Small Mammals of the Guthrie-Bancroft Farm - Year 8

Colby Hill Ecological Project, Lincoln and Bristol, Vermont

2012 Final Report

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Summary

From 11-26 July 2012, small mammals were again sampled in ecosystems 1, 6, 14 and 20 on the Guthrie-Bancroft parcel on Colby Hill, Lincoln. A total of 236 captures were made this year, verifying 10 species of small mammals. Overall trap success in 2012 was 24.9%. This year a second specimen of the rare Southern bog lemming (*Synaptomys cooperi*) was caught in the same ecosystem (ES 14) and microhabitat as in 2005.

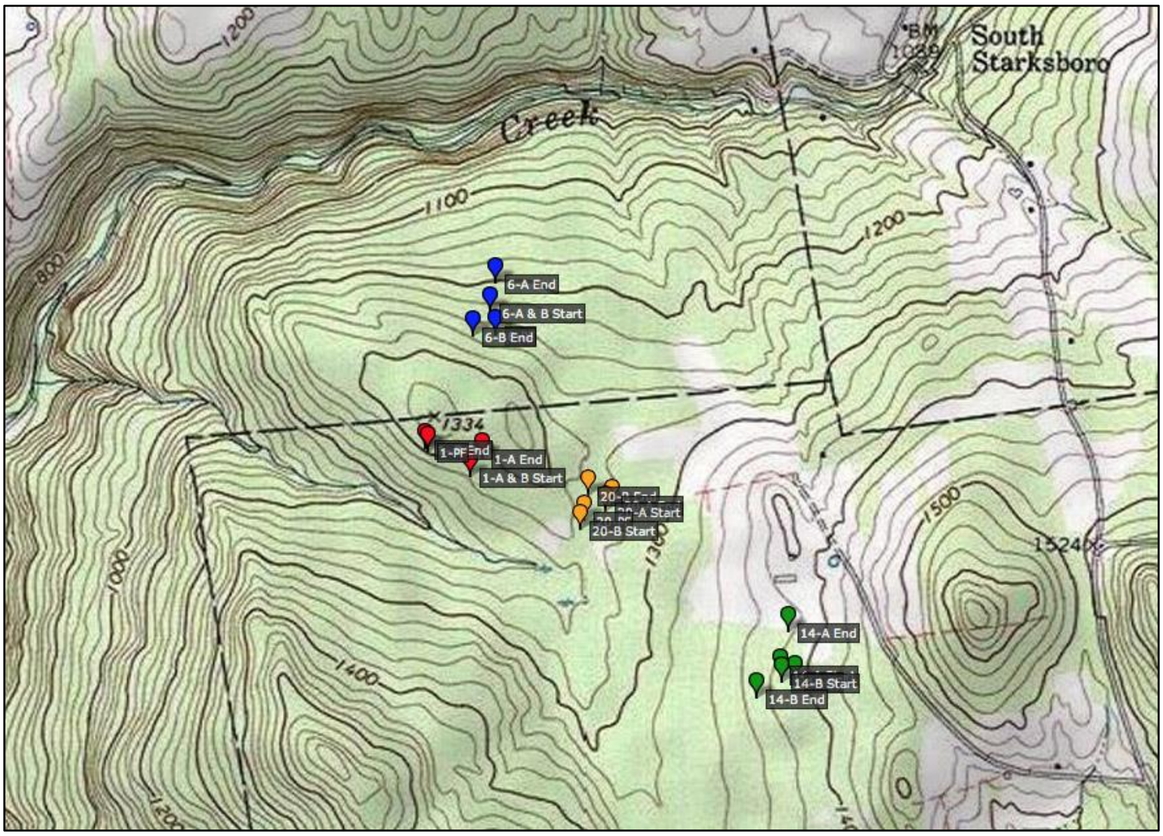

Fig.1: Map of Colby Hill with 2012 GPS-determined sampling localities. Green = ES 14, Red= ES1, orange = ES 20, Blue = ES6.

Introduction

In 2012 small mammal sampling was repeated on Colby Hill in the eighth year for Ecosystems (ES) 14 and 20 and in the seventh year for ES 1 and 6. No meteorological data were collected on the study site in 2012. The study period 11-26 July 2012 was comparatively drier than the record rain and flood year 2012. In this report we attempt to look at summaries and averages or weighted averages of the data and emerging population patterns from the first 8 (7) years of sampling in anticipation of a peer-reviewed publication of this long-term monitoring project.

Materials and Methods

In 2012 the number of traps used in each habitat was again increased to 79 traps (Shermans and pitfalls) compared to past years (see Appendix I). This year, two traplines of 17 or 18 stations with two Sherman live traps each were placed in each of the four sampled ecosystems (ES). The pitfall traps were increased to 7 in each ecosystem. As in previous years, bait was "old fashioned" oatmeal flavored with peanut butter. No weather station was employed this year but we are currently trying to obtain climate data for the town of Lincoln for the sampling periods since 2000. Individuals of *Peromyscus* were marked with a rodent ear punch (National Band & Tag Company, Newport, KY) to identify recaptures. Field procedures complied with standard recommended field methods and guidelines from the American Society of Mammalogists (Sikes et al. 2011, Wilson et al. 1996). As in 2011, several additional individuals of *Peromyscus* sp. were kept for molecular identification to species. These vouchers and all animals that died in Sherman or pitfall traps are permanently preserved in the Zadock Thompson Natural History Collection (ZTNHC) of the University of Vermont. DNA was extracted from nine specimens collected in the summer of 2012 from the following localities at the Colby Hill, Guthrie-Bancroft Parcel: ES1 (n = 2), ES6 (n =1), ES14 (n =4), and ES20 (n =2). The 5' end of the mitochondrial cytochrome b gene was amplified with the polymerase chain reaction (PCR) method and sequenced. Readable sequences were obtained for 8 extractions and the resulting sequences were aligned against reference sequences of *Peromyscus leucopus* (DQ000483) and *Peromyscus maniculatus* (JF489123) taken from GenBank. The alignments for the sequences are shown in Appendix VI.

Results

<u>2012 Data Overview</u>

Table 1 provides an overview of the 2012 captures, trap nights and trap success. Trap success in the different ecosystems in 2012 ranged from 20.3% in ES 14 to 30.8% in ES 6 (Average: 24.9%; Table 1). No additional species were verified from the Guthrie-Bancroft parcel in 2012, but a second individual of the Southern bog lemming (*Synaptomys cooperi*) was captured in the same ecosystem, microhabitat and trapping method as in 2005 (ES 14; pitfall traps in fern area). This year 236 captures (including recaptures) were made from 10 species of small mammals with a trap effort of 948 trapnights. Trap effort was slightly increased from previous years. For comparison of totals from all years see Appendix I.

Ecosystem (ES) No.	1	6	14	20	Totals 2012
ES Definition:	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	
No. of nights trapped	3	3	3	3	12
No. of Traps	79	79	79	79	316
Trapnights	237	237	237	237	948
Shrews & Moles					
Blarina brevicauda	5	7	2	6	20
Sorex fumeus	2		1	5	8
Sorex cinereus				1	1
Sorex palustris					0
Parascalops breweri					0
Rodents					
Peromyscus sp.	43	49	21	9	122
Napaeozapus insignis	4	1	5	8	18
Zapus hudsonius					0
Microtus pennsylvanicus				18	18
Microtus pinetorum					0
Myodes gapperi	8	12	17	2	39
Synaptomys cooperi			**1**		**1**
Tamias striatus	2	3	1		6
Tamiasciurus hudsonicus					0
Glaucomys volans					0
*Glaucomys sabrinus**					0
Carnivores					
Mustela sp.		1		2	3
No. of Species	6	6	7	8	10
No. of Captures	64	73	48	51	236
Trap Success (%)	27.0	30.8	20.3	21.5	24.9

*Northern Flying Squirrel only captured once in a bat net near ES 20 in 2002, not on the traplines

Table 1: 2012 small mammal captures, ecosystems sampled, and trap success, listing all species known from Guthrie-Bancroft parcel so far. The bog lemming, re-verified for the second time this year, is highlighted in **bold**.

<u>Comments on species captured in 2012</u>

Shrews (Family Sciuridae)

***Blarina brevicauda* (Short-tailed Shrew)**

The Short-tailed shrew was the third most abundant species in 2012, with 20 individuals captured (28 in 2011). Figure 2 shows the occurrence of this species in all four habitats since the beginning of the study in 2000. The species is most abundant in ES 6 (seepy terrain rich northern hardwood forest) and least abundant in ES 20 (alder swamp sedge meadow). Weighted averages of the weight for all individuals measured since 2000 is 17.5 g. Weighted averages for the three dominant groundcover types measured around trap sites are: 53.1% leaf litter, 35.2% herbs, and 14.7% woody debris (Appendix V).

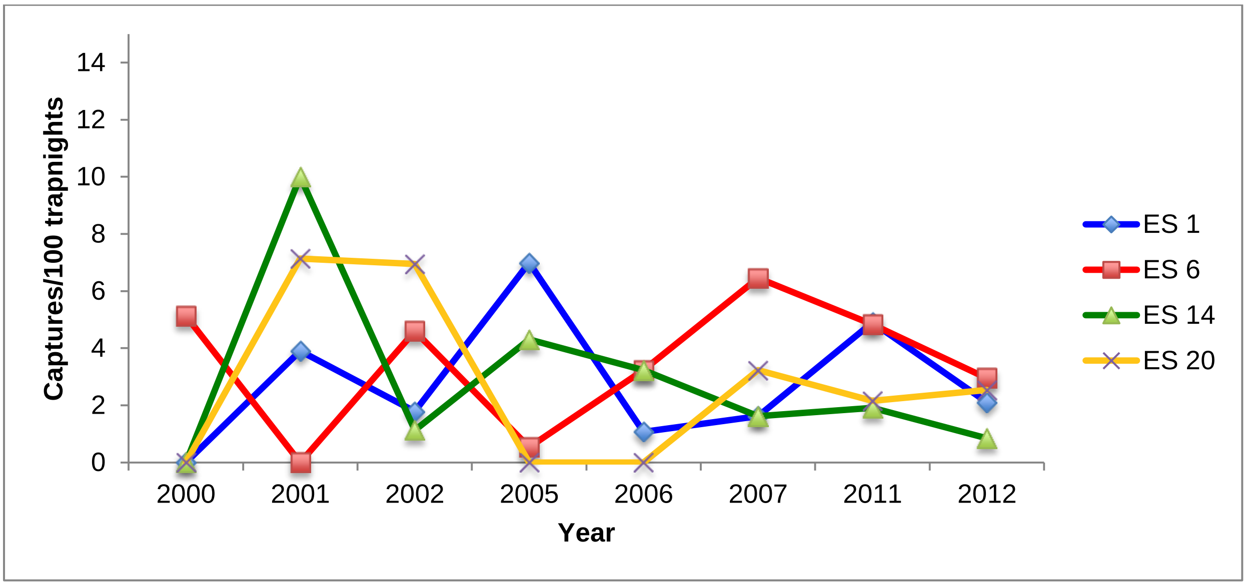

Fig. 2: *Blarina brevicauda* captures per 100 trap nights over the 8 (7) years in each of the four ecosystems. This species is most common in ES 6 (52 captures to date; compare Table 3).

***Sorex cinereus* (Masked Shrew)**

With only one individual caught in a pitfall trap in ES 20, numbers of this tiny shrew were as low this year as they were in 2000 and 2001 (see Appendix I). Weighted averages for 46 individuals caught in 7 years of sampling were: 4.2 g for individual weight, 75.7% canopy cover and dominant groundcover types of 53.2% herbs, 30.3% leaf litter and 10.3% grass cover (see Appendix V).

***Sorex fumeus* (Smoky shrew)**

The smoky shrew was not caught in 2011 but "reappeared" in 2012 with eight individuals, two in ES 1, 1 in ES 14 and 5 in ES 20 (see Table 1). This is the first year five individuals were caught in ES 20 (alder swamp/sedge meadow, edge of former beaver pond). Weighted average for 13 individuals from 4 years of sampling this species were 7.2 g (range 6.9 - 7.8g) for individual weight and 85.4% canopy cover. Dominant groundcover types were 49.2% herbs, 23.8% leaf litter and 22.7% grass cover (see Appendix V). Average weight is slightly lower than the 7.6 g published by Owen (1984) for 30 individuals (range: 6.5 - 9.9 g). Based on data from central New York state, Jameson (1949:231) suggested that "[t]here may be some interspecific intolerance between *fumeus* and *cinereus*." Our long-term population data for both species appear to support this suggestion (Fig. 3).

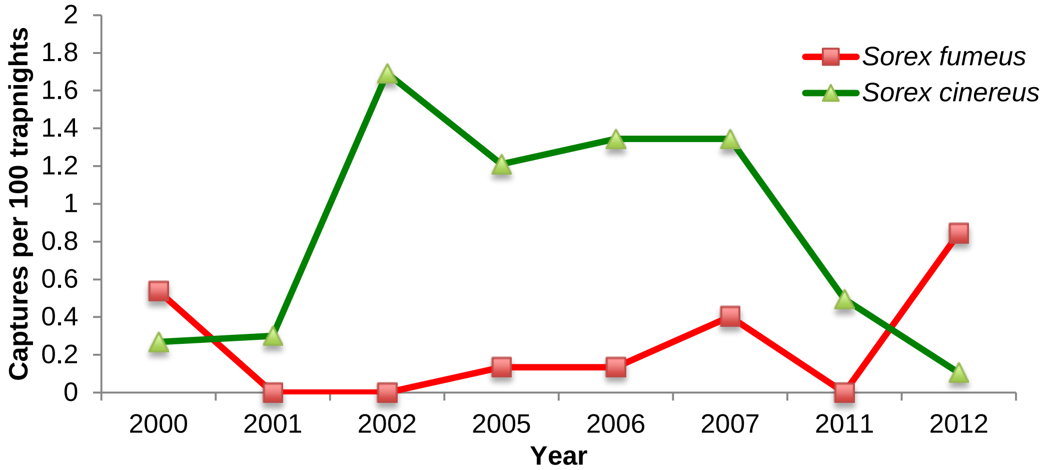

Fig. 3: Comparison of captures per 100 trapnights in all four ecosystems for *Sorex cinereus* and *S. fumeus* between 2000 and 2012.

Rodents

***Napaeozapus insignis* (Woodland Jumping Mouse)**

Eighteen individuals of this forest species were recorded in 2012, the most (8) in ES 20 and the fewest (1) in ES 6. This pattern is also reflected in the 8 (7) year ecosystem totals. Close to half (49) of all 101 *N. insignis* caught in the four ecosystems included in the longterm study so far were caught in ES 20 (see Fig. 3 and Table 3). Selected weighted averages for 111 individuals from all ecosystems and eight years of sampling are: 20.9 g for individual weight, 77.0% canopy cover and dominant groundcover types of 41.6% herbs, 38.7% leaf litter and 7.1% grass cover (see Appendix V). Fluctuations of *N. insignis* population levels in the fours ecosystems expressed as captures per 100 trapnights are shown in Fig. 4.

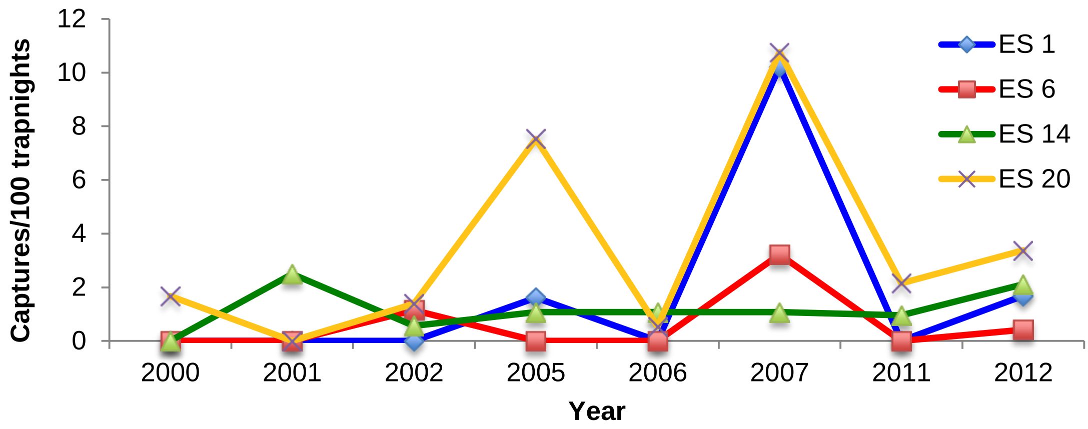

Fig. 4: Captures per 100 trapnights of *Napaeozapus insignis* over the 8(7) years in each of the four ecosystems.

***Microtus pennsylvanicus* (Meadow Vole)**

18 individuals of the meadow vole were captured in 2012, the highest number since 2005 (23 individuals).

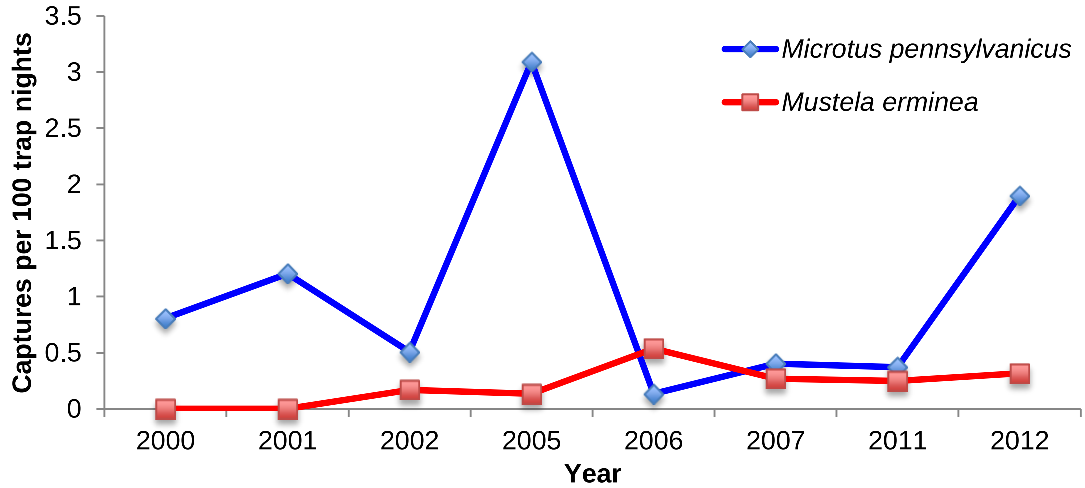

Fig. 5: Captures per 100 trapnights for the vole *Microtus pennsylvanicu*s (8 years of data) and its major predator, *Mustela erminea (*6 years of data) in ES 20.

Within the four ecosystems selected for the long-term study all but one meadow vole caught in ES 14, occurred in ES 20 (App. II). Weighted averages for 57 individuals from all ecosystems and eight years of sampling were 29.0 g for individual weight, and 35.6% for canopy cover. Dominant groundcover types of 51.1% herbs, 40.2% grasses, and 2.9% leaf litter showing the preference of this species for dense undercover and more open canopy (see Appendix V). No strong predator-prey relationship is visible between meadow voles and weasels in ES 20 (Fig 5). Both species seem to prefer this open successional habitat over the other more forested areas. Our eight-year meadow vole data from ES 20 seem to confirm the 2-5 year cyclic population fluctuations observed in North American voles, including the meadow vole (Reich 1981, Ostfeld et al. 1993).

***Myodes gapperi* (Red-backed Vole)**

Thirty-nine individuals of *Myodes gapperi* were captured in 2012. Total captures for this species have been declining gradually since 2005 (95 individuals). As in previous years most 2012 captures (N=17) were made in ES 14. Weighted averages for 414 individuals from all ecosystems and eight years of sampling were: 18.4 g for individual weight, 85.3% for canopy cover and dominant groundcover types of 49.1% leaf litter, 34.7% herbs, and 5.7% bare soil (see Appendix V).

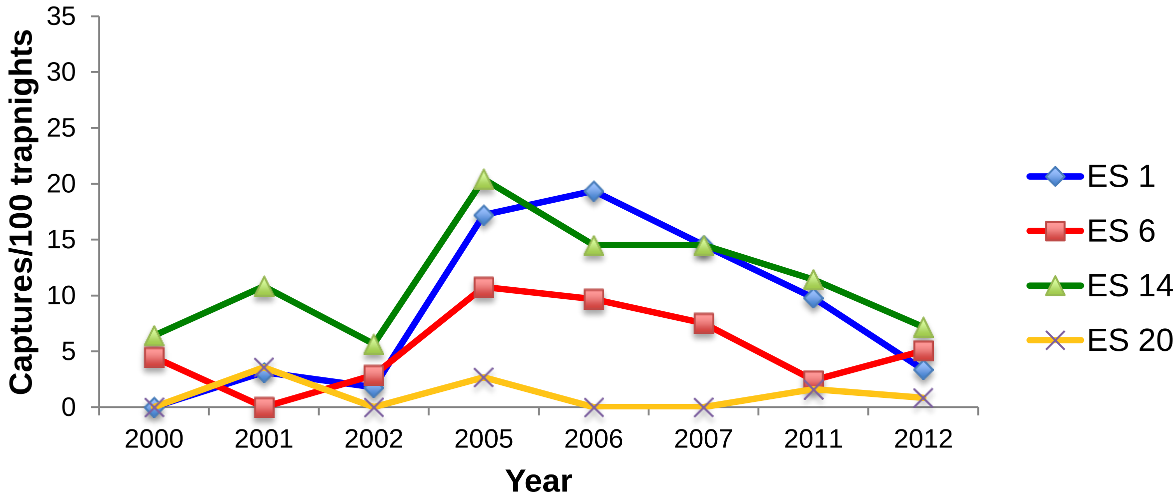

Fig. 6: Captures per 100 trap nights of *Myodes gapperi* over the 8(7) years in each of the four ecosystems.

The bare soil value is indicative of the fact that this species is often caught around overturned root balls with exposed soil, especially common in the poorly drained spruce-fir northern hardwood forest of ES 14 where 42.5% of all Red-backed voles (N=166) were captured in 8 years of sampling. A cyclic pattern is not as clear as in the meadow vole, rather, there appears to be a gradual decline in this species since 2005 (Fig. 6).

***Synaptomys cooperi* (Southern bog lemming)**

A second specimen of this rarely caught species was found in a waterlogged pitfall trap on 25 July 2012 in dense fern (40 % herbs) in Ecosystem 14, in the same fern area where the first specimen was captured on 3 August 2005. Since out last capture in 2005 six other bog lemmings were obtained from 3 localities in Orleans Co. northeastern Vermont and from Chittenden Co. (Kilpatrick and Benoit 2011).

***Tamias striatus* (Eastern Chipmunk)**

Six individuals of the Eastern chipmunk were captured this year, two in ES 1, three in ES 6 and 1 in ES 14. Weighted averages for 34 individuals from all ecosystems and eight years of sampling were: 75.5 g for individual weight, 87.4% for canopy cover and dominant groundcover types of 53.2% leaf litter, 28.2% herbs, and equal percentages of 4.85 % bare soil an grass cover (see Appendix V). Half (15) of the thirty individuals captured in the four ecosystems over the eight years of sampling were captured in ES 1 (well-drained, mesic red oak hardwood forest) indicating a clear preference for this habitat type.

***Peromyscus* sp. (White-footed and Deer Mouse)**

With 122 individuals caught in 2012, more *Peromyscus* sp. than in all previous years were caught, three more than in the peak year 2007 (N=119; compare Fig. 7). This is at least partially explained by the increased trapping effort in 2012. Weighted averages for 672 individuals from all ecosystems and eight years of sampling were: 17.9 g for individual weight, 97.8% canopy cover and dominant groundcover types of 23.4% herbs, 59.2% leaf litter and 11.7% woody debris (see Appendix V).

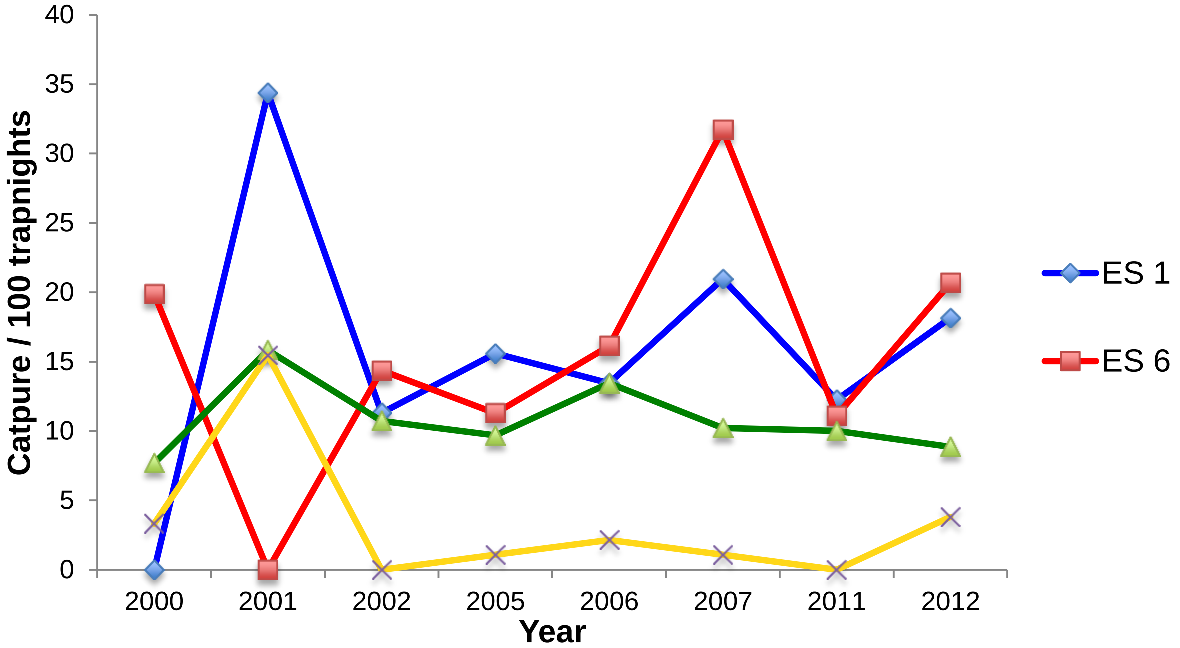

Fig. 7: *Peromyscus sp.* captures per 100 trapnights in the four habitats over 8(7) years. There was no trapping in ES 6 in 2001.

<u>*Peromyscus* Species Identification</u>

The majority of the *Peromyscus* sequenced were identified as White-footed mice (*P. leucopus*) having sequences nearly identical to the reference sequence DQ000483 but differing by a single transition at position 75 (see Appendix VI for aligned sequences). In 2012 this protocol revealed the presence of both Deer mouse (*Peromyscus maniculatus*) and White-footed mouse (*P. leucopus*) from 2 locations, Ecosystem 14 (poorly drained spruce-fir northern hardwood forest) and ES 20 (alder swamp/sedge meadow edge of former beaver pond).

Only 2 of the 8 mice sequenced were identified as deer mice (*P. maniculatus*). Although the sequences of these mice were different from the reference sequence of a deer mouse (JF489123) at 4 sites (about a 1% sequence divergence), they differed from the reference sequence of a White-footed mouse (DQ000483) at 23 sites.

Location	Specimen Number (Catalogue Number)	PCR Reaction (Sequence Number)	Species Identification
ES1 B15	2 MAH	Per5-4	*P. leucopus*
ES1 B16	2 MZL	Per6-1	*P. leucopus*
ES14 A08	6 MNP	Per4-3	*P. maniculatus*
ES14 A16	4 MNP	Per4-1	*P. leucopus*
ES14 A17	2 MPK	Per1-1	*P. leucopus*
ES14 B06	3 MKW	Per6-3	*P. leucopus*
ES20 A01	3 FSB	Per5-2	*P. leucopus*
ES20 B05	2 FEP	Per1-3	*P. maniculatus*

Table 2: Locality, catalogue number, and sequence number for the *Peromyscus* identified to species from the Colby Hill Ecological Project collected in the Summer 2012.

Together with last year's molecular results we have shown that the forest form of the Deer mouse (*Peromyscus maniculatus gracilis*) does co-occur with *P. leucopus* in all four sampled ecosystems on Colby Hill, but in much lower numbers than *P. leucopus*. It appears to be clearly more common on Colby Hill, than it was reported from Salisbury Ridge by Brooks et al. (1998), however those authors admitted that they did not use biochemical methods to check identification and thus may have missed *P. maniculatus* in their samples.

Small Carnivores

***Mustela erminea* (Ermine or Short-tailed weasel)**

Three individuals of this small carnivore were captured in 2012, one in ES 6 and two in ES 20. Weighted averages for 13 individuals from all ecosystems and eight years of sampling were

97.8 g for individual weight and 73.5% canopy cover. Dominant groundcover types were 61.2% herbs, 19.6% leaf litter and 14.6% grass (see Appendix V).

Species Accumulation and Diversity

The species accumulation curve for the seven (ES 1 & 6) and eight (ES 14 & 20) years of sampling small mammal data on Colby Hill is shown in Figure 8.

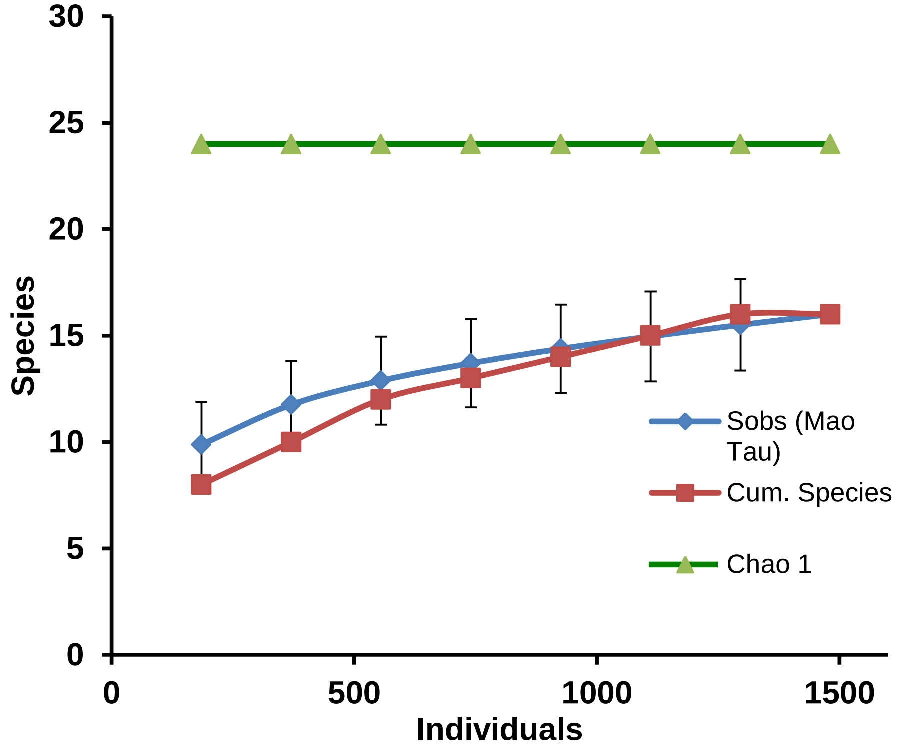

Fig. 8. Cumulative Species curve (Sample–based Rarefaction curve **(**“Mao Tau”-curve; Colwell 2009), and Richness Estimator (Chao1 Mean) for 8 (7) years and four Ecosystems sampled on Colby Hill between 2000 and 2012. Vertical bars: ± 1 *SD.*

The curve is based on 1481 total captures over the seven or eight year sampling in the four habitats (see App. I + II), with 16 total species (*Peromyscus maniculatus* and *P. leucopus* pooled). We have been advised to use the Chao 1 richness estimator (green) with count data instead of the Chao 2 estimator, which is used with incidence data, and also display it as a horizontal line for the largest sample size that this asymptotic estimator is rising towards (N. Gotelli in litt.). Estimated richness is still 24 species. Potential additional small mammal species occurring on the Guthrie Bancroft Land are Northern flying squirrel (*Glaucomys sabrinus*), which was verified in a bat net near ES 20 in 2002, Star-nosed mole (*Condylura cristata*), known from other areas on Colby Hill and the Pygmy shrew (*Sorex hoyi*). Less likely candidates are Long-tailed or Rock shrew (*Sorex dispar*), and Rock vole (*Microtus chrotorrhinus*), whose nearest recent (post-1990) records are in Salisbury Township and Underhill Township, respectively (Kilpatrick and Benoit 2011). In their long-term study on Salisbury ridge it took Brooks et al. (1998) 12 years to capture the first Star-nosed mole and 15 years to capture the first Long-tailed shrew.

Species	ES1	ES6	ES 14	ES20	Totals
Blarina brevicauda	41	52	37	27	157
Sorex fumeus	3	1	6	5	15
Sorex cinereus	15	9	16	6	46
Sorex palustris	0	0	0	1	1
Parascalops breweri	0	1	0	0	1
Peromyscus sp.	224	238	154	32	648
Napaeozapus insignis	26	9	17	49	101
Zapus hudsonius	0	0	0	13	13
Microtus pennsylvanicus	0	0	1	57	58
Microtus pinetorum	1	0	0	0	1
Myodes gapperi	130	81	166	13	390
Synaptomys cooperi	0	0	2	0	2
Tamias striatus	15	6	5	4	30
Tamiasciurus hudsonicus	1	1	0	2	4
Glaucomys volans	0	1	0	0	1
Mustela sp.	0	2	2	9	13
Totals:	456	401	406	218	1481
No. of Species (S):	9	11	10	12	16
a) Simpson' Index D *	0.453	0.410	0.321	0.162	
b) 1-D **	0.547	0.590	0.679	0.838	
c) Evenness E = (1/D)/S	0.245	0.222	0.311	0.513	
d) Shannon Index H' ***	0.997	1.345	0.823	0.558	
e) Evenness J'=H'/lnS	0.454	0.561	0.358	0.224	

***** Probability of two individuals belonging to the same species.
****** Probability of two individuals belonging to different species.
******* Average degree of uncertainty in predicting to what species an individual chosen at random from a sample will belong.

Table 3: Small Mammal Diversity indices calculated from 7 and 8 years of data collected on the Guthrie-Bancroft parcel on Colby Hill. See text for details on the indices.

Table 3 shows the recalculated values for the diversity indices including the 2012 data. After 7 (8) years of sampling on the Guthrie-Bancroft we can attempt to describe diversity more rigorously using widely used indices. Table 3 shows the multi-year totals for each ecosystem and a number of widely used diversity indices calculated following Magurran (2004):

a) Simpson's index $D = \Sigma n_i [n_i - 1]/N[N-1]$, or the probability of any two individuals drawn at random from an finite community belonging to the same species.

b) The complement of Simpson's index, 1-D, or the probability of any two individuals drawn at random from a finite community belonging to different species.

c) Evenness of the community. $E = (1/D)/S$, were S is the number of species in the sample.

d) Shannon Index $H' = -\Sigma p_i \ln p$, the average degree of uncertainty in predicting to what species an individual chosen at random from a sample will belong.

e) Evenness in species abundance $J' = H'/\ln S$ (ratio of observed diversity to maximum diversity)

Climate Data 2012

No climate data were recorded on the study site during the small mammal sampling in 2012. We are currently trying to obtain official climate data for the town of Lincoln for all years and sampling periods.

Discussion

With 236 individual captures and 10 species recorded the 2012, albeit with a somewhat higher trapping effort we obtained the third-highest number of captures since 2007 and 2005. With up to 8 years of sampling in two of the four habitats we are just starting to see some patterns emerge, like the (still weak) response of weasels to the population fluctuations of meadow voles in ES 20 (Fig. 4) or the possible interspecific dynamics between *Sorex fumeus* and *S. cinereus* populations (Fig. 2).

Many different ecological responses to recent climate changes have been known for over a decade now (Walther et al. 2002). Good evidence for the impact of climate change on small mammals, like the upward change in elevational limits of species, has also come from re-sampling studies of old mammal survey transects in the Rocky Mountains (Moritz et al. 2008). With long-term data it will also be interesting to see if there is some impact of the accelerated climate change in Vermont on small mammal population levels and diversity. Based on evidence of a historical decrease in mammal richness, increased species turnover, and possibly increasing abundance of generalist species from the end of the Pleistocene epoch about 11,700 years ago to today, some scientists predict a "restructuring of small mammal communities, significant loss of richness, and perhaps the rising dominance of 'weedy' species" in the future (Blois et al. 2010:771).

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Appendix I

7/8-year Annual Small Mammal Captures (16 species) in all four Ecosystems

Year:	2000	2001	2002	2005	2006	2007	2011	2012	Total
No. of nights trapped	9	11	12	12	12	12	12	12	**92**
No. of Traps	124	90	197	248	248	248	276	316	**1431**
Trapnights	372	332	591	744	744	744	807	948	**5282**
Shrews/Moles									
Blarina brevicauda	8	23	18	22	14	24	28	20	**157**
Sorex fumeus	2	0	0	1	1	3	0	8	**15**
Sorex cinereus	1	1	10	9	10	10	4	1	**46**
Sorex palustris	0	0	0	0	0	0	1	0	**1**
Parascalops breweri	0	0	0	0	0	1	0	0	**1**
Rodents									
Peromyscus sp.	45	76	63	70	84	119	69	122	**648**
Napaeozapus insignis	1	3	4	19	3	47	6	18	**101**
Zapus hudsonius	3	0	0	4	3	3	0	0	**13**
Microtus pennsylvanicus	3	4	3	23	1	3	3	18	**58**
Microtus pinetorum	0	0	0	0	1	0	0	0	**1**
Myodes gapperi	17	20	18	95	81	68	52	39	**390**
Synaptomys cooperi	0	0	0	1	0	0	0	1	**2**
Tamias striatus	0	1	2	1	4	8	8	6	**30**
Tamiasciurus hudsonicus	0	1	0	0	0	2	1	0	**4**
Glaucomys volans	0	0	1	0	0	0	0	0	**1**
Carnivores									
Mustela sp.	0	0	1	1	4	2	2	3	**13**
Total Captures:	**80**	**129**	**120**	**246**	**206**	**290**	**174**	**236**	**1481**
Species Detected:	**8**	**8**	**9**	**11**	**11**	**12**	**10**	**10**	**16**
Cumulative Species:	**8**	**10**	**12**	**13**	**14**	**15**	**16**	**16**	**16**

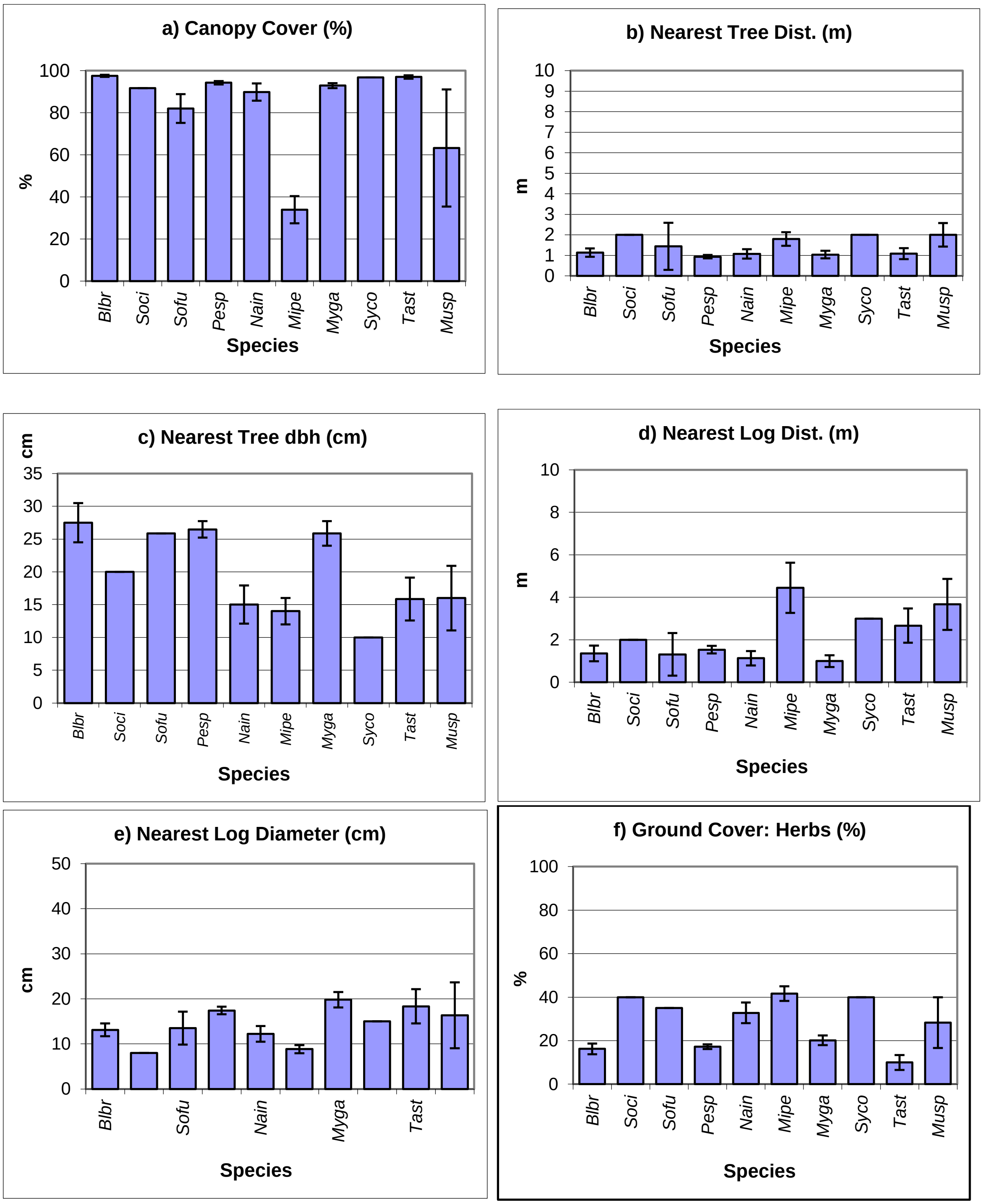
Appendix II

Detailed Overview of results from 8 (7) years of small mammal sampling in the four Ecosystem on the Guthrie-Bancroft parcel between 2000 and 2012.

Ecosystem (ES) No.	**ES 1 (7 years)**							**ES 6 (7 years)**							**ES 14 (8 years)**								**ES 20 (8 years)**								**Total**	**Total**
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								**2012 only**	**All Years**
Year:	**01**	**02**	**05**	**06**	07	11	**12**	**00**	**02**	**05**	**06**	**07**	11	**12**	**00**	**01**	**02**	**05**	06	**07**	11	**12**	**00**	**01**	**02**	**05**	**06**	**07**	11	**12**		
No. of nights trapped	4	3	3	3	3	3	**3**	3	3	3	3	3	3	**3**	3	4	3	3	3	3	3	**3**	3	3	3	3	3	3	3	**3**	**12**	**92**
No. of Traps	32	56	62	62	62	68	**79**	52	58	62	62	62	69	**79**	52	30	59	62	62	62	70	**79**	20	28	24	62	62	62	69	**79**	**316**	
Trapnights	128	168	186	186	186	204	**237**	156	174	186	186	186	207	**237**	156	120	177	186	186	186	210	**237**	60	84	72	186	186	186	186	**237**	**948**	**5282**
Shrews & Moles																																
Blarina brevicauda	5	3	13	2	3	10	**5**	8	8	1	6	12	10	**7**		12	2	8	6	3	4	**2**		6	5			6	4	**6**	**20**	**157**
Sorex fumeus					1		**2**					1			2			1	1	1		**1**								**5**	**8**	**15**
Sorex cinereus		3	5	1	3	3		1	5			3				1	2	3	7	2	1					1	2	2		**1**	**1**	**46**
Sorex palustris																													1			**1**
Parascalops breweri												1																				**1**
Rodents																																
Peromyscus sp.	44	19	29	25	39	25	**43**	31	25	21	30	59	23	**49**	12	19	19	18	25	19	21	**21**	2	13		2	4	2		**9**	**122**	**648**
Napaeozapus insignis			3		19		**4**		2			6		**1**		3	1	2	2	2	2	**5**	1		1	14	1	20	4	**8**	**18**	**101**
Zapus hudsonius																							3			4	3	3				**13**
Microtus pennsylvanicus																1							3	3	3	23	1	3	3	**18**	**18**	**58**
Microtus pinetorum				1																												**1**
Myodes gapperi	4	3	32	36	27	20	**8**	7	5	20	18	14	5	**12**	10	13	10	38	27	27	24	**17**		3		5			3	**2**	**39**	**390**
Synaptomys cooperi																		1				**1**									**1**	**2**
Tamias striatus	1	1	1	1	3	6	**2**				1	2		**3**			1			1	2	**1**					2	2			**6**	**30**
Tamiasciurus hudsonicus					1							1												1					1			**4**
Glaucomys volans									1																							**1**
Carnivores																																
Mustela sp.											1			**1**					1		1				1	1	2	2	1	**2**	**3**	**13**
No. of Species	4	5	6	6	8	5	**6**	4	6	3	5	9	3	**6**	3	6	6	7	7	7	7	**7**	4	5	4	7	7	8	7	**8**	**10**	**16**
No. of Captures	54	29	83	66	96	64	**64**	47	46	42	56	99	38	**73**	24	49	35	71	69	55	55	**48**	9	26	10	50	15	40	17	**51**	**236**	**1481**
Trap Success (%)	42.2	17.3	44.6	35.5	51.6	31.4	**27.0**	30.1	26.4	22.6	30.1	53.2	18.4	**30.8**	15.4	40.8	19.8	38.2	37.1	29.6	26.2	**20.3**	15.0	31.0	13.9	26.9	8.1	21.5	9.1	**21.5**	**24.9**	**28.0**

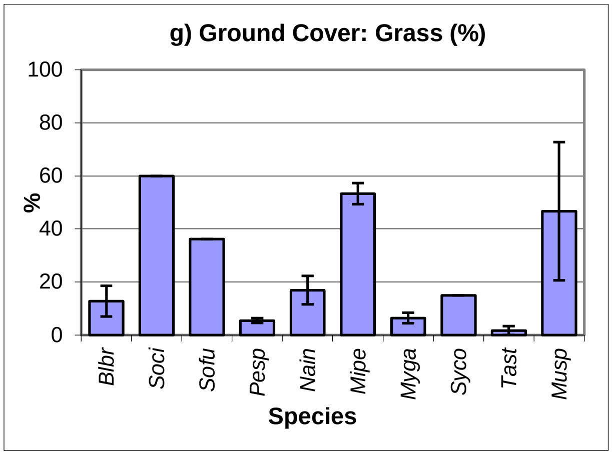
Appendix III

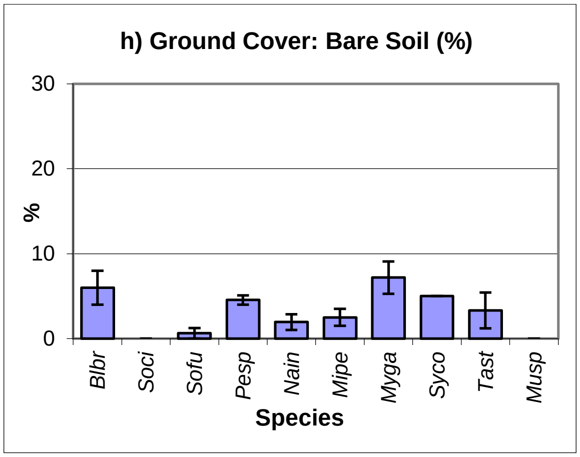
2012 Microhabitat data from trap sites summarized by Small Mammal Species. Species abbreviations and sample sizes are: *Blbr* = *Blarina brevicauda* (n=20), *Soci* = *Sorex cinereus* (n =1), *Sofu* = *Sorex fumeus* (n=8), *Mipe* = *Microtus pennsylvanicus* (n=18), *Myga* = *Myodes gapperi* (n=39), *Syco* = *Synaptomys cooperi* (n=1), *Nain* = *Napaeozapus insignis* (n=18), *Pesp* = *Peromyscus* sp. (n=122), and *Tast* = *Tamias striatus* (n=6), *Musp* = *Mustela* sp. (n=3).

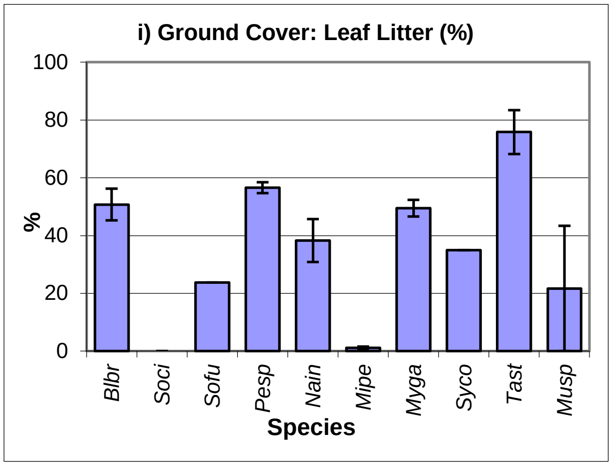


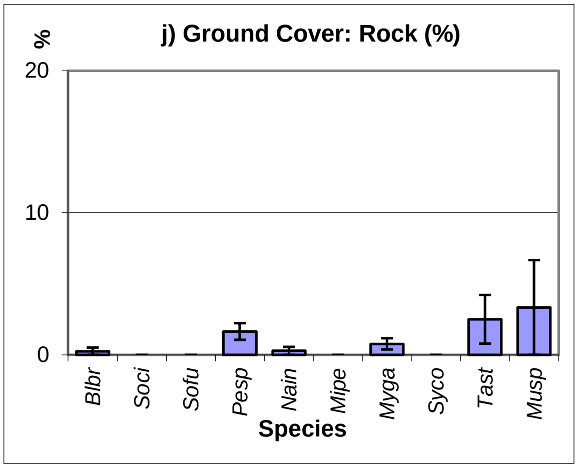
contd. App. III

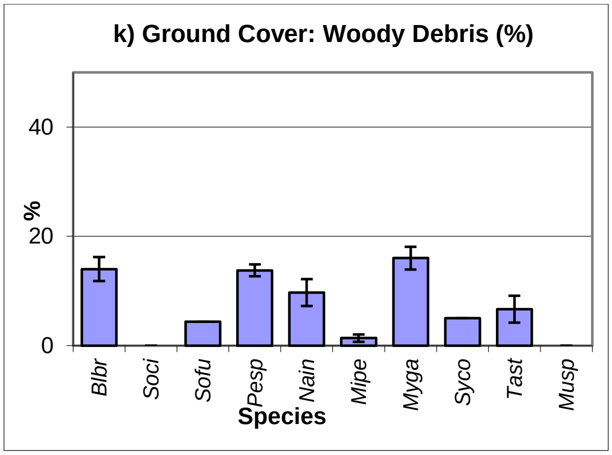
Microhabitat summarized by Small Mammal Species





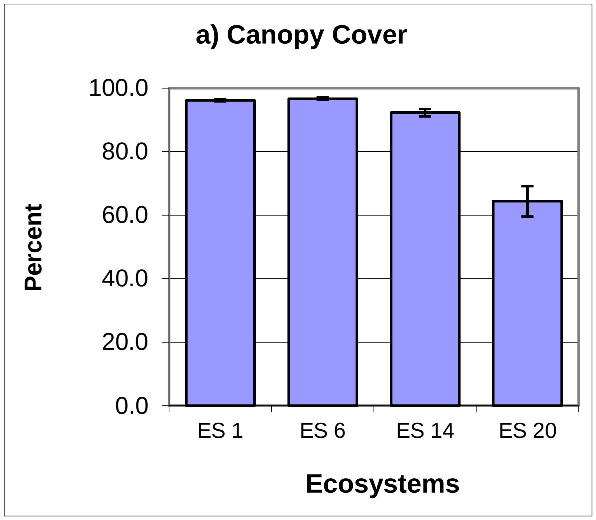


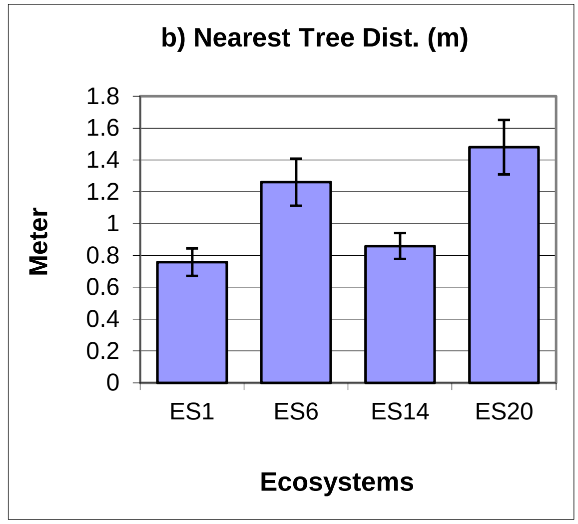


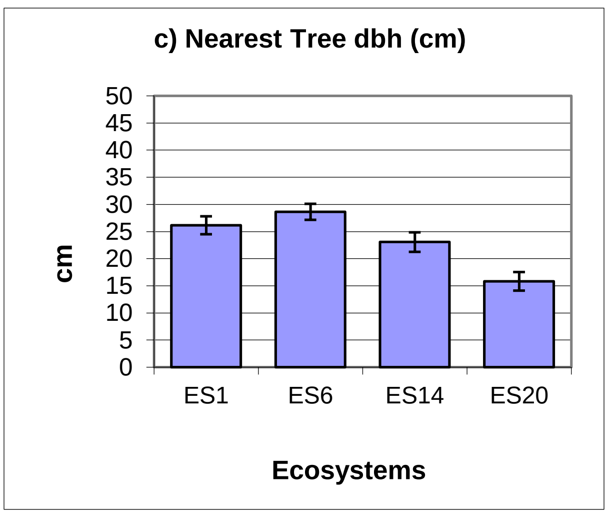


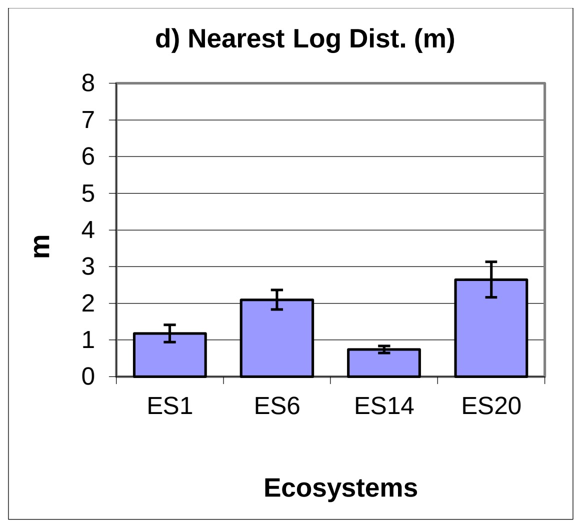
Appendix IV

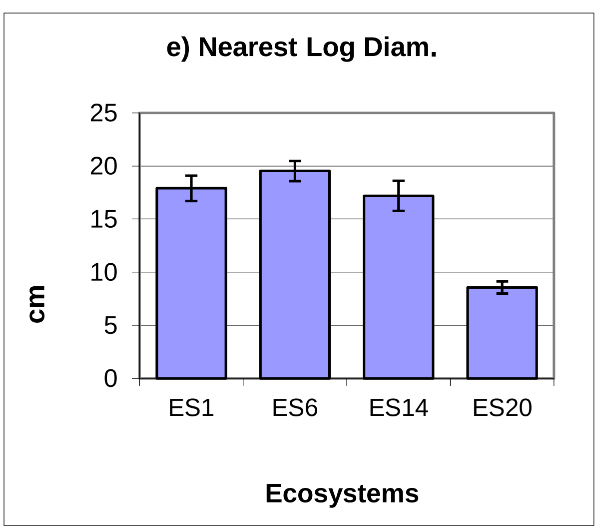
2012 Microhabitat Data from trap sites summarized by Ecosystem.

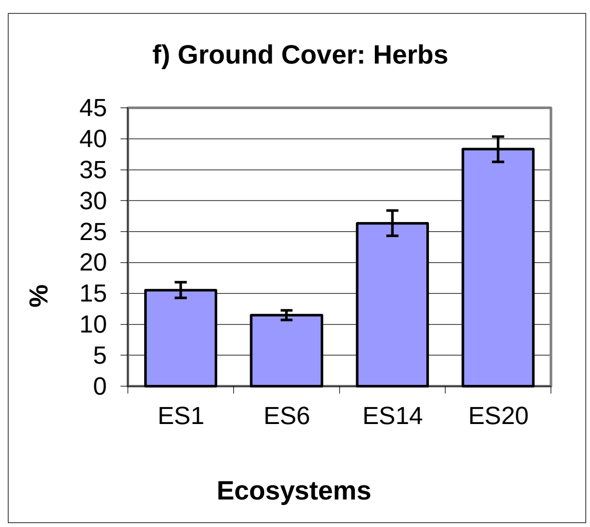






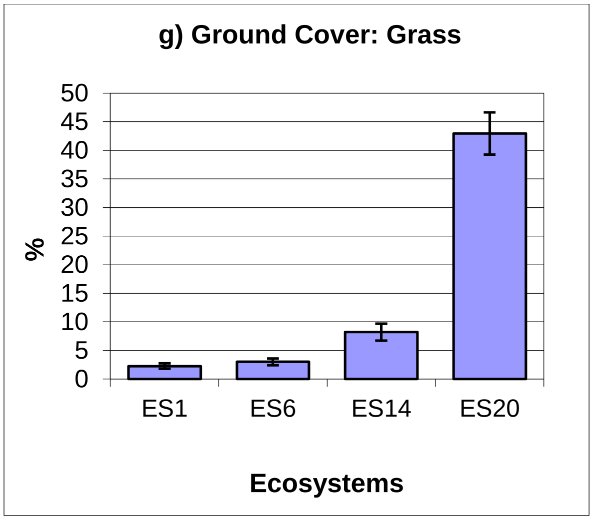


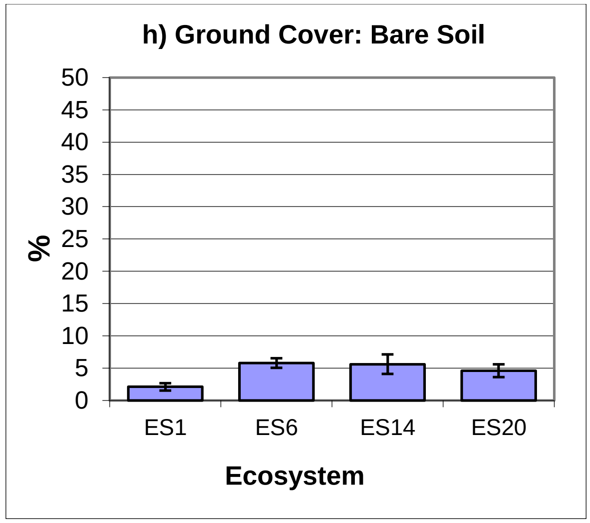


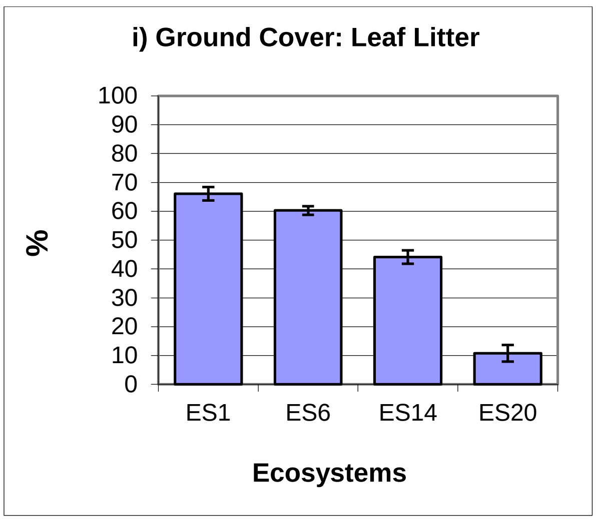


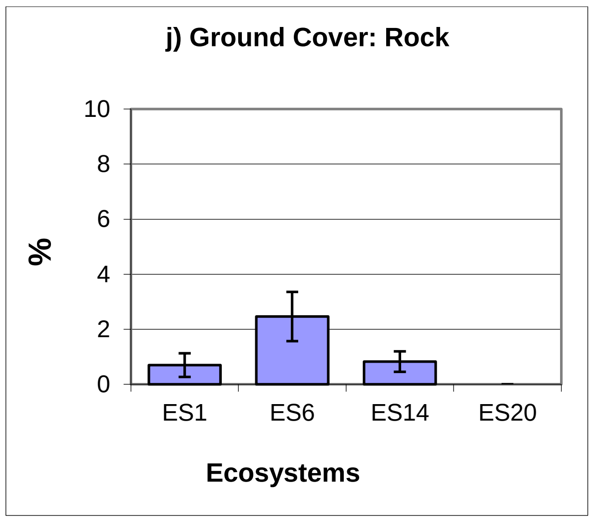
Appendix IV contd.

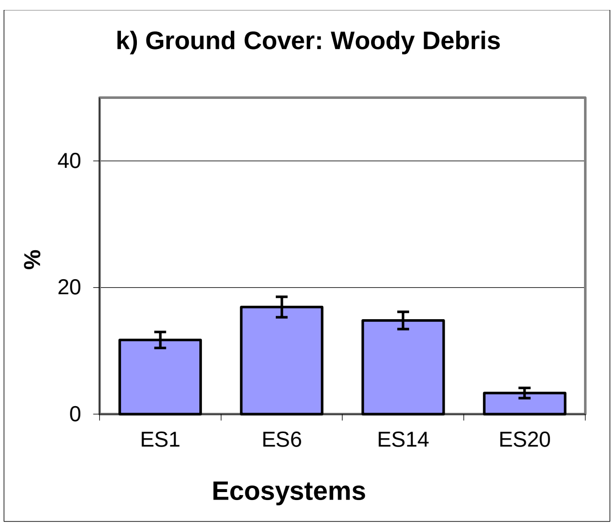
2012 Microhabitat Data from trap sites summarized by Ecosystem.











Appendix V
Weighted Averages of Colby Hill Small Mammal Weight and Habitat Data collected between 2000 and 2012

					Nearest Tree		Nearest Log		Groundcover Types					
Species	Years Averaged	No. caught	Average weight (g)	Canopy Cover	Nearest Tree dist. (m)	Nearest Tree dbh (cm)	Nearest log dist. (m)	Nearest log diam. (cm)	herbs (%)	grass (%)	bare soil (%)	leaf (%)	rock (%)	wood (%)
Shrews/Mole														
Blarina brevicauda	7	172	17.54	76.00	1.92	22.67	1.30	14.13	35.22	7.61	7.25	53.10	4.22	14.72
Sorex cinereus	7	46	4.22	75.70	2.33	19.64	2.18	8.50	53.15	10.30	5.04	30.29	0.68	1.33
Sorex fumeus	4	13	7.16	85.37	1.75	22.23	1.42	13.31	49.23	22.69	1.15	23.85	0.00	3.08
Sorex palustris	1	1	11.00	14.72	4.50	28.00	1.50	10.00	40.00	55.00	5.00	0.00	0.00	0.00
Parascalops breweri	1	1	45.00	97.92	2.60	18.00	1.00	5.00	40.00	20.00	10.00	20.00	5.00	0.00
Squirrels														
Glaucomys volans	1	1	?	80.00	1.00	60.00	0.00	10.00	20.00	0.00	0.00	80.00	0.00	n/a
Tamias striatus	7	34	75.54	87.41	1.16	19.81	1.16	16.03	28.24	4.85	4.85	53.24	1.91	6.59
Tamiasciurus hudsonicus	4	4	96.50	64.24	0.65	17.75	2.88	7.75	56.25	11.25	1.25	18.75	0.00	13.33
Voles														
Myodes gapperi	7	414	18.37	85.26	1.24	21.11	0.96	13.48	34.66	2.96	5.24	49.11	2.75	12.33
Microtus pennsylvanicus	7	57	29.00	35.61	6.55	10.13	3.30	7.73	51.05	40.18	2.37	2.89	1.58	3.54
Microtus pinetorum	1	1	21.00	93.76	0.10	10.00	0.30	10.00	40.00	0.00	0.00	60.00	0.00	n/a
Synaptomys cooperi	2	2	22.00	95.32	3.00	12.50	3.00	13.50	62.50	7.50	2.50	25.00	0.00	5.00
Mice														
Napaeozapus insignis	7	111	20.89	77.04	1.57	17.91	1.03	11.37	41.62	7.11	5.27	38.68	2.70	7.42
Zapus hudsonius	3	10	18.89	63.08	4.02	8.10	1.57	14.50	61.50	16.50	3.00	9.00	0.50	3.30
Peromyscus sp.	7	672	17.89	81.06	1.12	23.62	1.05	12.82	23.43	3.05	5.28	59.20	3.33	11.70
Weasels														
Mustela erminea	6	13	97.85	73.49	1.71	14.31	2.30	12.46	61.15	14.62	1.54	19.62	1.54	1.43

Appendix VI

Cytochrome *b* Gene sequences of a subset of *Peromyscus* from Colby Hill in 2012

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                                                            50
P_leu    ATGACAAACATCCGAAAAAAACACCCACTACTTAAAATTATCAATGAATC
Per5-2   NNNNNNAACNTCCGAANAAAACNCCCACTACTTAAAATTATCAATGAATC
Per5-4   NNGANNAACNTCCNNNNNNNACNCCCACTACTTAAAATTATCAATGAATC
Per6-1   NNGNNAANNNTCCGANNNNNNNNNCCCACTACTTAAAATTATCAATGAATC
Per6-3   NNNNNNNNNNTCCGNNNNNNNNCNCCCNCNACTTAAAATTATCAATGAATC
Per4-1   ANGANNAACNTCCNNNNNNNACNCCCACTACTTAAAATTATCAATGAATC
Per1-1   NTGNNNNNNNNNNNANNNNNNNNNNNNCTACTTNANATTATCNATGAATC
P_man    ATGACAAACATCCGAAAAAAACACCCATTAATTAAAATCATCAATGAATC
Per4-3   NNGNCNNNCGTCCGANNNNAACATCCACTAATTAAAATCATCAATGAATC
Per1-3   NNGACAANCNTCCGGNAAAAACATCCACTAATTAAAATCATCAATGAATC

                                                           100
P_leu    CTTCATTGATCTCCCAACCCCATCTAACATCTCATCATGATGAAACTTCG
Per5-2   CTTCATTGATCTCCCAACCCCATCCAATATCTCATCATGATGAAACTTCG
Per5-4   CTTCATTGATCTCCCAACCCCATCCAATATCTCATCATGATGAAACTTCG
Per6-1   CTTCATTGATCTCCCAACCCCATCCAATATCTCATCATGATGAAACTTCG
Per6-3   CTTCATTGATCTCCCAACCNCATCCAATATCTCATCATGATGAAACTTCG
Per4-1   CTTCATTGATCTCCCAACCCCATCCAATATCTNNNNNNGATGAAACTTCG
Per1-1   CTTCATTGATCTCCNNACNNNNGNNGNTNTTNNNNNNNNNTGAAACTTCG
P_man    CTTCATTGATCTCCCANCCCCATCCAATATNTCATCATGATGAAACTTCG
Per4-3   CTTCATTGATCTCCCAGCCCCATCCAACATTTCATCATGATGAAACTTCG
Per1-3   CTTCATTGATCTCCCAGCCCCATCCAACATTTCATCATGATGAAACTTCG

                                                           150
P_leu    GATCCTTACTTGGACTGTGCCTAGTAATTCAAATTTTAACTGGCCTATTC
Per5-2   GATCCTTACTTGGACTGTGCCTAGTAATTCAAATTTTAACTGGCCTATTC
Per5-4   GATCCTTACTTGGACTGTGCCTAGTAATTCAAATTTTAACTGGCCNANNN
Per6-1   GATCCTTACTTGGACTGTGCCTAGTAATTCAAATTTTAACTGGCCTATTC
Per6-3   GATCCTTACTTGGACTGTGNNNNGTAATTCAAATTTTAACTGGCCTATTC
Per4-1   GATCCTTACTTGGACTGTGCCTAGTAATTCAAATTTTAACTGGCCTATTC
Per1-1   GATCCTTACTTGGACTGTGCCTAGTAATTCAAATTTTAACTGGCCTATTC
P_man    GATCCCTACTTGGAGTATGCCTAATAATTCAAATTCTAACAGGCTTATTT
Per4-3   GATCCTTACTTGGAGTATGCCTAATAATTCAAATTCTAACAGGCTTATTT
Per1-3   GATCCTTACTTGGAGTATGCCTAATAATTCAAATTCTAACAGGCTTATTT

                                                           200
P_leu    TTAGCCATACACTACACATCAGACACAACTACAGCATTCTCATCCGTAAC
Per5-2   TTAGCCATACACTACACATCCGACACAACTACAGCATTCTCATCCGTAAC
Per5-4   NNNGCCATACACTACACATCCGACACAACTACAGCATTCTCATCCGTAAC
Per6-1   TTAGCCATACACTACACATCCGACACAACTACAGCATTCTCATCCGTAAC
Per6-3   TNAGCCATACACTACACATCCGACACAACTACNGCATTCTCATCCGTAAC
Per4-1   TTAGCCATACACTACACATCCNACACAACTACNGCATTCTCATCCGTAAC
Per1-1   TTAGCCATACACTACACATCCGACACAACTACAGCATTCTCATCCGTAAC
P_man    CTAGCCATACACTACACATCAGACACAACTACAGCATTCTCATCAGTAAC
Per4-3   CTAGCTATGCACTACACATCAGACACAACTACAGCATTCTCATCAGTAAC
Per1-3   CTAGCTATGCACTACACATCAGACACAACTACAGCATTCTCATCAGTAAC

                                                           250
P_leu    ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
Per5-2   ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
Per5-4   ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
Per6-1   ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
Per6-3   ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
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Per4-1   ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
Per1-1   ACATATCTGCCGAGACGTAAACTACGGATGACTAATCCGATATATACACG
P_man    ACACATCTGCCGAGACGTCAACTACGGCTGACTTATCCGATATATACACG
Per4-3   ACACATCTGCCGAGACGTCAACTACGGCTGACTTATCCGATACATACACG
Per1-3   ACACATCTGCCGAGACGTCAACTACGGCTGACTTATCCGATACATACACG

                                                          300
P_leu    CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
Per5-2   CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
Per5-4   CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
Per6-1   CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
Per6-3   CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
Per4-1   CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
Per1-1   CAAACGGAGCCTCAATATTCTTTATCTGCTTATTCCTGCACGTAGGACGA
P_man    CAAACGGAGCCTCAATATTCTTCATCTGCTTATTCCTTCATGTAGGACGA
Per4-3   CAAACGGAGCCTCAATATTCTTCATCTGCTTATTCCTTCATGTGGGGCGA
Per1-3   CAAACGGAGCCTCAATATTCTTCATCTGCTTATTCCTTCATGTGGGGCGA

                                                          350
P_leu    GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
Per5-2   GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
Per5-4   GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
Per6-1   GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
Per6-3   GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
Per4-1   GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
Per1-1   GGAATATACTACGGATCCTACACATTCAAAGAAACATGAAACATTGGAGT
P_man    GGAATATATTATGGATCATACACATTCANAGAGACATGAAACATTGGAGT
Per4-3   GGGATATACTACGGATCATACACATTCACAGAGACATGAAACATTGGAGT
Per1-3   GGGATATACTACGGATCATACACATTCACAGAGACATGAAACATTGGAGT

                                                          400
P_leu    AGTACTCCTATTTGCCGTAATAGCAACAGCATTCATAGGGTATGTACTCC
Per5-2   AGTGCTCCTATTTGCCGTAATAGCAACAGCATTCATAGGATATGTACTCC
Per5-4   AGTGCTCCTATTTGCCGTAATAGCAACAGCATTCATAGGATATGTACTCC
Per6-1   AGTGCTCCTATTTGCCGTAATAGCAACAGCATTCATAGGATATGTACTCC
Per6-3   AGTGCTCCTATTTGCCGTAATAGCAACAGCATTCATAGGATATGTACTCC
Per4-1   AGTGCTCCTATTTGCCGTAATAGCAACAGCATTCATAGGATATGTACTCC
Per1-1   AGTGCTCCTATTTGCCGTAATAGCAACAGCATTCATAGGATATGTACTCC
P_man    TGTACTATTATTTGCTGTAATAGCAACAGCATTCATAGGGTATGTACTTC
Per4-3   TATATTATTATTTGCTGTAATAGCAACAGCATTCATAGGGTACGTACTTC
Per1-3   TATATTATTATTTGCTGTAATAGCAACAGCATTCATAGGGTACGTACTTC

                                                          450
P_leu    CATGAGGACAAATATCCTTCTGAGGAGCCACAGTAATTACTAACCTACTA
Per5-2   CATGAGGACAAATATCATTCTGANGA
Per5-4   CATGAGGACAAATATCATTCTGANGAGC
Per6-1   CATGAGGACAAATATCATTCTGA
Per6-3   CATGAGGACAAATATCATTCTGA
Per4-1   CATGAGGACAAATATCATTCTG
Per1-1   CATGAGGACAAATATCATTCTGA
P_man    CATGAGGACAAATATCCTTCTGAGGAGCCACAGTAATTACCAACCTATTA
Per4-3   CATGAGGACAAATATCATTCTGA
Per1-3   CATGAGGACAAATATCATTCTGAGG
```

Reference Sequences:

Peromyscus leucopus	DQ000483
Peromyscus maniculatus	JF489123