physiognomic structure, aphyllous shrubs, stem succulents, and rosettes were consistently of low importance. Shrubs and forbs were consistently important, as were (to a lesser degree) evergreens and grasses. Graminoids were significantly more important about unoccupied dens than near those of N. cinerea, and forbs were significantly more prominent about dens of N. mexicana than those of N. albigula. Possibly both N. cinerea and N. albigula are exhibiting here a sensitivity to disturbance. If so, however, there are no strong indications of it elsewhere in the data.

Indices of diversity may be a more sensitive measure of ecological structure than importance values, if animals are responding to overall character of the vegetation rather than to its specific composition. Nonetheless, the woodrats studied showed no differential response to that structure, either floristic or habitat diversity. Of course, sample sizes in the present study may be too small to allow trends to be expressed. Also, the statistical tests allowed by the data are not robust. Nonetheless, the obvious tentative conclusion is that there is no differential preference of woodrats on the study area for particular vegetational communities.

Finley (1958) studied ecological distribution of woodrats in Colorado and provided the only previous comparative ecological studies of the three species investigated here. He made no formal studies of vegetation about woodrat dens, noting that "the physical aspect of the environment seems to have greater importance for the survival of wood rats than the kinds of plants present. . . ." (p. 334). Finley had no record of sympatry of all three species together. He encountered N. cinerea and N. mexicana in sympatry at a number of localities in Montezuma County. Distinctions between habitats were not altogether clear, but N. cinerea seemed to occupy higher cliffs or piles of large blocky rock. Enough exceptions were noted, however, that Finley suspected (p. 529) that competition for dens sites must occur in some instances. Food preferences of the two species differed little, and neither seemed to be food-limited. Dens of N. cinerea usually had greater quantities of sticks, bones, and cactus joints, but exceptions were conspicuous.

In Dolores Canyon, near Gateway, Mesa Co., N. albigula and N. mexicana were taken in sympatry, the former on the valley floor, on boulder-strewn alluvial fans and benches, and at the bases of cliffs, and the latter on steep canyon sides and along the bases of cliffs. Thus, there was habitat overlap along cliff bases. In this zone, dens of N. albigula were identifiable immediately because of their great quantity of cactus spines. Finley (p. 529) suggested that competition for denning sites might occur in this narrow zone of overlap, but the abundance of food and dietary differences would preclude trophic competition. N. cinerea occurs in the immediate area, but actual sympatry was not demonstrated. Close sympatry also was seen between N. albigula and N. mexicana at other localities in southwestern Colorado. Habitat distinctions were slight and denning sites were similar so that ". . . there is probably some competition for shelter between these species, but only during times when the combined populations in an area exceed the number of favorable den sites" (p. 530).

Other workers, considering different species, have shown more marked differences in habitat and/or diet of sympatric species of Neotoma. Wood (1969) studied rodents of desert rangelands in Dona Ana County, New Mexico. He found that both N. albigula and N. micropus reached greatest densities on the chamiza-mesquite cover-type. Diets of both species were comprised almost exclusively of plant foods, but the proportion

of the diet derived from various classes of forage differed. N. micropus ate relatively more green vegetation (43 vs. 38 per cent of diet by volume) and more succulent vegetation (20 vs. 7 per cent) than did N. albigula, whereas N. albigula ate more yucca leaves (33 vs. 16 per cent) than did N. micropus. Wood (1969:17) concluded that these dietary differences minimized competition for trophic resources. Wright (1973) documented the sympatry of N. micropus and N. albigula in the same area. He suggested that coexistence was an ecological novelty in the vicinity of Las Cruces, due to disturbance of the landscape by overgrazing. Competition for cover was suspected between the woodrats, but dietary differences were supposed to minimize overall effects of competition.

Cameron (1971) investigated competition between N. fuscipes and N. lepida in the Mojave Desert of southeastern California. The animals built dissimilar houses and generally were ecologically distinctive, although both species preferred oak foliage as food. Where the species occurred in "micro-sympatry," however, the diet of N. lepida shifted to emphasize juniper. Laboratory studies suggested that N. fuscipes is behaviorally dominant to N. lepida, and thus is competitively superior.

The present study showed broad agreement with the suggestion of Finley (1956) that vegetation per se is of little importance to distributional ecology of woodrats. On the other hand, the often pronounced differences in den sites or construction observed in southwestern Colorado were not obvious in the study area in southeastern Utah. Physiographic situation was closely controlled in the present study, and no obvious differences were seen among dens. Indeed, there seems to be a complex serial occupation of dens by woodrats of various species over the course of decades or centuries. Studies of food habits and preferences are incomplete, and data on den structure have not been examined in detail, but at present it seems that the most fruitful field for further study may be laboratory investigation of behavioral interactions. My present hypothesis is that habitat segregation occurs at the level of individual agonistic interactions. The landscape contains a seeming surfeit of suitable sites for woodrat dens. Competition for them should occur only when dispersing individuals approach the same crevice at the same time. Otherwise, competition should be minimal, for at this time in the ecological evolution of local communities, there seems to be no common requisite of the three species in short supply.

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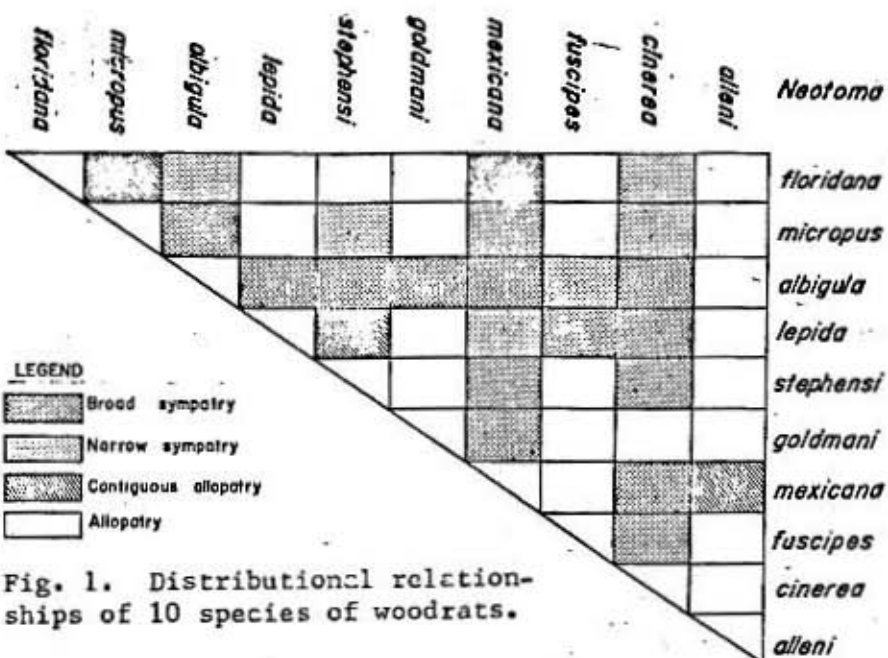


Fig. 1. Distributional relationships of 10 species of woodrats.



Fig. 2. Superimposed continental ranges of 10 species of woodrats (*Neotoma*).

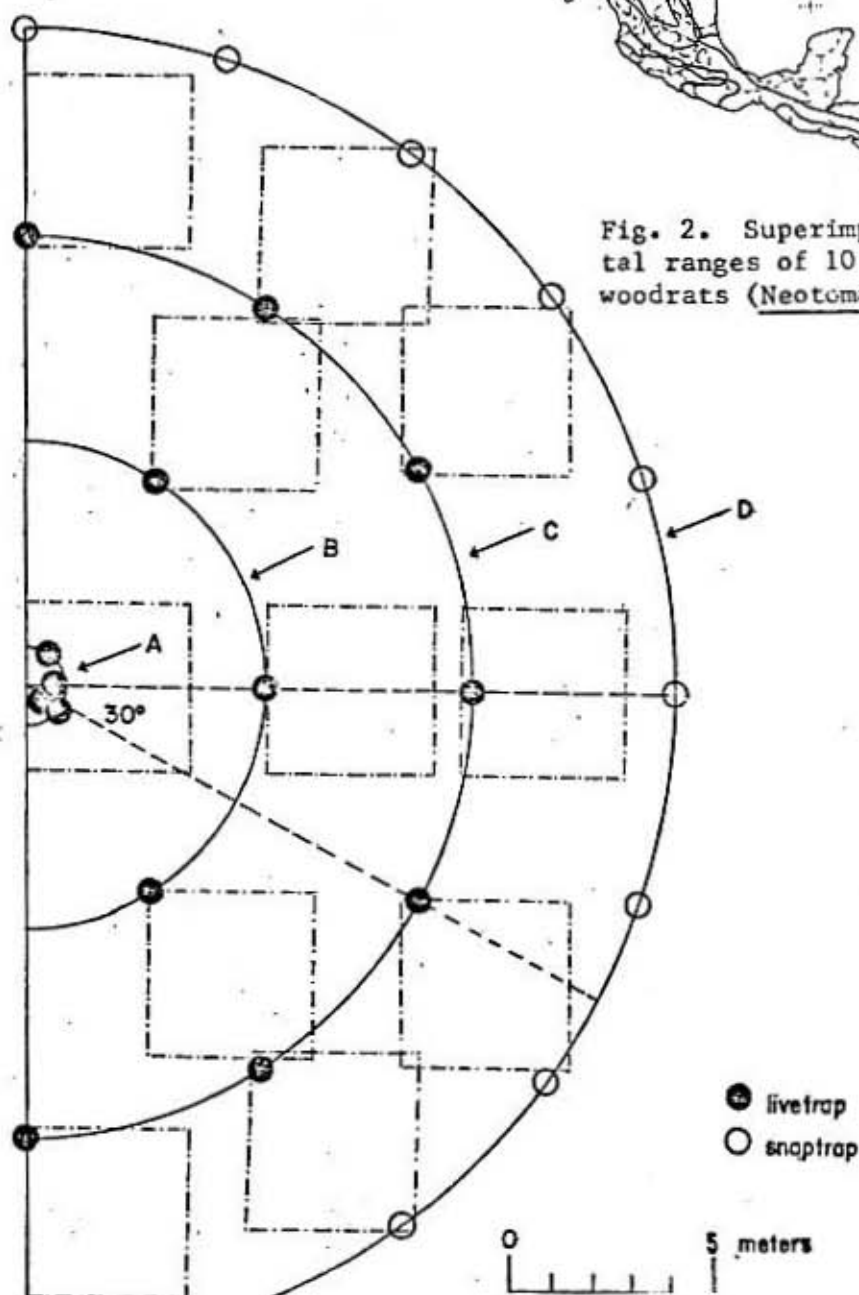


Fig. 3. Plan of sampling grid (for description, see text).

TABLE 1. Average absolute importance of synusiae on grids.

Dens of:	Broadleaved, deciduous trees	Needleleaved, evergreen trees	Shrubs	Aphyllous shrubs	Stem succulents	Rosettes	Graminoids	Forbs
<i>Neotoma mexicana</i>	100.0	165.8	310.4	17.2	94.1	48.8	193.7	331.7
No. of grids	6	9	12	1	5	3	10	12
Minimum	0	0	177	0	0	0	0	255
Maximum	218	255	493	209	209	218	336	432
<i>Neotoma albigula</i>	110.0	174.7	297.1	52.2	52.2	0	172.0	285.6
No. of grids	2	3	4	1	1	0	3	4
Minimum	0	0	218	0	0	0	0	175
Maximum	236	236	493	209	209	0	261	373
<i>Neotoma cinerea</i>	109.0	220.2	293.2	104.5	52.2	31.7	127.2	283.2
No. of dens	2	4	4	2	1	1	3	4
Minimum	0	209	218	0	0	0	0	208
Maximum	227	227	491	209	209	127	218	335
occupied	89.6	141.8	261.8	52.2	81.7	79.5	197.2	308.5
No. of dens	3	5	8	2	3	3	8	8
Minimum	0	0	209	0	0	0	0	227
Maximum	218	258	427	209	227	209	281	446

TABLE 2. Mean relative synusial importance values for vegetation about woodrat dens. Index is sum of three percentages: relative frequency, relative density, and relative coverage of synusia with respect to entire grid.

Dens of:	Broadleaved, deciduous trees	Needleleaved, evergreen trees	Shrubs	Aphyllous shrubs	Rosettes	Stem succulents	Forbs	Graminoids
<i>Neotoma mexicana</i>	15.6	35.8	89.9	2.5	6.3	5.5	114.4	30.2
No. of grids	11.5	27.8	104.7	0.4	1.5	5.7	116.0	39.6
Minimum	0	0	66.8	3.5	0.0	0.0	111.0	38.2
Maximum	20.0	59.0	93.2	6.5	4.8	2.5	116.2	29.8
<i>Neotoma albigula</i>	10.5	40.8	83.4	4.1	15.9	7.0	111.4	30.1
No. of dens	12.6	36.0	83.4	4.1	15.9	7.0	111.4	30.1
Minimum	0	0	66.8	3.5	0.0	0.0	111.0	38.2
Maximum	20.0	59.0	93.2	6.5	4.8	2.5	116.2	29.8

TABLE 3. Plant species diversity and habitat diversity on sampling grids adjacent to woodrat dens. For explanation, see text.

Den No.	Species Diversity		Habitat Diversity	
	Simpson's 1'	Shannon's H'	Simpson's 1'	Shannon's H'
<i>Neotoma mexicana</i>				
1	.19630	2.63653	.29019	1.93925
3	.15978	3.09984	.41566	1.49079
4	.15151	2.98000	.25387	2.06752
5	.53059	1.65686	.65385	0.92681
7	.17960	2.81436	.74242	0.60940
8	.21401	2.89436	.52632	1.35937
10	.27653	2.43730	.35730	1.85797
12	.07665	3.45850	.31372	2.02633
13	.17509	3.04415	.41667	1.51799
14	.20982	2.78714	.44346	1.35319
23	.18269	2.73714	.50580	0.98729
24	.11234	3.42846	.42590	1.41937
<i>Neotoma cinerea</i>				
2	.12836	3.59178	.20331	2.78184
19	.08736	3.37633	.49885	1.44859
22	.16995	2.91251	.29433	1.82941
25	.12179	3.34940	.49463	1.29947
<i>Neotoma albigula</i>				
16	.05550	3.62593	.33496	1.86456
20	.06842	3.28416	.23684	2.04144
22	.16995	2.91251	.29433	1.82941
23	.18269	2.73714	.50580	0.98729
Unoccupied dens				
6	.30960	2.02702	.49344	1.05160
9	.32149	2.45836	.58143	1.14285
11	.19371	2.17128	.41168	1.50645
15	.14130	2.86910	.50725	1.40822
17	.20000	2.23346	.22505	2.03065
18	.08421	3.28416	.16842	2.39044
21	.06926	3.44383	.15584	2.56057
26	.12079	3.24608	.46277	1.22467
Kruskal-Wallis H-Statistic	6.906243 n. s.	6.400706 n. s.	1.532787 n. s.	0.637166 n. s.