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SMALL MAMMALS OF THE REGIONAL COPPER-NICKEL STUDY AREA

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INTRODUCTION TO THE REGIONAL COPPER-NICKEL STUDY

The Regional Copper-Nickel Environmental Impact Study is a comprehensive examination of the potential cumulative environmental, social, and economic impacts of copper-nickel mineral development in northeastern Minnesota. This study is being conducted for the Minnesota Legislature and state Executive Branch agencies, under the direction of the Minnesota Environmental Quality Board (MEQB) and with the funding, review, and concurrence of the Legislative Commission on Minnesota Resources.

A region along the surface contact of the Duluth Complex in St. Louis and Lake counties in northeastern Minnesota contains a major domestic resource of copper-nickel sulfide mineralization. This region has been explored by several mineral resource development companies for more than twenty years, and recently two firms, AMAX and International Nickel Company, have considered commercial operations. These exploration and mine planning activities indicate the potential establishment of a new mining and processing industry in Minnesota. In addition, these activities indicate the need for a comprehensive environmental, social, and economic analysis by the state in order to consider the cumulative regional implications of this new industry and to provide adequate information for future state policy review and development. In January, 1976, the MEQB organized and initiated the Regional Copper-Nickel Study.

The major objectives of the Regional Copper-Nickel Study are: 1) to characterize the region in its pre-copper-nickel development state; 2) to identify and describe the probable technologies which may be used to exploit the mineral resource and to convert it into salable commodities; 3) to identify and assess the impacts of primary copper-nickel development and secondary regional growth; 4) to conceptualize alternative degrees of regional copper-nickel development; and 5) to assess the cumulative environmental, social, and economic impacts of such hypothetical developments. The Regional Study is a scientific information gathering and analysis effort and will not present subjective social judgements on whether, where, when, or how copper-nickel development should or should not proceed. In addition, the Study will not make or propose state policy pertaining to copper-nickel development.

The Minnesota Environmental Quality Board is a state agency responsible for the implementation of the Minnesota Environmental Policy Act and promotes cooperation between state agencies on environmental matters. The Regional Copper-Nickel Study is an ad hoc effort of the MEQB and future regulatory and site specific environmental impact studies will most likely be the responsibility of the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency.

INTRODUCTION

As part of the Regional Copper-Nickel Study a 2-year field study of small mammals was carried out in northeastern Minnesota. Two aspects of this study are treated in this report: an analysis of the relationships between small mammals and their habitats, and an examination of how these measurements can serve in predicting or monitoring environmental impacts of mining operations.

This research was part of the study of the terrestrial ecosystem. Field data on small mammals were collected in 1976 and 1977. Both years of data were used in the analysis. The vegetation classifications and measurements of habitat features utilized in this report were based on vegetation methods chosen and data colleciton and analyses reported in a first level report on terrestrial vegetation.

Ecological relationships between small mammals and their habitats

Distribution, abundance, and species diversity of small mammals may be influenced by a variety of habitat features. Habitat associations were recognized by Burt (1957), Gunderson (1959), Spencer and Pettus (1966), Banfield (1974), Richens (1974), and Kalin (1976); and recently correlations between small mammal abundance and cover types (Brower and Cade, 1966; Rosenzweig and Winakur, 1969; Lovejoy, 1973; Miller and Getz, 1977), vegetation structure (M'Closkey and Fieldwick, 1975; M'Closkey and Lajoie, 1975), soil types (Rosenzweig and Winakur, 1969), and soil moisture (Pruitt, 1959; Buckner, 1966; Lovejoy, 1973) have been attempted.

Previous studies in northeastern Minnesota have dealt with population dynamics (Beer et al., 1954; Frenzel, 1957) or general habitat associations (Ohmamm et al., 1973; Timm, 1975). Several researchers in this region have approached relationships between small mammals and habitat features in a qualitative way (Ahlgren, 1966; Krefting and Ahlgren, 1974).

The present study attempts to quantify habitat relationships of small mammal distribution, abundance, and diversity. For ground-dwelling species, variations in amount of cover, litter, and soil moisture may be critical; shrub layer variables may relate to arboreal species. Experiments to measure directly resources and explore causal relationships were not feasible in this study, but structural factors can be expected to reflect the availability of shelter from predators, of nesting sites, of food, and of other resources.

Species richness and diversity are commonly-used measures of the small mammal community. Relationships have been found between these measures and various habitat features (Kalin, 1976; Whitford, 1976; Miller and Getz, 1977). Rosenzweig and Winakur (1969) accounted for species diversity by the observed habitat requirements of the individual species. An attempt was made here to relate richness and diversity measures with features that may reflect habitat diversity. By providing a greater array of resources for the individual species, the more diverse and patchy habitat may support a more diverse small mammal community.

By measuring habitat features in a variety of habitat types, those features that are related to small mammal abundance and diversity independent of habitat type may be revealed. In addition, any relationships can be examined over a wide range of values for each habitat feature.

Assessment of impacts on small mammals

The goals of environmental impact assessment are to predict significant impacts caused by an action and to provide this information to decision-makers for use as a basis for stopping or altering a proposed action. The sequence of approaching impact assessment - describing the proposed action, defining anticipated physical and chemical changes, and deciding upon and accurately measuring aspects of the biota that will be impacted - is crucial to its effectivenes. Due to insufficient funding and time, this sequence is often not followed: the resulting environmental impact assessment may stress immediate and direct impacts while ignoring long-term and indirect ones, or may make predictions that cannot be verified by pre- and post-operational studies on treatment and control sites.

Environmental impact assessments often consist of floristic and faunal surveys conducted prior to an action from which an index of species diversity is derived. This index is then used as a measure of the value of that particular community; subsequent siting decisions may attempt to preserve those communities with the highest diversity.

Community worth may also be ranked according to other criteria: value as critical habitat for rare and endangered species, the uniqueness of the community, economic value, biological value as a pollution sink and nutrient cycler (Westman, 1977), and aesthetic value.

Although diversity has merit as a decision-making tool, its temporal fluctuations (Whitford, 1976) and possible insensitivity to population decreases make diversity a generally unsatisfactory "magic number" (Hedgpeth, 1973; Eberhardt 1976) for measuring impacts. Measures on individual species or other ecosystem characteristics may provide more information on impacts than does species diversity.

High natural variability in all aspects of the environment (animal populations, vegetation, productivity, decomposition rates, physical and chemical parameters) impose a large constraint on the collection of assessment data. Even in a properly designed monitoring program including pre- and post-operational sampling, large sample sizes are needed to separate change attributable to an action's impact from change caused by natural variability in space and time.

Inherent variability is well illustrated by small mammal populations, whose fluctuating abundance (Krebs and Myers, 1974) and plasticity in litter size and frequency (Iverson and Turner, 1976; Rintamaa et al., 1976) make impact-related changes difficult to detect. Nonetheless, impact assessments often include field studies of small mammals. Such studies can examine impacts on the basis of their importance to individual species or in light of their effects on ecosystem function.

The latter "holistic" approach (Odum, 1977; States et al., 1978) to impact assessment has gained importance and acceptance as widespread alterations of ecosystems due to man's activities are documented (Gorham and Gordon, 1960; Jordan, 1975; Tamm, 1976; Wright and Gjessing, 1976). The part of small mammals in energy and nutrient flow in forest ecosystems appears minor (reviewed by Potter, 1978). They may however contribute to ecosystem resiliency and resistance by regulating certain ecosystem processes (Chew, 1978) and maintaining higher trophic levels (Wagner, 1978; Potter, 1978).

Small mammals and the Regional Copper-Nickel Study

The present small mammal study is part of the Regional Copper-Nickel Study, an impact assessment conducted with legislative funds by the Minnesota State Planning Agency and addressing heavy metals mining development in northeastern Minnesota. Resulting changes that might impact small mammal populations are listed in Table 1 for each stage. The objectives of the Regional Copper-Nickel Study are to (1) describe the environment of the region prior to the start of mining operaitons, (2) determine the potential for changes caused by development, and (3) to assess the impacts on the region's environment.

The small mammal portion of this assessment has two parallel objectives: to describe small mammal distribution, abundance, and diversity by habitat type and to assess the possible impacts of the proposed action on small mammals. Surveys of populations within different habitat types provide data for faunal descriptions and for assessing impacts caused by gross land use changes. Relationships between small mammal abundance and features of their habitats are an important key in assessing impacts of physical and chemical changes in the environment. Vegetation composition, structure, and spatial arrangement may be altered by mining heavy metals. If species abundance is related to specific habitat features, then a change in that abundance may be predicted from any impact-related change in those habitat features.

DESCRIPTION OF THE STUDY AREA

The small mammal studies were conducted in the 5180 km^2 Regional Copper-Nickel Study Area. The Study Area is characterized by rolling, glaciated topography, and is a mosaic of vegetation of boreal and northern xeric forest types (Maycock and Curtis, 1960). A large portion of the eastern one-third of the Study Area is underlain by bedrock of the Duluth Complex. Copper and nickel sulfide ores are exposed at the surface along the contact line between the Duluth Complex and older rocks to the west. Along and directly east of this contact line is the region where mining would occur.

Glacial deposits overlie the bedrock in the area (Wright and Watts, 1969). Shallow soils with areas of exposed bedrock are characteristic of the northern poriton of the Study Area, whereas deeper, more loamy soils are found in the southern portion (Minnesota Department of Natural Resources, 1976; Olcott and Siegal, 1978).

The presettlement vegetation of the Study Area, as compiled from land survey data of the 1880's (Marshner, 1930), consisted of four major types: aspen-birch-conifer, white and red pine, jack pine barrens and openings, and conifer bogs and swamps. Distribution of these types closely corresponded to physiographic features (Sather, 1979). With subsequent logging over the past 90 years, aspen-birch-conifer has increased and pine has decreased (Table 2). Today, plantations of pines a few natural stands of jack pine account for virtually all the present coverage of these species.

The average yearly precipitation of Babbitt, Minnesota (in the west-central portion of the Study Area) is 721.4 mm. Monthly precipitation in April through September for the two study years and a thirty-year average is given in Table 3.

METHODS

Site Selection

An attempt was made to allocate sites equally among forest management vegetation types as classified by the U.S. Forest Service (Stone, 1966) with respect to stand age and soil type. Seventy-one sites were arbitrarily selected based on accessibility and apparent homogeneity of the forest management type. Study sites were located in wetlands, upland forests of various ages, and clear cuts (Fig. 1).

Field procedures

One or more trapping grids was established on each of the 71 sites for a total of 87 grids - 40 in 1976 and 47 in 1977. A standard grid consisted of 8 x 8 trap stations laid out 15 m apart with the aid of compass and rangefinder. Exceptions to this shape were made where sites were irregular. Grids were placed in a minimum of 15 m from an appreciable change in vegetation.

One Museum Special Snap trap was placed at each station. Traps were prebaited for 2 nights, then baited and set for 5. Bait was a mixture of peanut butter and rolled oats. Traps were checked once daily and collected specimens were frozen. All trapping occurred during the summer months.

Specimens were identified from external features of body measurements, pelage, and dentition. Specimens of questionable identity were examined by the curatorial staff of the Bell Museum of Natural History, Unviersity of Minnesota, and compared to known specimens in the museum colleciton.

Vegetation on all sites was surveyed by a relevé method involving a visual assessment of form, structure, and species composition (Mueller-Dombois and Ellenberg, 1974). In addition, quantitative data were collected on systematically placed plots within one grid per site. Trees (dbh > 7.0 cm) were counted on 5 15 x 15 m plots on each grid, shrubs > 1 m high counted on 20 2 x 2 m plots, and low shrubs ($\leq$ 1 m high) and ground cover percentage on 15 1 x 1 m plots (Figs. 3 and 4).

Density of the shrub layer was ranked by a visible-intercept method on each tree plot. Sampling points were located 2 m inward from the four corners of each tree plot. More or less than 50% coverage of a 25 cm^2 card was recorded by the observer at the corner for 8 contiguous 25 cm intervals between 0 and 200 cm above ground level.

Deadfall was measured on 0.5 m transects laid parallel to trap lines of 47 grids. For each deadfall > 7.0 cm in diameter, diameter at point of transect intersection was measured and length estimated. The length and number of transects on each grid varied. Transects were also omitted if they followed along distinct windrows.

Litter depth was measured as the depth to mineral soil by probings made 1 m outward from 25 randomly chosen stations on each of 47 grids.

Data Analysis

Relative density was estimated as the total number of specimens caught divided by the area of the grid. Discrepancies in which one night of trap data were missing between the field and museum tallies on five grids were corrected; the appropriate numbers of individuals were added to the museum tallies and assigned species according to their proportion on the grids during the other four trap nights. Small mammal numbers diversity (SMD) was calculated as:

$$\frac{1}{\Sigma p_i^2}$$

where p_i is the proportion comprised by the i^{th} species (Rosenzweig and Winakur, 1967).

A sum-of-squares clustering method using an absolute distance measure (Orloci, 1967) based on plant species presence and abundance on site releves grouped sites according to vegetational similarity (Sather, 1979). Data from 206 additional releves (Cushing et al; 1972) from the region were included to broaden the data base. Each site was classified into four vegetation groups according to canopy, high shrub, low shrub, and herb species.

Plant species numbers, basal area, stem number, and percent cover of 12 ground cover types were estimated from the quantitative data. Ground cover diversity (GCD) was calculated as:

$$\frac{1}{\Sigma p_i^2}$$

where p_i is the average proportion comprised by the i^{th} cover type. As a measure of spatial heterogeneity, ground cover patchiness was measured as:

$$\text{Patchiness}_j = {}^{n}j/n_s \; (\Sigma\, SD_i)$$

where SD_i is the standard deviation of the i^{th} cover type on grid j, n_j is the number of cover types on grid j, and n_s is the smallest number of cover types on any grid.

Foliage height diversity in the shrub layer (FHD) was calculated as:

$$\frac{1}{\Sigma p_i^2}$$

where p_i is the proportion of the > 50% coverage observations that is contained in the i^{th} 25 cm interval. Structural patchiness was measured as:

$$\Sigma\, SD_i$$

where SD_i is the standard deviation on the average proportion of > 50% coverage observations among the 5 tree plots in the i^{th} interval.

A deadfall index was generated by estimating cover of individual deadfalls as diameter at point of intersection x estimated length x 100, obtaining an average estimate of deadfall cover per transect, and dividing by transect area. Average litter depth was calculated.

Site indices of moisture, nutrients, heat, and light were obtained by averaging the corresponding synecological values of each plant species present on the relevé (Bakuzis, 1959).

Contingency table analysis examined associations of small mammals with broad habitat types of upland coniferous forest, upland deciduous forest, wetland, and clear-cut, and with vegetation groups defined by cluster analysis as described previously. Data from several grids which were classified into small anomalous vegetation groups were omitted. Spearman's rank correlation (Siegal, 1956) determined significant relationships between species relative density and small mammal community features and habitat features derived from the quantitative data. Data from grids trapped in June of 1976, which sampled populations earlier in the breeding season not comparable to those sampled in later summer months were omitted from the correlations. In both analyses, data from each year were treated separately.

RESULTS

Small mammal species - habitat associations

Vegetation categories used in contingency table analysis and their corresponding vegetation groups as defined by cluster analysis (Sather, 1979 ; see also Appendix) are presented in Table 4. The distribution pattern of small mammals among these categories from which contingency tables were derived is shown in Tables 5 through 9. The results of chi-square tests on these contingency tables are given in Tables 10 through 14.

Relative densities (Tables 15 and 16) were correlated with the habitat features shown in Tables 17 and 18. The resulting rank correlation coefficients are given in Tables 19 and 20.

Sorex arcticus

Although sample size was small in 1976, Sorex arcticus was strongly associated both years with wetlands, particularly those with ericaceous low growth. The species was most frequently found on grids having heath-like low shrubs and wetland herbs.

The relative density of Sorex arcticus was correlated both years with low shrub stem density, moisture, and light. Other significant habitat features include moss and low woody ground cover. In this study, Sorex arcticus attained its highest relative densities in bogs with a dense cover of low shrubs such as Chamaedaphne calyculata (leatherleaf).

Many researchers (Quimby, 1943; Buckner, 1957; Burt, 1957; Jackson, 1961; Banfield, 1974) have noted the association of Sorex arcticus with wetland habitats, such as tamarack and black spruce swamps and alder and willow marshes. Some investigators have stated that this species is found in moist situations (Gunderson and Beer, 1953; Burt, 1957; Iverson et al., 1967; Kalin, 1976) whereas others have suggested that Sorex arcticus prefers drier habitats (Buckner, 1957; Banfield, 1974; Timm, 1975). Buckner (1966) demonstrated an inverse relationship between soil moisture (measured by the depth of the water table) and the population of Sorex arcticus within lowlands. The current study supports the view that moisture is an important component of the habitat for Sorex arcticus.

Sorex cinereus

Within the Study Area, Sorex cinereus was a habitat generalist. It was found on 80 of 87 grids, although the species did favor wetlands in 1976.

Moisture appears to be an important factor in determining the relative density of Sorex cinereus. These two measures were significantly correlated for both years of data. No other habitat feature shows such consistency. The correlations with low shrub stem density and percent moss cover suggest that higher densities of this species are found in wetlands with ericaceous low growth.

Much of the literature on Sorex cinereus mentions its wide range of habitats (Jackson, 1961; Richens, 1974; Timm, 1975; Kalin, 1976), although some authors have claimed that this species prefers marshes (Quimby, 1943; Spencer and Pettus, 1966) and boggy area (Manville, 1949). Banfield (1974), while mentioning the broad habitat spectrum over which Sorex cinereus can be found, stressed humidity as a restricting factor. Lyon (1936), Manville (1949), Buckner (1957), and Getz (1961b) referred to this species' close ties with moist habitats. Kalin (1976) found the largest populations of Sorex cinereus in mixed lowlands. Lowland habitats, whether bog or deciduous appear to contain higher relative densities of Sorex cinereus than uplands.

Microsorex hoyi

The distribution pattern of Microsorex hoyi changed over the two study years. The species was associated with wetlands, heath-type low shrubs, and wetland herbs in 1976; there were no significant habitat associations in 1977. Microsorex hoyi appears to have changed from an associate of wetland habitats in 1976 to a habitat generalist in 1977. However, the sample size in 1976 was small and may account for the observed difference.

Relative densities of Microsorex hoyi, following much the same pattern of relationships with habitat features as Sorex cinereus, were significantly correlated with moisture during both years, with low shrub stem density during 1976, and with percent moss cover in 1977. As with both Sorex species, the relative density of Microsorex hoyi is related to habitat moisture.

There is disagreement in the literature on the habitat preference of Microsorex hoyi. Burt (1957), Jackson (1961), and Banfield (1974) stressed the association of this species with grassy forest clearings. In contrast, other authors have found this species in marshy areas (Spencer and Pettus, 1966; Long, 1972). Burt (1957) and Jackson (1961) stated that this species inhabits dry situations, and Buckner (1966) found Microsorex hoyi only rarely in the bogs he studied. Gunderson and Beer (1953) grouped this species with the Sorex shrews in their association with moisture. The results of this study suggest that the habitat association of Microsorex hoyi is plastic, while the relationship between the species' abundance and moisture remains constant. Wetlands may have acted as refugia for Microsorex hoyi during the drought in 1976. Greater rainfall producing moister conditions in

1977 may have allowed this species to expand into upland habitats.

Blarina brevicauda

Blarina brevicauda was strongly associated in 1976 with deciduous and mixed coniferous-deciduous forest habitats. Tests among canopy and high shrub categories were also significant in 1976; Blarina brevicauda was most frequently found in mixed and aspen-birch canopy types and in habitats with dense or no high shrubs. None of these associations was significant in 1977 when the sample size for Blarina brevicauda was small.

The results of the correlation analysis on Blarina brevicauda are inconclusive. For 1976, only the positive relationship between relative density and structural patchiness was significant. The high number of significant correlations in the 1977 data is probably due to the small proportion of grids on which this species was caught.

It is frequently stated that Blarina brevicauda has a broad habitat association (Manville, 1949; Jackson, 1961; Kalin, 1976). Many researchers have also emphasized a preference for deciduous forests (Pruitt, 1959; Ozoga and Verme, 1968; Richens, 1974; Timm, 1975). Blarina brevicauda will withdraw to favorable refugia during dry periods (Banfield, 1974), a possible explanation for the relatively high populations of Blarina brevicauda concentrated in deciduous and mixed forest habitats during 1976.

Many authors have mentioned the preference of Blarina brevicauda for moist habitats (Burt, 1957; Pruitt, 1959; Getz, 1961; Jackson, 1961; Banfield, 1974) and deep leaf litter (Manville, 1949; Pruitt, 1953; Banfield, 1974). These relationships are not indicated in these data. The extremes in both precipitation and apparent population density during the study may have acted together in masking similar relationships.

Tamias striatus

Tamias striatus was observed almost exclusively in upland deciduous forests during 1976. It was positively associated with aspen-birch forests, dense high shrubs and mesic herbs. These habitat associations were not repeated in 1977, perhaps because of the small sample size.

For 1976, the highest relative densities of Tamias striatus were found in habitats with a well-developed, patchy shrub layer. Correlations between relative density and the number of high shrub stems, foliage height diversity, and structural patchiness were significant. As with Blarina brevicauda, the data for 1977 are inadequate for meaningful correlation analysis.

The association of Tamias striatus with deciduous habitats has been noted by several authors (Banfield, 1974; Kalin, 1976). Forbes (1966), however, found high numbers of this in jack pine forests as well as aspen forests, and Timm (1975) caught Tamias striatus in all forest types. The results of the current study support the view (Gunderson and Beer, 1953; Burt, 1957; Hoffmeister and Mohr, 1957; Jackson, 1961) that Tamias striatus is associated with brushy woods and brushlands. Forbes (1966) stated that this chipmunk is associated with an understory of Corylus cornuta (hazel), the species which largely makes up the dense high shrub layer on deciduous grids in the study area.

Eutamius minimus

A strong association with clearcut habitats was demonstrated by Eutamias minimus. The association with upland coniferous forests may be due to the proximity of clearcuts to these stands. There was no significant association with any specific vegetation category; the vegetational composition of the clearcut is apparently not important.

Eutamias minimus showed no significant relationships with the limited number of habitat features available for 1976. Correlations in the data of 1977 occurred between relative density and tree basal area, percent cover of deadfall, the deadfall transect index, percent cover of bare ground, ground cover diversity, and ground cover patchiness. Fewer trees, more deadfall, and greater diversity and patchiness of ground cover may be characteristic of clearcut habitats.

These results support the findings of previous researchers. Manville (1949), Burt (1956), and Banfield (1974) mentioned this species' preference for openings with brush and slash piles. Timm (1975) stated that Eutamias minimus is common on recently logged or burned areas. Forbes (1966) captured the highest numbers of this chipmunk in disturbed areas with rock, brush, and slash piles.

Peromyscus maniculatus

In both years, Peromyscus maniculatus showed a marked negative association with wetland habitats. Tests on the broad habitat categories are highly significant, with similar results found in the tests on the specific vegetation categories of canopy, high shrubs, and herbs.

Although Peromyscus maniculatus exhibited strong correlations with three of the four synecological coordinates in 1976, these relationships did not appear in the following year's data. For 1977, the relative density of this species was positively related to the amount of litter; the greater the percent cover of litter and its depth, the higher the relative density of Peromyscus maniculatus. These tests could not be repeated for the 1976 data.

The avoidance of wet habitats by Peromyscus maniculatus has been noted by Banfield (1974) and Timm (1975). These two researchers, along with Manville (1944) and Jackson (1961), referred to the ubiquitousness of this species in forested uplands. Manville (1949) and Jackson (1961) implied a relationship between dead material in a habitat and the presence of Peromyscus maniculatus.

Because some mice of the genus Peromyscus are arboreal, a relationship might be expected between the relative density of Peromyscus species and some measure of the vertical component of the habitat, such as foliage height diversity or shrub density. Such relationships have been noted for Peromyscus leucopus (M'Closkey and Fieldwick, 1975; M'Closkey and Lajoie, 1975). Miller and Getz (1977) and the present study have found no evidence to support this hypothesis in Peromyscus maniculatus.

Clethrionomys gapperi

Clethrionomys gapperi, the most ubiquitous of the small mammals caught on the Study Area is a habitat generalist. It was captured on 85 of 87 grids. In those contingency table tests that are significant (high shrubs in 1976; low shrubs in 1977), differences between the observed and expected values are small.

Litter and deadfall appear to be important components of the habitat for Clethrionomys gapperi. The greater the percent of litter and deadfall in the ground cover, the higher the relative density of this species in 1977. These relationships could not be tested for the 1976 data. Other significant correlations in the 1977 data were not repeated in that for 1976.

The literature presents conflicting views on the habitat association of Clethrionomys gapperi. Burt (1957), Timm (1975), and Kalin (1976) considered upland deciduous and mixed forests to be its preferred habitat. Conifer swamps were mentioned as important habitats by Manville (1949), Gunderson (1959), and Timm (1975). Banfield (1914) stated that coniferous forests are preferred. The present results agree with those reported by Jackson (1961) and Richens (1974); Clethrionomys gapperi is abundant in a broad range of habitats.

Many researchers have noted a preference by Clethrionomys gapperi for moist habitats (Manville, 1949; Jackson, 1961; Getz, 1968; Banfield, 1974). Kalin (1976) found this species under a variety of moisture conditions. The importance of deadfall and litter to this vole has been stressed by Gunderson (1954) and Banfield (1974). Miller and Getz (1977) found a positive correlation between relative abundance of Clethrionomys gapperi and percent cover of debris (including deadfall and rocks) similar to that found here.

Microtus pennsylvanicus

Microtus pennsylvanicus showed a difference in its distribution pattern between the two years. This species demonstrated a strong association with all categories of wetland vegetation in 1976; it was a habitat generalist in 1977.

Microtus pennsylvanicus followed a similar pattern of relationships to habitat features as Sorex arcticus. There were strong positive correlations between the relative density of Microtus pennsylvanicus and low shrub density, high shrub basal area, and moisture in both 1976 and 1977. Certain significant correlations, including the percent cover of graminoids, mosses, low woody plants, and bare ground, could only be tested for 1977. In this study, Microtus pennsylvanicus attained its highest relative densities in bogs and other habitats with a high proportion of grasses in the ground cover.

Many researchers have stated that Microtus pennsylvanicus prefers lowland meadows that provide both moisture and dense grass cover (Manville, 1944; Burt, 1957; Hoffmeister and Mohr, 1957; Jackson, 1961; Timm, 1975). Getz (1961a) found a tentative correlation between the abundance of this species and the amount of graminoid cover. Microtus pennsylvanicus is also found in upland meadows (Banfield, 1974; Richens, 1974; Timm, 1975; Kalin, 1976): it attained its highest relative density on one such grid during this study.

In agreement with most literature, Microtus pennsylvanicus displayed an association with wetlands in 1976. However, this relationship was not maintained during the second year of study. As has been hypothesized for Microsorex hoyi, wetlands may have acted as refugia for Microtus pennsylvanicus in 1976.

Zapus hudsonius

Zapus hudsonius appears to be a habitat generalist within the study area. Only one Chi-square test, that on the herb categories in 1976, was significant. This association with disturbance species of herbs was not repeated in 1977.

For 1977, a high proportion of forbs and bare ground and high heat and light were favorable to high relative densities of Zapus hudsonius. There were no significant correlations in the 1976 data.

Most of the literature on Zapus hudsonius refers to a preference for moist habitats (Lyon, 1936; Quimby, 1951; Dexter, 1954; Hoffmeister and Mohr, 1957; Timm, 1975), such as lowland meadows. Others have collected the species in a wide range of habitats (Manville, 1949; Getz, 1961c; Iverson and Turner, 1967; Kalin, 1976). Kalin (1976) concluded that this species has a broad habitat spectrum. Implied relationships between Zapus hudsonius and moisture and brushy areas (Jackson, 1961; Whitaker, 1963) were not evident in the present data.

Napaeozapus insignis

In 1976, Napaeozapus insignis was associated with upland deciduous forests. This association did not extend to the specific vegetation categories. Only the test on canopy categories was significant in 1977, with the mixed forest canopy being favored. However, the sample size in 1977 was small and may have affected the results.

As with Blarina brevicauda and Tamias striatus, the results of the correlation analysis on Napaeozapus insignis are inconclusive. A single significant correlation occurred between the relative density of this species and nutrients in the 1976 data. The large number of significant correlations for 1977 is probably due to the small sample size.

Sheldon (1934), Jackson (1961), Iverson and Turner (1973), and Lovejoy (1973) all noted the association of Napaeozapus insignis with deciduous forests. Timm (1975) and Kalin (1976) found the species in mixed upland forests. A relationship between the relative density of Napaeozapus insignis and moisture (either in the soil or as running water) has been widely implied (Sheldon, 1934; Iverson and Turner, 1973; Lovejoy, 1973; Banfield, 1974; Timm, 1975). Other researchers have found an association between high densities of Napaeozapus insignis and dense shrub and herb cover (Brower and Cade, 1966; Miller and Getz, 1977).

Distributional patterns of small mammals

Sorex cinereus was the most abundant and frequent species on the wetland sites (Tables 21 through 23), while other species of shrews and Eutamias minimus were relatively frequent, but not abundant. Peromyscus maniculatus, an upland species, was found in cedar swamps. Clethrionomys gapperi was present in all wetland types; Microtus pennsylvanicus was more abundant in tamarack bogs. Synaptomys cooperi was captured on one site in a closed tamarack stand.

Clethrionomys gapperi and Sorex cinereus codominated mature upland forest sites (Tables 22 and 23). Peromyscus maniculatus was generally third in average abundance. Eutamias minimus was characteristic of mature pines; Tamias striatus attained high frequency and abundance only in mature aspen-birch sites. Blarina brevicauda was characteristic of deciduous and mixed forest sites. Several other species were consistently present at low relative densities.

Eutamias minimus codominated with Clethrionomys gapperi on upland sites (Table 23). Sorex cinereus, Peromyscus maniculatus, and Zapus hudsonius were also commonly found species. The single grassland site was dominated by Microtus pennsylvanicus.

Small mammal community - habitat associations

The value of small mammal community characteristics are listed in Tables 24 and 25. The results of correlation analysis between these characteristics and specific habitat features (Tables 17 and 18) are shown in Tables 26 and 27.

Small mammal species richness, diversity, and total relative density were not consistently correlated with any habitat feature. In 1977, insectivore diversity showed a strong positive correlation with percent cover of mosses, accompanied by a negative correlation with forb ground cover. The diversity of cricetids and zapodids was positively correlated with percent cover of litter in 1977. These relationships could not be tested for 1976.

The correlations in 1977 between insectivore diversity and moisture, nutrients, and heat were not found in the 1976 data. The negative relationship between diversity of cricetids and zapodids and moisture was found both years. Drier sites appear to favor a more evenly distributed community of cricetid and zapodid species.

The ratio of insectivore relative density to total relative density showed strong correlations to numerous habitat features in 1977. Only one of these significant relationships, a positive one with moisture, was repeated in the 1976 data. The proportion of insectivores captured on a grid was directly related to the moisture of the grid site. Significant correlations with ground covers and deadfall cannot be tested for 1976.

Small mammal diversity

No significant difference in small mammal diversity (Tables 24 and 25, see also Appendix) was observed among the three major trapping periods of 1976. Temporal differences in diversity may not be revealed in the limited time span of this field season. However, the average diversity was significantly higher in 1976 compared to 1977 ($t = 3.50$, $p < .001$). The ten replicated grids had a significantly higher diversity in 1976 (Mann-Whitney, p. < .01). This difference was not significant in Mann-Whitney comparisons among grids of the same canopy type. This may be due to the smaller sample sizes in the statistical test.

In 1976, the diversity of upland deciduous habitats was significantly higher than that of upland coniferous (Mann-Whitney, $p < .01$) and wetland (Mann-Whitney, $p < .05$) habitats. There were no significant differences among these habitats in 1977. The difference in diversity between clearcuts and mature upland forests was not significant.

Trophic groups of the small mammal community

In 1976, wetland sites contained a significantly higher proportion of insectivores (Sorex arcticus, Sorex cinereus, Microsorex hoyi, Blarina brevicauda) than upland coniferous forests and a significantly lower proportion of granivores and omnivores (Tamias striatus, Eutamias minimus, Peromyscus maniculatus, Zapus hudsonius, Napaeozapus insignis) (Fig. 5 and Table 28). The proportions of all three trophic groups are significantly different between wetlands and upland conifers in 1977 (Fig. 5 and Table 29), with the proportions of granivores and omnivores and grazers (*Clethrionomys gapperi*, *Synaptomys cooperi*, *Microtus pennsylvanicus*) being higher and that of insectivores being lower in the upland conifers. Proportions of insectivores and grazers in wetlands are significantly higher and lower respectively compared to upland deciduous forests. Clearcuts contained a significantly higher proportion of granivores and omnivores than any other type and a significantly lower proportion of insectivores than either upland deciduous forests or wetlands.

In a comparison of proportions within each trophic group between years (Table 30), only one was significant; there was a greater proportion of grazers in wetlands in 1976 than in 1977.

DISCUSSION

Habitat ecology

High site moisture may favor high insectivore abundance by providing favorable humidity conditions within their tunnels (Pruitt, 1959; Getz, 1961) to compensate for a rapid rate of evaporative water loss (Chew, 1951) or by favoring larger populations of invertebrates, the major food resource of insectivores. *Blarina brevicauda* did not exhibit a positive response to moisture but might be associated with moister microhabitats within upland deciduous forest sites than measurements of soil moisture at individual trapping stations would detect.

Dependance on moisture may help account for insectivore distribution between two years of extreme precipitation. The restriction of *Microsorex hoyi* to wetland sites and the avoidance by *Sorex cinereus* of upland coniferous sites in 1976, followed by the ubiquitousness of both species in 1977, may have been influenced by the moisture regime.

Sorex arcticus appears to be less plastic in habitat association. The decrease in Blarina brevicauda populations is unexplained by the present data, although moisture conditions in 1976 may have played a role.

Rodent species show little response to soil moisture conditions; they have comparatively lower rates of evaporative water loss (Chew, 1951; Getz, 1968) and will tolerate drier habitats. Habitat features of litter, deadfall, shrubs, and forbs, which may provide nesting sites, foraging areas, predator visibility, and food, are important determinants of these species' abundances. Microtus pennsylvanicus alone shows a positive correlation with moisture and a distribution pattern similar to Microsorex hoyi, perhaps as a response to a high rate of evaporative loss (Lindeborg, 1952; Getz, 1961).

The high small mammal diversity of mature upland deciduous forest sites in 1976 appears largely due to the associations of Blarina brevicauda, Tamias striatus, and Napaeozapus insignis with that habitat type. The latter two species were caught in greatest numbers during trapping period A in 1976; trappability apparently decreased over the field season. The time of trapping in 1977 coincided with the three later periods in 1976; the absence of Tamias striatus and Napaeozapus insignis in 1977 may result from a similar temporal change in trappability. Blarina brevicauda was captured throughout the 1976 field season; the decreased trappability in 1977 appears due to an actual decrease in abundance.

Small mammal richness and diversity did not show the hypothesized response to measures of habitat diversity. These measures are derived from shrub density and ground cover data collected on a very small area of the trapping grid and probably do not adequately reflect spatial diversity on a grid.

Responses of richness and diversity do not appear consistently for any habitat feature; responses of individual species to habitat features differ from year to year in many cases and are reflected in the richness and diversity indices. Other attempts to correlate small mammal richness and diversity with individual habitat features (Kalin, 1976; Miller and Getz, 1977) have had limited success. Models that account for interactions among habitat features (Rosenzweig and Winakur, 1969), among species, and between habitat features and time would be more useful in determining causal relationships.

Trophic community similarities between upland coniferous and deciduous forest sites might imply a similar proportionality in the available resources. Of 12 comparisons of resource-related habitat features (shrub stem densities, cover of herbs, forbs, graminoids, and mosses, foliage height diversity, structural patchiness, ground cover diversity, ground cover patchiness, moisture, and nutrients), only structural patchiness (Mann-Whitney, $p < .05$) and nutrients (Mann-Whitney, $p < .05$) are significantly different between the two upland forests. Further studies of the apparent similarity of these two habitat types might incorporate small mammal biomass estimates, species - specific differences in metabolism and food consumption, and measurement of habitat features directly pertinent to food availability, such as invertebrate populations, fungi abundance, and seed production.

The high proportion of granivores and omnivores on clearcut sites may result from greater availability of food resources and nesting sites in the debris. The composition of herbaceous vegetation on clearcuts is determined by the degree of disturbance to the ground cover during logging (Dyrness, 1973). A higher seed production of both forest-floor plants and invader species, as measured by quantitative studies on seed and fruit availability (Brown et al. 1975), could provide an increased amount of resources for this trophic group.

Mining-related impacts on small mammals

The patterns of species distribution and abundance as described by this study are adequate to predict impacts of gross land use changes when specific sites have been chosen for phases of the mining operation (open pit mines, waste rock disposal areas, milling and concentrating plants, smelters) in which the natural habitat and its associated animal populations are completely displaced. These land use changes are limited in area and impacts on common small mammals consequently would be limited in scope. Impact on rare species with localized populations would be more severe. Only one such species, *Microtus chrotorrhinus*, may be present on the Study Area. A few isolated colonies have been found in northeastern Minnesota (Timm, 1974; Buech et al., 1977) though none was detected during the present study.

The effects of mitigation efforts, such as reclamation, can be reasonably predicted from existing literature (Mumford and Bramble, 1973; Kirkland, 1976; Sly, 1976).

Changes in physical and chemical properties of the environment - especially increased levels of heavy metals and sulfur dioxide - have a greater potential for widespread impact due to dissemination over large areas. Few studies have examined the effects of chronic, low-level exposure to these substances (Schroeder and Mitchner 1971; Alarie et al., 1975; Webster, 1978). Such exposure to toxic substances may affect reproduction (Schroeder and Mitchner, 1971; Webster, 1978), behavior (Burton et al., 1977), and resistence to stress (Port et al., 1975). Sensitivity to toxic substances is generally species-specific (Scott et al., 1959; Barrett, 1968). Assessment of such impacts is not addressed in the current study.

Indirect impacts on small mammal populations may result from long-term alteration of their habitats by physical and chemical changes. If the affected habitat features are correlated with small mammal abundance, then a prediction may be made of the effect on that abundance. Lowering the water table in wetlands and a hypothesized sensitivity of hazel to acid rainfall would result in an adverse impact on insectivores and _Tamias striatus_ respectively, according to the present results. Similarly, the increased deadfall in a forest heavily impacted by sulfur dioxide and characterized by dying trees may result in temporary increased populations of _Eutamias minimus_.

This approach to assessing indirect impacts has two weaknesses. The most meaningful habitat features for small mammals are not known with certainty; their measurement may be neglected in the field studies, yet may be the most altered by physical and chemical changes. Soil fungi and seeds are important food sources (Martin et al., 1951; Whitaker, 1962; Fogel and Trappe, 1978) whose abundance and production are adversely affected by heavy metal and acid loadings (Miller and McCallan, 1957; Houston and Dochinger, 1977; Phillips et al., 1977). Even when relevant habitat features are considered, data that adequately predict their alteration, such as susceptibility of individual plant species to acid rainfall, may be lacking.

The index of diversity is limited in its usefulness as a measure of community value in siting procedures. Mature upland deciduous forests contain the most diverse small mammal community, but because each component of the terrestrial ecosystem may attain its highest diversity in different habitats, siting decisions considering overall diversity would not necessarily preserve the highest small mammal diversity. Species richness may even be greatest in communities that have been the most disturbed by man; weedy species invade natural plant associations (Sather, pers. comm.) to increase species numbers. Young plantations with a few old trees standing may provide sufficient structural diversity to support more bird species (Pfannmuller 1978). Communities considered unique - such as conifer bogs with high numbers of rare plant species (Sather, 1979), unique bird species associations (Pfannmuller 1978) and small mammals of limited habitat range -

may be among the least rich and diverse in species.

Both diversity and relative abundance measures are poor indicators of impact-related changes in small mammal populations. Both are subject to temporal fluctuations and large variability within single habitat types. In addition, diversity indices are unresponsive to density changes; taken alone, these indices might fail to indicate a severe population decrease. While the response of some individual species to habitat features is pronounced, there is no consistent response of species diversity to any habitat feature that would permit predictions of indirect impacts.

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Anticipated Environmental Changes

Stage of Mining Development	A Major land requirement	B Major power requirement	C Major water requirement	D Subsidence	E Leaching of sulfides	F Leaching of heavy metals	G Sulfide emissions	H Heavy metal emissions	I Dust	J Noise
Exploratory Drilling	x				x	x				x
Open pit mining	x				x	x			x	x
Underground Mining				x	x	x				
Milling	x	x	x						x	x
Concentrating	x	x	x		x	x			x	
Smelting	x	x	x				x	x		

Table 1. Stages in the development of a heavy metals mining and processing industry and their anticipated changes in land use and the physical and chemical environment.

Table 2 Proportion of communities in Study Area and state.

FOREST TYPE	HA. IN STUDY AREA	% OF STUDY AREA	HA. IN STATE	% OF STATE	% OF STATEWIDE TOTAL IN STUDY AREA
White, Red, Jack Pine	47.927	8.7	560,153	2.6	8.6
Spruce-Fir	129,712	23.5	1,428,342	6.6	9.1
Oak	0	0	558,927	2.6	0
Elm-Ash-Cottonwood	777	1.0	534,746	2.5	0.1
Maple-Birch-Basswood	113	0.0	422,974	1.9	0.0
Unproductive	25,758	4.7	434,395	2.0	5.9
Unforested	59,416	20.0	13,571,724	62.3	.4
Aspen-Birch	288,434	52.2	4,283,342	19.7	6.7

Table 3. Monthly precipitation of Babbitt, Minnesota for the two study years and its thirty-year average.

	Precipitation (mm)					
	April	May	June	July	August	September
1976[a]	25.1	7.6	144.8	36.3	15.0	40.9
1977[b]	30.5	116.3	156.2	88.6	169.4	144.0
1941 to 1970[a] average	55.9	81.0	114.3	96.5	102.6	88.6

[a]From USNOAA, 1976
[b]From USNOAA, 1977

	Contingency Table Vegetation categories	Vegetation Groups[a]
Broad habitat types	Upland coniferous (UC)	mJP, mRP, mWS
	Upland deciduous (UD)	mAB, mABF, MIX
	Wetland (W)	BS, cT, oT, CED, SC
	Clear cut (CC)	yJP, yRP, yWS, yAB, yAB
Canopy	Wetland (WET)	BS, cT,oT,CED,SC
	Jack pine (JP)	JP
	Red pine (RP)	RP
	Mixed (MIX)	MIX, ABF
	Aspen-Birch (AB)	AB
High Shrubs	Wetland (WET)	I, IV, VIIA
	Conifer (CON)	III, VIIB, VIII
	Sparse (SP)	II, IV
	Dense (DEN)	V, X
	None (NON)	None
Low shrubs	Heath (HEA)	LT, EB
	Raspberry-Hazel (RH)	RH
	Hazel complex (HC)	H, HMM, AH
	Other (OTH)	CON, AB, AW, None
Herbs (1976)	Wetland (WET)	CB, NRW
	Mesic (MES)	AA, NM
	Disturbed (DIS)	DIS, LV
Herbs (1977)	Wetland (WET)	CB, NRW
	Mixed (MIX)	MIX, AA
	Northern mesic (NM)	NM
	Disturbed (DIS)	DIS, LV

Table 4. Vegetation categories used in contingency table analyses and their corresponding vegetation groups as defined by cluster analysis.

[a] See Appendix, Tables A through D, for abbreviations and definitions of vegetation groups. c = closed, m = medium-aged and mature, o = open. y = clearcut.

Table 5. Species distribution among broad habitat types in 1976 and 1977 as indicated by the number of grids on which the species was captured at least once. CC = clearcut. UC = mature upland coniferous forest. UD = mature upland deciduous forest. W = wetland. The total number of grids of each each type is given in parentheses. The single grassland grid (G29) was omitted from the analysis.

	1976			1977			
Species[a]	UC (13)	UD (17)	W (10)	UC (14)	UD (14)	W (10)	CC (8)
Sorex arcticus	0	2	4	4	2	8	2
Sorex cinereus	9	16	10	13	14	10	7
Microsorex hoyi	0	1	3	6	9	6	1
Blarina brevicauda	5	17	6	3	3	1	0
Tamias striatus	1	11	0	2	2	0	1
Eutamias minimus	4	5	6	7	3	4	8
Peromyscus maniculatus	12	15	4	10	12	2	5
Clethrionomys gapperi	13	17	9	14	14	9	8
Microtus pennsylvanicus	1	1	8	1	2	4	2
Zapus hudsonius	6	7	1	4	3	2	4
Napaeozapus insignis	2	7	0	0	3	0	1

[a] Spermophilus franklinii, Glaucomys sabrinus, and Synaptomys cooperi were also caught in small numbers.

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	1976					1977				
	WET (10)	JP (6)	RP (7)	AB (10)	MIX (7)	WET (10)	JP (9)	RP (6)	AB (8)	MIX (10)
Sorex arcticus	4	0	0	2	0	8	2	2	2	1
Sorex cinereus	10	4	5	10	6	10	9	5	7	10
Microsorex hoyi	3	0	0	1	0	6	3	2	3	6
Blarina brevicauda	6	2	3	10	7	1	2	0	0	3
Tamias striatus	0	0	1	8	3	0	2	1	1	1
Eutamias minimus	6	2	2	5	0	4	7	3	4	3
Peromyscus maniculatus	4	5	7	8	7	2	7	5	6	8
Clethrionomys gapperi	9	6	7	10	7	9	9	6	8	10
Microthus pennsylvanicus	8	1	0	1	0	4	1	1	1	1
Zapus hudsonius	1	3	3	5	2	2	4	3	2	2
Napaeozapus insignis	0	0	2	5	2	0	0	0	0	4

Table 6. Species distribution among canopy categories in 1976 and 1977 as indicated by the number of grids on which the specie was captured at least once. Abbreviations correspond to those in Table 4. The total number of grids in eac category is given in parentheses. Grassland (G29) and white spruce (G34, G35, G36) were omitted due to thei small sample size.

	1976				1977				
	WET (5)	SP (15)	DEN (9)	NON (11)	WET (8)	CON (7)	SP (9)	DEN (13)	NON (9)
Sorex arcticus	2	1	0	3	5	2	4	2	2
Sorex cinereus	5	11	9	10	8	7	9	12	8
Microsorex hoyi	2	1	1	0	5	4	5	6	2
Blarina brevicauda	1	8	9	10	1	2	1	1	2
Tamias striatus	0	2	7	3	0	0	1	2	2
Eutamias minimus	1	7	4	3	3	5	3	5	5
Peromyscus maniculatus	1	13	9	8	2	3	7	9	8
Clethrionomys gapperi	4	15	9	11	7	7	9	13	9
Microtus pennsylvanicus	4	3	0	3	4	2	1	2	0
Zapus hudsonius	1	6	4	3	1	2	2	6	3
Napaeozapus insignis	0	4	4	1	0	1	1	0	2

Table 7. Species distribution among high shrub categories in 1976 and 1977 as indicated by the number of grid on which the species was captured at least once. Abbreviations correspond to those in Table 4. The total number of grids in each category is given in parentheses. G34 was omitted from the analysis it belongs in an anomalou high shrub group, IX (see Appendix).

Table 8. Species distribution among low shrub categories in 1976 and 1977 as indicated by the number of grids on which the species was captured at least once. Abbreviations correspond to those in Table 4. The total number of grids in each category is given in parentheses.

	1976				1977			
	HEA (7)	RH (13)	HC (13)	OTH (7)	HEA (12)	RH (18)	HC (11)	OTH (6)
Sorex arcticus	4	0	2	0	9	5	2	0
Sorex cinereus	7	11	10	7	12	18	10	5
Microsorex hoyi	3	1	0	0	7	7	6	2
Blarina brevicauda	4	8	10	6	2	3	2	0
Tamias striatus	0	4	4	4	1	2	2	0
Eutamias minimus	3	5	2	5	6	9	4	3
Peromyscus maniculatus	3	11	11	6	4	13	8	4
Clethrionomys gapperi	7	13	13	6	12	18	11	5
Microtus pennsylvanicus	6	1	1	2	3	5	1	1
Zapus hudsonius	0	6	6	2	1	8	4	1
Napaeozapus insignis	0	3	3	3	0	2	1	1

	1976			1977			
	WET (10)	MES (15)	DIS (15)	WET (11)	MIX (7)	NM (10)	DIS (17)
Sorex arcticus	4	0	2	9	1	3	3
Sorex cinereus	10	13	12	11	7	10	15
Microsorex hoyi	3	1	0	7	4	5	6
Blarina brevicauda	6	13	9	2	2	1	2
Tamias striatus	0	9	3	0	1	0	3
Eutamias minimus	6	5	4	5	1	3	11
Peromyscus maniculatus	4	14	13	2	5	7	13
Clethrionomys gapperi	9	15	15	10	7	10	17
Microtus pennsylvanicus	8	0	2	4	2	1	3
Zapus hudsonius	1	4	9	2	1	2	9
Napaeozapus insignis	0	5	4	0	1	2	1

Table 9. Species distribution among herb categories in 1976 and 1977 as indicated by the number of grids on which the species was captured at least once. Abbreviations correspond to those in Table 4. The total number of grids in each category is given in parentheses. G25 and G26, as anomalous members of a coherent herb group (Sather, pers. comm.), were omitted from the analysis.

	1976				1977								
	X^2	UC	UD	W	X^2	UC	UD	W	X^2	UC	UD	W	CC
Sorex arcticus	7.43			*	11.51			**	12.15			**	
Sorex cinereus	6.13			*	3.02				1.65				
Microsorex hoyi	6.21			*	1.42				6.16				
Blarina brevicauda	13.92		**		0.58				2.52				
Tamias striatus	17.12		**		1.61				1.62				
Eutamias minimus	2.81				2.51				13.04	**			**
Peromyscus maniculatus	11.21	**	**		11.51	**	**		11.51	**	**		
Clethrionomys gapperi	3.98				4.08				2.51				
Microtus pennsylvanicus	21.67				4.66				4.54				
Zapus hudsonius	3.66				0.32				2.53				
Napaeozapus insignis	6.82		*		5.40				5.63				

Table 10. Results of chi-square tests on contingency tables using broad habitat types. Chi-square value "is given; the number of asterisks denotes level of significance" (* = significant at α = .05 level, ** = significant at α = .01 level). To indicate habitat association, asterisks are placed under those categories in which observed value was greater than the expected value. Abbreviations follow those of Table 4.

	1976						1977					
	X^2	WET	JP	RP	AB	MIX	X^2	WET	JP	RP	AB	MIX
Sorex arcticus	8.49						11.90	*				
Sorex cinereus	7.02						4.14					
Microsorex hoyi	6.67						2.67					
Blarina brevicauda	14.06				**	**	4.90					
Tamias striatus	20.14				**	**	2.68					
Eutamias minimus	7.09						4.78					
Peromyscus maniculatus	12.67		*	*	*	*	11.72		*	*	*	*
Clethrionomys gapperi	3.98						4.09					
Microtus pennsylvanicus	22.40	**					3.96					
Zapus hudsonius	4.64						3.08					
Napaezapus insignis	9.19						15.03					**

Table 11. Results of Chi-square tests on contingency tables using canopy categories. Chi-square value is given; the number of asterisks denotes level of significance (* = significant at α = .05 level, ** = significant at α = .01 level). To indicate habitat association, asterisks are placed under those categories in which observed value was greater than expected value. Abbreviations follow those of Table 4.

	1976					1977					
	X^2	WET	SP	DEN	NON	X^2	WET	CON	SP	DEN	NON
Sorex arcticus	5.84					6.07					
Sorex cinereus	4.72					2.27					
Microsorex hoyi	6.42					3.59					
Blarina brevicauda	14.08			**	**	1.94					
Tamias striatus	13.95			**		3.33					
Eutamias minimus	1.89					3.27					
Peromyscius maniculatus	13.25		**	**		9.55			*	*	*
Clethrionomys gapperi	9.19		*	*	*	4.20					
Microtus pennsylvanicus	10.91	*			*	7.64					
Zapus hudsonius	1.33					2.92					
Napaeozapus insignis	5.28					4.29					

Table 12. Results of Chi-square tests on contingency tables using high shrub categories. Chi-square value is given; the number of asterisks denotes level of significance (* = significant at α = .05 level, ** = significant at α = .01 level). To indicate habitat association, asterisks are placed under those categories in which observed value was greater than expected value. Abbreviations follow those of Table 4.

	1976					1977				
	X^2	HEA	RH	HC	OTH	X^2	HEA	RH	HC	OTH
Sorex arcticus	14.03	**				13.37	**			
Sorex cinereus	3.58					3.60				
Microsorex hoyi	10.70	*				1.82				
Blarina brevicauda	2.11					1.24				
Tamias striatus	5.46					1.35				
Eutamias minimus	6.38					0.60				
Peromyscus maniculatus	5.68					5.54				
Clethrionomys gapperi	4.11					9.16	*	*	*	
Microtus pennsylvanicus	17.23	**			**	1.58				
Zapus hudsonius	5.36					5.19				
Napaeozapus insignis	3.67					1.83				

Table 13. Results of Chi-square tests on contingency tables using low shrub categories. Chi-square value is given; the number of asterisks denotes level of significance (* = significant at α = .05 level, ** = significant at α = .01 level). To indicate habitat association, asterisks are placed under those categories in which observed value was greater than expected value. Abbreviations follow those of Table 4.

	1976				1977				
	X^2	WET	MES	DIS	X^2	WET	MIX	NM	DIS
<u>Sorex arcticus</u>	7.66	*			14.21	**			
<u>Sorex cinereus</u>	2.10				3.14				
<u>Microsorex hoyi</u>	6.30	*			2.39				
<u>Blarina brevicauda</u>	3.17				1.37				
<u>Tamias striatus</u>	11.43		**		4.03				
<u>Eutamias minimus</u>	2.89				6.10				
<u>Peromyscus maniculatus</u>	11.35		**	**	10.73		*	*	*
<u>Clethrionomys gapperi</u>	4.09				4.08				
<u>Microtus pennsylvanicus</u>	22.36	**			2.55				
<u>Zapus hudsonius</u>	7.23			*	6.11				
<u>Napaeozapus insignis</u>	4.10				3.05				

Table 14. Results of Chi-square tests on contingency tables using herb categories. Chi-square value is given; the number of asterisks denotes level of significance (* = significant at α = .05 level, ** = significant at α = .01 level). To indicate habitat association, asterisks are placed under those categories in which observed value was greater than expected value. Abbreviations follow those of Table 4.

	Sorex arcticus	*Sorex cinereus*	*Microsorex*	*Blarina*	*Tamias*	*Eutamius*	*Peromyscus*	*Clethrionomys*	*Microtus*	*Zapus*	*Napaeozapus*
T03B	0	0	0	0	0	3.7	2.2	5.2	0	0.7	0
T08C	0	5.6	0	3.5	0	0	6.3	4.9	0	0	0
T09C	0	7.8	0.7	8.5	0.7	0.7	3.5	9.9	0	0	0
T16I[a]	0.7	22.2	0.7	0.7	0	0	0	20.1	6.9	0	0
T17I	0	20.2	0	3.0	0	11.1	2.0	5.1	20.2	0	0
T26B	0	3.8	0	1.0	0	0	18.0	6.6	0	0	1.0
T27B	0	2.9	0	1.9	2.9	2.9	5.8	10.6	0	0	3.9
T28B	0	26.8	0.8	1.7	0	0.8	0	14.3	4.2	0	0
T29B	0	9.1	0	13.6	0.9	2.7	20.9	9.1	0	0	0
T30C	0	18.1	0	2.8	0	1.4	0	9.0	0	0	0
T32C	0	17.0	0	0.7	0	0	5.2	23.7	0	0	0
T33C	0	2.8	0	0.7	0	0	6.3	18.8	0	0	0
T34C	0	7.1	0	1.8	0.9	0	12.4	9.8	0	0	0
T15I	2.7	8.2	0	0	0	0	0	2.7	17.1	0	0

[a]Relative density of *Synaptomys cooperi* = 2.1

Table 15. Relative densities in numbers per ha of small mammals on 14 grids trapped in 1976. Letters suffixed to grid numbers indicate the trapping period; B = 27 July to 2 August, C = 31 August to 6 September, I = 5 August to 11 August. Relative density data from a fourth trapping period (A = 22 June to 28 June) were omitted. Other grids trapped in 1976 lack corresponding quantitative vegetation data.

Table 16. Relative densities in numbers per ha of small mammals on grids trapped during 1977. All trapping occured within the time period of July to August 22.

	Sorex arcticus	Sorex cinerces	Microsorex	Blarina	Tamias	Eutamias	Peromyscus	Clethrionomys	Microtus	Zapus	Napaeozapus
G01	3.5	11.1	0	0	0	1.4	0	8.3	0	0.7	0
G02	0.7	2.1	0	0	0	0	0	0.7	0	0	0
G03	1.7	17.6	0	0	0	0	0	5.9	0	0	0
G04	0	32.6	4.4	1.5	1.5	0.7	1.5	9.6	0	0.7	0
G05	0	22.9	0.7	0	0	2.1	9.0	5.6	0	0	0.7
G06	1.4	19.8	0.7	0	0	0	0	5.6	0.7	0	0
G07	0	0.7	0	0	0	9.6	0	5.2	0	0.7	0
G08	0	1.6	0	0	0.8	7.1	4.0	19.1	0	0	0
G09	0.7	23.6	2.0	0	0	0	0.7	12.8	2.0	0	0
G10	2.8	30.6	0	0	0	4.9	0	9.7	0	0	0
G11	0	0.7	0.7	0	0	26.4	4.9	2.8	0.7	0.7	0
G12	0	4.2	0	0	0	0	3.5	2.8	0	0	0
G13	0	2.1	0	0	0	3.5	12.5	6.9	0	0.7	0
G14	0	16.0	0.7	0	0	0	0	21.5	4.9	0	0
G15	0	27.8	0.7	0.7	0	0	0	15.3	0	0	0
G16	0	0.7	0	0	0	2.1	0	9.0	0	0.7	0
G17	0.7	10.4	1.4	0	0	0	0.7	16.7	0	0	0
G18	0	2.1	0	0	0	1.4	0	0	0.7	0.7	0
G19	0	1.4	0	0	0.7	9.0	9.0	5.6	0	1.4	0
G20	2.2	1.5	0	0	0	0.7	3.0	1.5	0	0.7	0
G21	0	0	0	0	0	0	6.9	3.5	0	1.4	0
G22	0	11.8	0	0	0	11.1	0	2.1	2.1	0	0
G23	0.7	3.7	1.5	0	0	0	3.7	6.7	0	0	0
G24	0	27.1	2.1	0	0	0	4.2	9.0	0	0	0
G25	0	10.4	0	0	0	2.1	6.3	6.3	0	0	0
G26	0	22.2	0	0	0.7	3.5	0.7	14.6	0	0	0
G27	0	22.9	0	2.1	0.7	0.7	12.5	29.2	0	0	0
G28	4.9	33.3	1.4	0.7	0	2.1	0	23.6	0	0	0
G29	0	2.3	0	0	0	0	0	0.8	43.7	2.3	0
G30	0	1.4	0	0	0	0	0.7	4.9	0	0.7	0
G31	0.7	37.5	4.2	4.2	0	0	0	3.5	0	0	0
G32	0	2.0	1.0	0	0	0	3.0	5.1	0	0	0
G33	0	18.1	3.5	0	0	0	6.9	17.4	0	0.7	0
G34	3.5	7.8	0	0	0	0.7	0	2.8	1.4	0	0
G35	0	15.3	0.7	0.7	0	0	3.5	70.1	0	0	0
G36	0	5.6	1.4	0	0	0	0	7.6	0	0	0
G37	0	1.5	0	0	0	9.0	14.1	20.0	0	0	0.7
G38	0	21.5	0.7	0	0	0	9.7	21.5	0	0	0
G39	0	21.8	0	0	0	0	2.4	22.6	0	0	0
G40	0	0	0	0	0	4.9	17.4	2.1	0	0	0
G41	0.7	3.5	0	0	0	0	4.9	1.4	0	0.7	0
G42	0	27.8	0.7	0	0	0	3.5	6.3	0	0	0.7
G43	0.7	12.6	1.5	0	0	0.7	5.9	4.4	0	0	0
G44	0	15.3	8.3	0	0	0.7	0.7	7.6	0	0	0
G45	2.1	15.7	1.4	0	0	0	0	0.7	5.5	0	0
G47	0	14.1	0	0.7	0	0	0.7	17.6	0	0	0.7
G48	3.5	47.9	[illegible]	0	0	0	0	[illegible]	0.7	[illegible]	0

PRELIMINARY DRAFT REPORT SUBJECT TO REVIEW

	Total number of high shrub species	Average high shrubs basal area cm^3/m	Average high shrub number of stems/m^2	Total number of low shrub species	Average low shrub number of stems/m^2	Foilage height diversity	Structural patchiness	Moisture	Nutrients	Heat	Light
T03B	7	2.4	0.6	7	1.5	4.41	1.31	2.34	1.97	1.89	3.17
T08C	6	2.1	0.6	6	1.7	4.49	1.95	2.51	2.26	2.20	3.23
T09C	10	3.8	2.2	14	7.9	6.59	1.81	2.61	2.06	1.97	2.77
T15I	2	4.5	1.3	7	87.0	3.94	1.03	4.73	1.27	1.09	4.55
T16I	11	2.9	3.3	15	39.9	5.98	1.47	3.76	1.83	1.65	3.72
T17I	9	2.5	1.6	7	9.5	4.29	1.59	3.83	2.07	1.72	3.04
T26B	2	0.3	0.5	5	3.3	2.69	1.20	2.41	2.11	2.08	3.00
T27B	6	1.2	2.0	5	1.9	7.67	1.97	2.27	2.22	2.08	3.03
T28B	4	2.4	1.0	11	13.1	7.16	2.46	3.77	1.83	1.57	3.31
T29B	4	3.3	5.5	10	5.1	7.62	3.24	2.14	2.05	2.11	3.38
T30C	3	1.9	0.4	4	2.1	2.98	1.09	2.82	1.86	1.45	2.82
T32C	4	0.5	0.5	7	4.8	3.36	0.97	2.48	2.13	2.11	3.25
T33C	8	2.0	2.0	10	3.7	5.98	1.87	2.55	2.29	2.04	2.80
T34C	7	2.0	3.4	13	6.4	7.71	2.56	2.33	2.06	2.17	3.31

Table 17. Values for habitat features measured on 14 grids trapped in 1976. Data from grids trapped in period A were omitted. Other grids trapped in 1976 lack corresponding quantitative vegetation data. Data on ground features were omitted; all quantitative vegetation measurements were made during 1977 and ground cover might have changed markedly between years.

Grid	Total number of tree species	Average tree basal area cm^2/m^2	Total number of high shrub species	Average high shrub basal area cm^2/m^2	Average high shrub number of stems/m^2	Total number of low shrub species	Average low shrub number of stems/m^2	Average percent cover of herbs	Average percent cover of forbs	Average percent cover of graminoids	Average percent cover cover of moss	Average percent cover of litter	Average percent cover of deadfall	Average percent cover of low woody plants	Average percent cover of vascular plants
1	4	1.21	11	4.0	1.5	8	20.4	23.8	8.4	14.9	9.0	33.2	20.9	13.1	36.9
2	1	2.67	2	1.4	0.3	4	84.7	6.6	3.5	3.1	57.2	6.1	0.3	29.5	36.3
3	3	22.83	4	2.4	1.0	11	13.1	11.1	7.9	3.4	63.3	3.1	0.4	14.7	26.0
4	3	8.50	7	7.9	6.2	6	11.6	22.7	16.6	5.4	1.9	55.3	8.0	12.1	34.8
5	9	6.15	9	5.0	4.3	10	10.9	35.4	27.5	7.9	0.9	48.5	3.6	11.6	47.0
6	1	12.29	5	2.2	0.7	7	26.5	46.4	4.5	30.0	29.9	2.7	1.3	19.5	66.1
7	0	0	8	5.5	5.2	8	9.9	58.2	56.8	0.9	0.4	17.7	5.0	10.5	68.7
8	0	0	11	9.1	5.1	11	6.0	51.8	51.8	0.1	3.4	21.7	18.0	5.1	56.9
9	3	20.01	5	2.9	3.4	10	7.3	53.6	49.5	0.8	2.8	26.3	1.0	13.7	67.3
10	0	0	9	9.2	5.4	8	14.7	51.6	37.8	8.1	0.2	11.0	4.0	33.2	84.8
11	0	0	5	1.7	0.7	7	29.1	23.1	16.2	6.8	1.4	22.7	13.3	25.1	48.2
12	4	15.37	10	5.1	1.4	16	5.1	75.1	59.8	10.9	0.5	11.5	5.1	7.8	82.9
13	2	5.32	2	0.4	0.4	7	3.7	46.2	43.8	2.4	0.1	20.9	3.0	2.6	48.8
14	5	13.50	8	2.7	0.8	6	2.8	32.7	32.0	0.3	3.3	37.1	10.9	12.2	45.1
15	4	28.98	4	0.1	0.2	5	1.0	42.0	41.9	0.1	4.2	45.1	5.6	1.4	43.9
16	4	7.76	8	2.8	2.2	9	5.5	58.0	38.6	19.4	0.3	32.5	0.3	8.6	66.8
17	2	33.78	5.	0.3	0.3	5.	1.7	67.2	66.3	0.5	11.3	15.3	2.9	2.1	70.5
18	2	1.02	4	8.8	7.6	10	15.1	19.6	10.9	6.3	12.8	19.9	0	28.5	48.2
19	0	0	6	0.6	0.3	4	10.7	43.4	32.7	6.7	0.5	24.5	1.6	6.5	49.9
20	3	21.27	9	2.5	3.0	8	10.3	43.0	40.3	0.6	1.3	31.5	0	23.1	66.8

Table 18. Values for habitat features measured on grids trapped in 1977.

	Average percent cover mosses and lichens	Average percent cover of dead material	Average percent cover of bare ground	GCD	Ground cover patchiness	FHD	Structural patchiness	Deadfall transect index	Moisture	Nutrients	Heat	Light	Litter depth
G01	9.0	64.1	0	4.70	3.27	5.10	1.68	9.41	3.09	1.95	1.80	3.47	6.0
G02	57.2	6.5	0	2.38	1.41	3.15	0.77	0.31	4.44	1.31	1.25	4.25	0
G03	3.3	3.5	7.2	2.38	2.41	7.16	2.46	2.09	3.37	1.94	1.74	3.34	3.2
G04	1.9	63.3	0	2.79	2.01	7.61	2.56	3.10	2.83	2.38	2.02	2.93	3.7
G05	0.9	52.1	0	3.02	1.72	5.44	1.57	1.54	2.43	2.12	2.09	3.33	3.9
G06	9.9	4.1	0	3.27	1.92	5.72	1.98	0.30	4.21	1.67	1.33	4.13	0
G07	0.4	22.7	8.1	2.68	3.71	6.90	1.84	9.24	2.15	2.21	2.33	3.41	1.2
G08	3.5	39.7	0	2.85	2.02	7.24	2.25	11.89	2.53	2.20	2.18	3.00	3.4
G09	3.5	27.3	1.9	3.02	2.72	4.72	2.29	1.70	2.56	2.08	2.02	3.08	5.9
G10	0.2	15.0	0	3.61	2.91	6.87	1.27	8.45	2.51	2.36	2.25	2.94	1.2
G11	1.4	35.9	14.5	6.19	5.57	2.69	1.02	71.74	2.27	1.98	2.07	3.57	3.6
G12	0.5	16.6	0	2.54	2.32	4.55	1.62	3.47	2.66	2.53	2.30	2.86	0.9
G13	0	23.9	27.3	3.20	2.20	1.73	0.56	1.84	2.36	2.09	2.13	3.80	2.4
G14	6.8	48.1	0.1	3.76	3.96	5.56	2.02	4.43	2.62	2.03	1.97	2.95	3.4
G15	4.3	50.7	1.2	2.60	2.64	2.53	1.20	3.45	2.67	2.31	2.14	2.65	2.2
G16	0.4	32.8	0	3.34	1.85	4.90	1.33	1.26	2.19	2.23	2.26	3.43	4.2
G17	11.3	18.2	0	2.09	1.62	3.43	1.25	1.88	2.35	2.00	1.98	3.37	3.9
G18	12.8	19.9	19.1	5.42	4.12	6.78	2.75	0.51	3.74	2.28	2.02	3.28	0
G19	0.5	26.1	23.5	4.82	3.37	2.84	0.86	11.60	2.31	2.38	2.47	3.47	1.1
G20	1.7	31.5	0	3.16	2.13	6.61	2.01	4.49	2.03	2.00	2.25	3.61	3.3

Table 18 cont'd.

	Total number of tree species	Average tree basal area cm^2/m^2	Total number of high shrub species	Average high shrub basal area cm^2/m^2	Average high shrub number of stems/m^2	Total number of low shrub species	Average low shrub number of stems/m^2	Average percent cover of herbs	Average percent cover of forbs	Average percent cover of graminoids	Average percent cover of moss	Average percent cover of litter	Average percent cover of deadfall	Average percent cover of low woody plants	Average percent cover of vascular plants
G21	4	37.98	7	0.4	0.5	8	3.9	38.2	31.7	0.2	4.6	52.7	1.1	2.6	40.7
G22	2	0.67	4	5.0	0.8	4	3.5	48.0	37.8	9.2	2.0	30.5	3.9	7.6	55.7
G23	3	44.20	2	0.6	0.7	6	4.1	20.0	19.2	0.6	2.9	70.8	0.7	5.1	25.6
G24	1	48.81	6	0.2	0.2	5	6.9	41.7	39.3	0.7	3.7	28.0	0.1	25.9	68.2
G25	2	0.19	6	0.9	1.1	12	14.6	30.1	24.6	5.5	1.2	26.3	1.8	13.5	43.6
G26	5	6.81	7	4.1	2.3	15	17.9	29.9	25.3	2.6	16.3	27.5	4.4	14.9	44.8
G27	4	48.70	4	3.5	3.2	9	3.7	32.8	31.1	1.2	1.3	61.0	1.2	3.8	36.5
G28	1	0.08	15	7.2	1.7	17	17.2	31.0	23.3	7.7	1.7	17.3	12.4	37.7	68.7
G29	0	0	2	0.2	0.2	1	3.1	94.5	53.8	39.4	0	1.1	0	3.3	97.8
G30	3	35.50	5	0.2	0.4	3	3.5	68.1	63.0	4.9	9.6	12.9	1.1	5.1	73.2
G31	3	10.68	11	2.9	3.3	15	34.9	22.8	17.3	5.5	33.4	9.7	0.7	28.8	51.6
G32	4	17.65	6	2.0	2.5	8	7.1	51.1	45.3	0.5	0.1	34.9	1.9	11.7	63.1
G33	4	51.79	8	3.1	3.1	13	5.9	37.7	37.2	0.2	2.3	41.1	9.5	5.6	43.3
G34	2	1.39	5	2.3	1.3	9	11.1	50.0	21.1	28.4	7.1	16.5	3.3	19.4	69.5
G35	4	6.67	14	3.6	4.0	10	8.3	50.4	13.7	36.2	1.0	22.1	3.0	21.2	71.6
G36	2	16.52	7	5.7	0.9	6	2.8	23.8	22.8	0.3	48.1	23.9	0.7	2.5	27.3
G37	0	0	6	0.6	0.3	6	7.9	8.7	7.1	0.7	0.1	64.5	15.5	2.1	10.8
G38	6	29.60	11	2.3	1.8	10	2.0	44.0	29.5	14.5	2.2	49.7	1.7	2.5	46.4
G39	2	20.59	10	3.2	3.5	8	3.4	41.7	40.8	0.9	0.9	46.4	1.0	2.5	46.2
G40	2	3.42	3	0.3	0.4	9	8.5	22.2	20.9	0.6	0.5	45.7	7.7	18.5	40.7
G41	4	19.20	6	4.3	0.7	3	10.7	33.5	32.8	0.7	2.1	47.5	0.3	16.2	50.0
G42	4	20.16	6	2.1	0.6	6	1.7	61.0	47.3	9.5	5.1	29.7	0	3.7	64.7

Table 18 cont'd.

	Average percent cover mosses and lichens	Average percent cover of dead material	Average percent cover of bare ground	GCD	Ground cover patchiness	FHD	Structural patchiness	Deadfall transect index	Moisture	Nutrients	Heat	Light	Litter depth
G21	4.9	53.9	0.5	2.65	2.08	2.39	0.81	0.63	2.17	2.02	2.15	3.47	5.6
G22	2.1	34.4	7.8	3.93	3.33	4.64	1.68	3.82	2.26	2.17	2.17	3.28	1.5
G23	2.9	71.5	0	1.85	1.71	4.69	1.48	0.07	2.52	2.26	2.15	3.05	3.8
G24	3.7	28.1	0	3.31	2.65	3.70	1.39	1.81	2.45	2.13	1.97	3.11	3.2
G25	14.9	28.1	13.4	5.54	4.44	3.38	0.86	5.66	2.70	2.02	1.93	3.38	4.6
G26	17.9	31.9	5.3	5.14	4.72	5.53	1.93	10.70	2.65	1.74	1.81	3.52	4.7
G27	1.3	62.2	0	2.14	1.00	6.98	2.09	8.70	2.52	2.10	1.92	2.88	4.5
G28	1.7	29.7	0	4.03	2.28	4.84	1.53	3.42	2.85	2.13	1.92	3.38	1.8
G29	0.5	1.1	0.6	2.24	1.60	2.68	0.64	0	2.27	2.38	2.60	4.03	0.6
G30	12.9	13.9	0	2.30	2.34	3.03	0.96	0.93	2.53	2.17	2.08	3.27	2.5
G31	34.4	10.3	3.7	4.19	3.05	5.98	1.47	0.09	3.76	1.83	1.45	3.72	0
G32	0.3	36.8	0	2.89	1.62	7.28	1.52	2.21	2.43	2.16	2.07	3.20	2.9
G33	6.0	50.7	0	3.11	2.78	5.96	1.96	5.78	2.44	2.15	2.13	2.87	4.4
G34	7.1	19.8	3.7	5.08	4.77	4.20	1.52	2.09	2.63	2.27	2.21	3.47	1.4
G35	1.0	25.1	2.3	4.10	3.18	6.71	1.75	2.35	2.89	2.57	2.14	2.96	0.9
G36	48.2	24.5	0	2.93	3.25	7.70	1.06	0.14	2.53	2.12	2.13	3.53	1.8
G37	0	80.1	9.1	2.22	2.87	1.97	0.64	16.25	2.76	2.40	2.14	2.84	4.3
G38	2.2	51.4	0	2.81	2.00	4.65	1.62	3.62	2.71	2.35	2.19	2.82	4.5
G39	0.9	47.4	5.5	2.59	2.26	7.25	2.02	1.16	2.40	2.23	2.07	2.97	3.0
G40	0.5	53.3	5.5	3.39	2.66	1.87	0.42	2.51	2.31	2.43	2.38	2.93	3.0
G41	2.1	47.9	0.1	2.77	1.68	2.61	0.57	2.41	2.40	2.20	2.18	3.22	1.4
G42	5.1	29.7	0.5	3.06	2.68	4.49	1.95	0.45	2.56	2.49	2.16	2.89	0.9

Table 18 cont'd.

	Total number of tree species	Average tree basal area cm^2/m^2	Total number of high shrub species	Average high shrub basal area cm^2/m^2	Average high shrub number of stems/m^2	Total number of low shrub species	Average low shrub number of stems/m^2	Average percent cover of herbs	Average percent cover of forbs	Average percent cover of graminoids	Average percent cover of moss	Average percent cover of litter	Average percent cover of deadfall	Average percent cover of low woody plants	Average percent cover of vascular plants
43	5	33.60	4	1.6	0.3	8	4.4	27.1	15.5	9.5	27.5	24.9	6.2	6.7	35.4
44	3	19.69	3	5.9	0.6	5	28.7	9.3	8.9	0.4	67.6	10.0	0.7	10.1	20.4
45	0	0	2	4.5	1.3	7	87.0	5.5	5.4	0.1	16.3	0.5	0	76.4	81.9
47	3	13.35	10	3.8	2.2	14	7.9	35.7	33.1	1.1	1.1	42.9	1.9	18.0	53.8
48	0	0	3	11.0	7.0	3	5.2	50.0	5.1	44.4	15.3	5.1	0	5.9	55.9

Table 18 cont'd.

	Average percent cover mosses and lichens	Average percent cover of dead material	Average percent cover of bare ground	GCD	Ground cover patchiness	FHD	Structural patchiness	Deadfall transect index	Moisture	Nutrients	Heat	Light	Litter depth
G43	28.5	31.1	5.0	5.41	6.32	4.34	1.27	7.24	3.13	2.18	1.91	2.84	0
G44	68.6	10.7	0.3	2.06	2.02	4.46	1.50	1.05	3.75	1.46	1.25	3.96	0
G45	16.5	0.5	1.1	1.63	1.01	3.94	1.03	0	4.58	1.47	1.47	4.63	0
G47	1.1	44.7	0.3	3.06	1.96	6.59	1.81	2.32	2.38	2.17	2.15	3.19	2.5
G48	20.8	5.1	18.3	3.76	3.56	6.46	2.20	0.45	3.87	2.32	2.06	3.32	0

Table 18 cont'd.

	Sorex arcticus	Sorex cinereus	Microsorex	Blarina	Tamias	Eutamias	Peromyscus	Clethrionomys	Microtus	Zapus	Napaeozapus
Total number of high shrub species	.310	-.019	.505	.134	.308	.192	-.048	.318	.285	.469	.151
Average high shrub basal area cm^2/m^2	.631*	.270	.573*	.070	.226	.193	-.346	-.226	.565*	.464	-.018
Average high shrub number of stems/m^2	.430	.030	.422	.289	.714**	.096	.273	.249	.279	.311	.241
Total number of low shrub species	.480	.303	.772**	-.008	.342	-.121	-.054	.468	.395	.382	.020
Average low shrub number of stems/m^2	.686**	.684**	.630*	-.087	.136	-.134	-.414	.156	.792**	.200	.095
Foliage height diversity	.229	-.069	.467	.343	.788**	.201	.277	.344	.087	.355	.311
Structural patchiness	.090	-.073	.373	.555*	.695**	.253	.458	.130	.047	.323	.330
Moisture	.629*	.582*	.544*	-.199	-.325	-.037	-.777**	-.143	.810**	.292	.062
Nutrients	-.041	-.545*	-.074	.243	.307	-.059	.667**	.143	-.238	.325	.536*
Heat	.002	-.435	-.027	.357	.540*	-.165	.878**	.110	-.333	.356	.440
Light	.687**	.421	.321	-.259	.164	-.140	-.159	-.052	.570*	.386	.133

Table 19. Coefficients of Spearman's rank correlations between small mammal relative densities and habitat features for the 1976 data. * = significant at = .05 level, ** = significant at = .01 level.

	Sorex arcticus	Sorex cinereus	Microsorex	Blarina	Tamias	Eutamias	Peromyscus	Clethrionomys	Microtus	Zapus	Napaeozapus
Total number of tree species	-.001	.207	.213	.424**	.365*	-.184	.261	.258	.042	.139	.455**
Average tree basal area cm^2/m^2	.066	.185	.373**	.366*	.301*	-.469**	.284	.263	-.012	.077	.354*
Total number of high shrub species	.081	.169	.045	.476**	.416**	.131	.077	.492**	-.028	.181	.467**
Average high shrub basal area cm^2/n^2	.280	.333*	.147	.402**	.473**	.261	-.288*	.078	.303*	.074	.379**
Average high shrub number of stems/m^2	.222	.309*	.106	.456**	.476**	.191	-.36	.175	.260	.134	.371*
Total number of low shrub species	.156	.160	.013	.472**	.404**	.206	.144	.303*	.091	.003	.421**
Average low shrub number of stems/m^2	.481**	.027	.080	.350*	.401**	.371	-.164	-.283	.291*	.204	.349*
Average percent cover of forbs	-.158	-.149	-.103	.244	.375**	.025	.149	.166	.134	.337*	.383**
Average percent cover of graminoids	.313*	.176	-.079	.333*	.312*	.209	-.152	-.170	.396**	.230	.412**
Average percent cover of mosses	.464**	.288*	.419**	.283	.339*	-.269	-.350*	-.167	.338*	-.032	.287
Average percent cover of litter	-.190	-.047	.047	.400**	.454**	.151	.579**	.388**	-.005	.228	.533**
Average percent cover of deadfall	.015	-.037	.043	.408**	.478**	.524**	.238	.425**	.131	.123	.409**

Table 20. Coefficients of Spearman's rank correlations between small mammal relative densities and habitat features for the 1977 data. * = significant at α = .05 level, ** = significant at α = .01 level.

	Sorex arcticus	*Sorex cinereus*	*Microsorex*	*Blarina*	*Tamias*	*Eutamias*	*Peromyscus*	*Clethrionomys*	*Microtus*	*Zapus*	*Napaeozapus*
Average percent cover of low woody plants	.516**	.129	.115	.393**	.301*	.183	-.282	-.293*	.403**	.110	.314*
Average percent cover of dead material	-.140	-.073	.043	.410**	.483**	.267	.550**	.420**	.009	.236	.512**
Average percent cover of bare ground	.077	-.101	-.090	.290	.368*	.414**	.117	-.211	.490**	.294*	.434**
Ground cover diversity	.217	.075	.035	.321*	.366*	.459**	-.027	-.072	.368*	.235	.333*
Ground cover patchiness	.114	.010	.044	.232	.332*	.432**	-.059	-.030	.371*	.194	.340*
Foliage height diversity	.201	.345*	.207	.464**	.494**	.002	-.277	.299*	.185	.020	.353*
Structural patchiness	.209	.459**	.217	.424**	.506**	-.019	-.208	.297*	.358*	.029	.387**
Deadfall transect index	.010	-.127	-.189	.333*	.569**	.648**	.366*	.355*	.073	.247	.379*
Litter depth	-.034	-.069	-.010	.278	.479**	.218	.430**	.498**	.066	.262	.424**
Moisture	.463**	.491**	.402**	.439**	.350*	-.171	-.273	.025	.324*	-.184	.359*
Nutrients	-.102	-.059	-.071	.364*	.397**	.150	.237	.083	.183	.238	.480**
Heat	-.103	-.439**	-.361*	.203	.353*	.275	.257	-.097	.191	.450**	.446**
Light	.384**	-.266	-.010	.181	.304*	.174	-.338*	-.480**	.436**	.410**	.176

Table 20 cont'd

Canopy Type	Number of grids	*Sorex arcticus*	*Sorex cinereus*	*Microsorex hoyi*	*Blarina brevicauda*	*Tamias striatus*	*Eutamias minimus*	*Peromyscus maniculatus*
BS	9	1.0 (0-3.5)	15.7 (2.1-26.8)	1.2 (0-8.3)	1.6 (0-9.7)	-	0.6 (0-1.4)	0.4 (0-2.1)
cT	3	1.9 (0.7-4.2)	26.3 (19.1-37.5)	1.6 (0-4.2)	3.8 (0.7-6.4)	-	0.7 (0-2.1)	0.7 (0-2.1)
oT	2	2.4 (2.1-2.7)	12.0 (8.2-15.7)	0.7 (0-1.4)	-	-	-	-
CED	2	0.4 (0-0.7)	16.4 (12.6-20.2)	0.8 (0-1.5)	1.5 (0-3.0)	-	5.9 (0.7-11.1)	4.0 (2.0-5.9)
SC	2	1.7 (0-3.5)	25.0 (2.1-47.9)	0.7 (0-1.4)	-	-	0.7 (0-1.4)	-
yJP	2	-	1.4 (0.7-2.1)	0.4 (-0.07)	-	-	14.9 (3.5-26.4)	8.7 (4.9-12.5)
mJP	11	0.5 (0-4.9)	12.2 (0.7-33.3)	0.3 (0-1.4)	0.4 (0-2.1)	0.1 (0-0.7)	1.3 (0-3.6)	2.2 (0-12.5)
yRP	1	-	1.4 -	-	-	0.7 -	9.0 -	9.0 -
mRP	10	0.3 (0-2.2)	8.2 (0-27.1)	0.4 (0-2.1)	0.3 (0-1.8)	0.1 (0-0.9)	2.0 (0-11.1)	6.1 (0-18.0)
yWS	1	3.5 -	7.8 -	-	-	-	0.7 -	2.8 -
mWS	2	-	10.5 (5.6-15.3)	1.1 (0.7-1.4)	0.4 (-0.7)	-	-	1.8 (0-3.5)
yAB	3	0.9 (0-2.8)	10.4 (0-30.6)	-	-	-	6.5 (4.9-9.6)	5.8 (0-17.4)
mAB	11	0.4 (0-3.6)	11.3 (1.6-26.5)	0.7 (0-3.5)	3.3 (0-13.6)	0.7 (0-2.9)	1.3 (0-7.1)	5.8 (0-20.9)
yABF	1	-	1.5 -	-	-	-	9.0 -	14.1 -
mABF	12	0.1 (0-0.7)	13.5 (3.5-27.8)	0.3 (0-0.7)	1.2 (0-3.8)	0.1 (0-0.7)	0.2 (0-2.1)	5.2 (0-9.7)
MIX	2	-	23.4 (14.1-32.6)	2.2 (0-4.4)	1.1 (0.7-1.5)	0.8 (0-1.5)	0.4 (0-0.7)	1.1 (0.7-1.5)
GR	1	-	2.3 -	-	-	-	-	-

Table 21. Average relative densities in numbers per ha of species within each canopy type. Range in relative density is given in parentheses. Data from grids trapped in period A of 1976 are omitted. c = closed, m = medium-aged and mature, o = open, y = clearcut, AB = Aspen-Birch, ABF = Aspen-Birch-Fir, BS = Black spruce, CED = Cedar, GR = grassland, JP = Jack pine, MIX = Mixed coniferous-deciduous, RP = Red pine, SC = Shrub carr, T = Tamarack, WS = White spruce.

Canopy Types	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis
BS	7.6 (0.7-16.7)	-	0.8 (0-4.2)	0.1 (0-0.7)	-
cT	16.3 (3.5-25.4)	0.9 (0-2.1)	10.1 (0-22.3)	-	-
oT	1.7 (0.7-2.7)	-	11.3 (5.5-17.1)	-	-
CED	4.7 (4.4-5.1)	-	10.1 (0-20.2)	-	-
SC	0.7 (0-1.4)	-	0.7 (0.7)	0.4 (0-0.7	-
yJP	4.9 (2.8-4.9)	-	0.4 (0-0.7)	0.7 (0.7)	-
mJP	12.8 (4.9-29.2)	-	-	0.2 (0-0.7)	-
yRP	5.6 -	-	-	1.4 -	-
mRP	7.0 (1.5-23.7)	-	0.1 (0-2.1)	0.3 (0-1.4)	0.1 (0-1.0)
yWS	-	-	1.4 -	-	-
mWS	38.9 (7.6-70.1)	-	-	-	-
yAB	5.7 (2.1-9.7)	-	-	0.2 (0-0.7)	-
mAB	10.7 (2.2-22.6)	-	0.4 (0-2.2)	0.3 (0-1.4)	0.4 (0-3.9)
yABF	20.0	-	-	-	0.7 -
mABF	12.1 (1.4-21.5)	-	0.4 (0-4.9)	0.2 (0-1.5)	0.1 (0-0.7)
MIX	13.6 (9.6-17.6)	-	-	0.4 (0-0.7)	0.4 (0-0.7)
GR	0.8 -	-	43.7 -	2.3 -	-

Table 21 cont'd.

Table 22. Abundance pattern of small mammals among canopy types. Abbreviations of canopy types correspond to those in Table 21. The number of grids of each type appears in parentheses next to the abbreviation. Species are ranked in order of their frequency of occurrence (in parentheses). Occurrence is defined as at least one capture on a grid. Species of equal frequency are ordered by average density (Table 21). Both years of data are combined.

BS (11)	
Sorex cinereus	(1.00)
Clethrionomys	(.91)
Eutamias	(.55)
Sorex arcticus	(.45)
Microtus	(.45)
Microsorex	(.36)
Blarina	(.27)
Peromyscus	(.27)
Zapus	(.18)

cT (3)	
Sorex cinereus	(1.00)
Clethrionomys	(1.00)
Blarina	(1.00)
Sorex arcticus	(1.00)
Microsorex	(.67)
Synaptomys	(.67)
Microtus	(.67)
Eutamias	(.33)
Peromyscus	(.33)

oT (2)	
Sorex cinereus	(1.00)
Microtus	(1.00)
Sorex arcticus	(1.00)
Clethrionomys	(1.00)
Microsorex	(.50)

CED (2)	
Sorex cinereus	(1.00)
Eutamias	1.00)
Clethrionomys	(1.00)
Peromyscus	(1.00)
Microtus	(.50)
Blarina	(.50)
Microsorex	(.50)
Sorex arcticus	(.50)

SC (2)	
Sorex cinereus	(1.00)
Microtus	(1.00)
Sorex arcticus	(.50)
Microsorex	(.50)
Eutamias	(.50)
Clethrionomys	(.50)
Zapus	(.50)

yJP (2)	
Eutamias	(1.00)
Peromyscus	(1.00)
Clethrionomys	(1.00)
Sorex cinereus	(1.00)
Zapus	(1.00)
Microsorex	(.50)
Microtus	(.50)

mJP (13)	
Clethrionomys	(1.00)
Sorex cinereus	(.85)
Peromyscus	(.77)
Eutamias	(.54)
Zapus	(.38)
Blarina	(.31)
Sorex arcticus	(.15)
Microsorex	(.15)
Tamias	(.15)
Microtus	(.08)

yRP (1)
Eutamias
Peromyscus
Clethrionomys
Sorex cinereus
Zapus
Tamias

mRD (12)	
Clethrionomys	(1.00)
Peromyscus	(.92)
Sorex cinereus	(.75)
Zapus	(.42)
Eutamias	(.33)
Blarina	(.25)
Microsorex	(.17)
Sorex arcticus	(.17)
Napaeozapus	(.17)
Microtus	(.08)
Tamias	(.08)

Table 22 cont'd

yWS (1)	
Sorex cinereus	
Sorex arcticus	
Peromyscus	
Microtus	
Eutamias	

mWS (2)	
Clethrionomys	(1.00)
Sorex cinereus	(1.00)
Microsorex	(1.00)
Peromyscus	(.50)
Blarina	(.50)

yAB (3)	
Eutamias	(1.00)
Clethrionomys	(1.00)
Sorex cinereus	(.67)
Peromyscus	(.33)
Sorex arcticus	(.33)
Zapus	(.33)

mAB (15)	
Sorex cinereus	(1.00)
Clethrionomys	(1.00)
Peromyscus	(.93)
Blarina	(.67)
Tamias	(.60)
Eutamias	(.40)
Zapus	(.40)
Napaeozapus	(.33)
Microsorex	(.27)
Sorex arcticus	(.20)
Microtus	(.13)

yABF (1)	
Clethrionomys	
Peromyscus	
Eutamias	
Sorex cinereus	
Napaeozapus	

mABF (14)	
Clethrionomys	(1.00)
Sorex cinereus	(.93)
Peromyscus	(.86)
Blarina	(.57)
Microsorex	(.36)
Napaeozapus	(.29)
Zapus	(.21)
Tamias	(.21)
Microtus	(.07)
Eutamias	(.07)
Sorex arcticus	(.07)

MIX (2)	
Sorex cinereus	(1.00)
Clethrionomys	(1.00)
Blarina	(1.00)
Peromyscus	(1.00)
Microsorex	(.50)
Tamias	(.50)
Eutamias	(.50)
Zapus	(.50)
Napaeozapus	(.50)

GR (1)	
Microtus	
Sorex cinereus	
Zapus	
Clethrionomys	

Table 23. Abundance pattern of small mammals among broad habitat types. CC = clearcut, UC = mature upland coniferous forest, UD = mature upland deciduous forest, W = wetland. The number of grids of each habitat type appears in parentheses next to its abbreviation. Species are ranked in order of their frequency of occurrence (in parentheses). Occurrence is defined as at least one capture on a grid. Species of equal frequency are ordered by average relative density. Both years of data are combined.

UC (27)		UD (31)	
Clethrionomys	(1.00)	Clethrionomys	(1.00)
Sorex cinereus	(.81)	Sorex cinereus	(.97)
Peromyscus	(.81)	Peromyscus	(.90)
Eutamias	(.41)	Blarina	(.65)
Zapus	(.37)	Tamias	(.42)
Blarina	(.30)	Microsorex	(.32)
Microsorex	(.22)	Zapus	(.32)
Sorex arcticus	(.15)	Napaeozapus	(.32)
Tamias	(.11)	Eutamias	(.26)
Microtus	(.07)	Sorex arcticus	(.13)
Napaeozapus	(.07)	Microtus	(.10)

WET (20)		CC (8)	
Sorex cinereus	(1.00)	Eutamias	(1.00)
Clethrionomys	(.90)	Clethrionomys	(1.00)
Sorex arcticus	(.60)	Sorex cinereus	(.88)
Microtus	(.60)	Peromyscus	(.63)
Eutamias	(.50)	Zapus	(.50)
Microsorex	(.45)	Sorex arcticus	(.25)
Blarina	(.35)	Microtus	(.25)
Peromyscus	(.30)	Microsorex	(.13)
Zapus	(.15)	Tamias	(.13)
Synaptomys	(.10)	Napaeozapus	(.13)

	Small mammal richness	Small mammal richness of insectivores, cricetids, and zapodids	Total relative density (number/ha)	Total relative density of insectivores, cricetids, and zapodids (no./ha)	Small mammal diversity	Diversity of insectivores, cricetids, and zapodids	Small mammal diversity of insectivores	Small mammal diversity of cricetids and zapodids	Insectivore species / Cricetid, zapodid species	Insectivore density / Total relative density
T03B	4	3	11.9	8.2	3.05	2.05	0	2.05	0	0
T08C	4	4	20.1	20.1	3.84	3.84	1.90	1.97	1.0	.45
T09C	7	5	31.8	30.4	4.14	3.80	2.17	1.63	1.5	.56
T15I	4	4	30.8	30.8	2.53	2.53	1.60	1.31	1.0	.36
T16I	7	7	53.5	53.5	3.00	3.00	1.19	1.86	1.3	.45
T17I	6	5	61.6	50.5	3.88	2.98	1.29	1.70	0.7	.36
T26B	5	5	30.3	30.3	2.39	2.39	1.47	1.77	0.7	.16
T27B	7	5	30.9	25.1	5.02	3.63	1.92	2.55	0.7	.19
T28B	6	5	48.6	47.8	2.50	2.42	1.19	1.54	1.5	.61
T29B	6	4	56.2	52.6	3.99	3.53	1.92	1.73	1.0	.38
T30C	4	3	31.2	29.9	2.34	2.15	1.30	1.00	2.0	.70
T32C	4	4	46.7	46.7	2.48	2.48	1.09	1.42	1.0	.38
T33C	4	4	28.5	28.5	2.03	2.03	1.47	1.60	1.0	.12
T34C	5	4	32.0	31.1	3.36	3.18	1.47	1.97	1.0	.29

Table 24. Values of small mammal community characteristics on 14 grids trapped during 1976. Data from grids trapped in period A were omitted. Other grids trapped in 1976 lack quantitative vegetation data.

	Small mammal richness	Small mammal richness of insectivores, cricetids, and zapodids	Total relative density (number/ha)	Total relative density of insectivores, cricetids and zapodids (no./ha)	Small mammal, diversity	Diversity of insectivores, cricetids, and zapodids	Diversity of insectivores	Diversity of cricetids and zapodids	Insectivore species /Cricetid zapodid species	Insectivore species /Total relative density
G01	5	4	25.0	23.6	3.01	2.71	1.57	1.16	1.0	.62
G02	3	3	3.5	3.5	2.27	2.27	1.60	1.00	2.0	.80
G03	3	3	25.2	25.2	1.82	1.82	1.19	1.00	2.0	.77
G04	8	6	52.6	50.4	2.34	2.15	1.37	1.47	1.0	.76
G05	6	5	41.0	38.9	2.61	2.37	1.06	2.07	0.7	.61
G06	5	5	28.2	28.2	1.87	1.87	1.22	1.25	1.3	.77
G07	4	3	16.3	6.7	2.20	1.59	1.00	1.28	0.5	.11
G08	5	3	32.5	24.6	2.45	1.59	1.00	1.40	0.5	.06
G09	6	6	41.7	41.7	2.39	2.39	1.23	1.43	1.0	.63
G10	4	3	47.9	43.1	2.17	1.79	1.18	1.00	2.0	.77
G11	7	6	36.8	10.4	1.85	3.25	2.00	2.52	0.5	.13
G12	3	3	10.4	10.4	2.92	2.92	1.00	1.98	0.5	.40
G13	5	4	25.7	22.2	2.98	2.36	1.00	1.98	0.3	.09
G14	4	4	43.1	43.1	2.50	2.50	1.09	1.43	1.0	.39
G15	4	4	44.4	44.4	1.96	1.96	1.10	1.00	3.0	.66
G16	4	3	12.5	10.4	1.80	1.31	1.00	1.15	0.5	.07
G17	5	5	29.9	29.9	2.29	2.29	1.41	1.08	1.5	.42
G18	4	3	4.9	3.5	3.26	2.27	1.00	2.00	0.5	.60
G19	6	4	27.1	17.4	3.70	2.59	1.00	2.23	0.3	.08
G20	6	5	9.6	8.9	4.83	4.24	1.92	2.33	0.7	.42
G21	3	3	11.8	11.8	2.24	2.24	0	2.24	0	0
G22	4	3	27.1	16.0	2.70	1.72	1.00	2.00	0.5	.74
G23	5	5	16.3	16.3	3.56	3.56	2.13	1.85	1.5	.36
G24	4	4	42.4	42.4	2.14	2.14	1.15	1.76	1.0	.69

Table 25. Values of small mammal community characteristics on grids trapped during 1977.

	Small mammal richness	Small mammal richness of insectivores, cricetids, and zapedids	Total relative density (number/ha)	Total relative density of insectivores, cricetids and zapodids (no./ha)	Small mammal diversity	Diversity of insectivores, cricetids, and zapodids	Diversity of insectivores	Diversity of cricetids and zapodids	Insectivore species /Cricetid zapodid species	Insectivore species /Total relative density
G25	4	3	25.0	22.9	3.27	2.81	1.00	2.00	0.5	.45
G26	5	3	41.7	37.5	2.41	1.99	1.00	1.09	0.5	.59
G27	6	4	68.1	66.7	3.01	2.89	1.18	1.72	1.0	.34
G28	6	5	66.0	63.9	2.56	2.41	1.43	1.00	4.0	.63
G29	4	4	49.1	49.1	1.26	1.26	1.00	1.14	0.3	.05
G30	4	4	7.6	7.6	2.20	2.20	1.00	1.58	0.3	.18
G31	6	6	50.7	50.7	1.77	1.77	1.50	1.00	2.0	.92
G32	4	4	11.1	11.1	3.10	3.10	1.80	1.88	1.0	.27
G33	5	5	46.5	46.5	3.14	3.14	1.37	1.78	0.7	.46
G34	5	4	16.2	15.5	3.17	2.92	1.75	1.80	1.0	.73
G35	5	5	90.3	90.3	1.58	1.58	1.18	1.10	1.5	.18
G36	3	3	14.6	14.6	2.33	2.33	1.47	1.00	2.0	.48
G37	5	4	45.2	36.3	3.00	2.19	1.00	2.02	0.3	.04
G38	4	4	53.5	53.5	2.80	2.80	1.06	1.75	1.0	.42
G39	3	3	46.9	46.9	2.21	2.21	1.00	1.21	0.5	.47
G40	3	2	24.3	19.4	1.79	1.24	0	1.24	0	0
G41	5	5	11.1	11.1	3.20	3.20	1.38	1.85	0.7	.37
G42	5	5	38.9	38.9	1.84	1.84	1.05	2.10	0.7	.73
G43	6	5	25.9	25.2	3.10	2.93	1.36	1.96	1.5	.59
G44	5	4	32.6	31.9	2.94	2.82	1.84	1.18	1.0	.74
G45	5	5	25.3	25.3	2.25	2.25	1.45	1.24	1.3	.76
G47	5	5	33.9	33.9	2.24	2.24	1.00	1.16	0.7	.44
G48	5	5	54.9	54.9	1.30	1.30	1.21	1.80	1.5	.96

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Table 25 cont'd.

	Small mammal richness	Small mammal richness of insectivores, cricetids and zapodids	Total relative density	Total relative density of insectivores, cricetids and zapodids	Small mammal diversity	Diversity of insectivores, cricetids and zapodids	Diversity of insectivores	Diversity of cricetids and zapodids	Insectivore species /Cricetid zapodid species	Insectivore density / Total relative density
Total number of high shrub species	.473	.392	.205	.122	.397	.267	-.037	.396	.062	.051
Average high shrub basal area cm^2/m^2	.318	.190	.295	.389	.411	.321	.227	-.123	.282	.299
Average high shrub number of stems/m^2	.635*	.388	.432	.441	.564*	.504	.442	.337	.110	-.078
Total number of low shrub species	.474	.401	.455	.571*	.185	.211	-.020	.027	.415	.147
Average low shrub number of stems/m^2	.420	.527	.653*	.807**	.011	.130	-.022	-.434	.437	.396
Foliage height diversity	.582*	.284	.260	.157	.588*	.513	.391	.462	.147	-.040
Structural patchiness	.488	.237	.231	.116	.516	.468	.437	.458	.084	.020
Moisture	.004	.295	.196	.288	-.310	-.196	-.246	-.616*	.451	.552*
Nutrients	-.069	.067	-.308	-.421	.084	.147	.277	.316	-.337	-.351
Heat	.013	-.029	-.116	-.167	.310	.446	.323	.526	-.262	-.341
Light	.066	.090	.364	.557*	.087	.199	-.193	.030	.087	.027

Table 26. Coefficients of Spearman's rank correlations between small mammal community characteristics and habitat features for the 1976 data. * - significant at α = .05 level, ** = Significant at α = .01 level.

	Small mammal richness	Richness of insectivores, cricetids, and zapodids	Total relative density	Relative density of insectivores, cricetids, and zapodids	Small mammal diversity	Diversity of insectivores, cricetids, and zapodids	Diversity of insectivores	Diversity of cricetids and zapodids	Insectivore species /Cricetid-zapodid species	Insectivore density /Total relative density
Total number of tree species	.083	.163	.008	.140	.222	.325*	.059	.040	.110	-.022
Average tree basal area cm²/m²	-.046	.195	-.046	.104	.116	.337*	.182	.021	.213	.022
Total number of high shrub species	.124	.072	.245	.225	.017	.008	-.073	-.102	.029	-.095
Average high shrub basal area cm²/m²	.195	.027	.160	.133	.077	-.066	.133	-.159	.221	.362*
Average high shrub number of stems/m²	.223	.098	.224	.205	.027	-.083	.061	-.064	.129	.201
Total number of low shrub species	.125	-.035	.108	.145	.106	.084	-.100	-.103	.034	-.006
Average low shrub number of stems/m²	.328*	.149	-.116	-.152	.066	.072	.353*	-.119	.157	.368*
Average percent cover of forbs	-.128	-.093	-.069	-.089	-.009	-.037	-.343*	.092	-.342*	-.401**
Average percent cover of graminoids	.164	.126	.174	.126	-.198	-.198	-.065	.057	.027	.206
Average percent cover of mosses	.050	.152	-.131	-.021	-.081	.026	.415**	-.272	.504**	.602**
Average percent cover of litter	.116	.072	.105	.106	.346*	.270	-.141	.357*	-.234	-.376*
Average percent cover of deadfall	.210	.004	.229	.117	.166	.097	-.085	.003	-.082	-.229

Table 27. Coefficients of Spearman's rank correlations between small mammal community characteristics and habitat features for the 1977 data. * = significant at α = .05 level, ** = significant at = .01 level.

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	Small mammal richness	Richness of insectivores, cricetids, and zapodids	Total relative density	Relative density of insectivores cricetids, and zapodids	Small mammal diversity	Diversity of insectivores, cricetids and zapodids	Diversity of insectivores	Diversity of cricetids and zapodids	Insectivore species /Cricetid zapodid spec	Insectivore diversity/Total relative density
Average percent cover of low woody plants	.206	.185	-.104	-.107	-.074	.014	.340*	-.165	.275	.403**
Average percent cover of dead material	.181	.076	.143	.113	.340*	.267	-.099	.312*	-.221	-.397**
Average percent cover of bare ground	.085	-.034	.079	-.020	-.036	-.169	-.271	.275	-.272	-.031
Ground cover diversity	.263	.074	.070	-.011	.069	.001	-.025	.176	-.034	.120
Ground cover patchiness	.082	-.074	.059	-.056	.051	-.033	-.106	.186	-.091	.083
Foliage height diversity	.082	.029	.189	.209	-.030	-.099	.198	-.269	.355*	.277
Structural patchiness	.219	.167	.276	.296*	.021	-.061	.088	-.036	.221	.354*
Deadfall transect index	.261	-.089	.165	.010	.354*	.214	-.129	.208	-.209	-.302*
Litter depth	.102	-.013	.097	.085	.234	.231	-.104	.152	-.234	-.359*
Moisture	.130	.201	.183	.298*	-.033	-.029	.335*	-.306*	.571**	.628**
Nutrients	-.088	-.062	.183	.143	-.074	-.263	-.386**	.189	-.225	-.309*
Heat	-.153	-.188	-.139	-.224	.012	-.135	-.400**	.287	-.468**	-.561**
Light	.096	.028	-.343*	-.360*	-.092	-.026	.250	-.133	-.026	.129

Table 27 cont'd.

	UC-UD	UC-W	UD-W
Insectivores	NS	*	NS
Granivores and Omnivores	NS	*	**
Grazers	NS	NS	NS

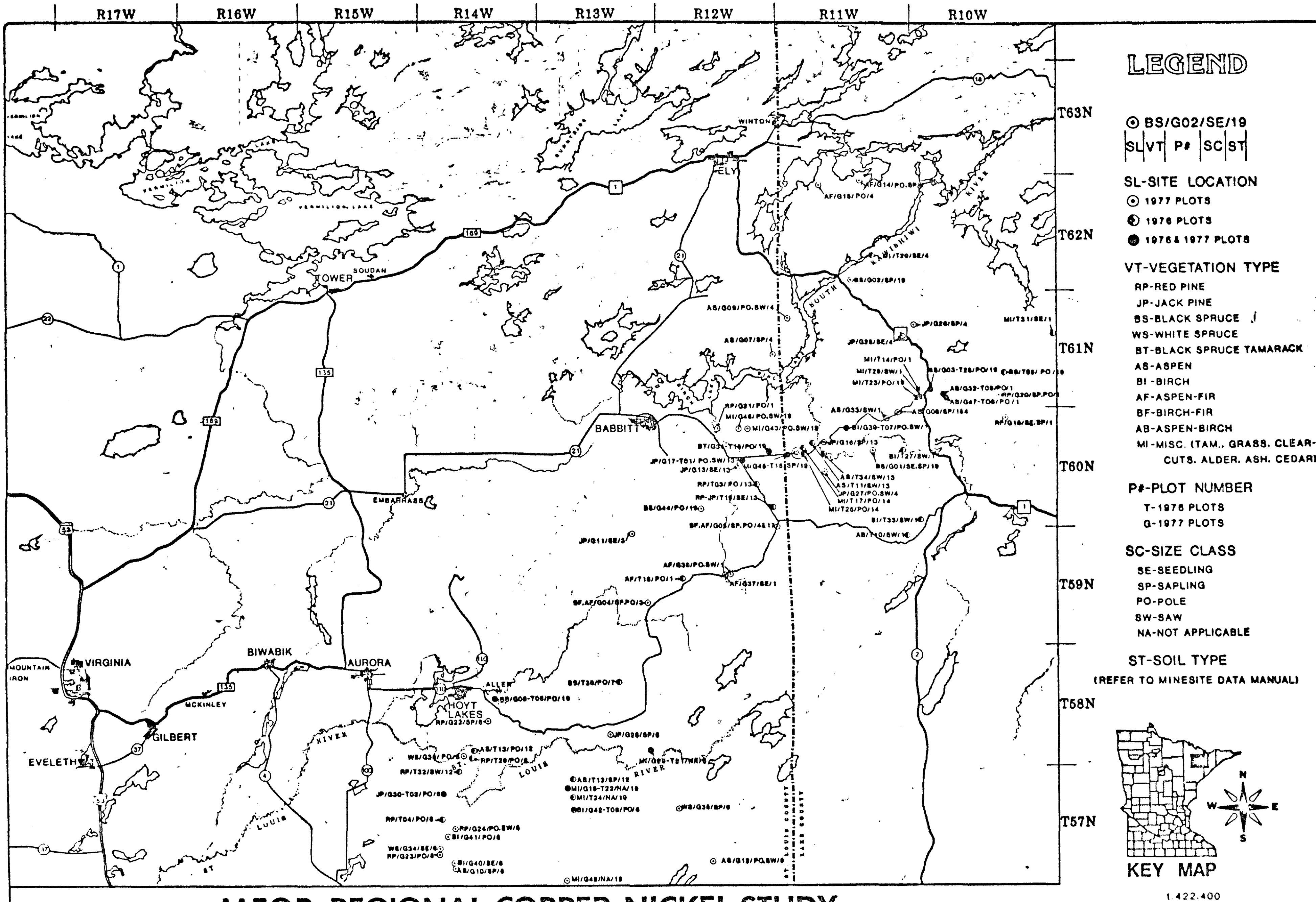
Table 28. Mann-Whitney comparisons between broad habitat types of the proportions of trophic groups on grids trapped in 1976. Data from grids trapped during period A were omitted. Abbreviations for broad habitat type follow those in Table 23. NS = not significant, * = significant at α = .05 level, ** = significant at α = .01 level.

	UC - UD	UC - W	UC - CC	UD - W	UD - CC	W - CC
Insectivores	NS	* *	NS	* *	*	* *
Granivores and Omnivores	NS	*	*	NS	* *	* *
Grazers	NS	* *	*	*	NS	NS

Table 29. Man-Whitney comparisons between broad habitat types of the proportions of trophic groups on grids trapped in 1977. Abbreviations for broad habitat types follow those in Table 23. NS = not significant, * = significant at α = .05 level, * * = Significant at α = .01 level.

	UC 1976-1977	UD 1976-1977	W 1976-1977
Insectivores	NS	NS	NS
Granivores and Omnivores	NS	NS	NS
Grazers	NS	NS	**

Table 30. Mann-Whitney comparisons between years of the proportions of trophic groups caught within the same broad habitat type. NS = not significant, * = significant at α = .05 level, ** = significant at α = .01 level. Abbreviations follow those in Table 23.



MEQB REGIONAL COPPER-NICKEL STUDY

FIGURE 1 TERRESTRIAL FIELD SAMPLE SITES

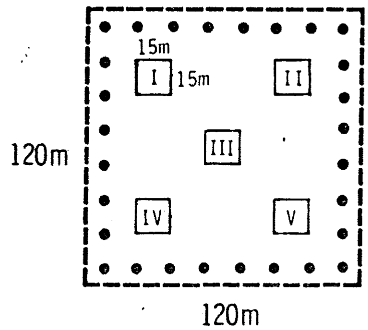


Figure 3. Placement of the 5 tree plots within an 8 X 8 trap station grid. Dots indicate the outermost row of traps.

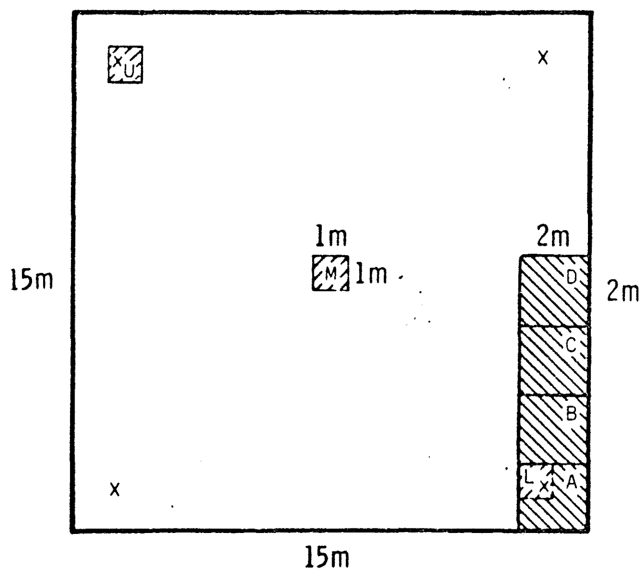


Figure 4. Placement of high shrub, low shrub, and ground cover plots and shrub density sampling points within each tree plot. A, B, C, and D are high shrub plots, and U, M, L are low shrub and ground cover plots. Shrub density sampling points are indicated by an " X ".

Figure 5. Average proportions of three trophic groups- insectivores, granivores and omnivores, and grazers (See text for species composition of groups) - in each of the broad habitat types. Data from period A of 1976 and the grassland were omitted. Abbreviations follow those in Table 23.

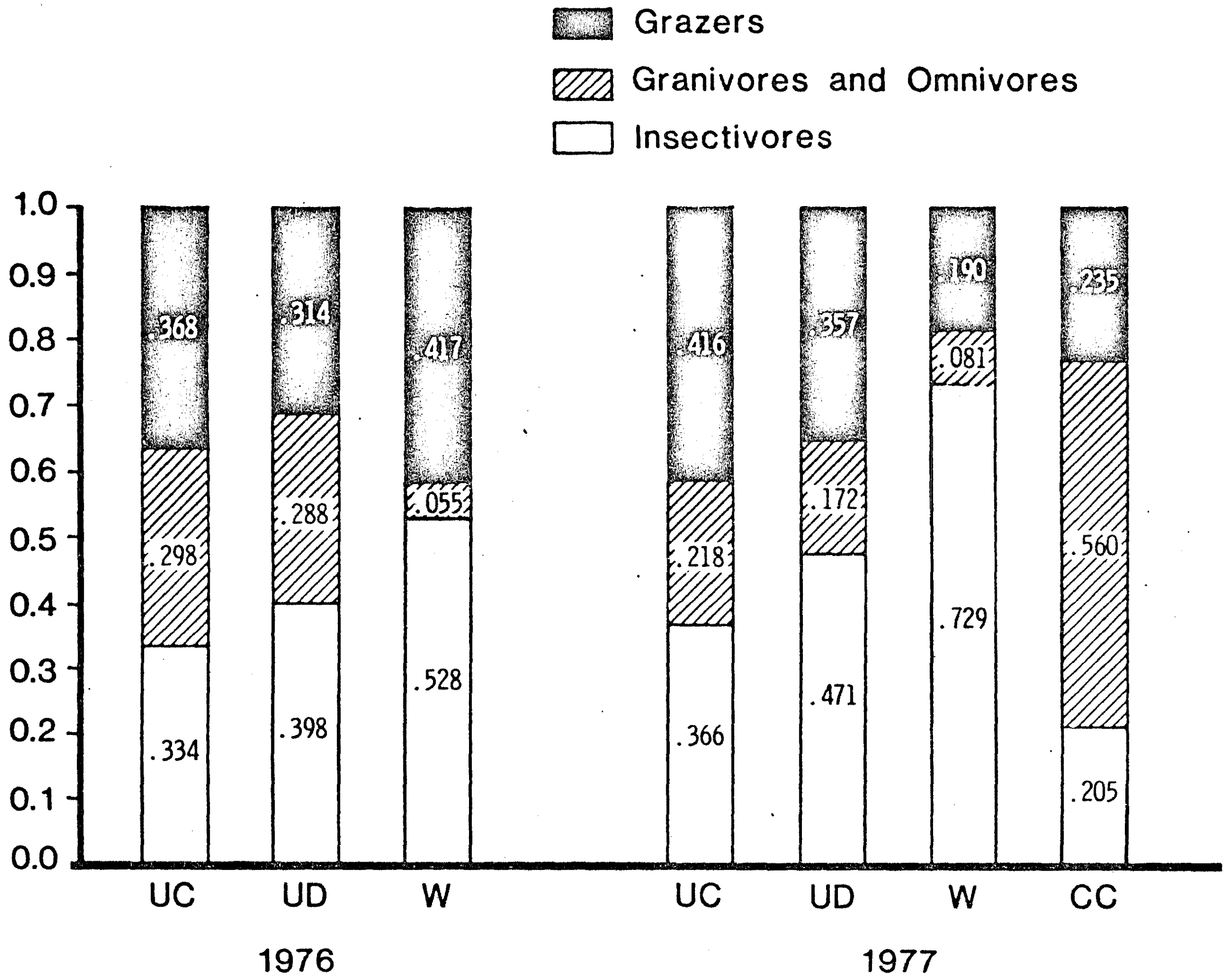


Table A. Canopy groups as defined by cluster analysis on releves (Sather, 1979) and the characteristic plant species of each group.

Group	Characteristic Species
Black spruce (BS)	*Picea mariana*
Tamarack (T)	*Larix laricina*
Cedar (CED)	*Thuja occidentalis*
Jack pine (JP)	*Pinus banksiana*
Red pine (RP)	*Pinus resinosa*
Aspen -Birch (AB)	*Populus tremuloides* *Betula papyrifera*
Aspen-Birch-Fir (ABF)	*Populus tremuloides* *Betula papyrifera* *Abies balsamea*
Mixed coniferous-deciduous (MIX)	*Populus tremuloides* *Betula papyrifera* *Abies balsamea* *Pinus banksiana*
Shrub carr (SC)	*Alnus rugosa*
Grassland (GR)	-
White spruce (WS)	*Picea glauca*

Table B. High shrub groups as defined by cluster analysis on releves (Sather, 1975) and the characteristic plant species of each group.

Group	Characteristic species
I	*Alnus rugosa*
II	Sparse shrubs *Salix* spp. *Alnus crispa*
III	*Abies balsamea* *Acer rubrum*
IV	Sparse shrubs *Populus tremuloides* *Amelanchier* spp. *Corylus cornuta*
V	Dense shrubs *Corylus cornuta* *Alnus crispa* *Acer spicatum*
VI	*Larix laricina* *Picea mariana*

Group	Characteristic species
VII A	*Picea mariana*
VII B	*Picea mariana* *Abies balsamea*
VIII	*Picea mariana* *Populus tremuloides*
IX	Anomalous stands *Picea mariana* *Abies balsamea* *Populus tremuloides* *Rubus idaeus*
X	Dense shrubs *Populus tremuloides* *Corylus cornuta* *Amelanchier* spp. *Rubus idaeus* *Rosa acicularis*
None	No high shrub layer

Table C. Low shrub groups as defined by cluster analysis on releves (Sather, 197) and the characteristic plant species of each group.

Group	Characteristic species
Labrador tea (LT)	*Ledum groenlandicum* *Alnus rugosa*
Ericaceous bogs (EB)	*Chamaedaphne calyculata* *Andromeda glaucophylla* *Ledum groenlandicum* *Kalmia polifolia*
Alder wetland (AW)	*Alnus rugosa*
Conifer (C)	*Picea mariana* *Abies balsamea*
Raspberry-Hazel (RH)	*Rubus idaeus* *Corylus cornuta* *Amelanchier* spp. *Diervilla lonicera* *Salix bebbiana*
Aspen-Birch (AB)	*Populus tremuloides* *Betula papyrifera*
Hazel (H)	*Corylus cornuta*
Hazel-Mountain maple (HMM)	*Corylus cornuta* *Acer spicatum* *Lonicera canadensis*
Alder-Hazel (AH)	*Alnus crispa* *Corylus cornuta*
None	No low shrub layer

Table D. Herb groups as defined by cluster analysis on releves (Sather, 197) and the characteristic plant species of each group.

Group	Characteristic species
Conifer bog (CB)	*Vaccinium oxycoccus* *Gaultheria hispidula* *Carex* spp.
Nutrient-rich wetland (NRW)	*Lycopus uniflorus* *Mentha arvensis*
Mixed stands n. of Laurentian Divide (MIX)	*Cornus canadensis* *Linnaea borealis* *Anemone quinquefolia* *Lycopodium* spp.
Disturbed sites (DIS)	*Achillea millefolium* *Anaphalis margaritacea*
Northern mesic (NM)	*Actaea* spp. *Mitella nuda* *Aster macrophyllus* *Aralia nudicaulis* *Viola* spp. *Dryopteris spinulosa*
Aspen-Aster-Aralia (AA)	*Aster macrophyllus* *Aralia nudicaulis* *Pteridium*
Lathyrus-Vicia-Apocynum (LV)	*Lathyrus* spp. *Vicia* *Apocynum*

Site	Broad habitat type	Canopy type	High shrub type	Low-shrub type	Herb type
T01	UC	mJP	IV	RH	LV
T02	UC	mJP	IV	RH	NM
T03	UC	mRP	IV	AH	LV
T04	UC	mRP	NON	RH	DIS
T05	W	BS	VIIA	AW	CB
T06	W	BS	VIIA	EB	CB
T07	UD	mAB	V	NON	AA
T08	UD	mABF	V	HMM	LV
T09	UD	mAB	V	RH	AA
T10	UD	mABF	NON	HMM	AA
T11	UD	mAB	IV	RH	LV
T13	UD	mAB	NON	H	DIS
G01	W	BS	VIIB	LT	CB
G02	W	BS	VI	EB	CB
G03	W	BS	II	LT	CB
G04	UD	MIX	X	RH	LV
G05	UD	mABF	II	RH	NM
G06	W	BS	VIIA	EB	CB
G07	CC	yAB	X	RH	LV
G08	UD	mAB	X	HMM	LV
G09	UD	mAB	V	RH	AA
G10	CC	yAB	NON	RH	NM
G11	CC	yJP	VIIB	RH	DIS
G12	UD	mABF	V	RH	NM
G13	CC	yJP	NON	RH	DIS
G14	UD	mABF	X	HMM	MIX
G15	UD	mABF	III	HMM	MIX
G16	UC	mJP	V	AH	LV
G17	UC	mJP	IV	RH	LV
G18	W	SC	I	NON	NRW
G19	CC	yRP	NON	RH	AA
G20	UC	mRP	X	AH	LV
G21	UC	mRP	X	AH	LV
G22	UC	mRP	VI	RH	NM
G23	UC	mRP	IV	HMM	NM
G24	UC	mRP	III	C	LV

Site	Broad habitat type	Canopy type	High shrub type	Low shrub type	Herb type
T14	W	cT	NON	LT	NRW
T15	W	oT	VI	EB	CB
T16	W	cT	I	EB	CB
T17	W	CED	NON	NON	CB
T26	UC	mRP	IV	NON	LV
T27	UD	mAB	IV	NON	AA
T28	W	BS	II	LT	CB
T29	UD	mAB	X	NON	AA
T30	W	BS	NON	RH	CB
T32	UC	mRP	IV	RH	NM
T33	UD	mABF	NON	HMM	AA
T34	UC	mRP	X	C	AA
G25	UC	mJP	VIIA	LT	MIX
G26	UC	mJP	IV	LT	MIX
G27	UC	mJP	NON	HMM	LV
G28	UC	mJP	VIII	LT	CB
G29	-	GR	IV	RH	LV
G30	UC	mJP	IV	RH	NM
G31	W	cT	I	EB	CB
G32	UD	mAB	V	RH	AA
G33	UD	mAB	V	HMM	LV
G34	CC	yWS	IX	RH	LV
G35	UC	mWS	IV	RH	NM
G36	UC	mWS	X	NON	NM
G37	CC	yABF	III	AB	LV
G38	UD	mABF	NON	HMM	LV
G39	UD	mAB	V	NON	AA
G40	CC	yAB	NON	AB	LV
G41	UD	mABF	NON	RH	NM
G42	UD	mABF	NON	HMM	NM
G43	W	CED	II	LT	CB
G44	W	BS	VIIA	EB	CB
G45	W	oT	VI	EB	CB
G47	UD	MIX	NON	RH	AA
G48	W	SC	I	LT	CB

Table E. Vegetation classification of each trapping grid.

Table F. Generic and common names of small mammal species mentioned in text.

Sorex arcticus	Arctic shrew
Sorex cinereus	Masked shrew
Microsorex hoyi	Pygmy shrew
Blarina brevicauda	Short-tailed shrew
Tamias striatus	Eastern chipmunk
Eutamias minimus	Least chipmunk
Spermophilus franklinii	Franklin's ground squirrel
Glaucomys sabrinus	Northern flying squirrel
Peromyscus leucopus	White-footed mouse
Peromyscus maniculatus	Woodland deer mouse
Clethrionomys gapperi	Red-backed vole
Synaptomys cooperi	Southern bog lemming
Microtus chrotorrhinus	Rock vole
Microtus pennsylvanicus	Meadow vole
Zapus hudsonius	Meadow jumping mouse
Napaeozapus insignis	Woodland jumping mouse

Table G. Numbers of specimens caught and grid area for each trapping grid.

	Grid Area	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda.	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Peromyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total
Black spruce																
T05A	0.6525	0	2	0	0	0	2	0	0	0	0	0	3	1	0	8
106A	1.4175	0	3	0	0	0	0	0	0	0	4	0	0	0	0	7
T06B	1.44	0	17	1	0	0	0	0	0	1	1	0	2	0	0	22
T28B	1.1925	0	32	1	2	0	1	0	1	0	17	0	5	0	0	59
T28C	1.44	2	27	0	14	0	2	0	0	3	24	0	1	0	0	73
T30C	1.44	0	26	0	4	0	2	0	1	0	13	0	0	0	0	46
G01	1.44	5	16	0	0	0	2	0	0	0	12	0	0	1	0	36
G02	1.44	1	3	0	0	0	0	0	0	0	1	0	0	0	0	5
G03	1.1925	2	21	0	0	0	0	0	0	0	7	0	0	0	0	30
G06	1.4175	2	28	1	0	0	0	0	0	0	8	0	1	0	0	40
G044	1.44	0	22	12	0	0	1	0	0	1	11	0	0	0	0	47
Tamarack Closed																
T14I	0.4725	2	9	0	3	0	1	0	0	1	12	0	11	0	0	39
T16I	1.44	1	32	1	1	0	0	0	0	0	29	3	10	0	0	77
G31	1.44	1	54	6	6	0	0	0	0	0	5	1	0	0	0	73
Open																
T15I	1.4625	4	12	0	0	0	0	0	0	0	4	0	25	0	0	45

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Table G. Continued

	Grid Area	Sorex arcticus	Sorex cincreus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrimus	Peromyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total
G45	1.4625	3	23	2	0	0	0	0	0	0	1	0	8	0	0	37
Cedar																
T17I	0.99	0	20	0	3	0	11	0	0	2	5	0	20	0	0	61
G43	1.35	1	17	2	0	0	1	0	0	8	6	0	0	0	0	35
Red Pine																
T03A	0.8325	0	0	0	0	0	0	0	0	2	13	0	0	8	1	24
T04A	1.3275	0	2	0	0	0	0	0	0	6	2	0	0	5	0	15
T03B	1.35	0	0	0	0	0	5	0	2	3	7	0	0	1	0	18
T26B	1.0575	0	4	0	1	0	0	0	1	19	7	0	0	0	1	33
T03C	1.4175	0	14	0	0	0	6	0	3	8	3	0	0	0	0	34
T32C	1.35	0	23	0	1	0	0	0	1	7	32	0	0	0	0	64
T34C	1.1250	0	8	0	2	1	0	0	1	14	11	0	0	0	0	37
G19	1.44	0	2	0	0	1	13	0	0	13	8	0	0	2	0	39
G20	1.35	3	2	0	0	0	1	0	0	4	2	0	0	1	0	13
G21	1.44	0	0	0	0	0	0	0	0	10	5	0	0	2	0	17
G22	1.44	0	17	0	0	0	16	3	0	0	3	0	3	0	0	42
G23	1.35	1	5	2	0	0	0	0	0	5	9	0	0	0	0	22
G24	1.44	0	39	3	0	0	0	0	0	6	13	0	0	0	0	61
Pure Aspen-Birch																

Table G. Continued

	Grid Area	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Peromyscus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total
T07A	1.2375	0	1	0	3	18	1	0	0	5	15	0	0	2	10	55
T09A	0.99	0	2	0	3	6	0	0	0	2	13	0	0	5	13	44
T11A	1.3725	0	2	0	7	3	0	0	0	11	1	0	0	1	7	32
T13A	1.44	0	1	0	2	0	0	0	0	0	9	0	0	0	0	12
T09B	1.4175	0	3	0	5	3	1	0	0	12	4	0	0	0	3	31
T13B	1.3950	5	37	0	3	0	0	0	0	0	3	0	3	2	0	53
T27B	1.0350	0	3	0	2	3	3	0	1	6	11	0	0	0	4	33
T29B	1.1025	0	10	0	15	1	3	0	0	23	10	0	0	0	0	62
T09C	1.4175	0	11	1	12	1	1	0	1	5	14	0	0	0	0	46
T13C	1.44	1	13	0	10	1	0	0	1	12	9	0	0	1	0	48
G07	1.35	0	1	0	0	0	13	0	0	0	7	0	0	1	0	22
G08	1.26	0	2	0	0	1	9	0	0	5	24	0	0	0	0	41
G09	1.4850	1	35	3	0	0	0	0	0	1	19	0	3	0	0	62
G10	1.44	4	44	0	0	0	7	0	0	0	14	0	0	0	0	69
G32	0.99	0	2	1	0	0	0	0	5	3	5	0	0	0	0	16
G33	1.44	0	26	5	0	0	0	0	0	10	25	0	0	1	0	67
G39	1.2375	0	27	0	0	0	0	0	0	3	28	0	0	0	0	58
G40	1.44	0	0	0	0	0	7	0	0	25	3	0	0	0	0	35
Aspen-Birch-Fir																
T08A	1.44	0	1	0	2	2	0	0	0	4	8	0	0	3	1	21
T10A	1.44	0	0	0	2	2	0	0	0	4	13	0	0	0	2	23
T08B	1.3275	0	15	0	5	0	0	0	0	10	26	0	0	2	0	58
T10B	1.44	0	11	0	4	1	0	0	1	7	17	0	0	0	0	41

Table G. Continu

	Grid Area	Sorex arcticus	Sorex cincreus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Peromyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total
T08C	1.44	0	8	0	5	0	0	0	0	9	7	0	0	0	0	29
T10C	1.44	0	16	0	4	0	0	0	1	10	23	0	0	0	0	54
T33C	1.44	0	4	0	1	0	0	0	0	9	27	0	0	0	0	41
G05	1.44	0	33	1	0	0	3	0	0	13	8	0	0	0	1	59
G12	1.44	0	6	0	0	0	0	0	0	5	4	0	0	0	0	15
G14	1.44	0	23	1	0	0	0	0	0	0	31	0	7	0	0	62
G15	1.44	0	40	1	1	0	0	0	0	0	22	0	0	0	0	64
G37	1.35	0	2	0	0	0	12	0	0	19	27	0	0	1	0	61
G38	1.44	0	31	1	0	0	0	0	0	14	31	0	0	0	0	77
G41	1.44	1	5	0	0	0	0	0	0	7	2	0	0	1	0	16
G42	1.44	0	40	1	0	0	0	0	0	5	9	0	0	0	1	56
Mixed Coniferous Deciduous																
G04	1.35	0	44	6	2	2	1	0	0	2	13	0	0	1	0	71
G47	1.4175	0	20	0	1	0	0	0	0	1	25	0	0	0	1	48
Shrub carr																
G18	1.44	0	3	0	0	0	2	0	0	0	0	0	1	1	0	7
G48	1.44	5	69	2	0	0	0	0	0	0	2	0	1	0	0	79
Grassland																
G29	1.2825	0	3	0	0	0	0	0	0	0	1	0	56	3	0	63
White Spruce																
G34	1.4175	5	11	0	0	0	1	2	0	0	4	0	2	0	0	25
G35	1.44	0	22	1	1	0	0	0	0	5	101	0	0	0	0	130
G36	1.44	0	8	2	0	0	0	0	0	0	11	0	0	0	0	21

	Grid area	*Sorex arcticus*	*Sorex cinereus*	*Microsorex hoyi*	*Blarina brevicauda*	*Tamias striatus*	*Eutamias minimus*	*Spermophilus franklinii*	*Glaucomys sabrinus*	*Peromyscus maniculatus*	*Clethrionomys gapperi*	*Synaptomys cooperi*	*Microtus pennsylvanicus*	*Zapus hudsonius*	*Napaeozapus insignis*	Total
Jack pine																
T01A	1.44	0	0	0	0	0	0	0	0	5	9	0	2	3	0	19
T02A	1.44	0	0	0	0	0	0	0	0	1	4	0	0	1	0	6
T01B	1.3725	0	6	0	1	0	5	0	1	1	8	0	0	0	0	22
T02B	1.44	0	14	0	0	0	0	0	0	0	29	0	0	1	0	44
T01C	1.2825	0	6	0	0	0	1	0	2	2	8	0	0	0	0	19
T01C	1.44	0	20	0	2	0	0	0	1	1	7	0	0	0	0	31
G11	1.44	0	1	1	0	0	38	0	0	7	4	0	1	1	0	53
G13	1.44	0	3	0	0	0	5	0	0	18	10	0	0	1	0	37
G16	1.44	0	1	0	0	0	3	0	0	0	13	0	0	1	0	18
G17	1.44	1	15	2	0	0	0	0	0	1	24	0	0	0	0	43
G25	1.44	0	15	0	0	0	3	0	0	9	9	0	0	0	0	36
G26	1.44	0	32	0	0	1	5	0	0	1	21	0	0	0	0	60
G27	1.44	0	33	0	3	1	1	0	0	18	42	0	0	0	0	98
G28	1.44	7	48	2	1	0	3	0	0	0	34	0	0	0	0	95
G30	1.44	0	2	0	0	0	0	0	0	1	7	0	0	1	0	11

Table H. Species relative densities, small mammal richness, and small mammal diversity for each trapping grid. Spermophilus franklinii and Glaucomys sabrinus were omitted from richness and diversity calculations.

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
Black Spruce																	
T05A	0	3.1	0	0	0	3.1	0	0	0	0	0	4.6	1.5	0	12.3	4	3.55
T06A	0	2.1	0	0	0	0	0	0	0	2.8	0	0	0	0	4.9	2	1.96
T06B	0	11.8	0.7	0	0	0	0	0	0.7	0.7	0	1.4	0	0	15.3	5	1.63
T28B	0	26.8	0.8	1.7	0	0.8	0	0.8	0	14.3	0	4.2	0	0	49.4	6	2.50
T28C	1.4	18.8	0	9.7	0	1.4	0	0	2.1	16.7	0	0.7	0	0	50.8	7	3.51
T30C	0	18.1	0	2.8	0	1.4	0	0.7	0	9.0	0	0	0	0	32.0	4	2.34
G01	3.5	11.1	0	0	0	1.4	0	0	0	8.3	0	0	0.7	0	25.0	5	3.01
G02	0.7	2.1	0	0	0	0	0	0	0	0.7	0	0	0	0	3.5	3	2.27
G03	1.7	17.6	0	0	0	0	0	0	0	5.9	0	0	0	0	25.2	3	1.82
G06	1.4	19.8	0.7	0	0	0	0	0	0	5.6	0	0.7	0	0	28.2	5	1.87
G44	0	15.3	8.3	0	0	0.7	0	0	0.7	7.6	0	0	0	0	32.6	5	2.94
Tamarack																	
Closed																	
T14I	4.2	19.1	0	6.4	0	2.1	0	0	2.1	25.4	0	23.3	0	0	83.6	7	4.21
T16I	0.7	22.2	0.7	0.7	0	0	0	0	0	20.1	2.1	6.9	0	0	53.4	7	3.00
G31	0.7	37.5	4.2	4.2	0	0	0	0	0	3.5	0.7	0	0	0	50.8	6	1.77

Table H. Continued

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
Open																	
T15I	2.7	8.2	0	0	0	0	0	0	0	2.7	0	17.1	0	0	30.7	4	2.53
G45	2.1	15.7	1.4	0	0	0	0	0	0	0.7	0	5.5	0	0	25.4	5	2.25
Cedar																	
T17I	0	20.2	0	3.0	0	11.1	0	0	2.0	5.1	0	20.2	0	0	61.6	6	3.88
G43	0.7	12.6	1.5	0	0	0.7	0	0	5.9	4.4	0	0	0	0	25.8	6	3.10
Jack pine																	
T01A	0	0	0	0	0	0	0	0	3.5	6.3	0	1.4	2.1	0	13.3	4	3.03
T02A	0	0	0	0	0	0	0	0	0.7	2.8	0	0	0.7	0	4.2	3	1.99
T01B	0	4.4	0	0.7	0	3.6	0	0.7	0.7	5.8	0	0	0	0	15.9	5	3.47
T02B	0	9.7	0	0	0	0	0	0	0	20.1	0	0	0.7	0	30.5	3	1.86
T01C	0	4.7	0	0	0	0.8	0	1.6	1.6	6.2	0	0	0	0	14.9	4	2.75
T02C	0	13.9	0	1.4	0	0	0	0.7	0.7	4.9	0	0	0	0	21.6	4	1.98

Table H continued

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
Jack Pine (continued)																	
G11	0	0.7	0.7	0	0	26.4	0	0	4.9	2.8	0	0.7	0.7	0	36.9	7	1.85
G13	0	2.1	0	0	0	3.5	0	0	12.5	6.9	0	0	0.7	0	25.7	5	2.98
G16	0	0.7	0	0	0	2.1	0	0	0	9.0	0	0	0.7	0	12.5	4	1.80
G17	0.7	10.4	1.4	0	0	0	0	0	0.7	16.7	0	0	0	0	29.9	5	2.29
G25	0	10.4	0	0	0	2.1	0	0	6.3	6.3	0	0	0	0	25.1	4	3.27
G26	0	22.2	0	0	0.7	3.5	0	0	0.7	14.6	0	0	0	0	41.7	5	2.41
G27	0	22.9	0	2.1	0.7	0.7	0	0	12.5	29.2	0	0	0	0	68.1	6	3.01
G28	4.9	33.3	1.4	0.7	0	2.1	0	0	0	23.6	0	0	0	0	66.0	6	2.56
G30	0	1.4	0	0	0	0	0	0	0.7	4.9	0	0	0.7	0	7.7	4	2.20
Red Pine																	
T03A	0	0	0	0	0	0	0	0	2.4	15.6	0	0	9.6	1.2	28.8	4	2.42
T04A	0	1.5	0	0	0	0	0	0	4.5	1.5	0	0	3.8	0	11.3	4	3.26
T03B	0	0	0	0	0	3.7	0	1.5	2.2	5.2	0	0	0.7	0	13.3	4	3.05
T26B	0	3.8	0	1.0	0	0	0	1.0	18.0	6.6	0	0	0	1.0	31.4	5	2.39
T03C	0	9.9	0	0	0	4.2	0	2.1	5.6	2.1	0	0	0	0	23.9	4	3.15
T32C	0	17.0	0	0.7	0	0	0	0.7	5.2	23.7	0	0	0	0	47.3	4	2.48
T34C	0	7.1	0	1.8	0.9	0	0	0.9	12.4	9.8	0	0	0	0	32.9	5	3.36

Table H. continued

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
Red pine continued																	
G19	0	1.4	0	0	0.7	9.0	0	0	9.0	5.6	0	0	1.4	0	27.1	6	3.70
G20	2.2	1.5	0	0	0	0.7	0	0	3.0	1.5	0	0	0.7	0	9.6	6	4.83
G21	0	0	0	0	0	0	0	0	6.9	3.5	0	0	1.4	0	11.8	3	2.24
G22	0	11.8	0	0	0	11.1	2.1	0	0	2.1	0	2.1	0	0	29.2	4	2.70
G23	0.7	3.7	1.5	0	0	0	0	0	3.7	6.7	0	0	0	0	16.3	5	3.56
G24	0	27.1	2.1	0	0	0	0	0	4.2	9.0	0	0	0	0	42.4	4	2.14
Pure Aspen-Birch																	
T07A	0	0.8	0	2.4	14.6	0.8	0	0	4.0	12.1	0	0	1.6	8.1	44.4	8	4.39
T09A	0	2.0	0	3.0	6.1	0	0	0	2.0	13.1	0	0	5.1	13.1	44.4	7	4.65
T11A	0	1.5	0	5.1	2.2	0	0	0	8.0	0.7	0	0	0.7	5.1	23.3	7	4.38
T13A	0	0.7	0	1.4	0	0	0	0	0	6.3	0	0	0	0	8.4	3	1.67
T09B	0	2.1	0	3.5	2.1	0.7	0	0	8.5	2.8	0	0	0	2.1	21.8	7	4.51
T13B	3.6	26.5	0	2.2	0	0	0	0	0	2.2	0	2.2	1.4	0	38.1	6	1.97
T27B	0	2.9	0	1.9	2.9	2.9	0	1.0	5.8	10.6	0	0	0	3.9	31.9	7	5.02
T29B	0	9.1	0	13.6	0.9	2.7	0	0	20.9	9.1	0	0	0	0	56.3	6	3.99
T09C	0	7.8	0.7	8.5	0.7	0.7	0	0.7	3.5	9.9	0	0	0	0	32.5	7	4.14
T13C	0.7	9.0	0	6.9	0.7	0	0	0.7	8.3	6.3	0	0	0.7	0	33.3	7	4.44

Table H. Continued

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
Pure Aspen-Birch continued																	
G07*	0	0.7	0	0	0	9.6	0	0	0	5.2	0	0	0.7	0	16.2	4	2.20
G08	0	1.6	0	0	0.8	7.1	0	0	4.0	19.1	0	0	0	0	32.6	5	2.45
G09	0.7	23.6	2.0	0	0	0	0	0	0.7	12.8	0	2.0	0	0	41.8	6	2.39
G10*	2.8	30.6	0	0	0	4.9	0	0	0	9.7	0	0	0	0	48.0	4	2.17
G32	0	2.0	1.0	0	0	0	0	5.1	3.0	5.1	0	0	0	0	16.2	4	3.10
G33	0	18.1	3.5	0	0	0	0	0	6.9	17.4	0	0	0.7	0	46.6	5	3.14
G39	0	21.8	0	0	0	0	0	0	2.4	22.6	0	0	0	0	46.8	3	2.21
G40*	0	0	0	0	0	4.9	0	0	17.4	2.1	0	0	0	0	24.4	3	1.79
Aspen-Birch-Fir																	
T08A	0	0.7	0	1.4	1.4	0	0	0	2.8	5.6	0	0	2.1	0.7	14.7	7	4.45
T10A	0	0	0	1.4	1.4	0	0	0	2.8	9.0	0	0	0	1.4	16.0	5	2.69
T08B	0	11.3	0	3.8	0	0	0	0	7.5	19.6	0	0	1.5	0	43.7	5	3.27
T10B	0	7.6	0	2.8	0.7	0	0	0.7	4.9	11.8	0	0	0	0	28.5	5	3.36
T08C	0	5.6	0	3.5	0	0	0	0	6.3	4.9	0	0	0	0	20.3	4	3.84
T10C	0	11.1	0	2.8	0	0	0	0.7	6.9	16.0	0	0	0	0	37.5	4	3.12
T33C	0	2.8	0	0.7	0	0	0	0	6.3	18.8	0	0	0	0	28.6	4	2.03

Table H. Continued

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
Aspen-Birch-Fir																	
G05	0	22.9	0.7	0	0	2.1	0	0	9.0	5.6	0	0	0	0.7	41.0	6	2.61
G12	0	4.2	0	0	0	0	0	0	3.5	2.8	0	0	0	0	10.5	3	2.92
G14	0	16.0	0.7	0	0	0	0	0	0	21.5	0	4.9	0	0	43.1	4	2.50
G15	0	27.8	0.7	0.7	0	0	0	0	0	15.3	0	0	0	0	44.5	4	1.96
G37	0	1.5	0	0	0	9.0	0	0	14.1	20.0	0	0	0	0.7	45.3	5	3.00
G38	0	21.5	0.7	0	0	0	0	0	9.7	21.5	0	0	0	0	53.4	4	2.80
G41	0.7	3.5	0	0	0	0	0	0	4.9	1.4	0	0	0.7	0	11.2	5	3.20
G42	0	27.8	0.7	0	0	0	0	0	5.5	6.3	0	0	0	0.7	39.0	5	1.84
Mixed Coniferous Deciduous																	
G04	0	32.6	4.4	1.5	1.5	0.7	0	0	1.5	9.6	0	0	0.7	0	52.5	8	2.34
G47	0	14.1	0	0.7	0	0	0	0	0.7	17.6	0	0	0	0.7	33.8	5	2.24
Shrub carr																	
G18	0	2.1	0	0	0	1.4	0	0	0	0	0	0.7	0.7	0	4.9	4	3.26
G48	3.5	47.9	1.4	0	0	0	0	0	0	1.4	0	0.7	0	0	54.9	5	1.30
Grassland																	
G29	0	2.3	0	0	0	0	0	0	0	0.8	0	43.7	2.3	0	49.1	4	1.26

Table H. Continued

	Sorex arcticus	Sorex cinereus	Microsorex hoyi	Blarina brevicauda	Tamias striatus	Eutamias minimus	Spermophilus franklinii	Glaucomys sabrinus	Permyscus maniculatus	Clethrionomys gapperi	Synaptomys cooperi	Microtus pennsylvanicus	Zapus hudsonius	Napaeozapus insignis	Total	Small mammal richness	Small mammal diversity
White Spruce																	
G34*	3.5	7.8	0	0	0	0.7	1.4	0	0	2.8	0	1.4	0	0	17.6	5	3.17
G35	0	15.3	0.7	0.7	0	0	0	0	3.5	70.1	0	0	0	0	90.3	5	1.58
G36	0	5.6	1.4	0	0	0	0	0	0	7.6	0	0	0	0	14.6	3	2.33