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DISTRIBUTION AND ABUNDANCE OF BOG LEMMINGS *(SYNAPTOMYS COOPERI* AND *S. BOREALIS)* AND ASSOCIATED SMALL MAMMALS IN LOWLAND HABITATS IN NORTHERN MINNESOTA

(SENSITIVE SMALL MAMMALS OF THE CHIPPEWA NATIONAL FOREST)

Project Report

Donald P. Christian

Department of Biology, University of Minnesota, Duluth

Duluth, MN 55812

Submitted to:

John Mathisen

Chippewa National Forest

Rt. 3, Box 244, Cass Lake, MN 56633

and

Rich Baker

Minnesota Department of Natural Resources

Nongame Wildlife Program

500 Lafayette Rd., St. Paul, MN 55155-4007

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INTRODUCTION

A high proportion of the mammal species in Minnesota are present in the state at or very near the limit of their geographic range (Hazard, 1982; Jones and Birney, 1988). The frequency of range boundaries in Minnesota mammals reflects the juxtaposition in the state of three major vegetation types - western tallgrass prairie, eastern deciduous forest, and conifer-dominated boreal forests (Coffin and Pfannmuller, 1988; Hazard, 1982; Jones and Birney, 1988). Mammal communities of forested northern Minnesota include a number of species of boreomontane faunal affinities that occur in this region at the extreme southern limits of their range (Jones, 1983; Jones and Birney, 1988; Nordquist, 1992). For a number of these species, the precise distributional boundaries and habitat associations in this region are not known. More thorough understanding of range limits and habitat distribution is needed to predict possible effects of forest management or other landuse practices on these and other animals, and to provide a biological basis for decision making about whether management or protection for such species is warranted.

The northern bog lemming (*Synaptomys borealis*) and the heather vole (*Phenacomys intermedius*) are extreme representatives of this group. The presence of both of these small rodent species in Minnesota is known from only a handful of specimens and a few localities in the northern tier of counties in the state. Both of these species have been accorded "Special Concern" status in Minnesota (Nordquist and Birney, 1988), and both were included on the Minnesota Department of Natural Resources Nongame Wildlife Program 1992-93 Priority Species list. Both also have been placed on the "Sensitive Species" list of the Chippewa National Forest (Beltrami, Casa, and Itasca counties) in north-central Minnesota. The Chippewa National Forest is in reasonable proximity to the known or presumed southern range limits of these species, so it is conceivable that either or both is present in the forest, even though neither species has been documented to occur there. The nearest locality records of *S. borealis* and of *P. intermedius* are, respectively, about 25 km to the north and about 120 km to the northeast of the Chippewa National Forest (Hazard, 1982), so it is more likely that S. *borealis* would occur in the forest.

Both *S*. *borealis* and *P*. *intermedius* have been reported from a variety of habitat types throughout their range, although *S*. *borealis,* and perhaps to a lesser extent, P. *intermedius* are rather poorly studied. *S. borealis* has been captured in "open bog and shrub carr - wet, open conditions with a dense low shrub layer of ericaceous plants" (Nordquist, 1992). Gunderson and Beer (1953) indicated that the species has been taken in damp grass and sedge meadows, in addition to bogs, but the basis for that statement is not clear. According to Banfield (1974), this species occurs most often in sphagnum-Labrador tea-black spruce bogs, but also is present in spruce forest with moss on the forest floor, in wet alpine meadows, and in alpine tundra. Clough and Albright (1987) captured S. *borealis* in New- England in sedge meadow habitat and in spruce-budworm-killed spruce-fir forest with dense shrub and ground vegetation. Other authors also have reported this species in spruce or tamarack-spruce forest (Soper, 1948; Smith and Foster, 1957).

P. intermedius is known from a wide range of habitats, including open pine or spruce forests with an understory of heaths, shrubby vegetation on forest margins, and moist, mossy meadows (Banfield, 1974). Heather-like ground vegetation seems to be a common feature of habitat for this species (McAllister and Hoffman, 1988). The only recent Minnesota records of P. *intermedius,* from the extreme northeast, are from open bog and muskeg (Etnier, 1989).

Thus, the habitat associations of these two species are broadly similar, and include a variety of lowland grass-sedge or heath habitats. Therefore, there is justification in a general survey of their presence and abundance to focus on a limited range of habitat types. In the present report, I describe results of surveys in the Chippewa National Forest aimed at documenting the occurrence and habitat associations of these species in the forest and in this portion of the state; the habitats sampled included grass-sedge meadows, heath bogs, and lowland conifer forests. A specific applied aspect of this objective was to be able to recommend whether these species should retain their status as "Sensitive" species on the Chippewa National Forest. There have been relatively few quantitative studies of small mammal abundance and species composition in these and other peatland-associated habitats (Nordquist and Birney, 1984; Nordquist, 1992); additional objectives of this study were to sample these three habitats in ways that allow comparison of relative abundance and composition of small-mammal communities inhabiting each, and to further our understanding of habitat distribution of small mammal species inhabiting these lowland habitats.

STUDY SITES

Sites were selected to maximize possibilities of capturing *Synaptomys borealis* and *Phenacomys intermedius.* This included focusing sampling efforts in the northern portion of the Chippewa National Forest (CNF), inasmuch as this region is virtually certainly at the extreme southern part of the range of these species in Minnesota (Hazard, 1982). Furthermore, as discussed and documented above, habitats selected for sampling were those indicated in the literature as being typically occupied by one or both of these species, including heath bogs, lowland/swamp conifer forests, and sedge meadows. Only sites near roads or otherwise readily accessible were selected for sampling, to facilitate sampling 50 sites (as specified in the work plan) in a short time period.

Preliminary selection of sites was based on screening of CDS stand data for the Blackduck and Marcell Ranger Districts of the CNF to select all stands >5 acres in size and representing the following CNF Animal Habitat Codes (type descriptions from CNF information): "05" (Open Heath Bog): Type 8 wetland. Water-logged, peaty soil supporting a spongy mat, often floating, with plants such as heaths, sphagnum, and sedges; "06" (Sedge Meadow Wetland): Seasonally flooded Type 2 wetland. Vegetation consists of dense stands of sedges, aquatic grasses, and rushes. Very little open water; "32" (Semi-open Lowland Conifer): Scattered tamarack and black spruce. Trees usually stunted and old, generally not a commercial stand. "33" (Closed Canopy Lowland

Conifer): Fully stocked stands of spruce, fir, larch or white cedar with high water table. No age differentiation.

Screening of the CDS files yielded 721 stands for the Blackduck District and 553 stands for the Marcell District. Subsequent examination of timber compartment maps resulted in a large number of stands being eliminated because of lack of accessibility. Approximately 130 potential sampling sites were identified prior to the field work. In the field, many of these sites were eliminated from consideration because 1) access was not possible, 2) their distance from other points to be sampled would have resulted in inefficient use of time and resources, or 3) examination of the sites suggested that they likely were not suitable habitat for the target species. Several of the sites sampled were not among those that had been identified before field work began; these sites were selected on the basis of their access and habitat features during field work. Some of these sites were on federal land, others on state, county, or private ownerships; all were within the boundaries of the CNF. Descriptions of each of the 50 sites sampled are provided in Appendix I of this report. Animal habitat type "32" (semiopen lowland conifer) was poorly represented in our sampling. Fewer of these sites were available to sample, and our investigation of these sites in the field suggested that some of these habitats should be given lower priority for sampling for the target species (e. g., some were dominated by deciduous trees, even though widely scattered conifer trees were present. However, the vegetation structure and composition of one site classified by the CNF as a type "32" habitat (site 20, Appendix I) was extremely similar to that of other sites classified as type "5" heath bog habitats, and has been included in the present analysis as a type "5" habitat. A number of sampled habitats classified as type "5" heath bog habitats contained scattered, stunted conifer trees, mostly black spruce. No attempt was made to distinguish between these and completely open bog sites; however, none of these sites with trees approached having a closed canopy.

METHODS

At each site, small mammals were sampled using a combination of 44 Museum Special snap traps (baited with moistened rolled oats) and 6 pitfall traps. Pitfall traps were cones (approximately 16 cm diameter top, approximately 26 cm deep) of 26-gauge galvanized sheet metal fastened at the seam with pop rivets. The pitfalls were pressed into the soil so that the rim was at or immediately below the surface. The water table at virtually all sites was close to the surface so the pitfalls filled partially with water, thereby assuring that captured animals would drown (conforming with guidelines for acceptable field methods in mammalogy adopted by the American Society of Mammalogists).

Traps were placed about 8 m apart in two lines >15-20 m apart, with 22 snap traps and 3 pitfalls in each line; pitfalls were interspersed among snap traps. Traps were set at a site during the afternoon of Day 1, checked on the morning of Day 2, at which time all captured animals were removed from traps and the snap traps re-baited as needed, and checked and removed from the site on the morning of Day 3. Trapping was conducted during 8-16 August; traps were set initially at 6-8 sites each day from 8-14 August, resulting in staggered and overlapping trapping times for the 50 sites. Thus, any effects of weather or other temporal differences on capture success should tend to be averaged out among the various sites.

All captured *Synaptomys* were prepared as study skins and skulls, unless the skin was too badly damaged to prepare, in which case the skull only was retained as a specimen; representative specimens of other species also were prepared. Skulls of small *Sorex* were retained for subsequent identification as *S*. *cinereus* or *S*. *hoyi*, using features of the dentition described by Hazard (1982). Skulls of Synaptomys were cleaned (using dermestid beetles), and identified to species using a combination of features, including the shape of the upper incisor (Banfield, 1974; Hamilton, 1943), the conformation of the lower molar toothrow (Banfield, 1974; Hazard, 1982; Jones and Bimey, 1988), and the presence or absence of a distinctive, sharp projection at the posterior margin of the palate (Connor, 1959; Hamilton, 1943; Hazard, 1982; Nordquist and Birney, 1988). All other rodents and shrews were identified on the basis of external features.

Statistical analyses of capture data were conducted using the Number Cruncher Statistical Systems (Hintze, 1987) on a ZEOS 486 computer. Analysis of variance or+ tests, using log-transformed data on numbers of captures, were used to test for differences in abundance among major habitat types. All data are presented as X±SE.

RESULTS

A total of 591 small mammals was captured during the study, including 5 star-nosed moles (*Condylura cristata*), 338 shrews representing 5 species (*Sorex arcficus, S. cinereus, S. hoyi, S. palustris*, and *Bladna brevicauda*), and 248 rodents representing 6 species (*Microtus pennsylvanicus, Clefhrionomys gapperi, Synaptomys cooperi, S. borealis, Peromyscus maniculatus*, and *Zapus hudsonius*). The most abundant small mammals captured were the masked shrew, *Sorex cinereus* (216 individuals), meadow vole, *Microtus pennsylvanicus* (139), arctic shrew, *Sorex arcticus* (73), and red-backed vole, *Clethrionomys gapperi* (56). Species captured in moderate numbers included the southern bog lemming, *Synaptomys cooped* (33), and short-tailed shrew, *Blarina brevicauda* (28). Small numbers of several species were captured, including the meadow jumping mouse, *Zapus.hudsonius* (13), pygmy shrew, *Sorex hoyi* (11), water shrew, *Sorex palustris* (7), star-nosed mole, *Condylura cristata* (5), woodland deer mouse, *Peromyscus maniculatus* (5), and northern bog lemming, *Synaptomys borealis* (2). No heather voles (*Phenacomys infermedius*) were captured during the study. Capture data for site number 11 (Appendix 1), the only open-canopy lowland conifer site (animal habitat type 32) sampled, were not included in subsequent statistical comparisons, although abundance and species composition at this site was generally similar to that on the close-canopy lowland conifer sites (type 33) sampled.

For several species, average number of captures per trap line differed significantly among heath bogs, sedge meadows, and lowland conifers (Tables 1A and 1 B); average abundance in these comparisons (and as reported in Tables 1 A and 1 B) reflects differences in the proportion of sites within a habitat at which a species was present as well as numerical differences between the sites where the species was present. Although they have not been computed specifically in this way, the values for abundance in Tables 1 A, 1 B, and 2 are equivalent to "catch per 100 trap-nights" used by various authors. However, such comparisons must be made cautiously, in part because of the effects of different traps and trap placement. For example, in the present study, as many as 10 individuals of several species were trapped in some pitfalls in a single night, which obviously is not possible with single-catch traps.

Abundance of *Sorex arcticus* (F = 5.74, P = 0.006, d. f. for this and the following comparisons = 2, 46), *Sorex palustris* (F = 5.26, P = 0.009), *Microtus pennsylvanicus* (F = 4.42, P = 0.0175), and *Zapus hudsonius* (F = 12.96, P < 0.0001) all differed significantly among habitat types, with specific comparison (Duncan's) test indicating significantly (P < 0.05) higher abundance in sedge meadows than in either bogs or lowland conifers. Other species for which abundance differed significantly with habitat type were *Sorex cinereus* (F = 10.47, P = 0.0002), significantly more abundant in bogs and lowland conifers than in sedge meadows; *Clethrionomys gapperi* (F = 5.48, P = 0.0074), significantly more abundant in lowland conifers than in either bogs or sedge meadows; and *Synaptomys cooperi* (F = 9.27, P = 0.0004), significantly more abundant in bogs than in either sedge meadows or lowland conifers. The effect of habitat type on abundance of *Sorex hoyi was* marginally nonsignificant (F = 2.94, P = 0.063), with a tendency for abundance to be highest in bogs and lowest in sedge meadows. Abundance of other species *(Condylura cristata, Blarina brevicauda, Synaptomys borealis*, and *Peromyscus maniculatus*) did not differ significantly among the three habitats (all P >_ 0.15); all of these species were ~° captured only in very small numbers and the absence of statistically significant differences in part reflects inadequate sample sizes.

Nearly all species showing significant differences in overall abundance among habitat types also differed significantly (all Fz 3.88, d. f. = 2, 46, all P~ 0.028) in frequency of occurrence within a habitat (i. e., the proportion of sites where the species was present, irrespective of abundance; Tables 1 A and 1 B). For these species (*Sorex arcticus, S. cinereus, S. hoyi, S. palustris, Clethrionomys gappen*, and *Synaptomys* *coopen*), differences in frequency of occurrence among habitats paralleled differences in overall abundance discussed above. In *Microtus pennsylvanicus*, for which overall abundance was significantly higher in sedge meadows, differences among habitat types in frequency of occurrence were marginally nonsignificant (F = 3.01, P = 0.059). The higher frequency of occurrence of *Peromyscus maniculatus* in lowland conifer than in heath bog and sedge meadow also approached statistical significance (F = 2.64, P = 0.08). When only sites where a species was present are considered (i. e., differences in frequency of occurrence among sites within a habitat type are eliminated), abundance for most species does not differ significantly among the three habitat types. The sole exception is *Sorex cinereus*, which was significantly more abundant at sites where present in heath bogs and lowland conifers than in sedge meadows (F = 4.38, d. f. = 2, 39, P = 0.019).

The apparent tendency of *Sorex hoyi* to be associated with ericaceous, rather than graminoid, habitats has not been reported previously. This species was found in association with *S. cinereus* at every site where it was captured and with both *S. arcticus* and *S. cinereus* at 3 of the 9 sites where it occurred. *Blarina brevicauda,* captured at 17 sites, was present at only 2 of the sites where *S. hoyi* was found.

Overall differences in small-mammal community composition among heath bogs, lowland conifers, and sedge meadows were compared using a calculated index of community similarity (Curtis, 1959). These calculations indicated a relatively high degree of similarity in species composition of small mammals in heath bogs and lowland conifers (similarity = 0.79), but low similarity in species composition between sedge meadows and either heath bogs (similarity = 0.44) or lowland conifers (similarity = 0.39).

The relatively unique species composition in sedge meadows reflects in large part the greater abundance of *Sorex arcticus, S. palustris*, *Microtus pennsylvanicus,* and *Zapus hudsonius* in these habitats than in either heath bogs or lowland conifers, as noted above.

Despite differences in species composition among habitats, there were no statistically significant differences in total number of individual small mammals or the number of either rodents or shrews in the three habitats (Table 2). Although shrews tended to be slightly more abundant in heath bogs and lowland conifers than in sedge meadows, and rodents to be more abundant in sedge meadows (Table 2), these differences were not statistically significant (for all comparisons, d. f. = 2, 46; for overall shrew numbers, F = 1.60, P = 0.21; for overall rodent numbers, F = 0.83, P = 0.44). Total numbers of small mammals (shrews and rodents combined) were nearly identical in the three habitats (Table 2; F = 0.00, P = 0.99). The number of species of shrews (F = 0.50, P = 0.61), of rodents (F = 0.05, P = 0.95), and of all small mammals (F = 0.23, P = 0.80) also did not differ significantly among the three habitats.

The relatively high catch of *Synaptomys* (33 *S. cooperi* at 16 sites, 2 *S. borealis* at 1 site) provides a basis for enhancing our understanding of distribution and habitat associations of these rodents in this part of Minnesota. We had considerable success trapping *Synaptomys,* most often by placing traps at the base of sphagnum hummocks or in or near the base or branches of ericaceous shrubs. Twenty *Synaptomys* were captured in snap traps, 15 in 'pitfalls; in several instances 2 or more individuals were captured in a single pitfall trap. As discussed above and as illustrated in Table 1 B, *Synaptomys was* captured in heath bogs and lowland conifer stands, but not in sedge meadows.

The site where *Synaptomys borealis was* captured (site number 45 - Appendix 1; Marcell District, Timber Management Compartment 159, stand 9) is a CNF animal habitat type 33, lowland conifer forest, mostly of black spruce. One *S. cooperi* also was captured at the site, although it is not possible to identify the precise spatial relationships between specimens of the two species at this site because it was not possible to identify the species of *Synaptomys* in the field. Stand No. 9 (37 acres) partially surrounds (on the east, south, and north) and grades into an 8-acre heath bog (stand 25 in compartment 159) which also was sampled. Although vegetative structure and composition at the latter site appeared qualitatively similar to other heath bogs in which we captured *S. cooperi,* no bog lemmings of either species were captured there.

It was beyond the scope of this project to conduct detailed vegetation measurements. Thus, it is difficult to draw precise comparisons between the site where both *Synaptomys* occurred and other lowland conifer sites, either the 16 sites at which no *Synaptomys* were captured or the 2 other sites at which *S. cooperi* but not *S. borealis* were captured. All three lowland conifer sites at which *Synaptomys was* captured were characterized by the presence of a sphagnum layer and of ericaceous shrubs, especially *Chamaedaphne calyculata* (leatherleaf); these shrubs were abundant and widespread at the site where *S borealis was* captured, patchily distributed at site 43, where only *S. cooperi* was captured, and present but not highly abundant at site 48, where only *S*. cooperi was captured. Black spruce was present at all of these sites; overstory trees-at site 43 included some cedar and tamarack. Ground vegetation at site

48 included a substantial and well-developed graminoid component. Some of the lowland conifer sites at which *Synaptomys* was absent lacked a well-developed ericaceous shrub component, but these shrubs were present at other such sites. Further study is needed to better discern whether precise relationships exist between the presence of either *S. cooped* or *S. borealis* and particular vegetative features.

In the western part of the Blackduck District of the CNF (ranges 30 and 31 W), *Synaptomys* was captured at only 1 of 5 heath bogs (20%) and none of the 14 lowland conifer stands sampled, for an overall capture frequency of 5% (1/19) in the two habitats combined. In the eastern part of the district (ranges 26 and 27 W), *Synaptomys* was captured in 9 of 11 heath bogs (82%) and none of 3 lowland conifer stands sampled, for an overall capture frequency of 64% (9 of 14). In the Marcell District (ranges 25-27W), *Synaptomys* was captured at 2 of 3 heath bogs (67%) and 3 of 5 (60%) of lowland conifer stands, yielding an overall capture frequency of 62% (5 of 8) for these habitats. Although sample sizes in these comparisons are limited, the patterns suggest the possibility of small-scale regional differences in abundance of *Synaptomys* species in this part of Minnesota. The basis for such a difference is not clear, but may be related to landscape level differences in availability of peatlands habitats and of resulting differences in connectivity between suitable habitat patches. In the Marcell District, 2 of the lowland conifer stands at which *Synaptomys* was captured are <3 km from each other and < 9 km of the third lowland conifer site where *Synaptomys* was present.

Small-mammal species composition at sites where *Synaptomys* was present tended to differ in several respects from sites where bog lemmings were absent (Tables 3 and 4). Considering heath bog habitats alone (Table 3; relevant to *S. coopen*), sites where bog lemmings were present had significantly more individual small mammals (t = 2.82, d. f. = 17, P = 0.02) and more shrews (t = 2.96, d. f. = 17, P = 0.011) than sites where bog lemmings were absent. The number of *Synaptomys* captured at these sites (mean of 2.15) does not fully account for the difference in number of individuals (>5 individuals) between sites where bog lemmings are present or absent. The tendency for more *Sorex cinereus* at sites where *Synaptomys* were present approached statistical significance (P = 0.08). In addition, heath bog sites where bog lemmings were present tended to have higher abundance of *Sorex arcticus, S. hoyi*, and *Microtus pennsylvanicus*, and lower abundance of *Clethrionomys gapperi*, but none of these differences was significant ($P \geq 0.30$). The calculated similarity index for small-mammal species composition at heath bog sites where *Synaptomys* are present and where absent is only 0.45 (*Synaptomys* excluded from species list for calculation of similarity). This low level of similarity is comparable to that between the assemblage of small mammals found in sedge meadows and either heath bogs or lowland conifer sites (see above), suggesting substantial faunal differences between sites where *Synaptomys* are present and where absent.

Considering heath bogs and lowland conifer stands together (Table 4; relevant to both *S. cooperi* and *S. borealis*), sites where bog lemmings were present were characterized by a significantly higher number of individual small mammals (t = 2.67, d. f. = 36, P = 0.01); again, the mean number of bog lemmings captured per site (2.19) does not fully explain this difference. The higher number of *Sorex cinereus* and of all shrews at sites where bog lemmings were present approached statistical significance (P = 0.06 - 0.07), as did the slightly higher number of rodents (P = 0.063); however, the magnitude of the difference in the latter comparison is less than the mean number of bog lemmings caught at heath and lowland conifer sites. As for heath bog sites, *Sorex awticus* and *Microtus pennsylvanicus* tended to be more abundant, and *Clethdonomys gapped* less abundant, at sites where bog lemmings were present. Species composition of small mammals captured at the site where both *Synaptomys* cooped and *S. borealis* were captured appeared typical of that at sites where only *S. cooped* was caught. The calculated similarity index is high (0.87) between sites where *Synaptomys was* present and where absent for combined heath bogs and lowland conifers. However, this calculation is severely biased because of the low frequency of occurrence of *Synaptomys* in lowland conifer stands.

Apparent associations between *Synaptomys* species and other arvicoline rodents warrant comment. *Synaptomys* was the sole arvicoline rodent present at only one of the 16 sites at which it was captured. In heath bog habitats, *S. cooperi* occurred with *Clethrionomys gapped* at 3 of 13 sites, with *Microtus pennsylvanicus* at 9 of 13 sites, and with both species at 1 site. In lowland conifer forests, *C. gapper* was present at 2 and M. *pennsylvanicus* at all of the 3 sites where *S. cooped* was captured. At the lowland conifer site where *S. borealis* was captured, all 4 of these arvicoline rodents were present. As noted above, bog lemmings tended to occur at sites with relatively high numbers of M. *pennsylvanicus* and relatively low numbers of *C. gapperi;* the abundance of *C. gapperi* in both heath bogs and lowland conifer stands during our sampling was relatively low (see Nordquist and Birney, 1980).

DISCUSSION

Phenacomys intermedius was not collected during our sampling on the CNF. It is possible that P. *intermedius* is present on the CNF in habitats other than those sampled, but the habitat types in which trapping was done are among those in which this species has been recorded elsewhere in its range; the only recent records of this species in Minnesota (Etnier, 1989) are from bog and muskeg, apparently comparable to the type "5" habitats sampled intensively in the present study. It is not surprising that this species was not detected on the CNF, given the distance between the forest and the nearest record in Minnesota (a specimen collected in 1940), and the fact that the only recent records are even further to the northeast, in the vicinity of Lake Saganaga on the Canadian border (Etnier, 1989). Thus, it probably is unlikely that this species is present on the CNF, and it is recommended that management and protection of P. *intermedius* be given lower priority than other species. However, it may be impossible to document satisfactorily the complete absence of a cryptic species of small mammal in an area, perhaps especially a species like *P*. *intermedius* at the edge of its range that, if present, may exist in small, isolated populations. Therefore, it is difficult to justify a recommendation that this species be eliminated completely from the list of "sensitive" species on the CNF. Although efforts directed specifically at documenting the occurrence of *P. interrnedius* on the forest may not be warranted, researchers working on the CNF should be alert for, opportunities to assess its presence in the course of monitoring activities or other studies. Efforts to protect habitats for *Synaptomys borealis* would provide at least a partial "safety net" for *P*. *intermedius,* should the latter species indeed be present on the forest.

The captures *of Synaptomys borealis* represent only the sixth locality record for this species in Minnesota, and the first record south of the extreme northern tier of counties in the state (Fig. 1). This record also is the southernmost locality record for this species in midwestern North America, and is the first documentation of the presence of this species within the boundaries of the CNF. Thus, it is clear that this species should be retained on the "Sensitive" species list. Obviously, this single locality record provides no indication of how widespread this species is in the CNF. *Synaptomys* is notoriously difficult to capture, and results of trapping studies may provide only a rough indication of their abundance or distribution (Nordquist and Birney, 1980). The number of *Synaptomys* captured during this study is relatively high, and these animals were caught at a large number of sites. This suggests that the methods we employed were quite effective at capturing *Synaptomys,* at least *S. cooperi*; relative vulnerabilities to capture of the two species of *Synaptomys* are not known but presumably are comparable. Nonetheless, it is possible that *S. borealis, S.* cooperi, or both were present but not captured at some of the other sites we sampled. In any event, it is clear that the occurrence of *S. borealis is* even more limited than that of S. cooperi, which is generally thought to be uncommon and to have a highly localized distribution (Nordquist and Birney, 1980; Nordquist, 1992). Thus, consideration probably needs to be given to protecting *S. borealis* and its habitats on the CNF, especially in the northern portions of the forest.

The capture of *S. borealis* at a single forested site provides little indication of the range of habitats occupied by this species on the CNF or in this portion of Minnesota. The other most recent records of S. *borealis* in Minnesota were from open bog and scrub fen sites (Nordquist and Birney, 1980), so it is clear that this species may be associated with both forested and non-forested sites. However, the capture of *S. borealis* in closed canopy, forested habitat on the CNF raises the possibility that it may be affected by timber harvesting or other timber-management practices. The response of this species to timber harvest has, to my knowledge, not been studied. The existence of this species in non-forested sites suggests that removal of canopy trees per se may be less critical than any direct or indirect effects on ground and shrub vegetation or alterations in the water table. It is possible that these effects can be minimized or avoided by use of particular approaches to harvesting and regeneration. Further work is needed to assess possible effects of forest management practices on this species. Of course, further work also is needed to document more thoroughly the occurrence and habitat distribution of *S. borealis* on the CNF; the potential for timber-management activities to affect habitat availability for this species depends in part on the species' relative occurrence in forested and non-forested habitats.

Examination of F. J. Marschner's map "The Original Vegetation of Minnesota" and of peatland maps presented by Wright (1992) and Glaser (1992) indicates that previous records of Synaptomys borealis in Minnesota, including the previous southernmost record (10 mi S of Big Falls in Koochiching County) are associated with the extensive stretches of more-or-less continuous peatland habitats in Roseau, Lake of the Woods, and Koochiching counties. The locality record described in the present report is in or near a distinctive patch of peatland that, on Marschner's map, is reasonably well connected (by other large patches of peatland) to these northern peatlands but to the southwest, south, and southeast tends to break up into small patches of peatland habitat in a matrix of primarily aspen forest. On the maps presented by Weight (1992) and Glaser (1992) this patch of peatland is somewhat isolated, but the extent of isolation is much greater to the south than the north. This landscape-level perspective suggests the- possibility that there is a real habitat discontinuity in this region that limits the southward extension of the range of *S. borealis*, and that it is very unlikely the species will be found substantially further south. Future efforts to refine our knowledge of the distribution of this species on the CNF should certainly include the extreme northeastern portion of the forest, which contains peatlands with high habitat connectivity (Forman and Godron, 1986) to the relatively continuous peatlands to the north. Unfortunately, access to many stands in this portion of the forest is difficult, and this area received little effort in our sampling. Differences in bog lemming captures (either *S. cooped* or *S. borealis*) between the western and eastern portions of the area studied were noted previously; these differences parallel the landscape-level differences in connectivity, but further study would be needed to determine whether these considerations are an important factor in determining distribution of bog lemmings in this region.

Northern Minnesota is one of the few areas in North America where the ranges of *S. borealis* and S. *cooperi* overlap (Banfield, 1974; Nordquist and Birney, 1988). In the present study, the two species were trapped in the same forest stand. To my knowledge, coexistence of these two congeners has not specifically been reported. *S. cooped* was not captured at either of the localities reported for *S. borealis by* Nordquist and Birney (1980). The specimen of *S. borealis* from 10 mi S of Big Falls was collected by L. J. Anderson on 28 May 1971. There is a specimen of *S. cooped* in the collection of the Bell Museum of Natural History collected by L. J. Anderson on 26 May 1971 at a locality 10 mi S of Big Falls, but efforts to locate field notes or otherwise document that these are indeed the same locality have not been successful. Thus, it is not known how widely the two co-occur in this region, but the possibility needs to be recognized that the presence of *S. cooperi* in habitats that apparently are suitable for its congener may be an additional factor limiting the distribution of *S. borealis* in this region. There has been substantial interest in interspecific interactions among arvicoline rodents, and the extent to which these species exclude each other from particular habitats (citations below). The occurrence of four species of arvicoline rodents in a single habitat, as at the site of capture of S. *borealis, is* unusual, and suggests the possibility of a potentially formidable array of interspecific interactions that may affect the distribution of S. *borealis, S. cooperi,* or both. It is not known whether the capture of S. *borealis* and the high frequency of *Synaptomys* in our samples is related to the relatively low densities of *Clethrionomys gapperi* on almost all of our study sites. In other studies, *C. gapperi* has been found to be common in almost all peatlands habitats except graminoid-dominated fens; in lowland conifer forests it often is the most abundant small rodent present (Nordquist and Birney, 1980; Nordquist, 1992). Populations of *C. gapperi* fluctuate among years; the lower-thanexpected frequency of capture of this species in bog and lowland conifer forests suggests that 1992 was a low year. The occurrence of *Synaptomys* seems to be highly sporadic among years (Martell, 1974; Nordquist and Birney, 1980; G. Nordquist, personal communication), as well as spatially, and it is possible that annual fluctuations in abundance of *C. gapperi* affect habitat occupancy by *Synaptomys* in different years. This scenario is strengthened by the observation in this study that *Synaptomys* tended to occur at sites where numbers of *C. gapped* were relatively low, although that trend was not statistically significant. In addition, *Synaptomys* tended to occur at sites where *Microtus pennsylvanicus* was relatively abundant. Although that pattern also was not statistically significant, it is of interest because negative associations between *S. cooperi* and *M. pennsylvanicus* have been reported elsewhere (Connor, 1959; Richmond and Rosland, 1949). The tendency for a positive association between *Synaptomys* and M. *pennsylvanicus* may be indirect, reflecting "the often-reported negative interactions and habitat exclusion between *C. gapped* and *M. pennsylvanicus* (Clough, 1964; Crowell, 1973; Grant, 1969; Morris, 1969; Turner et al., 1975). Further work is needed to determine the extent to which interspecific interactions among these species affect habitat distribution of *Synapfomys* species or other arvicoline rodents in northern Minnesota.

All *Synaptomys* captured during this study were associated with either unforested or forested habitats (open heath bogs; bogs with sparse, stunted conifers; or lowland conifer, especially black spruce, forest). A shrub layer of ericaceous plants was present at all sites where *Synapfomys* occurred. These habitat associations are generally in accord with those reported for either *S. borealis* or S. *cooped by* previous authors (Banfield, 1974; Buckner, 1957; Clough and Albright, 1987; Connor, 1959; Etnier, 1989; Gunderson and Beer, 1953; Smith and Foster, 1957; Soper, 1948). We did not capture either species of *Synaptomys* in any of the grass-sedge meadows sampled, even though several of the above authors and others (Getz, 1961; Timm, 1975) have reported these species from such habitats. In the heath bog and lowland conifer sites sampled during this study, there was a tendency for *Sorex arcticus* and *Microtus* *pennsylvanicus* to be more abundant at sites where *Synaptomys* was present than where absent. In the present study, both *S. arcticus* and *M. pennsylvanicus* were strongly associated with graminoid-dominated habitats (grass-sedge meadows); the tendency for these species to be associated with *Synaptomys* in heath bogs and lowland conifers provides indirect evidence for a positive relationship between *Synaptomys* and graminoids. Thus, results i of the present study are consistent with the conclusion that *Synaptomys* are associated with abundant grasses and sedges (Connor, 1959; Getz, 1961), but only in conjunction with the presence of ericaceous plants. However, it must be-recognized that our sampling of graminoid-dominated habitats was quite limited.

Sites where *Synaptomys was* captured were characterized by relatively high numbers of shrews and of individual small mammals. Although some of these differs ices in species composition are slight, they support the view that *Synaptomys* tend to occur in relatively diverse communities of small mammal species, as pointed out previously by Clough and Albright (1987) for S. *borealis.* The existence of consistent differences in small-mammal abundance and species composition at sites where *Synapfomys* are present and where they are absent suggests that occupancy of heath or lowland conifer habitats by bog lemmings is not merely random, as might be concluded by the typically sporadic captures of these species in small-mammal studies. Instead, occupancy of these habitats may be related to a suite of biological factors, presently unknown. The presence of other small-mammal species may be a direct factor, or may reflect vegetative or other habitat factors that also affect bog lemmings.

In the present study, the greater abundance of *Peromyscus maniculatus* and *Clethrionomys gapped* in forested than non-forested habitats, and of *Microfus pennsylvanicus* in sedge meadows is in complete agreement with our understanding of the natural history of these species (Hazard, 1982; Nordquist, 1992). Although it has been recognized that *Sorex arcticus* often is associated with graminoid ground cover (Heaney and Birney, 1975; Nordquist, 1992; Timm, 1975), the findings in the present study that this species was significantly more abundant in grass-sedge meadows than in the other two habitats, and that it tended to be associated with *M. pennsylvanicus* in heath and conifer habitats, provide striking quantitative demonstration of that trend. Although *Zapus hudsonius* often is viewed as being associated with lush ground cover (frequently graminoids; Gunderson and Beer, 1953; Timm, 1975; Whitaker, 1972), it has been found in a wide variety of habitats (Hazard, 1982; Nordquist, 1992), and its occurrence only in grass-sedge meadows in the present study is surprising.

Sorex cinereus is one of the most widespread and abundant small mammals in northern Minnesota, and often is regarded as an extreme habitat generalist (Hazard, 1982; Timm, 1975). Other authors have reported this species to occur in graminoid habitats; Nordquist (1992) indicated that its abundance in fen habitats is lower than in forested peatland sites, but regarded this shrew as showing no strong habitat preference. In the present study, *S. cinereus* was equally abundant in heath bogs and lowland conifer forests, but was significantly less abundant in grass-sedge meadows. These results suggest little habitat selectivity on the basis of tree-canopy presence, but strong selection for habitats with ground vegetation dominated by ericaceous shrubs rather than grasses and sedges. Buckner (1966) reported that numbers of *S. cinereus* and *S. arcticus* varied inversely, and it is possible that the patterns of habitat selection for these two species reflect interspecific interactions.

Nordquist (1992) indicated that *Sorex hoyi* shows no strong preference for any peatland or non-peatland habitat in northern Minnesota, and pointed out the considerable, variation in published reports of habitat preferences in this species. Other authors have reported *S. hoyi* in open, sphagnum bogs and in lowland (swamp) conifer habitats (Bailey, 1929; Brown, 1967; Buckner, 1966; Jackson; 1961; Long, 1972, but most authors regarded these as among the variety of habitat types used by the species. In the present study, S. *hoyi was* absent from grass-sedge meadows, and was found only in heath bogs and lowland conifer forests, conforming most closely to the pattern of habitat selection described by Brown (1967) for this species in the Rocky Mountains. This pattern differs slightly from that reported by Nordquist and Birney (1980), who found black spruce conifer swamps to have the highest relative abundance of this species, but open bogs as among the habitats with lowest relative abundance. However, relatively few *S. hoyi* were captured in the present study, and more work is needed to better determine the degree of its habitat selectivity in northern Minnesota.

In this study, there was striking similarity among heath bogs, lowland conifer forests, and grass-sedge meadows in the number of individual small mammals, rodents, shrews, and small mammal species captured. This results suggests that, despite differences in vegetation structure and in small-mammal species composition, these three communities may be broadly similar in terms of aspects of ecosystem function involving small mammals. Reuvers (1993) sampled small mammals by snap trapping at sites in upland aspen forests on the CNF during 1990 and 1991. Overall small-mammal abundance and rodent abundance in lowland habitats in the present study were comparable to those observed by Reuvers (1993) during 1990, but considerably lower than she reported for 1991. Shrew abundance in the present study was considerably higher in the present study, but it is not known to what extent that differences reflects use of pitfall traps. The average number of small-mammal species captured in the present study was comparable to that reported for Reuvers (1993) for aspen sites, providing no indication that the small mammal fauna at lowland sites sampled in the present study is depauperate. Again, use of pitfall traps in the present study, which almost certainly increased captures of some species (e. g., *Sorex hoyi*), dictate that such comparisons be made with caution.

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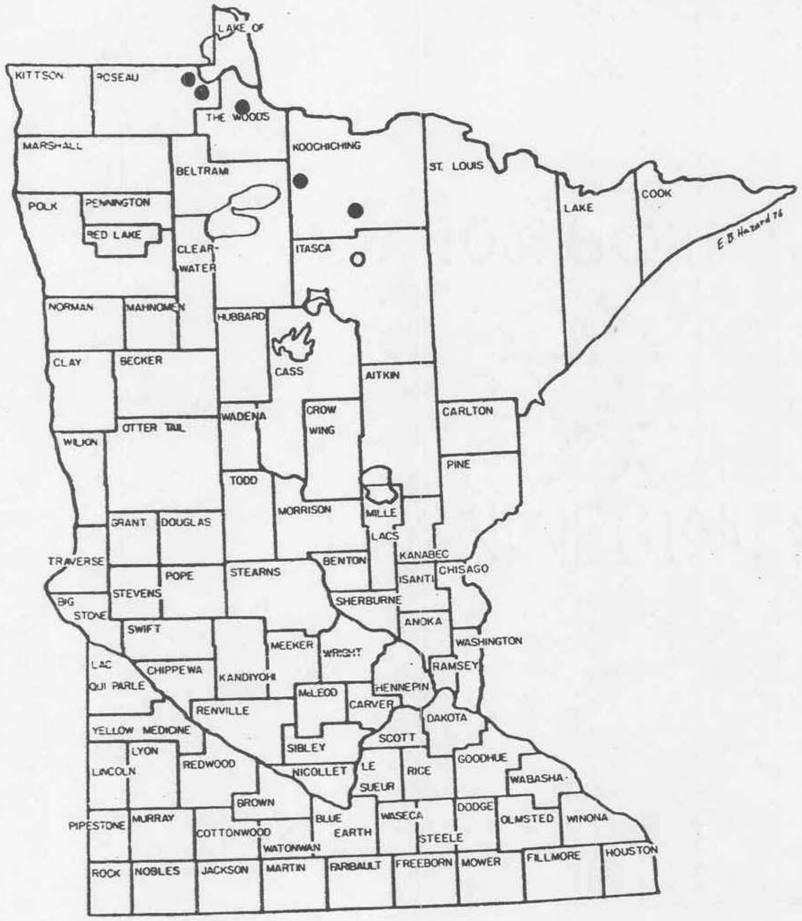

Figure 1.Location of previous records of *Synaptomys borealis* in Minnesota (closed circles) and of 1992 record in the Chippewa National Forest (open circle).

Table 1 A. Abundance (X±SE number of captures per site and [in parentheses] number of individuals) and frequency of occurrence (proportion and [in parentheses] number of trap lines where captured) of insectivores (moles and shrews) captured in surveys of lowland habitats in the northern Chippewa National Forest during August 1992. *'Sorex* species are either *S. cinereus* or *S. hoyi* but could not be positively identified,. usually because of animal damage to the skull of captured animals.

Habitat type		*Condylura cristata*	*Sorex arcticus*	*Sorex cinereus*	*Sorex hoyi*	*Sorex species**	*Sorex palustris*	*Blarina brevicauda*
Heath bog (n = 19)	Abundance	0.05±0.05 (1)	1.2±0.3 (22)	5.5±0.7 104)	0.4±0.1 (8)	0.1±0.1 (2)	0 (0)	0.3±0.1 (6)
	Frequency	0.05 (1)	0.47 (9)	1.0 (19)	0.37 (7)	0.11 (2)	0 (0)	0.26 (5)
Sedge meadow (n = 11)	Abundance	0.1010.10 (1)	3.411.2 (37)	1.110.4 (12)	0 (0)	0 (0)	0.510.2 (5)	0.510.2 (5)
	Frequency	0.09 (1)	0.82 (9)	0.55 (6)	0 (0)	0 (0)	0.36 (4)	0.27 (3)
Lowland conifer (n = 19)	Abundance	0.16±0.10 (3)	0.7±0.3 (14)	5.3±0.8 100)	0.2±0.1 (3)	0.1±0.1 (1)	0.1±0.1 (2)	0.8±0.3 (16)
	Frequency	0.16 (3)	0.32 (6)	0.89 (17)	0.11 (2)	0.05 (1)	0.11 (2)	0.42 (8)

Table 1B. Abundance (X±SE number of captures per site and [in parentheses] number of individuals) and frequency of occurrence (proportion and [in parentheses] number of sites where captured) of small rodents captured in surveys of lowland habitats in the northern Chippewa National Forest during August 1992.

Habitat type		*Microtus pennsylvanicus*	*Clethrionomys gapperi*	*Synaptomys cooperi*	*Synaptomys borealis*	*Peromyscus maniculatus*	*Zapus hudsonius*
Heath bog	Abundance	2.0±0.6 (38)	0.6±0.3 (11)	1.5±0.4 (28)	0 (0)	0 (0)	0 (0)
(n = 19)	Frequency	0.63 (12)	0.32 (6)	0.68 (13)	0 (0)	0 (0)	0 (0)
Sedge meadow	Abundance	5.7±2.0 (63)	0 (0)	0 (0)	0 (0)	0 (0)	1.2±0.5 (13)
(n = 11)	Frequency	1.0 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0.55 (6)
Lowland conifer	Abundance	1.9±0.5 (37)	2.3±0.7 (43)	0.3±0.2 (5)	0.1± 0.1 (2)	0.3±0.2 (5)	0 (0)
(n = 19)	Frequency	0.63 (12)	0.63 (12)	0.16 (3)	0.05 (1)	0.16 (3)	0 (0)

Table 2. Number of individuals and species of shrews, rodents, and shrews and rodents combined (X±SE) captured in three habitats sampled during small-mammal surveys in the Chippewa National Forest during August 1992.

	Individuals			**Species**		
Habitat type	Shrews	Rodents	Total	Shrews	Rodents	Total
Heath bog (n = 19)	7.5±0.7	4.1±0.7	11.6±1.0	2.1±0.2	1.6±0.2	3.7±0.3
Sedge meadow (n - 11)	5.4±1.1	6.9±2.4	12.4±2.8	2.0±0.3	1.5±0.2	3.5±0.3
Lowland conifer (n = 19)	7.2±0.9	4.8±1.0	12.2+1.4	1.8±0.2	1.610.2	3.5±0.3

Table 3. Abundance of coexisting small mammal species at sites in heath bog habitat in the Chippewa National Forest where *Synaptomys cooperi* were present or absent. Data are mean ± SE number of individuals captured in trap lines set in each habitat; n = number of sites sampled.

	Synaptomys present (n = 13)	*Synaptomys* absent (n = 6)
Sorex arcticus	1.38±0.38	0.67±0.67
Sorex cinereus	6.31±0.81	3.67±1.14
Sorex hoyi	0.46±0.18	0.33±0.22
Blarina brevicauda	0.31±0.13	0.33±0.33
Microtus pennsylvanicus	2.15±0.62	1.67±1.28
Clethrionomys gapperi	0.23±0.12	1.33±0.95
Number of shrews	8.62±0.75	5.00±0.97
Number of rodents	4.54±0.69	3.00±1.48
Number of individuals	13.23±0.88	8.02±1.63

Table 4. Abundance of coexisting small mammal species at sites in heath bog and lowland conifer habitat in the Chippewa National Forest where *Synaptomys cooperi* or *S. borealis* were present or absent. Data are meant SE number of individuals captured in trap lines set in each habitat; n = number of sites sampled.

	Synaptomys present (n = 16)	Synaptomys absent (n = 22)
Sorex arcticus	1.19±0.33	0.78±0.31
Sorex cinereus	6.44±0.66	4.59±0.72
Barina brevicauda	0.31±0.12	0.77±0.28
Microtus pennsylvanicus	2.52±0.54	1.67±0.54 -
Clethrionomys gapperi	1.06±1.06	1.68±0.45
Number of shrews	8.44±0.61	6.53±0.80
Number of rodents	5.75±1.02	3.54±0.68
Number of individuals	14.25±1.03	10.14±1.15

Appendix I. Descriptions of sites in the Chippewa National Forest (CNF), Beltrami and Itasca Counties, Minnesota, where small mammals were sampled during August 1992. District = CNF Ranger District; Cmpt. and stand = CNF timber compartment designation and stand number within that compartment. District and compartment in which stands of non-federal ownership are located are also provided to facilitate site identification; Type - CNF Animal Habitat Code (5 = open heath bog; 6 = sedge.meadow wetland; 32 = semi-open lowland conifer; 33 = closed canopy lowland conifer).

Site	Legal Description	District	Ownership	Cmpt.	Stand	Type	Comments
1	T148N R30W sec. 9	Blackduck	Federal	49	12	33	much of stand is sedge and heath; very open
2	T148N R30W see. 9	Blackduck	Federal	54	35	33	
3	T148N R30W sec. 11	Blackduck	Federal	55	16	33	
4	T148N R30W see. 10	Blackduck	Federal	54	22	6	
5	T148N R30W sec. 2	Blackduck	Federal	46	33	5	abund sm conifers
6	T148N R30W sec. 1	Blackduck	Federal	46	32	5	
7	T148N R29W sec. 6	Blackduck	Federal	32	2	33	
8	T147N R30W sec. 1, 2	Blackduck	Federal	107	13	6	
9	T147N R30W sec. 11, 12	Blackduck	Federal	107	17	6	
10	T148N R30W sec. 32	Blackduck	Federal	67	7	33	
11	T148N R31 W see. 35	Blackduck	Federal	85	33	32	dense alder under sparse cedar and tamarack
12	T148N R31 W sec. 35	Blackduck	Federal	85	5	33	thick sphagnum mat, shrubs absent
13	T148N R31 W sec. 15, 16	Blackduck	State	77		33	boggy cedar stand NW of Rice Pond
14	TI48N R31 W sec. 24	Blackduck	Federal	76	45/46	33	W of Hwy 39 at intersecion with F. R. 2207
15	T148N R30W see. 19	Bladcduck	Federal	60	16	33	E side of Hwy 39
16	T148N R31 W sec.25	Blackduck	Federal	76	39	6	N side of Turtle R., W of Hwy 39
17	TI48N R31 W sec. 25	Blackduck	Federal	84	21	33	
18	T148N R30W sec. 3	Blackduck	Federal	47	12	33	L
19	T148N R30W sec 2	Blackduck	State			5	N of Hwy 28, ca. 0.4 mi E intersection F. R. 2201
20	T148N R30W sec. 2	Blackduck	Federal	47	1	5	F.S. classif. - type 32; field appearance is type 5
21	T149N R30W sec. 35	Blackduck	State			5	W of F. R. 2203, N of F. R. 2201; site brushy to NW

22	T149N R27W sec. 30	Blackduck	Federal	235	4	5	on Co. Rd. 163, 1.5 mi S intersec. F. R. 2429
23	T149N R27W sec. 28	Blackduck	Federal	232	26	6	N bank Popple River, F. R. 2429
24	T149N R27W sec. 20	Blackduck	County			5	small heath bog NE of intersec Co. 163 & F. R. 2429
25	T149N R27W sec. 17	Blackduck	Private			6	extremely wet, grading into type 32
26	T149N R27W sec. 15	Blackduck	Private			6	S bank Popple River, F. R. 126
27	T149N R27W sec. 15	Blackduck	Federal	207	36	5	
28	T149N R27W sec. 10	Blackduck	Federal	189	28	5	NE of intersec. Hwy 29 & F. R. 126; stand design. ??
29	T149N R27W sec. 10	Blackduck	Federal	202	34	33	and adj. private land, SW intersec. Hwy 29 & F.R. 126
30	T149N R27W sec. 2	Blackduck	Federal	181	50	5	S part of stand, moderately dense, small black spruce
31	T149N R27W sec. 2	Blackduck	Federal	181	50	5	N part of stand, relatively open
32	T150N R27W sec. 35	Blackduck	State			5	bog mat at E end of small lake, E of Coddington L.
33	T150N R27W sec. 22	Blackduck	Federal			5	small bog mat, E edge of Glove Lake
34	T150N R27W sec. 34	Blackduck	State			5	heath E of Lost- Forty; open center, forested rim
35	T149N R27W sec. 13	Blackduck	Federal	204	8	5	
36	T149N R27W sec. 26	Blackduck	Federal	229	1	33	tamarack, black spruce, and cedar
37	T149N R27W sec. 35	Blackduck	State			33	adjacent to F. S. stand 10, cmpt. 229; largely cedar
38	T149N R26W sec. 3	Blackduck	Federal	185	9	5	S end of Noma Lake
39	T150N 26W sec. 33	Blackduck	Federal	184	30	6	extremely wet, with cattails, marsh marigolds
40	T150N R26W sec. 28-29	Marcell	Federal	163	?	5	small bog W of Hwy 27, immed. S of F. R. 3526
41	T150N R25W sec. 31	Marcell	Federal	178	7	33	dry on E, wet w/ black ash on W; abund. blowdo ns
42	T150N R26W sec. 1	Marcell	Federal	173	1	6	SW bank of Bigfork R off Hwy 14; dry meadow
43	T149N R25W sec. 28	Marcell	Federal	146	1	33	cedar - tamarack
44	T149N R25W sec. 22	Marcell	Federal	159	25	5	
45	T149N R25W sec. 22	Marcell	Federal	159	9	33	
46	T149N R25W sec. 25	Marcell	Federal	144	2 (?)	5	N side F. R. 2187, 1.1 mi W intersec. Hwy 6
47	T59N R27W sec. 3	Marcell	Federal	42	1	33	open, rather wet, substantial graminoid component
48	T59N R27W sec. 3	Marcell	Federal	42	4	33	

49	T149N R26W sec. 16, 17	Blackduck	Federal	187	41	6	sedge meadow SE of Henken Cr., N of Hwy 29
50	T149N R26W sec. 17	Blackduck	Federal	205	?	6	sedge meadow NW of Henken Cr., S of Hwy 29

Appendix II. Number of individuals of small mammal species captured at heath bogs (type 5), grass-sedge meadow (type 6), semi-open lowland conifer (type 32), and closed-canopy lowland conifer (type 33). Sites are arranged in numerical order within habitat type to facilitate cross-referencing with Appendix I.

type	Site No.	*Condylura cristata*	*Sorex arcticus*	*Sorex cinereus*	*Sorex hoyi*	*Sorex species**	*Sorex palustris*	*Blarina brevicauda*	*Microtus pennsylvanicus*	*Clethrionomys gapperi*	*Synaptomys cooperi*	*Synaptomys borealis*	*Peromyscus maniculatus*	*Zapus hudsonius*
5	5	0	0	4	0	0	0	0	0	1	0	0	0	0
5	6	0	0	7	1	0	0	0	1	0	0	0	0	0
5	19	0	4	3	0	0	0	1	3	0	1	0	0	0
5	20	0	0	7	1	0	0	0	0	0	1	0	0	0
5	21	0	0	1	0	0	0	2	8	1	0	0	0	0
5	22	0	4	1	1	0	0	0	0	0	0	0	0	0
5	24	0	3	5	0	0	0	1	2	0	1	0	0	0
5	27	0	2	8	1	1	0	0	2	0	4	0	0	0
5	28	0	1	4	0	0	0	1	3	0	2	0	0	0
5	30	0	2	6	0	0	0	0	0	1	3	0	0	0
5	31	0	2	1	0	1	0	0	1	0	4	0	0	0
5	32	0	3	6	0	0	0	0	4	0	5	0	0	0
5	33	0	0	2	0	0	0	0	1	0	0	0	0	0

type	Site No.	*Condylura cristata*	*Sorex arcticus*	*Sorex cinereus*	*Sorex hoyi*	*Sorex species**	*Sorex palustris*	*Blarina brevicauda*	*Microtus pennsylvanicus*	*Clethrionomys gapperi*	*Synaptomys cooperi*	*Synaptomys borealis*	*Peromyscus maniculatus*	*Zapus hudsonius*
5	34	0	0	11	0	0	0	0	0	0	1	0	0	0
5	35	0	0	6	0	0	0	0	8	0	1	0	0	0
5	38	0	0	5	1	0	0	1	3	1	1	0	0	0
5	40	0	0	9	1	0	0	0	0	1	3	0	0	0
5	44	0	0	7	0	0	0	0	0	6	0	0	0	0
5	46	1	1	11	2	0	0	0	2	0	1	0	0	0
6	4	0	14	0	0	0	0	0	2	0	0	0	0	0
6	8	0	2	3	0	0	0	0	5	0	0	0	0	0
6	9	0	5	2	0	0	0	2	24	0	0	0	0	5
6	16	0	0	3	0	0	0	0	8	0	0	0	0	1
6	23	0	2	0	0	0	1	0	2	0	0	0	0	2
6	25	1	2	1	0	0	2	0	1	0	0	0	0	0
6	26	0	3	2	0	0	0	2	3	0	0	0	0	0
6	39	0	0	1	0	0	1	0	11	0	0	0	0	2
6	42	0	1	0	0	0	0	0	3	0	0	0	0	0
6	49	0	5	0	0	0	0	0	2	0	0	0	0	1

type	Site No.	Condylura cristata	Sorex arcticus	Sorex cinereus	Sorex hoyi	Sorex species*	Sorex palustris	Blarina brevicauda	Microtus pennsylvanicus	Clethrionomys gapperi	Synaptomys cooperi	Synaptomys borealis	Peromyscus maniculatus	Zapus hudsonius
6	50	0	3	0	0	0	1	1	2	0	0	0	0	2
32	11	0	0	0	0	0	0	1	1	2	0	0	0	0
33	1	1	2	3	0	0	0	1	2	0	0	0	0	0
33	2	0	0	2	0	0	0	0	1	1	0	0	0	0
33	3	0	5	0	0	0	0	0	2	6	0	0	0	0
33	7	0	2	5	0	0	1	0	1	1	0	0	0	0
33	10	0	0	7	0	0	0	1	4	1	0	0	0	0
33	12	0	0	7	0	0	0	3	0	4	0	0	1	0
33	13	0	0	7	0	0	0	5	0	5	0	0	3	0
33	14	1	0	9	2	0	0	2	0	1	0	0	1	0
33	15	0	0	1	1	0	0	0	5	0	0	0	0	0
33	17	0	0	11	0	0	0	2	0	0	0	0	0	0
33	18	0	0	2	0	0	0	0	0	0	0	0	0	0
33	29	0	0	10	0	0	0	0	1	0	0	0	0	0
33	36	0	2	3	0	0	0	0	2	0	0	0	0	0
33	37	0	0	0	0	1	0	1	0	4	0	0	0	0

type	Site No.	Condylura cristata	Sorex arcticus	Sorex cinereus	Sorex hoyi	Sorex species*	Sorex palustris	Blarina brevicauda	Microtus pennsylvanicus	Clethrionomys gapperi	Synaptomys cooperi	Synaptomys borealis	Peromyscus maniculatus	Zapus hudsonius
33	41	0	0	4	0	0	0	0	0	2	0	0	0	0
33	43	0	0	7	0	0	0	0	4	13	1	0	0	0
33	45	0	0	7	0	0	0	1	3	1	1	2	0	0
33	47	1	2	8	0	0	1	0	7	4	0	0	0	0
33	48	0	1	7	0	0	0	0	5	0	3	0	0	0

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