Small Mammals of the Guthrie-Bancroft Farm - Year 4

Colby Hill Ecological Project, Lincoln and Bristol, Vermont

2005 Final Report

J. Decher and C. W. Kilpatrick

Summary

In 2005 we re-sampled the small mammals of the Guthrie-Bancroft parcel in ecosystems 1, 6, 14, and 20. This year 244 individual captures were made, including nine species of terrestrial (non-volant) small mammals. A new species encountered on this parcel this year was the rare Southern bog lemming *(Synaptomys cooperi*) captured in Ecosystem 14. A second Short-tailed weasel (*Mustela erminea*) was captured in ES 20. Analysis of all four years of small mammal data collected for the Guthrie-Bancroft parcel showed statistically significant differences between habitats for *Peromyscus* sp., *Microtus pennsylvanicus*, *Clethrionomys gapperi* and *Tamias striatus*.

Introduction

After our initial broad survey of small mammals of 10 ecosystems in 2000 we resampled and added selected ecosystems in 2001 (ES 1, 9, 14, 18, 20, and 25) and in 2002 (ES 1, 6, 10, 14, 20, and 25) and finally decided on four ecosystems to be re-sampled long-term continuing in 2005 (ES 1, 6, 14 and 20), most likely in 2 or 3-year intervals (for overview see Appendix I). For brief description of the four selected ES this year, see Appendix II. The objectives are to document a distinct mammal community composition in each ecosystem, continue to add additional rarer species to the list and observe changes in the small mammal communities over time as the ecosystems undergo successional natural transformation under the minimal-management scheme that is part of the "Forever Wild" conservation regime intended for the Guthrie-Bancroft parcel. This year's small mammal sampling took place between 19 July and 4 August 2005 and also included one night of bat netting.

Material and Methods

As part of a continued effort to standardize methods, this year ecosystems were all sampled with two replicate traplines, divided into 14 stations, with two Sherman traps per station, and one line of 6 pitfalls connected with a plastic driftfence for a total of 62 trap units. Traplines

were each run for three consecutive nights totaling 744 trapnights. At each station one trap was usually placed "low" in the micro-topography (undergrowth, along log or under woody debris) and one was placed "high" on a ridge, or above ground on a fallen log or a horizontal tree branch to account for different foraging niches of different species. Traps were baited with rolled oats flavored with peanut butter and checked every morning between 7:00 and 10:00 hours. As in 2002, habitat data were recorded at each successful trapsite using simple estimates of tree and log density and canopy and ground cover.

Similar to 2002 we recorded maximum and minimum temperature and rainfall with a digital thermo-hygrometer (Oregon Scientific, Inc.) and a standard All Weather Rain Gauge (Productive Alternatives, Inc., MN) placed in ecosystem 20 (alder swamp, sedge meadow, edge of former beaver pond), which we monitored daily throughout the study. Some of the animals that died in Sherman or pitfall traps during heavy rainfall were kept for further examination and as vouchers specimens and will be preserved in the Zadock Thompson Natural History Collection of the University of Vermont. As in previous years saliva samples were taken from rodents of the genus *Peromyscus* to use salivary amylase markers to find out which ones were deer mice *(Peromyscus maniculatus)* or white-footed mice *(Peromyscus leucopus)* following the method developed by Aquadro and Patton (1980) as modified by Kilpatrick et al. (1994). Sampled *Peromyscus* were marked with a specialized rodent ear punch (National Band & Tag Company, Newport, KY) to avoid taking multiple samples from recaptured individuals. We examined differences among ecosystem types in individual species abundance and diversity using the program JMP IN® (Sall et al. 2005).
Camera trapping, begun in 2004, continued this year during and following the trapping period at selected sites throughout the Guthrie-Bancroft Parcel using one Wildlife Pro Camera System from Camtrakker (http://www.camtrakker.com/) and beginning in September with an additional a second digital Cuddeback camera (http://www.cuddebackdigital.com/indexb.html) model. Results are summarized in a separate 2005 camera trap report.

Results and Discussion

Terrestrial Small Mammals

Figure 1 presents the map of the study area showing the sites re-sampled in 2005 and bar graphs showing occurrence of small mammal species as a percentage of trapping effort. Figure 2 presents the same bar graphs compared to those from the previous 2 or 3-year trapping efforts in the four ecosystems showing the variation in occurrence or abundance of individual species.

Table 1.1 shows an overview of trapping results for the four sampled ecosystems including those from previous three (or two) years for the same ecosystems. At the bottom of Table 1.2 diversity indices were calculated from proportions of the total number of small mammal captures in each ecosystem based on trapping effort. This year the highest Shannon Wiener diversity was obtained in ES 14 (H' = 1.24). The highest Simpson Index was obtained in ES 20 (1-D= 0.980). In Table 1.3 estimated biomass of small mammals per 100 trapnights are calculated using published average or actual weights of species caught. ES 1 had the highest biomass in 2005 with 920.6g. ES 1 also has the highest biomass for the 3-(or 4)-year multi-year average with 709.04g .

The list of small mammals recorded from the Guthrie-Bancroft Parcel was increased by one species, the Southern bog lemming (*Synaptomys cooperi)* in 2005. A second short-tailed weasel or ermine (*Mustela erminea*) was captured this year again in ES 20 - a species that was first added to the list in 2002. Appendix II provides an overview over all ecosystems sampled and all captures made since summer 2000 totaling 855 captures made in 3239 trapnights with an average of 26 percent trapping success.

Climate Data

Figure 3 shows minimum and maximum temperature, humidity, and amount of rainfall recorded between 19 July and 4 August 2005 in Ecosystem 20. These data make for interesting comparison with data recorded between 24 July and 13 August in 2002. Temperature ranged between 10.1 °C at night and 32.7 °C during the day in 2002 and between 12.6°C at night and 30.3°C during the day in 2005. Rainfall was more than twice as high in the 17-day period recorded in 2005 (85.3mm) compared to the 21-day period recorded in 2002 (41.2mm). Again there were substantial shifts in minimum (nocturnal) temperature and humidity during this year's recording period.

Microhabitat Data

Microhabitat Data collected at each trap stations as summarized by ecosystem in Figure 4. As in 2002, bar graphs show the predominant forest character of the four re-sampled ecosystems except for ES 20. This "alder swamp/sedge meadow," has the lowest canopy cover (65.4%, Fig. 4a), the highest percentages of herbaceous undergrowth (59.8%, Fig. 4f) and grass cover (26.2%, Fig. 4g), and the most exposed rocky surface (4%, Fig. 4j). Ecosystem 6 had the highest canopy cover (95.4%; Fig. 4a), densest leaf litter cover (61.91%; Fig. 4i), and highest average log diameter (13.19 cm; Fig. 4e). In Ecosystem 1 we measured the largest average diameter of nearest trees (24.6 cm; Fig. 4c) and the largest percentage of exposed bare soil (7.1%; Fig. 4h).

In Fig. 5 microhabitat data are summarized by small mammal species. Data for the species *Synaptomys cooperi* (n=1), *Sorex fumeus* (n=1),and *Zapus hudsonius* (n=4) are included for the first time. *Sorex fumeus*, *Clethrionomys gapperi* and *Tamias striatus* were associated with the highest canopy cover (Fig. 5a). *Sorex fumeus* and *Zapus hudsonius* were found at locations with the greatest distance from the nearest standing tree (Fig. 5b). *Sorex fumeus, Synaptomys cooperi* and *Mustela erminea* were associated with the most herbaceous cover (Fig. 5f). As expected the meadow vole, *Microtus pennsylvanicus,* was associated with the most grass cover (Fig. 5g). Short-tailed shrew, *Blarina brevicaud, Peromyscus* sp., *Clethrionomys gapperi* and *Tamias striatus* sites had the highest leaf litter cover (Fig. 5i).

Analysis of Variance

We found some difference among habitats for Simpson's Diversity index (1-D; p = 0.075) but not for the Shannon-Wiener index (Table 2). Individual species that showed greatest differences were *Peromyscus* sp. (p = 0.005), *Microtus pennsylvanicus* (p = 0.038), *Clethrionomys gapperi* (p = 0.02) and *Tamias striatus* (p = 0.026). *Peromyscus* had the highest abundance in "well-drained mesic red oak hardwood forest" (ES1) and the lowest abundance in the "alder swamp/sedge meadow" (ES 20). *Microtus* was meaningfully abundant only in ES 20. The red-backed vole (*C. gapperi*) reached highest abundances in "poorly drained spruce fir northern hardwood forest" (ES 14) and lowest in ES 20. Eastern chipmunk (*T. striatus*) was most common in ES 1.

Regression of small mammal and habitat data

Table 3 summarizes results of a simple linear regression matrix of habitat variables and small mammal data. Strong **positive** correlations were found only between number of *Peromyscus* sp. and leaf litter and number of woodland jumping mice (*Napaeozapus insignis*) and grass cover. Strong **negative** correlations existed between *Peromyscus* and both herb and grass cover and (not surprisingly) between leaf litter and both herb and grass cover.

Distribution of White-footed Mouse (*Peromyscus leucopus)* and Deer Mouse *(P. maniculatus)* based on salivary amylase variation

This year 47 saliva samples were collected from individual *Peromyscus* sp. in all four habitats. Saliva analysis results were not available at time of writing.

Bats

On 25 July 2005 we made another attempt to net bats at Guthrie using the canopy net and three other nets but did not capture any animals.

Rare and unique species caught in 2005

Synaptomys cooperi (Southern Bog Lemming). One specimen of this rarely caught species was found in a waterlogged pitfall trap on 3 August 2005 after very heavy rainfall on Aug. 2 (see Fig. 3b) in dense fern under relatively open canopy in Ecosystem 14. Other species captured in the same fern area were *Sorex fumeus, Sorex cinereus* and *Napaeozapus insignis*. There are only two other documented records of. *S. cooperi* from Addison County—Leicester, (Kirk 1916) and a UVM specimen from "2.3 miles southsouthwest of Middlebury" (C. W. Kilpatrick in litt.).

The vernacular name "bog lemming" is somewhat misleading because this species has been found ranging from grasslands in the Midwest, to wet meadows, dry broomsedge fields, pastures, grassy openings in woods, power-line rights of way, clearcuts, and among mossy boulders in spruce (*Picea* sp.) forests in southern Appalachia, to "mixed deciduous/coniferous forests in Nova Scotia and New Brunswick" and "sphagnum bogs or heavily forested areas" along the east coast of the United States (Linzey 1983). According to Connor (1959), only in

sphagnum bogs with shrub cover does *S. cooperi* surpass the number of *Microtus pennsylvanicus*. Linzey (1981) demonstrated that *M. pennsylvanicus* competitively excluded *Synaptomys* in southwestern Virginia, and in her monograph on *S. cooperi* she offers the concluding remark that "man-made clearings in places not readily colonized by *Microtus* (such as clearcuttings **within extensive forested areas**) favor *Synaptomys* (Linzey 1983, emphasis mine). This scenario may be a hint that the "poorly-drained spruce-fir northern hardwood forest" of Ecosystem 14 was not completely removed during Vermont's "deforested past" (Klyza and Trombulak 1999) allowing *S. cooperi* to survive in an isolated area. Sizeable populations of *M. pennsylvanicus* are only a few hundred meters away in the meadow (ES 21) and old fields (ES 22) of the Guthrie-Bancroft parcel. *M. pennsylvanicus* may be occassionally entering ES 14 along grassy logging roads as evidenced by the capture of one specimen in 2001 (Appendix II).

Short-tailed Weasel *(Mustela erminea).* A second female short-tailed weasel weighing 97g was captured in a Sherman trap in dense herbaceous growth in ES 20 on 28 July 2005. Like the specimen caught in the same ecosystem on 6 August 2003, this one was caught during one of the coldest night (12.6°C min. temp.) of the trapping period with the same 10.2mm (0.4 inches) of rainfall based on the measurements in ES 20 (Fig. 4 and 5). Probably because of these conditions the animal did not survive in the Sherman trap; it was preserved as a voucher specimen. The documented occurrence of *M. erminea* at Guthrie-Bancroft matches part of the habitat characterization stating that "[i]n the Holarctic, ermine tend to avoid dense forest and deserts, and settle in successional or forest-edge habitats, in scrub, alpine meadows, marshes, riparian woodlands, hedgerows, and riverbanks rich in small mammals, especially *Microtus* and *Arvicola"* (King 1983:4).

Evidence for the star-nosed Mole (*Condylura cristata*)

In late September 2005 several mole hills were discovered while scouting for camera trap sites at the lower (west) end of the old fields (ES22) at Guthrie. The area is covered with dense fern and other less prominent vegetation. A small intermittently flowing creek flows along the edge of this habitat. The mounds are quite conspicuous consisting of fresh elongated ridges of heavy dark "mucky" soil. Specially designed tube life traps were installed in the opened tunnels for two nights (Oct. 5 and 6), but without successful capture. The

species in question is most likely the star-nosed mole which constructs burrows "in or near marshy areas or streams" (Petersen and Yates 1980:3). The only other mole species occurring in Vermont, the hairy-tailed mole *(Parascalopus breweri)*, avoids "soils with high moisture or clay contents" (Hallett 1978:3). We will continue to try to trap both species in future years.

Other Observations in 2005

On 11 October 2005 the first picture of a fisher *(Martes pennanti)* was recorded for the study, with a second picture following on 21 October. Other species photographed this year were red fox, raccoon, moose and, for the first time, white-tailed deer. More detailed camera trap results are provided in a separate report.

Conclusions

With trapping success ranging from 23-45 percent in the four habitats sampled this year and 244 captures and 11 species caught this was the most productive year so far for small mammal trapping, as measured by individuals captured as well as by trapping success (Table 1.1 and Appendix II). We can now discern statistically significant differences in abundance between habitats for four of the small mammal species over a three or four year period. Several species like the northern and southern flying squirrrels, ermine, and southern bog lemming have only been recorded at very low levels or in only a single ecosystem, unsuitable for a meaningful analysis of variance.

Continued re-sampling shows that a few species are being gradually added to the list, for instance the surprise finding of the Southern bog lemming in ES 14 this year. Recent papers have suggested less invasive and less labor intensive techniques for sampling small mammals, such as the use of track tubes in Adirondack Park. However, we feel strongly that actual trapping of small mammal yields better resolution for species inventories and we agree with Glennon that especially "for rare species, track tubes do not represent an ideal assessment technique" (Glennon et al. 2002:741).

Acknowledgments

Funding for this study was provided by the Colby Hill Fund. Thanks to Stephanie Onyekaba for her field assistance in 2005. We thank Lester and Monique Anderson for allowing us to again use their cabin and garden shed at Well's Place, and to Vermont Family Forests for managing the project.

Literature Cited

Aquadro, C. F., and J. C. Patton. 1980. Salivary amylase variation in *Peromyscus*: use in species identification. Journal of Mammalogy, 61:703-707.

Chipman, R. B. 1994. Distribution, relative abundance, and habitat use by small mammals in Vermont. Unpublished M.S., University of Vermont. x+184 pp.

Connor, P. F. 1959. The bog lemming *Synaptomys cooperi* in southern New Jersey. Publications of the Museum of Michigan State University, Biology Series, 1:161-248.

Davis, W. H., and H. B. Hitchcock. 1965. Biology and migration of the bat *Myotis lucifugus* in New England. Journal of Mammalogy, 46:296-313.

Davis, W. H., and H. B. Hitchcock. 1994. A new longevity record for the bat *Myotis lucifugus*. Bat Research News, 35:61.

Fenton, M. B., and R. M. R. Barclay. 1980. Myotis lucifugus. Mammalian Species, 142:1-8.

Glennon, M. J., W. Porter, F., and C. L. Demers. 2002. An alternative field technique for estimating diversity of small-mammal populations. Journal of Mammalogy, 83:734-742.

Godin, A. J. 1977. Wild mammals of New England. Johns Hopkins University, Baltimore, xii+304 pp.

Hall, D. S. 1991. Diet of the northern flying squirrel at Sagehen Creek, California. Journal of Mammalogy, 72:615-617.

Hallett, J. G. 1978. Parascalops breweri. Mammalian Species, 98:1-4.

Kilpatrick, C. W., S. M. Rich, and K. L. Crowell. 1994. Distribution of the genus *Peromyscus* in coastal and inland southwestern Maine. Maine Naturalist, 2:1-10.

Kirk, G. L. 1916. The mammals of Vermont. Joint Bulletin, Vermont Botanical and Bird Club, 2:28-34.

King, C., M. 1983. Mustela erminea. Mammalian Species, 195:1-8.

Kiser, J. D., R. R. Kiser, V. Brack, Jr., and E. R. Britzke. 2001. A survey for eastern forest bats on Green Mountain and Finger Lake National Forests, with emphasis on the federally endangered Indiana bat (*Myotis sodalis)*. USDA - Forest Service Green Mountain & Finger Lakes National Forest & Environmental Solutions & Innovations (ESI). v+60 pp.

Klyza, C. M., and S. C. Trombulak. 1999. The story of Vermont - a natural and cultural history. University Press of New England, Hanover, NH, xii+240 pp.

Lapin, M. 2000. Landscape ecosystems of the Guthrie-Bancroft Farm, Approximation 2000. Preliminary Report. Colby Hill Ecological Project. 13 pp.

Linzey, A. V. 1981. Patterns of coexistence in *Microtus pennsylvanicus* and *Synaptomys cooperi*. Unpubl. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg 97pp.

Linzey, A. V. 1983. Synaptomys cooperi. Mammalian Species, 210:1-5.

Osgood, F. L., Jr. 1938. The mammals of Vermont. Journal of Mammalogy, 19:435-441.

Petersen, K. E., and T. L. Yates. 1980. Condylura cristata. Mammalian Species, 129:1-4.

Prescott, J., and P. Richard. 1996. Mammifères du Quebec et de l'est du Canada. Édition Michel Quintin, Waterloo, Quebec, 399 pp.

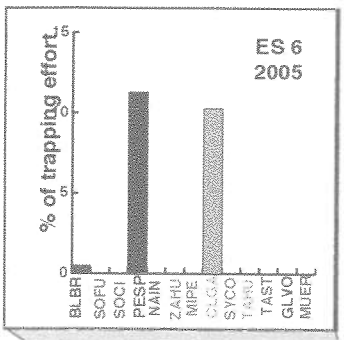
Sall, J., L. Creighton, and A. Lehman. 2005. JMP® Start Statistics - A guide to statistics and data analysis using JMP® and JMP IN® Software. 3 ed. SAS Institute and Brooks/Cole-Thomson Learning, Belmont, CA. xvi+560 pp.

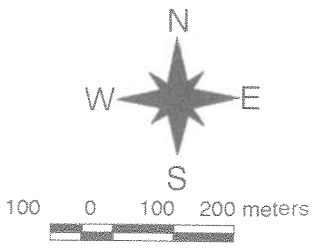
Shump, K. A., Jr., and A. U. Shump. 1982. Lasiurus cinereus. Mammalian Species, 185:1-5.

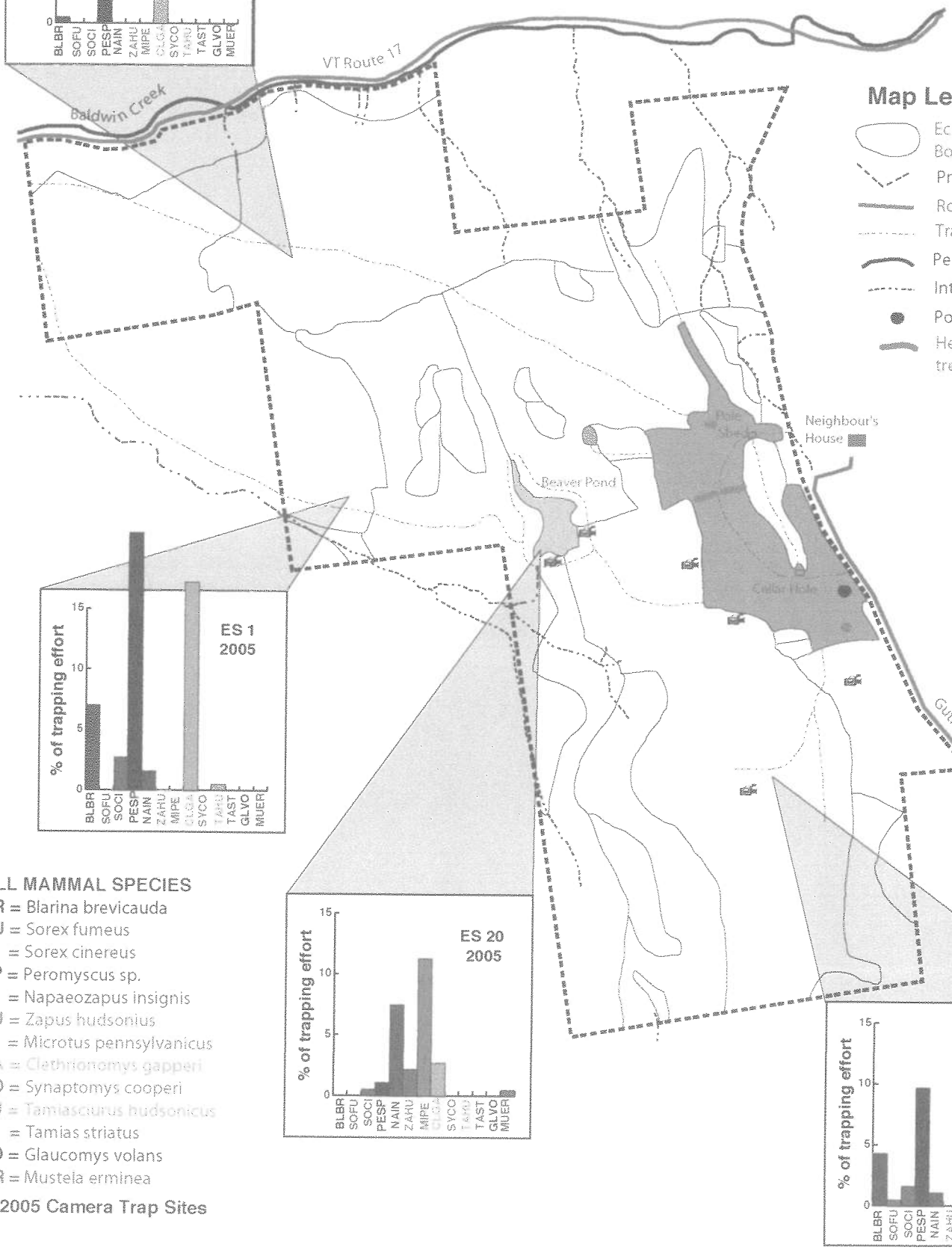
Weigl, P. D. 1978. Resource overlap, interspecific interaction and the distribution of the flying squirrels, *Glaucomys volans* and *G. sabrinus*. American Midland Naturalist, 100:83-96.

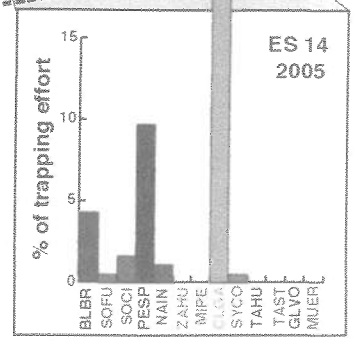
Whitaker, J. O., Jr., and W. J. Hamilton, Jr. 1998. Mammals of the Eastern United States. 3 ed. Cornell University Press, Ithaca, NY, 608 pp.

Figure 1--Map of Guthrie-Bancroft 2005 survey sites. Bar graphs show occurrence of small species as percent of trap effort (trap nights) Compare with data in Table 1.2.









SMALL MAMMAL SPECIES

BLBR = Blarina brevicauda
SOFU = Sorex fumeus
SOCI = Sorex cinereus
PESP = Peromyscus sp.
NAIN = Napaeozapus insignis
ZAHU = Zapus hudsonius
MIPE = Microtus pennsylvanicus
CLGA = Clethrionomys gapperi
SYCO = Synaptomys cooperi
TAHU = Tamiascurus hudsonicus
TAST = Tamias striatus
GLVO = Glaucomys volans
MUER = Mustela erminea

= 2005 Camera Trap Sites

Table 1.1-- 2005 Small mammal captures in 4 Ecosystems on Guthrie-Bancroft Farm, Lincoln, Vermont, compared to previous years' captures. 2005 data are in bold.

Ecosystem (ES) No.	1			6			14				20				All
ES Type:	well-drained mesic red oak hw forest			seepy terrain rich northern hw forest			poorly drained spruce-fir northern hw forest				alder swamp/sedge meadow edge of former beaver pond				TOTAL 2005
Year:	2001	2002	2005	2000	2002	2005	2000	2001	2002	2005	2000	2001	2002	2005	2005
No. of nights trapped	4	3	**3**	3	3	**3**	3	4	3	**3**	3	3	3	**3**	**12**
No. of Traps	32	56	**62**	52	58	**62**	52	30	59	**62**	20	28	24	**62**	**248**
Trapnights	128	168	**186**	156	174	**186**	156	120	177	**186**	60	84	72	**186**	**744**
Shrews															
Blarina brevicauda	5	3	**13**	8	8	**1**		12	2	**8**		6	5		**22**
Sorex fumeus							2			**1**					**1**
Sorex cinereus		3	**5**	1	5			1	2	**3**				**1**	**9**
Rodents															
Peromyscus sp.	44	19	**29**	31	25	**21**	12	19	19	**18**	2	13		**2**	**70**
Napeozapus insignis			**3**		2			3	1	**2**	1		1	**14**	**19**
Zapus hudsonius											3			**4**	**4**
Microtus pennsylvanicus								1			3	3	3	**21**	**21**
Clethrionomys gapperi	4	3	**32**	7	5	**20**	10	13	10	**38**		3		**5**	**95**
Synaptomys cooperi										**1**					**1**
Tamias striatus	1	1	**1**						1						**1**
Tamiasciurus hudsonicus												1			
Glaucomys volans					1										
Carnivores															
Mustela erminea													1	**1**	**1**
No. of Species	4	5	**6**	4	6	**3**	3	6	6	**7**	4	5	4	**7**	**11**
No. of Captures	54	29	**83**	47	46	**42**	24	49	35	**71**	9	26	10	**48**	**244**
Trap Success (%)	42.2	17.3	**44.6**	30.1	26.4	**22.6**	15.4	40.8	19.8	**38.2**	15.0	31.0	13.9	**25.8**	**32.8**

Table 1.2-- Diversity indices in 4 ecosystems calculated from proportions of each small mammal species per trap effort (trapnights) in each ecosystem. 2005 data are in bold.

Ecosystem (ES) No.	1			6			14				20				ALL
Year:	2001	2002	2005	2000	2002	2005	2000	2001	2002	2005	2000	2001	2002	2005	2005
Shrews															
Blarina brevicauda	0.039	0.018	**0.070**	0.051	0.046	**0.005**	0.000	0.100	0.011	**0.043**	0.000	0.071	0.069	**0.000**	**0.0296**
Sorex fumeus	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.013	0.000	0.000	**0.005**	0.000	0.000	0.000	**0.000**	**0.0013**
Sorex cinereus	0.000	0.018	**0.027**	0.006	0.029	**0.000**	0.000	0.008	0.011	**0.016**	0.000	0.000	0.000	**0.005**	**0.0121**
Rodents															
Peromyscus sp.	0.344	0.113	**0.156**	0.199	0.144	**0.113**	0.077	0.158	0.107	**0.097**	0.033	0.155	0.000	**0.011**	**0.0941**
Napeozapus insignis	0.000	0.000	**0.016**	0.000	0.011	**0.000**	0.000	0.025	0.006	**0.011**	0.017	0.000	0.014	**0.075**	**0.0255**
Zapus hudsonius	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000	0.000	**0.000**	0.050	0.000	0.000	**0.022**	**0.0054**
Microtus pennsylvanicus	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.008	0.000	**0.000**	0.050	0.036	0.042	**0.113**	**0.0282**
Clethrionomys gapperi	0.031	0.018	**0.172**	0.045	0.029	**0.108**	0.064	0.108	0.056	**0.204**	0.000	0.036	0.000	**0.027**	**0.1277**
Synaptomys cooperi	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000	0.000	**0.005**	0.000	0.000	0.000	**0.000**	**0.0013**
Tamias striatus	0.008	0.006	**0.005**	0.000	0.000	**0.000**	0.000	0.000	0.006	**0.000**	0.000	0.000	0.000	**0.000**	**0.0013**
Tamiasciurus hudsonicus	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000	0.000	**0.000**	0.000	0.012	0.000	**0.000**	**0.0000**
Glaucomys volans	0.000	0.000	**0.000**	0.000	0.006	**0.000**	0.000	0.000	0.000	**0.000**	0.000	0.000	0.000	**0.000**	**0.0000**
Carnivores															
Mustela erminea	0.000	0.000	**0.000**	0.000	0.000	**0.000**	0.000	0.000	0.000	**0.000**	0.000	0.000	0.014	**0.005**	**0.0013**
Number of Species	4	5	**6**	4	6	**3**	3	6	6	**7**	4	5	4	**7**	**11**
Simpson's Index D *	0.12	0.01	**0.06**	0.04	0.02	**0.02**	0.01	0.05	0.02	**0.05**	0.01	0.03	0.01	**0.02**	**0.03**
1-D **	0.88	0.99	**0.94**	0.96	0.98	**0.98**	0.99	0.95	0.98	**0.95**	0.99	0.97	0.99	**0.98**	**0.97**
Shannon-Wiener H' ***	0.92	0.71	**1.40**	0.93	1.02	**0.74**	0.62	1.35	0.81	**1.24**	0.69	1.11	0.63	**1.05**	**1.30**

* = Probability of picking two organisms that are the same species.

** = Probability of picking two organisms that are different species.

*** = Average degree of uncertainty in predicting to what species an individual chosen at random from a sample will belong.

Table 1.3-- Estimated small mammal biomass (grams) obtained per 100 trapnights in 4 ecosystem, based on average adult weight of species. 2005 data are in bold.

Ecosystem (ES) No.	1			6			14				20				
Year:	2001	2002	2005	2000	2002	2005	2000	2001	2002	2005	2000	2001	2002	2005	Indiv. Weight (g)*
Shrews															
Blarina brevicauda	63.7	29.1	**113.9**	83.6	74.9	**8.8**		163.0	18.4	**70.1**		116.4	113.2		16.3
Sorex fumeus							9.9			**4.1**					7.7
Sorex cinereus		6.4	**9.7**	2.3	10.3			3.0	4.1	**5.8**				**1.9**	3.6
Rodents															
Peromyscus sp.	687.5	226.2	**311.8**	397.4	287.4	**225.8**	153.8	316.7	214.7	**193.5**	66.7	309.5		**21.5**	20.0
Napeozapus insignis			**42.7**		30.5			66.3	15.0	**28.5**	44.2		36.8	**199.5**	26.5
Zapus hudsonius											107.5			**46.2**	21.5
Microtus pennsylvanicus								21.3			128.0	91.4	106.7	**289.0**	25.6
Clethrionomys gapperi	75.0	42.9	**412.9**	107.7	69.0	**258.1**	153.8	260.0	135.6	**490.3**	0.0	85.7		**64.5**	24.0
Synaptomys cooperi										**12.9**					24.0
Tamias striatus	43.0	32.7	**29.6**						31.1						55.0
Tamiasciurus hudsonicus												154.8			130.0
Glaucomys volans					23.6										41.0
Carnivores															
Mustela erminea													103.5	**40.1**	74.5
TOTAL Biomass/ES (g):	869.1	337.3	**920.6**	591.0	495.6	**492.6**	317.6	830.3	418.8	**805.3**	346.3	757.9	360.1	**662.7**	
Multi-Year Average:	709.04			526.43			592.99				531.77				

*= Average adult weight taken from Whitaker & Hamilton, 1998; actual weight or average of captured individuals used for *T. hudsonicus, G. volans, S. cooperi,* and *M. erminea.*

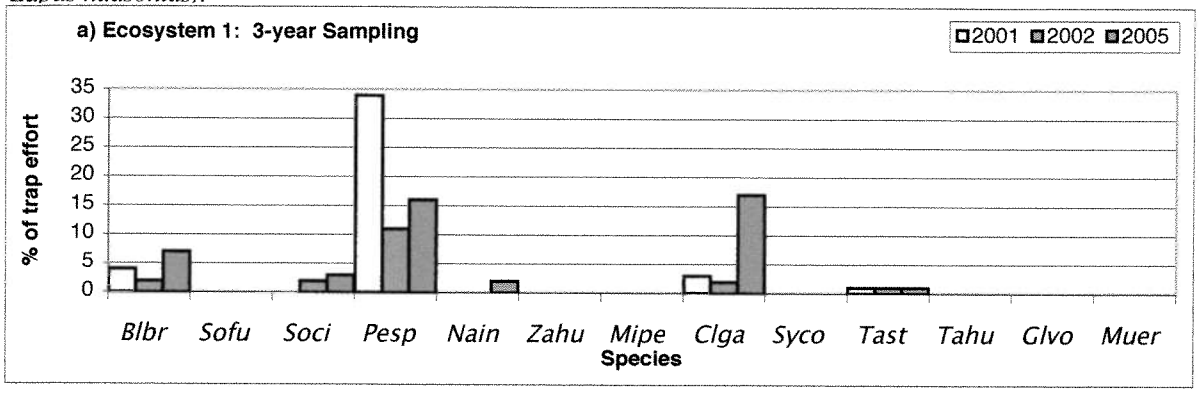
Table 2--Mean multi-annual (3 or 4 -year) relative abundances (RA) and their standard errors (SE) of each small mammal species and two diversity indices in the four ecosystems sampled, and analysis of variance. Asterisks (*) indicate statistically significant differences.

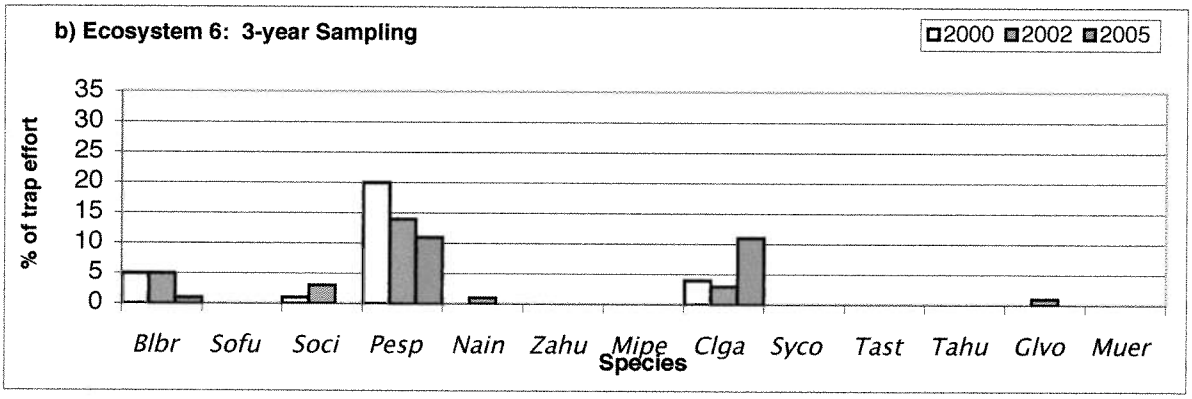
	ES 1 well-drained mesic red oak hardwood forest		ES 6 seepy terrain rich northern hardwood forest		ES 14 poorly drained spruce fir north. HW forest		ES 20 alder swamp/sedge meadow, edgeof former beaver pond		ANOVA		
	RA	SE	RA	SE	RA	SE	RA	SE	*F*	*P*	
Blarina brevicauda	0.042	0.015	0.034	0.014	0.039	0.022	0.035	0.02	0.651	0.691	
Sorex fumeus	0	0	0	0	0.005	0.003	0	0	1.586	0.279	
Sorex cinereus	0.015	0.008	0.012	0.009	0.009	0.003	0.001	0.001	1.213	0.399	
Peromyscus sp.	0.204	0.071	0.152	0.025	0.11	0.017	0.05	0.071	9.0882	0.005	*
Napaeozapus insignis	0.005	0.005	0.004	0.004	0.01	0.005	0.026	0.017	0.9709	0.506	
Zapus hudsonius	0	0	0	0	0	0	0.018	0.012	1.5961	0.277	
Microtus pennsylvanicus	0	0	0	0	0.002	0.002	0.06	0.018	4.3152	0.038	*
Clethrionomys gapperi	0.074	0.049	0.06	0.024	0.108	0.034	0.016	0.009	5.5511	0.02	*
Synaptomys cooperi	0	0	0	0	0.013	0.013	0	0	0.803	0.598	
Tamias striatus	0.006	7E-04	0	0	0.001	0.001	0	0	5.0237	0.026	*
Tamiasciurus hudsonicus	0	0	0	0	0	0	0.003	0.03	1.0556	0.465	
Glaucomys volans	0	0	0.002	0.002	0	0	0	0	1.0556	0.465	
Mustela erminea	0	0	0	0	0	0	0.005	0.003	1.3066	0.364	
Simpson's 1-D	0.935	0.031	0.969	0.007	0.968	0.011	0.984	0.006	3.232	0.075	
Shannon-Wiener H'	1.011	0.204	0.897	0.081	1.004	0.173	0.87	0.121	1.219	0.396	

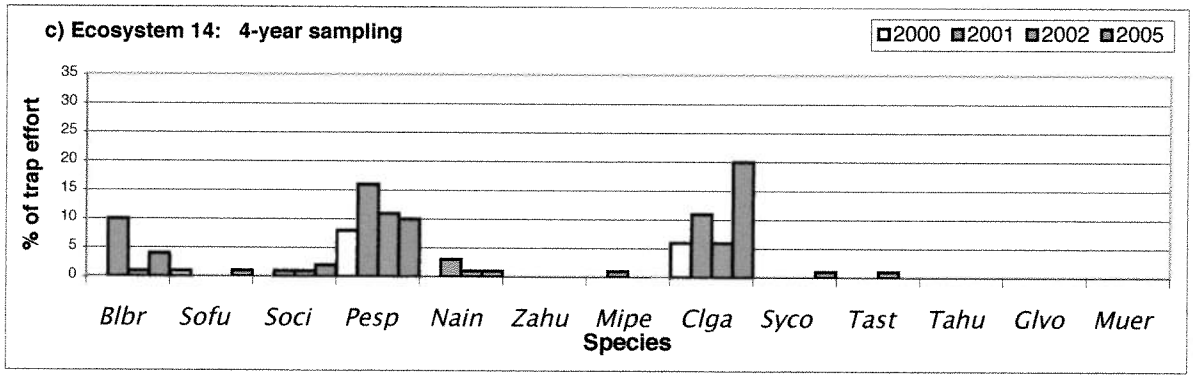
Table 3--Correlation matrix with r^2 values of simple correlations using means of 2-year habitat and 3 or 4-year small mammal data with at least 8 data points in four ecosystem on the Guthrie-Bancroft land. Bold-faced values indicate high positive or negative correlations.

	Blbr	*Soci*	*Pesp*	*Clga*	*Nain*	Canopy Cover	Leaf	Herbs	Grass	Rock
Blarina brevicauda		0.050	0.109	0.092	-0.012	-0.038	0.003	0.051	-0.091	-0.564
Sorex cinereus			0.008	0.082	0.002	0.110	0.410	-0.406	-0.273	-0.032
Peromyscus sp.				-0.016	-0.208	0.396	0.916	-0.872	-0.729	-0.030
Clethrionomys gapperi					-0.010	0.723	0.061	0.000	-0.149	-0.456
Napaeozapus insignis						-0.005	-0.502	0.229	0.818	0.455
Canopy Cover							0.352	-0.434	-0.149	0.024
Leaf								-0.859	-0.826	-0.056
Herb									0.525	-0.008
Grass										0.346
Rock										

Figure 2--Distribution of Small Mammals in the Guthrie-Bancroft Ecosystems sampled in 2000, 2001, 2002, and 2005. Bar graphs express percent of trapping effort in each ecosystem (Species accronyms: *Blbr = Blarina brevicauda, Clga = Clethrionomys gapperi; Glvo = Glaucomys volans; Mipe = Microtus pennsylvanicus; Muer = Mustela ermineaNain = Napeozapus insignis; Pesp = Peromyscus sp.; Sofu = Sorex fumeus; Soci = Sorex cinereus; Syco = Synaptomys cooperi; Tast = Tamias striatus; Tahu = Tamiasciurus hudsonicus; Zahu = Zapus hudsonius).*







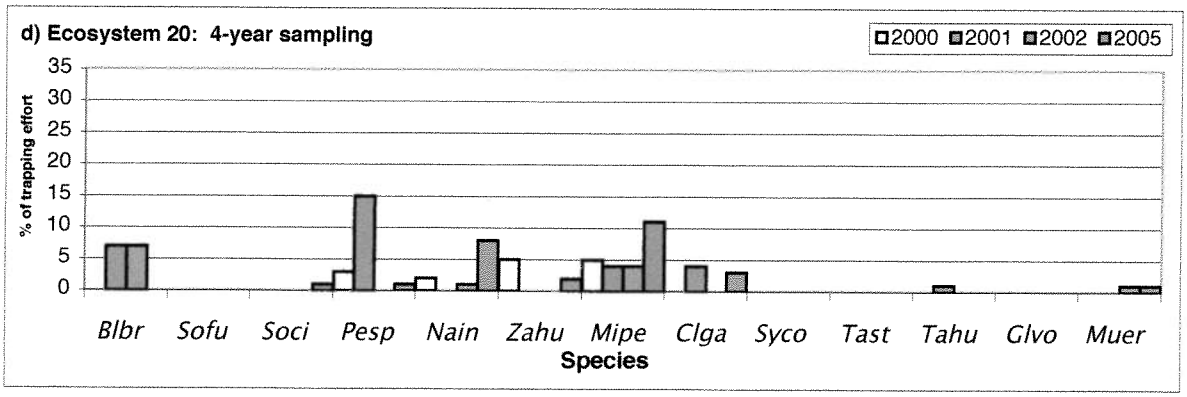
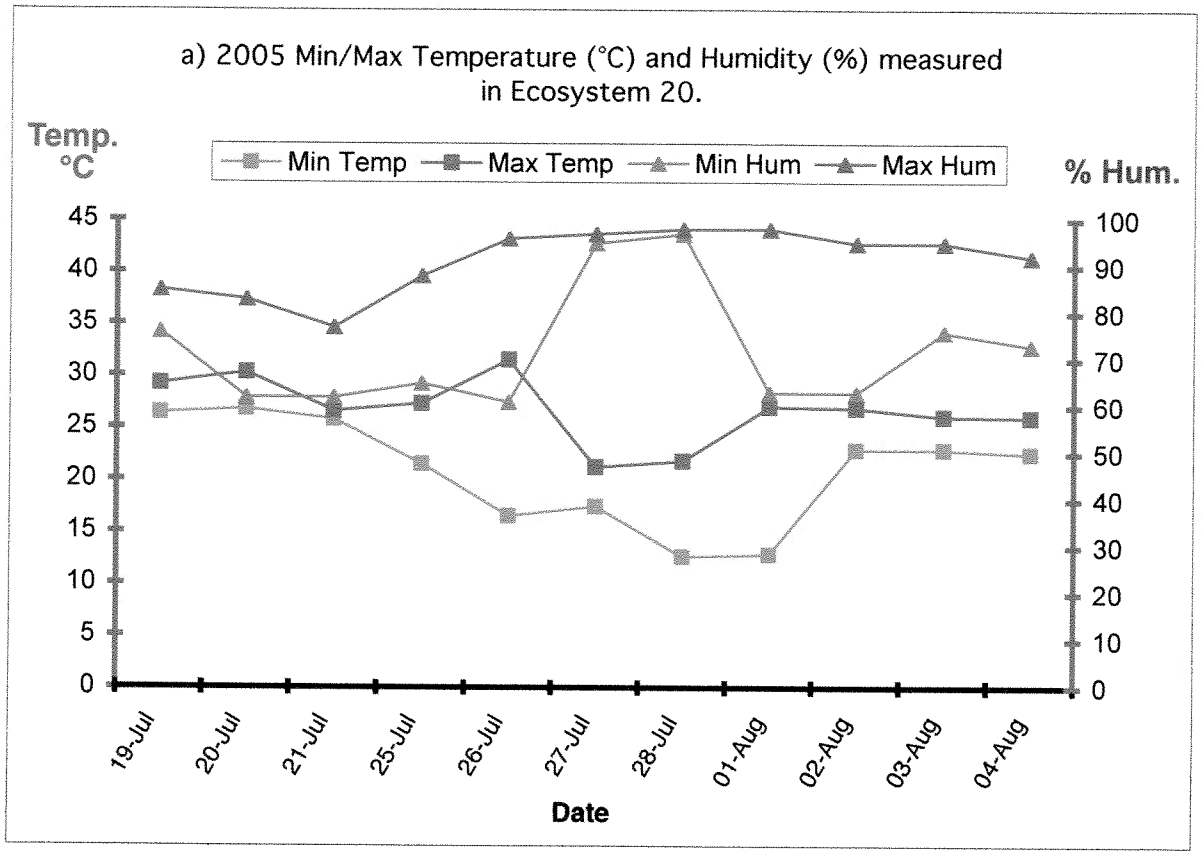


Figure 3--Meteorological Data recorded in Ecosystem 20 from 19 July to 4 August 2005



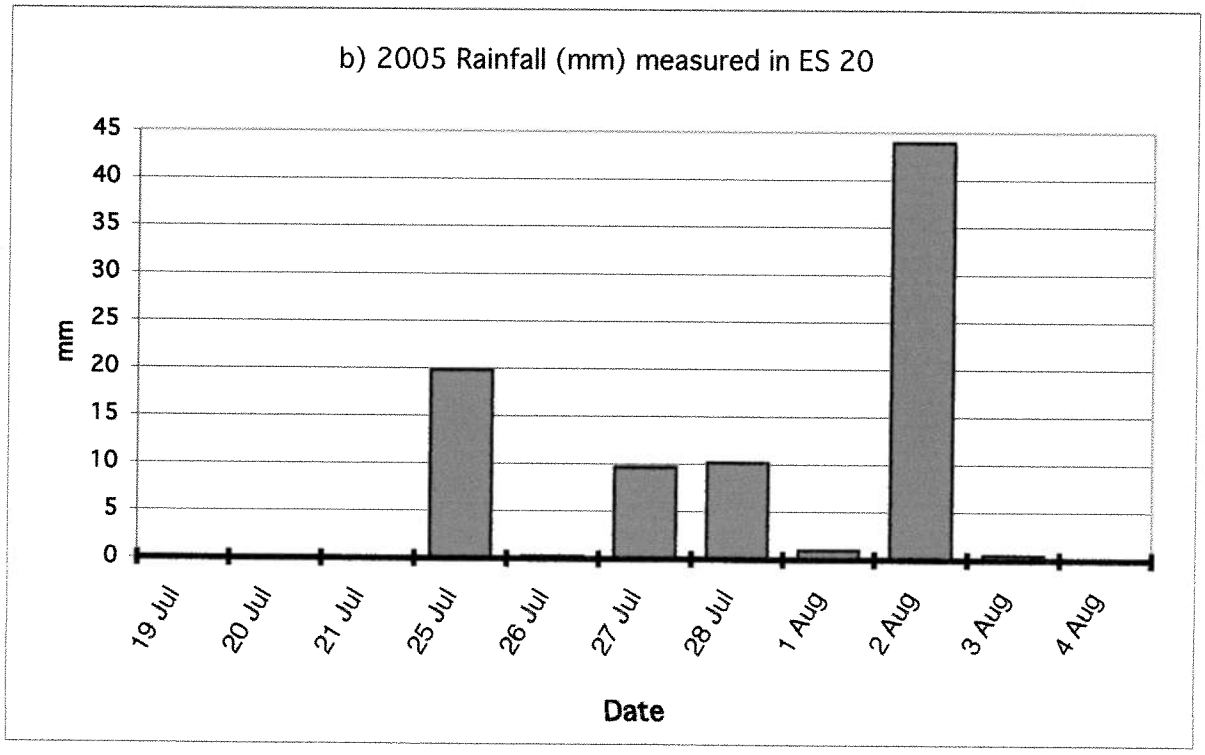


Figure 4-- 2005 Microhabitat Data from trap sites summarized by Ecosystem.

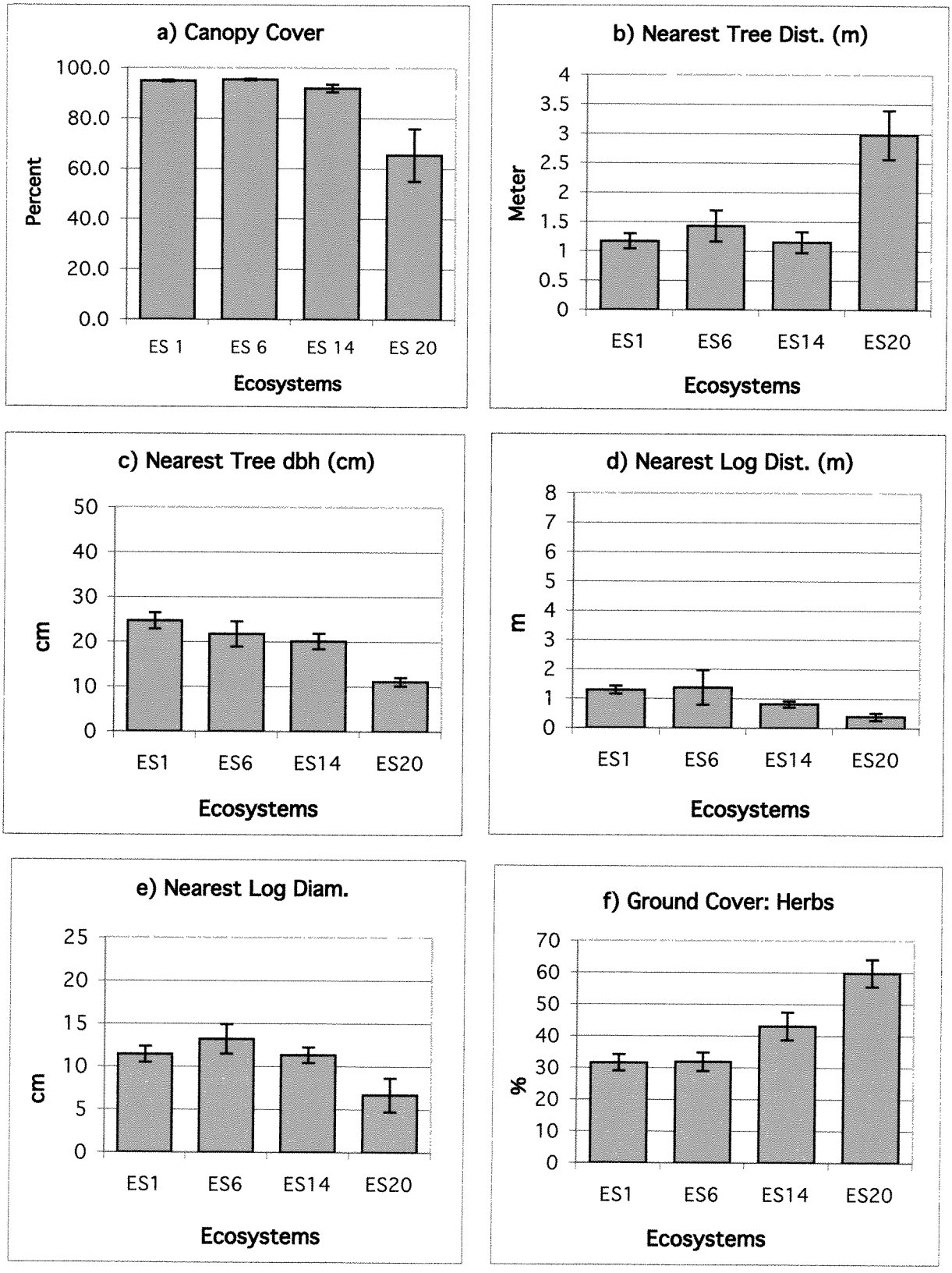
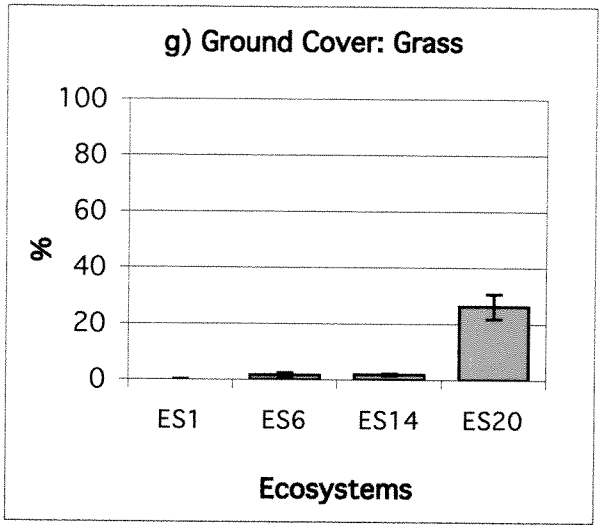
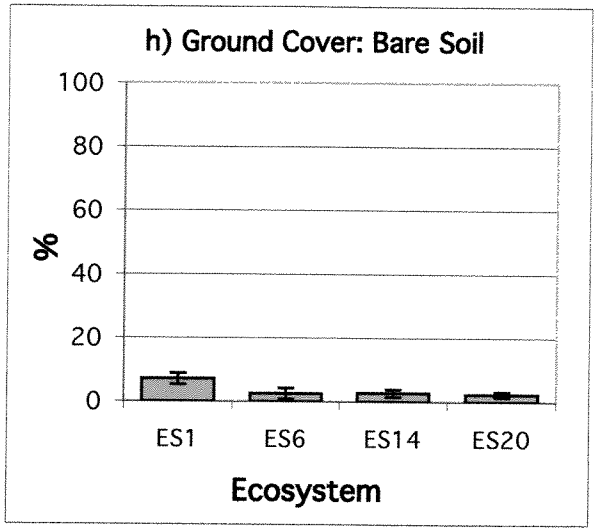
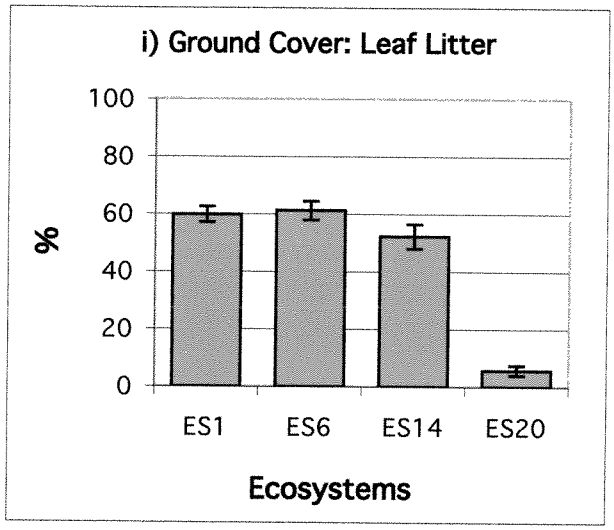


Figure 4 contd.--2005 Microhabitat Data summarized by Ecosystem







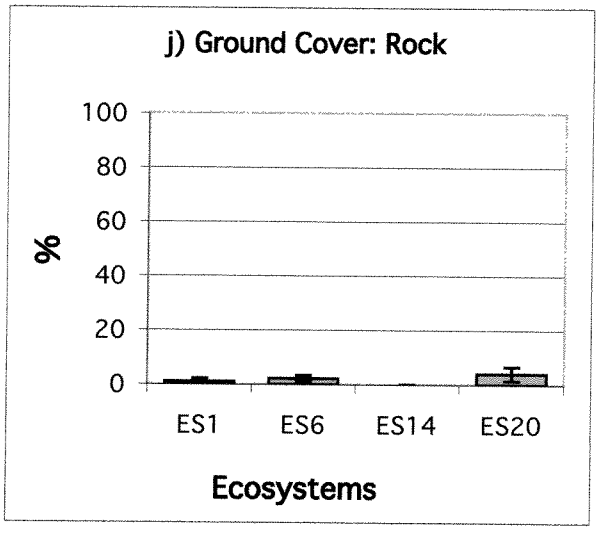


Figure 5-- 2005 Microhabitat Data from trap sites summarized by Small Mammal Species. Species abbreviations and sample sizes are: *Blbr* = *Blarina brevicauda* (n=22), *Clga* = *Clethrionomys gapperi* (n=19), *Mipe* = *Microtus pennsylvanicus* (n=3), *Muer* = *Mustela erminea* (n=1), *Nain* = *Napaeozapus insignis* (n=7), *Pesp* = *Peromyscus* sp. (n=88); *Soci* = *Sorex cinereus* (n=9), *Sofu* = *Sorex fumeus* (n=1), *Syco* = *Synaptomys cooperi (n=1)* ; and *Tast* = *Tamias striatus* (n=1), *Zahu* = *Zapus hudsonicus* (n=1).

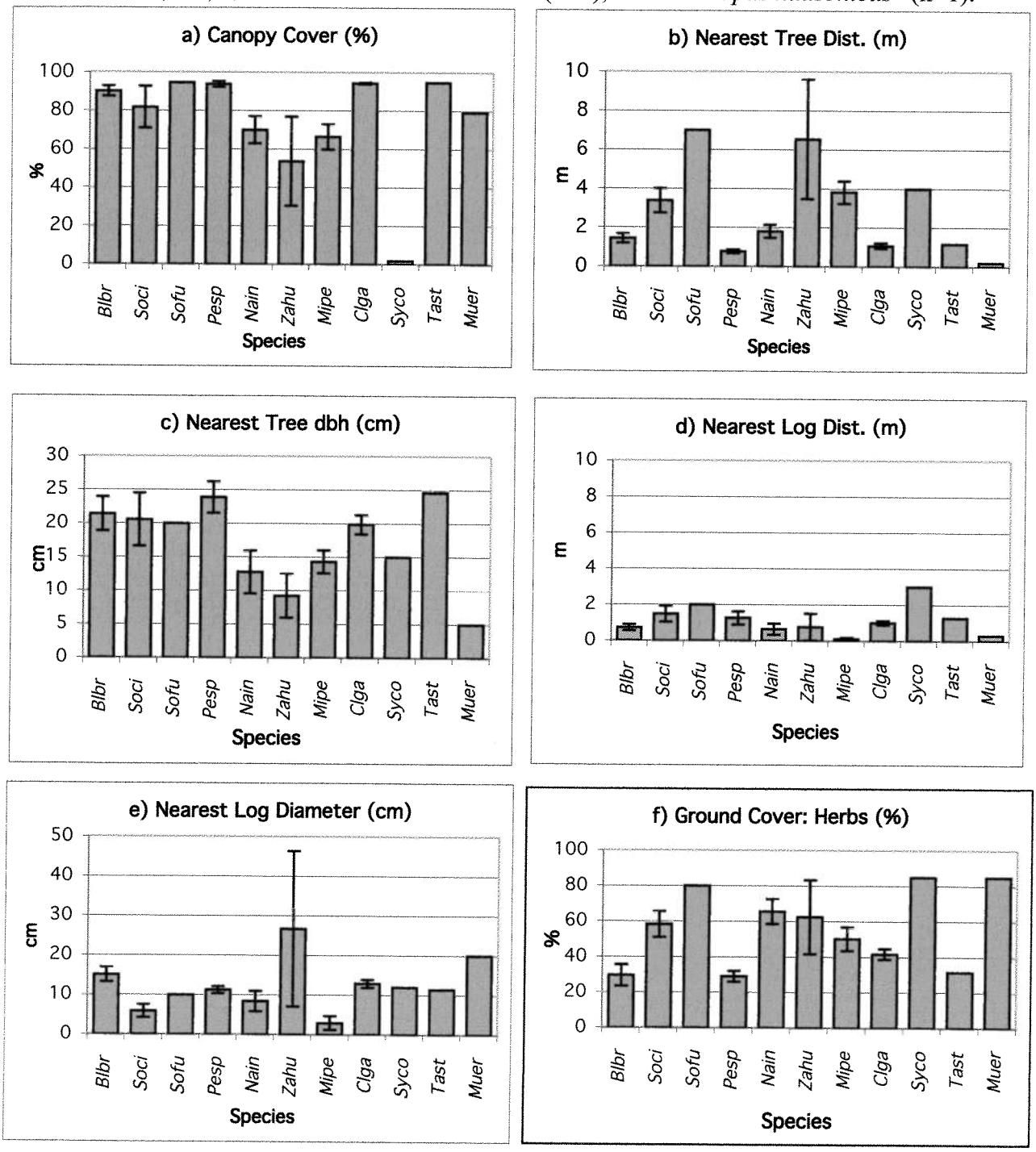
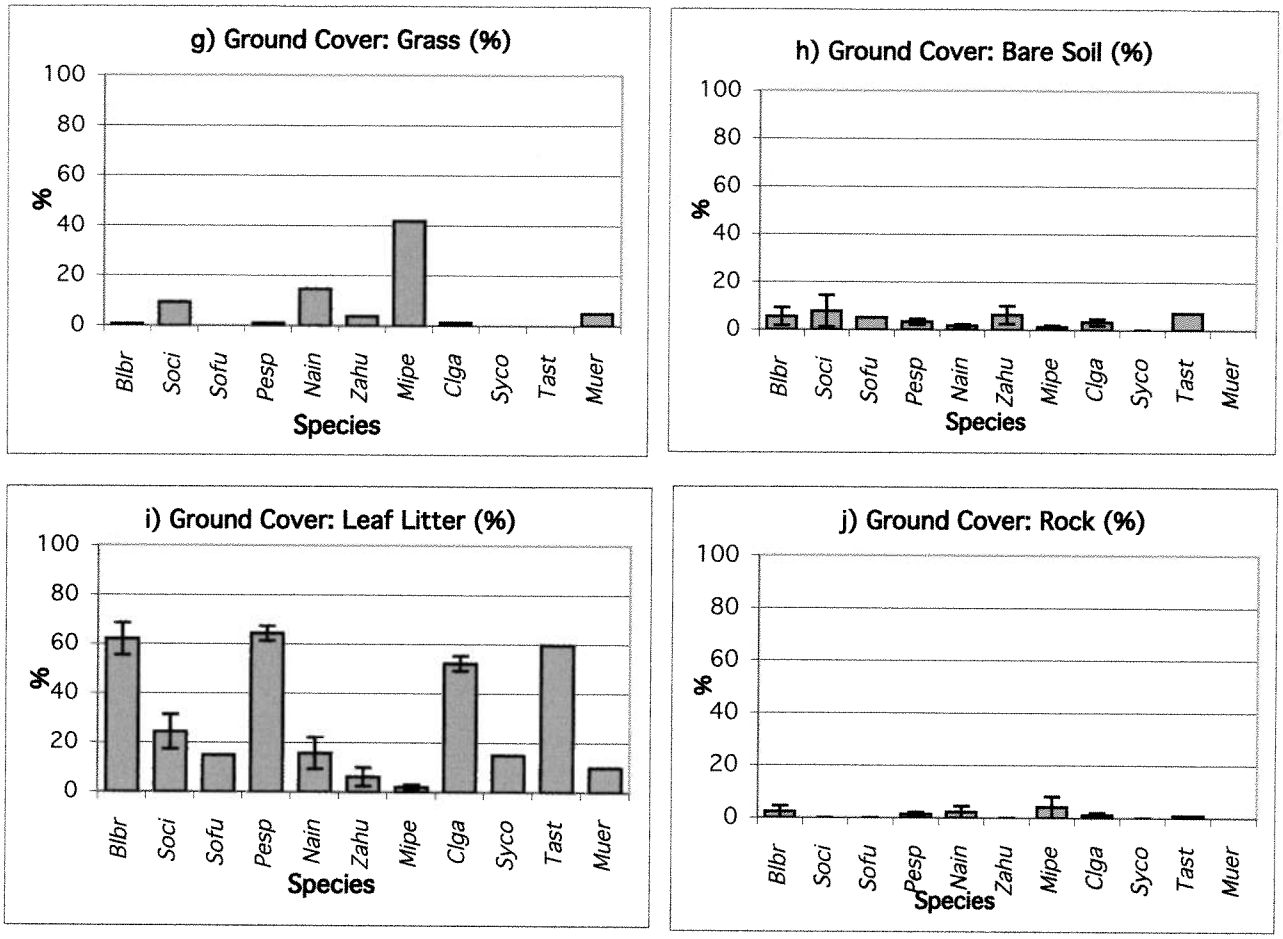


Figure 5-- 2005 Microhabitat Data summarized by Small Mammal Species.



Appendix II

Overview: Small mammal trap captures on the Guthrie-Bancroft parcel, Colby Hill, Lincoln, Vermont 2000, 2001, 2002 and 2005. Numbers reflect captures rather than separate individuals because they include some recaptured individuals.

Ecosystem (ES) No.	**1** well-drained mesic red oak hw forest			**2** well-drained northern hw forest w/ white pine	**6** seepy terrain rich northern hw forest			**7** well-drained transitio n hw forest	**8** steeply sloping hem-lock forest	**9** ±exc. drained north. hw forest w/ acid knoll outcrop.	**10** small stream riparian, yellow birch-sugar maple-white ash forest	**12** mod. well-drained yellow birch north. hw forest	**14** poorly drained spruce-fir northern hw forest				**18** poorly drained red maple-black ash swamp	**20** alder swamp/sedge meadow edge of former beaver pond				**22** un-main-tained old-fields	**25** Along small intermittent cold-mountain stream			**26** along perma-nent cold moun-tain stream	**Totals**
ES Type:																												
Year:	**2001**	**2002**	**2005**	**2000**	**2000**	**2002**	**2005**	**2000**	**2000**	**2001**	**2002**	**2000**	**2000**	**2001**	**2002**	**2005**	**2001**	**2000**	**2001**	**2002**	**2005**	**2000**	**2000**	**2001**	**2002**	**2000**	-
No. of nights trapped	4	3	**3**	3	3	3	**3**	3	3	4	3	3	3	4	3	**3**	4	3	3	3	**3**	3	3	4	3	3	**83**
No. of Traps	32	56	**62**	26	52	58	**62**	20	32	28	26	52	52	30	59	**62**	32	20	28	24	**62**	20	26	30	58	20	**1029**
Trapnights	128	168	**186**	78	156	174	**186**	60	96	112	78	156	156	120	177	**186**	128	60	84	72	**186**	60	78	120	174	60	**3239**
Shrews:																											
Blarina brevicauda	5	3	**13**	2	8	8	**1**	2		4		4		12	2	**8**	4		6	5		10	7	6	8		**118**
Sorex fumeus								1		1			2			**1**											**5**
Sorex cinereus		3	**5**		1	5				1				1	2	**3**					**1**						**22**
Rodents:																											
Peromyscus sp.	44	19	**29**	12	31	25	**21**	8	4	20	24	28	12	19	19	**18**	16	2	13		**2**	1	1	13	2	2	**385**
Napeozapus insignis			**3**	2		2		1	2		3			3	1	**2**	2	1		1	**14**	1	6	8		2	**54**
Zapus hudsonius																		3			**4**						**7**
Microtus pennsylvanicus														1		**1**	2	3	3	3	**21**	3	4	1			**42**
Clethrionomys gapperi	4	3	**32**	1	7	5	**20**		5	18	1	5	10	13	10	**38**	17		3		**5**			6		3	**206**
Synaptomys cooperi																**1**											**1**
Tamias striatus	1	1	**1**	3						3					1										1		**11**
Tamiasciurus hudsonicus																			1								**1**
Glaucomys volans						1																					**1**
Carnivores:																											
Mustela erminea																				1	**1**						**2**
No. of Species	4	5	**5**	5	4	6	**3**	4	3	6	3	3	3	6	6	**7**	5	4	5	4	**7**	4	4	5	3	3	**12**
No. of Captures	54	29	**83**	20	47	46	**42**	12	11	47	28	37	24	49	35	**72**	41	9	26	10	**48**	15	18	34	11	7	**855**
Trap Success	0.42	0.17	**0.45**	0.26	0.30	0.26	**0.23**	0.20	0.11	0.42	0.36	0.24	0.15	0.41	0.20	**0.39**	0.32	0.15	0.31	0.14	**0.26**	0.25	0.23	0.28	0.06	0.12	**0.26**

Appendix I

Ecosystem descriptions and summary comments of microhabitat and small mammal findings for sites sampled in 2005

Ecosystem descriptions are based on M. Lapin (2000) with the nearest equivalent natural community from Thompson and Sorenson (2000) in parentheses.

ES 1 = Well-drained, steeply sloping, fine sandy loam spodosol beech-maple-red oak-sweet birch forest (*mesic red oak hardwood forest*). - This habitat had second highest leaf litter ground cover (59.8%) after ES 6 this year (Fig. 4i) but it also had more than twice as much bare soil ground cover (7.05%; Fig. 4h) than the other three habitats sampled this year. Capture success was a record 45% in 2005. Density of red-backed voles (*Clethrionomys gapperi*) increased from 4 and 3 captures in 2001 and 2002, respectively, to 32 captures. *Blarina brevicauda* was also more common with 13 captures over 5 and 3 captures in the two previous sampling years. *Napaeozapus insignis* was added to the species list of this ecosystem.

ES 6 = Seepy terrain rich, moderately well-drained, steeply to very steeply sloping, seepy loam over fine sandy loam spodosol, Northern Hardwood Forest *(Rich Northern Hardwood forest)*. ES 6 had the highest leaf litter density (61.2%; Fig. 4i), greatest average fallen log diameter (13.2 cm; Fig. 4e) but also farthest average nearest log distance (1.4 m; Fig. 4d). Very similar ratios of small mammal species as in 2000 (Fig. 2 b). Only three species were caught here this year with *Clethrionomys gapperi* being almost equally abundant (n=20) as *Peromyscus* sp. (n=21).

ES 14 = Somewhat poorly drained, gently sloping, stony silt loam to fine sandy loam inceptisol, red spruce-balsam fir-hemlock-yellow birch (*spruce-fir northern hardwood forest)*. - Second highest herbaceous ground cover after ES 20, esp. in tree fall gaps and waterlogged fern area. 8 small mammal species were recorded this year with the Southern bog lemming (*Synaptomys cooperi)* being the new surprise find. AS in ES 1 and ES 6 red -backed voles were greatly increased this year.

ES 20 = Very poorly drained, level, muck over stony sandy loam inceptisol, alder-willow shrub swamp/sedge meadow (*Alder swamp/sedge meadow complex*). - This edge of a former "beaver pond" with abundant touch-me-not (*Impatiens*), and goldenrod (*Solidago* sp.) had the highest herbaceous cover (59.8%m Fig. 4f) and lowest canopy cover (65.4%, Fig. 4a) making this the most open habitat. A greatly increased number of meadow voles (*Microtus pennsylvanicus*) was sampled this year (n=21). The second capture of an Ermine or Short-tailed weasel (*Mustela erminea)* suggests that this is a regular predator in this area of dense herbaceous cover and pond remnants. The meadow jumping mouse *(Zapus hudsonius)* had last been recorded in ES 20 in 2000 (Fig. 2d).