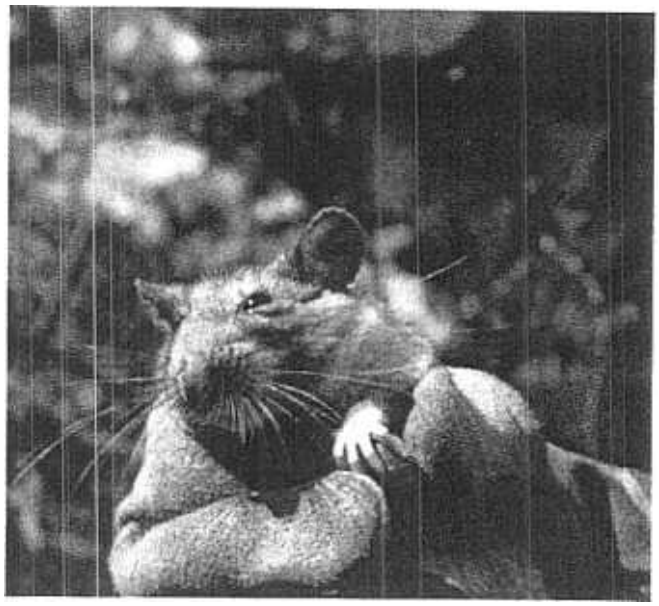
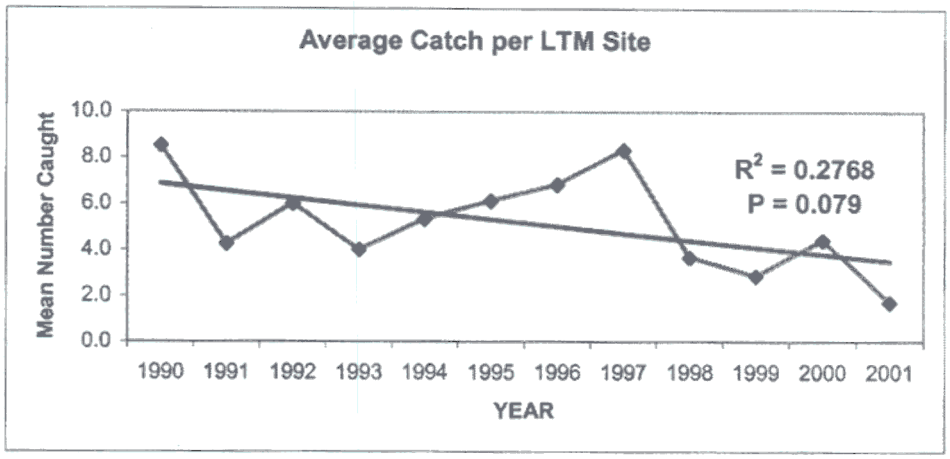
Analysis and Summary of Eleven Years of Allegheny Woodrat Trapping Data in Southwest Virginia, 1990-2000





Virginia Department of Game and Inland Fisheries
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11 December 2002

Michael T. Mengak, Ph.D.
Warnell School of Forest Resources
University of Georgia
Athens, Georgia 30602

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Instrument: Woodrat Contract

Agency: Virginia Department of Game and Inland Fisheries

Cooperator: University of Georgia

Title: Analyis and Summary of Eleven Years of Allegheny Woodrat Trapping in Southwest Virginia, 1990-2000

Principal Investigator: Michael T. Mengak, Ph.D., Assistant Professor, Wildlife Specialist, D. B. Warnell School of Forest Resources - UGA

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INTRODUCTION

The purpose of this report is to summarize all trapping and biological information collected during the course of trapping Allegheny woodrat (*Neotoma magister*) on numerous sites throughout Virginia over an 11-year (1990-2001) period. There are numerous immediate threats to the woodrats' survival including loss of habitat, habitat fragmentation, disease, genetic isolation, colony isolation, and predation. The long-term survival of the woodrat in the Blue Ridge and Ridge and Valley Provences of Virginia is not certain. I hypothesize that the Allegheny woodrat functions like a metapopulation complex in Virginia. Data from this project and numerous ancedotal accounts from cavers, hikers, biologists, naturalists and others suggests that the Allegheny woodrat should be added to the list of threatened or endangered species in the Commonwealth of Virginia. This report will review the evidence on the status of the Allegheny woodrat in Virginia.

It is necessary for land managers to have accurate information on species biology, population size and distribution in order to effectively conserve any species. This project was conducted to document the occurrence of woodrats across Virginia, to examine historic colonies for evidence of continued occupancy, and to monitor selected colonies using a trap and recapture method. In addition to population monitoring, large amonts of information on distribution and life history were collected. There were two objectives of the woodrat study. First, I wanted to document the occurrence and distribution of woodrats throughout Virginia. This included identifying potential woodrat habitat, locating these sites on the ground and determining if woodrats presently occupied the site. It also included a survey of known historic woodrat sites based on location information

attached to specimens housed in the Mammal Collection at the Smithsonian Museum of Natural History. Second, I wanted to observe the long-term trends in a woodrat capture index at selected sites on the national forest.

The purpose of this report is to summarize woodrat survey and monitoring efforts conducted in Virginia, to update the woodrat distribution map in Virginia, and to analyze monitoring data to determine effort needed to conduct long-term trend surveys and analysis. These data include both annual trapping at up to nine monitoring sites throughout southwest Virginia and occasional trapping in potential woodrat habitat.

Status

The Allegheny woodrat was initially listed as a Category II species under the Endangered Species Act of 1973 (as amended) by the US Fish and Wildlife Service (Federal Register, 1989). While Category II designations are no longer used by regulatory agencies, the woodrat remains imperiled throughout its geographic range. Currently, the Allegheny woodrat has a global ranking of G3G4 (G3=globally rare or uncommon, G4=globally widespread and apparently secure) (Wright, 2002). Wright (2002) reported that the woodrat is "not listed – presumably secure" in Virginia. However, Roble (2001) listed the state rank as S3 (S3 = rare or uncommon in state). Mengak (2000a) suggested that the woodrat was declining in Virginia.

The species is considered endangered, threatened, or of special concern by all states throughout its range (Laerm *et al.*, 2000). It is obvious that Wright's (2002) assessment of the woodrats' status is in need of revision. Virginia does not maintain an endangered and threatened species list but uses the federal list as a surrogate (R. Reynolds, pers. comm.)

Wright (2002) listed the Allegheny woodrat as extirpated (extinct) in CT, MA, and NY. It is doubtful that the species ever occurred in MA and CT (Wilson and Ruff, 1999). Wright (2002) listed it as endangered in MD, NJ, and OH; threatened in IN and PA; special concern in NC; rare in WV; in need of management in TN. The designation of rare in WV should be viewed cautiously (W. Ford, USFS, pers. comm.; S. B. Castleberry, UGA, pers. comm.). Wright (2002) further noted that the woodrat has no special designation in AL, GA (probably not within the range of *N. magister*), KY and VA. It is likely that the Allegheny woodrat does not occur in IN and GA (Wilson and Ruff, 1999) but is instead replaced by the eastern woodrat (*N. floridana*) in these states. Therefore, the Allegheny woodrat has significant conservation status in nine of the twelve actual

states within its range. The Allegheny woodrat has such a small distribution in AL (northeast corner in < 5 counties) that, if it occurs in Alabama, it is likely to be in peril in that state as well. The occurrence of the Allegheny woodrat in both GA and AL awaits definitive conformation through trapping and museum surveys.

The species has disappeared from New York; one population remains in New Jersey and dramatic declines have been reported from Pennsylvania and Maryland (Whitaker and Hamilton, 1998). They are considered rare in Tennessee (Kennedy and Harvey 2001). Populations in West Virginia, Kentucky, and Indiana currently seem secure (Thomas, 1998; Castleberry, 2000; Mengak, 2000a). Recent surveys in Ohio failed to locate woodrats (W. Peneston, pers. comm.). My research and report will address their status in Virginia.

Reasons for the decline are complicated and not clearly understood but may include loss of habitat and fragmentation of remaining habitat (Balcom and Yahner, 1996); genetic isolation (Castleberry, 2000; Castleberry et al. 2002c); loss of hard mast food resources due to forest harvesting (Castleberry et al., 2001) and chestnut blight (*Cryphonectria parasitica*) (Hall, 1985); impact of gypsy moths (*Lymantria dispar*) on oaks and other hardwood trees (Hall, 1985); vegetation change from white-tailed deer herbivory (Hassinger et al., 1996) infection as a secondary host to a fatal raccoon roundworm (*Baylisascaris procyonis*) parasitism (McGowan and Hicks 1996); and increased mammalian and avian predation (Balcom and Yahner, 1996).

There seems to be little actual evidence (i.e., peer-reviewed literature) to support any of these "reasons for decline". If fact, there is little published evidence supporting the concept of a decline. However, the anectodal evidence from researchers and numerous conference presentations and annual reports from several states clearly indicate the woodrat is in trouble. No studies presented at a 1979 bobcat conference provided evidence of bobcat predation on any woodrat (Genus *Neotoma*) species (Blum and Escherich 1979). However, Fox and Fox (1982) found woodrats in 0.6% (N=1) of 172 bobcat stomachs collected in West Virginia in 1977-1978. No rigorous study seems to exist in the published literature on the impact of mammalian or avian predators on woodrat survival.

Range

The Allegheny woodrat (*Neotoma magister*) has an historic range throughout the central and southern Appalachians from southern New York to northern Alabama (Whitaker and Hamilton, 1998). Linzey (1998) provides a general distribution of the species in Virginia but is not considered

plete descripti of woodrat distribution. M gak 996 998, 999 gives addi onal, specific locations of woodrat lonies Virgini ludin information the presence of woodrats counti not previously reported. All urrently kno woodrat locati will be summarized in this report.

Taxonomy

There has been uch debate the taxonomy this has, at times, been considered either separate species subspeci of the eastern woodrat (Sch artz and Odum, 957) R genetic and morphological studies hav confirmed th separate taxonomic status of *N. magister* (Hayes and Richmond, 993 Planz et al., 996; Ray 000; Edwards and Bradley 200

Habitat

Allegheny woodrat habitat consists of caves, cliffs, tal lds, rock outcrops, other rocky sites havin suffi ent crevices (1 ber and depth) to accommodate woodrats. Woodrats also inhabi abandoned vacant barns, homes, cabins, ther human structures In Virginia, woodrats found the lue Ri ge and Ridge and Valley Provinces In West Virginia, Castleberry *et al* (2002b) amined microhabitat selection by foraging Allegheny woodrats forest stands subject to levels of timber remo al and concluded that they tolerate wide range of macrohabitat conditions Woodrats foraged in areas with di understory but seemed unaffected by tree removal method. Balcolm and Yahner 996) discussed microhabitat and landscape characteristi of oodrat habitat Pennsyl

Natural History

Relatively ttle kno of Allegheny woodrat natural history the uthern Appalachian region. Maximum longevity of wild Allegheny woodrats has been reported to be 7. months, (734 days (Mengak et al 2002) considerably ceeding previous longevity estimates for both wil and capti woodrats (Mengak, 2000b

Uncertainty exists the literature about woodrat reproduction including timing, frequency gestation, and litter size. Gestati captiv woodrats has been reported to be betw 30 and 36 days (P le, 36). From data ten litters born captivity 940) reported average litter size of actly per brood" oole 940 reported that young are born from mid- March to September ut he reported birth mid- October Field guides and encyclopedias, often

anecdotal, report litter sizes of from two to six or seven, although not a single reference to primary literature is given to support such a high birth rate (for example, Linzey, 1998). Mengak (2002a) reports that woodrats in Virginia have an average litter size of 2.2 young per litter. Mengak (2002a) reports juvenile growth rates to average 1.26 g/d. Year to year recaptures rates for juveniles was 19% (Mengak 2002).

Woodrats have a diverse diet consisting of many different plant species and a variety of plant parts. Castleberry et al. (2002a) found that woodrats in both the Allegheny Plateau province of West Virginia and the Ridge and Valley province of Virginia consumed green vegetation, hard and soft mast and fungi during all seasons. Consumption of fungi and soft mast was higher in the Allegheny Plateau province than the Ridge and Valley province. Hard mast occurrence in the diet tracked acorn production and availability in both provinces during 1997 and 1998 (Castleberry et al. 2002a).

Castleberry et al. (2001) found the woodrat movements were greatest in 1998 following a poor mast crop in 1997. They found no difference in movements among three timber harvest methods in 1999 when hard mast was more available. Mean home range size for male and female woodrats in West Virginia during 1998-1999 was 6.5 ha and 2.2 ha, respectively (Castleberry et al., 2001). Mengak (2002b) found that during the period January-April, individual monthly home range for five woodrats (4F: 1M) in Virginia varied from 0.003 ha to 0.041 ha based on radio-collared individuals. Over 4 months, the individual composite home range varied form 0.021 ha to 0.105 ha. The average home range size for four females in his study was 0.179 ha.

Based on trapping and recaptures, Mengak (2002b) found the home range size was 0.189 ha for females and 0.234 ha for males at a Giles County study site and 0.068 ha for females and 0.063 ha for males at a Bath County study site.

STUDY AREA and METHODS

Study Areas

In 1987, Dr. John Pagels (Biology Department, VCU) wrote a short article in Virginia Wildlife magazine seeking information from people who had knowledge of Allegheny woodrats through caving, trapping or observation. In addition to this article, Dr. Pagels sent letters to mammalogists at several Virginia colleges and universities asking for their museum records and field observations of *N. magister*. I obtained the results of Pagels' surveys in 1989. In January

1989, I obtained the museum records of *N. magister* for Virginia from the Smithsonian Museum of Natural History. I also contacted cavers from the VPI Cave Club, Blacksburg. I obtained additional woodrat locations from books by Bailey (1946) and Handley and Patton (1947). These museum records, field observations and anecdotal reports formed the basis of a list of known woodrat observations in Virginia. The sites on this list were designated as "Historic Sites" if the observations were made prior to 1985 (i.e., five years prior to the beginning of my study). Records from 1985-1990 were designated "Recent Sites".

Historic sites, when trapped, were reclassified as 'active' – woodrat collected; 'inactive' – trapped but no woodrats collected; or 'unknown' – sites with inadequate location data that could not be located. Recent sites, when trapped, were reclassifed in the same manner.

I began this project by plotting on topographic maps the reported locations of *N. magister* in Virginia and visiting the sites to ascertain their current occupancy status. Sites with inadequate location data were not visited. Forest Service, National Park Service and DGIF personnel suggested additional sites. These sites were visited and trapped as funds became available. Personnel of these agencies assisted in surveying for woodrats when possible.

Most sites were trapped only once throughout the study to document the distribution and occurrence (i.e., presence or absence) of woodrats in the state but primarily on the national forest. Nine sites (eight on national forest and one site in Shenandoah National Park) were trapped annually in the fall, September- October (Mengak 1999). Not all sites were trapped annually throughout the entire study. For consistency with terminology used in my annual reports and other papers, these nine sites were designated as long-term monitoring (LTM) sites. Sites that were trapped only once or re-visited infrequently were designated survey sites. All sites were trapped and treated identically – only the frequency of trapping differed between sites. I initially trapped all LTM sites.

While I monitored up to four LTM sites, Forest Service personnel generally trapped the other five LTM sites. Survey sites were suggested by both VDGIF and Forest Service personnel and generally trapped by me with the assistance of students in the Environmental Science Program at Ferrum College. Forest Service and DGIF personnel trapped some survey sites. A few sites were reported by DGIF personnal and another contract researcher (Dr. W. McShea, Conservation and Research Center, Front Royal, VA) based on observations during annual bat hibernacula surveys and

other research. These sites numbered less than 5% of all sites. All data were combined and will be reported here.

Sites were classified on the basis of trapping results as follows: Active – at least one woodrat captured at the site; Inactive – trapping occurred but no woodrats were caught; Other – this category includes suspected woodrat habitat but which were not trapped because (a) they were too remote to trap in the time available; (b) were subjectively judged to have a low probability of capturing a woodrat based on a visual assessment of the rock; or (c) lacked sufficient locational data to find the site on the ground.

Trapping methods

Fieldwork at LTM sites began in October 1990 and ended in July 2000. Forest Service biologists continued to monitor four sites during 2001. During the study, some LTM sites were discontinued from trapping and other LTM sites were added such that not all nine LTM sites were used in all 11-years of the study. Once a LTM site was dropped from the study it was not trapped at a later date. Sites were dropped or added based on shifting budget priorities, available personal or site-specific objectives. All data are included in this report.

Survey sites were trapped throughout the study beginning in June 1990. Trapping effort at survey sites was not distributed evenly throughout the year, but some trapping occurred in every month. Most trapping occurred in the spring (May – June) or fall (September – October).

Two of the nine LTM sites were trapped for the entire 11-years. Also, these two sites were trapped at approximately 60-day intervals from 1996-2000, weather permitting. Additional trapping (in addition to annual monitoring) occurred at these two sites prior to 1998. All trapping conformed to standards of the American Society of Mammalogists but an animal care and use permit was not required. Appropriate state and federal permits were obtained for scientific collecting.

Tomahawk collapsible live traps (No. 201) baited with one-half an apple were used at all sites. Trapping effort generally involved setting 10-15 traps for one or two nights at nearly all survey sites. Occassionally, as few as five traps were set at a survey site if the area was too small to accommodate a higher number. At first, traps were set for only one night but later a second night of trapping was added if no animals were caught on the first night. At the LTM sites trapped annually, including the two sites trapped bi-monthly, forty traps were set for two nights. Occassionally, a LTM site was trapped for three or four nights in order to validate the sampling procedure.

All captured animal from both survey ites and LTM sites were treated dentically Captured animal tagged in both ears with sequentially numbered No. Monel al tag (Kentucky Band and Tag Co ghed to the nearest Pesola hanging spring scale, ed, examined for reproductive condi on, ectoparasites and verall body condition, and released at point of capture Captured animals were subj vely aged based combinati of weight (juveniles 7 g, subadults g 22 g, adults 225 g) pelage color and reproductive condition (palpati f fetuses; idence of lacati bare, exposed teats or expressi of milk; scrotal testes). A great deal information on the life history the Allegheny woodrat has been collected. Some f these data hav been reported elsewhere (Mengak 2000a, 2000b 2002a, 002b). Only data population trends of woodrats at LTM sites and presence/absence of woodrats at survey sites presented in this report.

Data Analysis

A catch per effort rati was calculated for each toring te. This index was computed

$$CE \quad A \quad \frac{\quad}{(T \quad N) \quad (S/2)}$$

Where, CE catch per effort catch per trap nights effort f the numerator is

A number of animals caught in trap session (usually nights)

T number f traps set in trap session,

N number nights in trap session (usually), and

number traps sprung but empty or with non-target species.

The data from two-night trapping ents (mark-recapture the protocal for LTM sites were used to compute Lincoln-Peterson estimate f population size at each monitoring site for each trap session. Computation followed the methods in Thompson et al (99 :88). The Lincoln-Peterson estimator used to determine oodrat abundance at each LTM. The expanse the toring site (hectares) was not determined so estimates f density ailable.

Presence-absence surveys analyzed with program PRESENCE. Program PRESENCE (formerly ESOR) estimates patch occupancy rates and related parameters including estimate of occupancy probability The program preforms simulations based the estimated probability of

detecting a woodrat at a site. Inputs to the program include a matrix composed of 0 and 1's to represent the presence or absence of an animal in an indiviudal trap. Thus the rows of the matrix consist of the individual survey sites and the columns represent the occurrence of a woodrat in the 5, 10 or 15 traps set at the site. The model ignores missing data as in the case of different numbers of traps set at each site or if the traps were left open for two nights as was the case when no woodrats were caught the first night. This occurred infrequently and only after 1997 when the trapping protocal was modified as explained above. If ten traps were set for two nights and no woodrats were caught then there are twenty columns of 0's for that entry in the data input matrix (MacKenzie et al. in press).

Output from the simulations was used to estimate the number of sites needed to detect various levels in change in mean occupancy rates. By specifying the Type I (alpha) and Type II (Beta) error rates, and using the formula for sample size estimation in Parkinson et al. (1988), I was able to model several scenarios for sample size needed for future surveys. The software is available from the Patuxent Wildlife Research Lab, USGS at http://www.mbr-pwrc.usgs.gov/ software.html.

Additional population modeling and analysis was conducted for sites where 10 or more woodrats were captured during the annual fall monitoring. Closed population models from Program CAPTURE were used to estimate population size, confidence intervals and probability of capture. Program CAPTURE is available at the Patuxent Wildlife Research Lab website. Details related to use of CAPTURE are given in Otis et al. (1978) and White et al. (1982). Other analyses and calculations were conducted using a Microsoft EXCEL spreadsheet. Statistical significance was set at alpha = 0.05 for all tests.

As a disclaimer, throughout this report woodrat sites will be ennumerated in various tables and text. Occassionally, a site was reported to me by a reputable observer but with incomplete location information such as no county name or no directions to the site. I have reported all known sites even those with incomplete data. This will result in summary numbers not being consistent from table to table in the text of this report. A complete list of all sites with as much location data as possible is provided in the Appendices to this report.

RESULTS

I trapped an average of 24 sites each year (Table 1). Occupancy rates by woodrats varied from 46% of the sites occupied in 1998 to 86% occupied in 1992. Occupancy rates do not reflect trends in woodrat population status but rather in the quality of sites as woodrat habitat. At first, the "easy" or "better" sites were trapped. In later years, a subset of sites was randomly chosen from a list provided by DGIF and USFS personnel. These sites undoubtly were not all suitable for woodrats but once randomly chosen from the list of sites available they were trapped if they meet our subjective criteria for expanse, location, accessibility and rock/crevice characteristics.

Throughout the study a total of 506 individual woodrats were caught 1,366 times in 11,021 trap nights of effort. Neither the number of sites trapped each year nor the effort was consistent from year to year but varied due to funding priorities. A total of 288 visits were made to 189 sites. I made 190 visits to survey sites throughout the study with some sites trapped in multiple years. The remaining visits were multiple visits to LTM sites throughout the study. At survey sites, I collected 240 woodrats in 2901 trap nights. Trapping effort and number of woodrats caught by others is not reported here. The overall occupancy rate for all woodrat survey sites visited and trapped during this study was 64.1% (Table 2).

Table 1. Number of Allegheny woodrat survey sites trapped each year and yearly occupancy rates by woodrats for sites in Virginia, 1990-2000. Sites trapped more than once in a year are counted only once in that year. Sites trapped by cooperators are excluded.

	Year										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Sites trapped each year	14	34	14	11	30	26	47	11	52	16	13
Sites with woodrats present	9	17	12	9	24	20	31	8	24	10	10
Percent of sites occupied	64	50	86	82	80	77	66	73	46	63	77

Table 2. Summary of all trapping effort at 189 survey sites in Virginia, 1990-2000.

Year	Trapped By	Number of Sites Trapped	Percent Active	Number of Trap Nights	Number of Woodrats Caught
1990	MTM[1]	11	54.5	222	16
	USFS	1	100.0		
	MTM	27	48.1	400	22
	USFS	1	0.0		
1992	MTM	12	75.0	214	37
1993	MTM	6	66.7	182	18
	MTM	19	73.7	382	47
	USFS	5	100.0		
	McSHEA	2	100.0		
	DGIF	1	100.0		
	MTM	9	44.4	185	15
	USFS	7	100.0		
	McSHEA		100.0		
	DGIF	3	100.0		
	MTM	42	61.9	494	44
	USFS	2	100.0		
	MTM	4	75.0	45	5
	USFS	1	100.0		
	McSHEA	1	100.0		
	MTM	39	51.2	577	24
	McSHEA	1	100.0		
	DGIF	1	100.0		
1999	MTM	8	50.0	100	6
2000	MTM	4	100.0	100	6
	USFS	2	0.0		
TOTAL		209[2]	64.1	2901	240

[1] MTM = Mengak; USFS = US Forest Service; McSHEA = Dr. W. McShea, Cons. Res. Center; DGIF = Dept. of Game and Inland Fisheries.

[2] Total exceeds 189 survey sites because some sites were trapped in more than one year.

The amount of trapping effort (percent of all trap nights) was greatest in 1998 (14% of all trap nights) followed by 1996 and 1994 – each year's effort was over 10% of the total effort (Figure 1). The years with the least effort were 1990 and 2001 – the first and last years of the project, respectively. Effort in all years was related to funding and availability of seasonal assistants.

Survey Site Summary

Throughout this study, I identified 253 sites as potential woodrat habitat. Forty-four (17.4%) were historic sites with records dating from as early as 1896 (Potomac River, 10 mi above Washington, D.C.; USNM Number 086450). Two hundred nine sites (82.6%) were recent sites. Of the 44 historic sites, 14 (31.8%) were active at the time of trapping (Table 3). Of the recent sites,

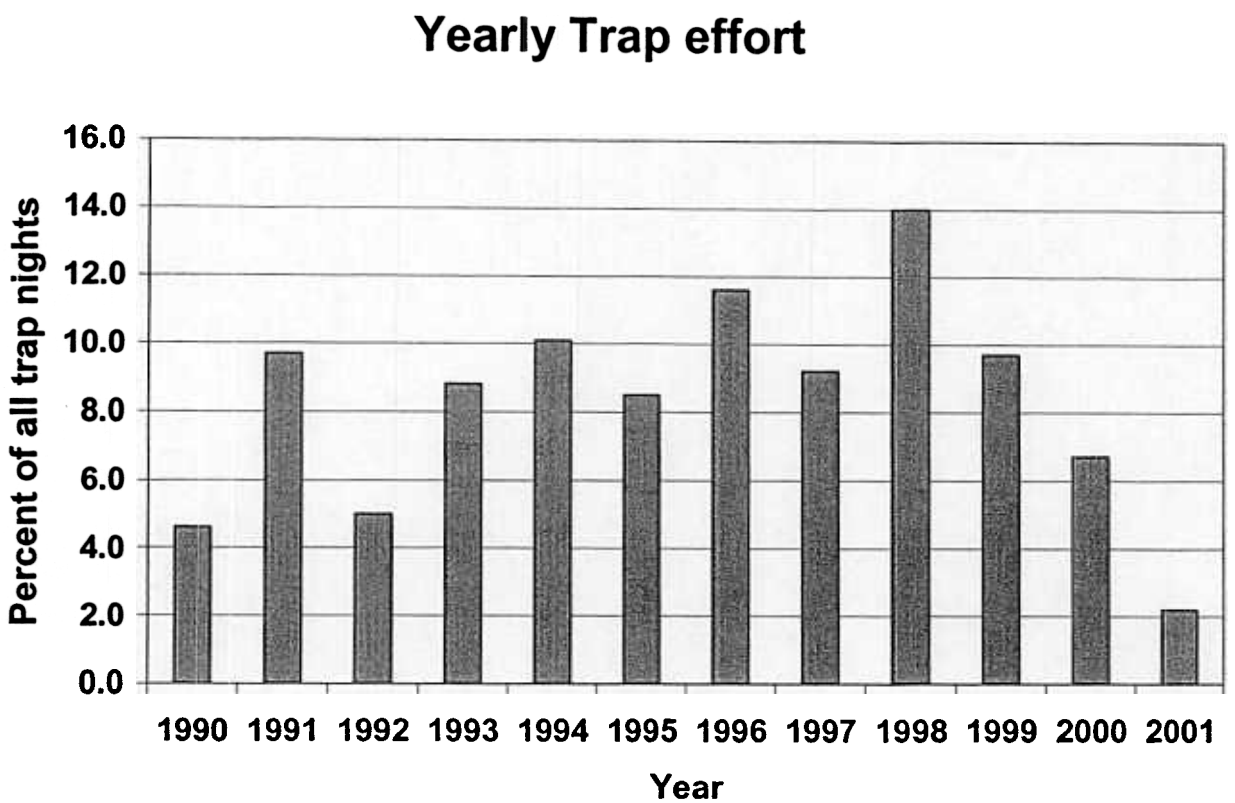


Figure 1. Percent of total trapping effort (TN=11,021) by year at all woodrat sites trapped in Virginia, 1990-2001.

105 (50.2 %) were active at the time of trapping or observation (Table 3). Therefore, trapping data or reliable observations (from mammalogists, USFS or DGIF biologists) are available for 191 (75.5%) of the 253 sites identified in this study. Of these sites, 119 (62.3%) were occupied by at least one Allegheny woodrat on the date of trapping or observation (Table 3).

A total of 189 sites were trapped throughout this study. I trapped 144 sites (Appendix A.1). Of these sites, 123 were visited only once and 55 (45.1%) were active. Forest Service, DGIF and others trapped 35 sites (Appendix A.2). Sites were located in 32 counties within the woodrats' range primarily on federal (national park or national forest) lands. Fewer than 15% of these sites were on private lands.

Of the 144 survey sites I trapped in this study, 22 (15.3%) were trapped more than once. This allowed me to examine whether woodrat sites remain occupied or if the site is unoccupied for a time – "local extinction" in the terminology of conservation biologists (Meffe and Carroll, 1997). Nine survey sites were trapped twice. Of these nine sites, one (Chimney Run) was not occuppied on

Table 3. Summary classification of all 253 woodrat sites in Virginia based on sites identified by trapping or from museum records and field notes.

Classification	Number	Percent of Classification	Percent of All Sites
Historic Sites	44		
Active	14	31.8	
Inactive	15	34.1	5.9
Unknown	15	34.1	
Recent Sites	209		
Active	105	50.2	41.5
Inactive	57	27.3	22.5
Unknown	47	22.5	18.6

Table 4. Frequency of occupancy (A=active; I=inactive) of 22 survey sites trapped on multiple occasions during the Allegheny woodrat project in Virginia, 1990-2000.

	YEAR										
Site Name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Trapped Two Times											
Back Creek Mtn – Left								A	I		
Bather's Cave				A						I	
Big Hellgate Creek Quarry										A	A
Brady's Cave				A						A	
Chimney Run						I	I				
Dismal Falls		A								I	
Fortney Branch							I	A			
Massanuttan Mtn.	A				A						
SNP-Big Devils Stairs	A				A						
Trapped Three Times											
Campbell Run Hollow								A	A		A
Castle Rock		A			A					I	
Cliff Dale Church							A		A		A
Hanging Rock		I					A		I		
SNP-Bearfence			A		A				A		
SNP-Big Meadows	A				A				A		
SNP-Cresent Rocks			A		A				A		
SNP-Franklin Cliffs			A		A				I		
SNP-Little Stony Man Trail			A		A				A		
Wind Rock			A		A				I		
Trapped Four Times											
SNP-Browntown Overlook			A		I	A			A		
SNP-North Marshall		A			I	A			A		
SNP-Pinnacles Cabin Area	I		A		A				I		

either trapping occasion and 4 were occupied on only one occasion. Of ten sites trapped three times, only six were occupied on all three occasions. Of three sites trapped four times, one was occupied twice and two were occupied three of the four times they were trapped (Table 4).

County Distribution

Twenty-seven counties had active woodrat sites (Table 5). Baily (1946) listed 13 counties where woodrats were recorded in Virginia, while Handley and Patton (1947) listed 17 counties. I recorded reports of woodrat sites in the additional counties of Floyd, Pulaski, Russell and Tazewell but did not trap at these locations. In addition, there are two records from 1899 in the Smithsonian Museum from Buckingham County. The location is listed only as Buckingham County with no details. Woodrats occur west of the Blue Ridge in Virginia although there are no current records for 11 counties in southwestern Virginia (Figure 2). Woodrats have been historically known from 3 counties along the south shore of the Potomac River, but were not collected there during this study.

It is likely that woodrats occur in the 11 southwestern counties shown between the cluster of known active counties in Figure 2 including the counties of Bland and Montgomery where trapping occurred but no animals were collected. Additional trapping is needed to confirm the occurrence of woodrats in these 11 counties.

Linzey (1998) included three counties in his range description - Albermarle, Culpeper and Fauquier – even though there are currently no known records of colonies. Trapping in these three counties will complete the distribution map for Virginia.

In summary, the range of the woodrat was confirmed in 27 counties or twice as many counties as reported by Bailey (1949) and 58% more counties that reported in Handley and Patton (1947). Additional trapping in those counties shown in Figure 2 will complete the distribution map for Virginia. Further, 190 sites were trapped throughout this study. Woodrats were confirmed as present in 53.1% (77 of 145) of the survey sites and 60.0% (108 of 180) of survey sites when data from cooperators is included. Valuable data on the natural history, habitat characteristics and distribution of the woodrat were collected during the 11-years of this study. A complete list of all sites trapped in this project, site status, date of trapping and site location is given in Appendix A.3. A list of sites that may have woodrats but were not trapped is given in Appendix A.4.

Table 5. List of counties with active and inactive woodrat sites as determined by trapping from 1990-2000.

County	Number of Active Sites	Number of Inactive Sites	Total	Other Authors[1]
Alleghany	17	7	24	
Amherst	1	0	1	
Augusta	7	6	13	
Bath	11	9	20	B, HP
Bedford		4	5	B, HP
Bland	0	1	1	B, HP
Botetourt	4	0	4	HP
Clarke	0	2	2	
	2	2	4	
Dickenson	2	3	5	
Fairfax	0	7	7	B, HP
Franklin	2	0	2	
Frederick	3	0	3	HP
Giles	12	3	15	B, HP
Greene	2	0	2	
Highland	1	0	1	B, HP
Lee	1	0	1	
Loudoun	0	4	4	B, HP
Madison	2	0	2	
Montgomery	0	1	1	
Nelson	6	0	6	
	5	3	8	
Patrick	1	1	2	
Rappahannock	6	1	7	B, HP
Roanoke	1	0	1	HP
Rockbridge	14	6	20	

Table 5. Continued.

County	Number of Active Sites	Number of Inactive Sites	Total	Other Authors[1]
Rockingham	3	3	6	
Scott	5		6	
Shenandoah	3	2	5	
Warren	3	1	4	B, HP
Washington	1	0	1	
Wise	2	3	5	
Counties not trapped in this study but reported by others.				
Buchanan				B, HP
Pualski				B
Russell				B, HP
Tazewell				B, HP
Wythe				HP

[1] B = Bailey (1946); HP = Handley and Patton (1947).

Long-term Trend Monitoring (LTM)

One of the most useful aspects of this project was the annual trapping of long term monitoring (LTM) sites. Initially four sites were monitored (including one on NPS land). Monitoring sites were added as Forest Service personnel assumed more responsibility for additional sites. Sites ranged from the Lee District in the north to the Clinch District in southwest Virginia. In 1997, two LTM sites were designated for more intensive trapping. Trapping was conducted at these two sites approximately every 60-70 days, weather permitting. This provided additional information on woodrat life history and year-round changes in woodrat populations.

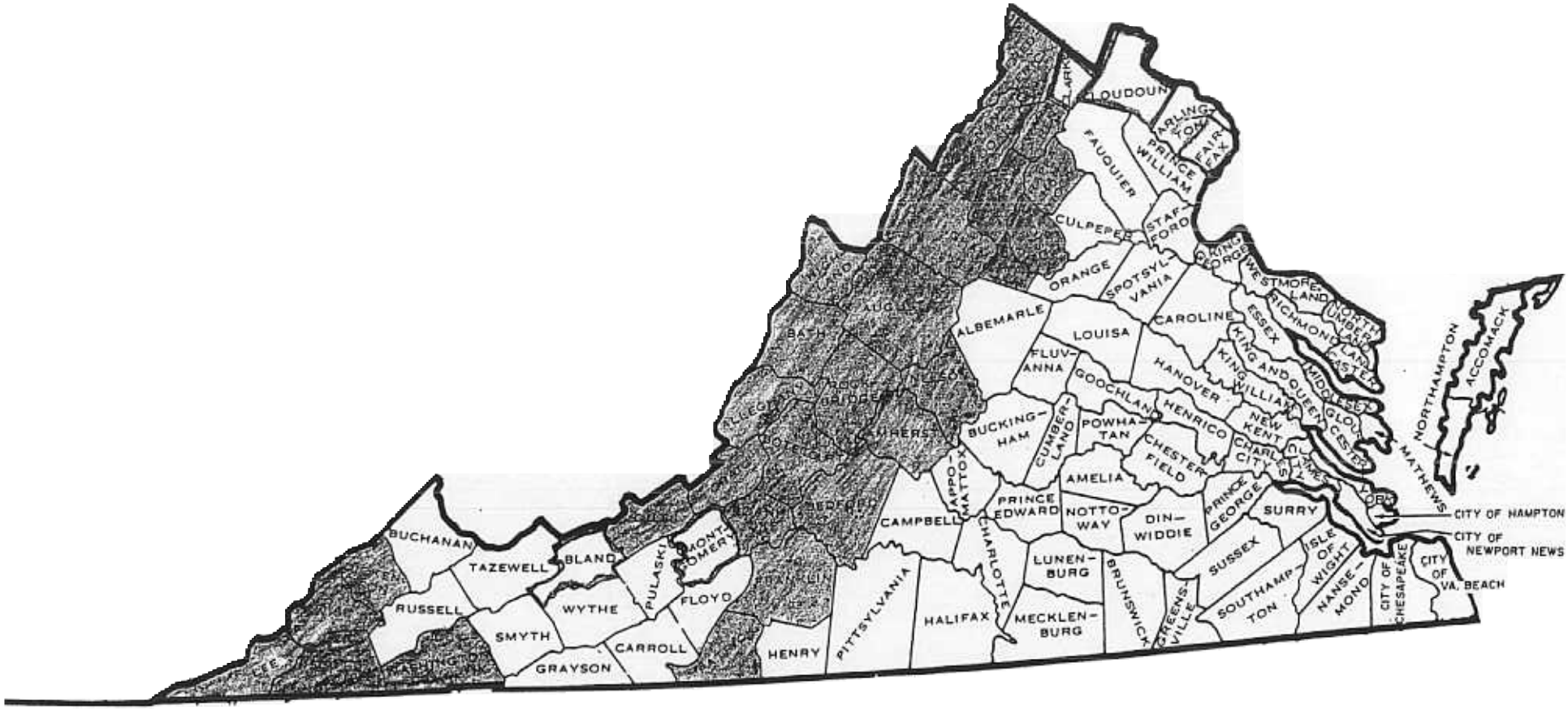


Figure 2. Map of Virginia with counties shaded to indicate Allegheny woodrat captures during the period covered by this study, June 1990 to July 2000.

The total number of woodrats captured at a LTM site during the annual fall monitoring varied from a high of 20 individuals to a low of zero (Table 6). At all LTM sites, the annual number of captures fluctuated - often moving from highest to lowest in 1-2 years. The capture index, expressed as number of woodrats caught per 10-trap nights effort is shown in Table 7. The capture index reflects the relative population level during the annual fall monitoring. The actual number of woodrats occupying a site year-round could be higher or lower.

At the Butt Mountain site in Giles County, the capture index fell rapidly twice during the study. In the first year (1990), 20 individuals were collected but the captures fell to just 3 animals in 1991. The capture index rose to another peak from 1995-1997. During 1997, several trapping sessions revealed that there were as many as 32 individually tagged woodrats at the sites with 20 individuals caught during the fall monitoring period. However, trapping in April, June and August 1998 failed to capture a single woodrat. One untagged adult male was collected in October 1998. The population remained very low at this site through 2000 when trapped ended.

Somewhat similar things occurred at both Devil's Marbleyard in Rockbridge County and The Stacks in Allegheny County. At the Marbleyard, the number of woodrats capture went from 10 in 1994 and 1995 to zero in 1999. At The Stacks, the number went from 14 in 1996 to just 3 individuals in 1999.

Close examination of Tables 6 or 7 fails to reveal any consistency in the timing of high or low capture indexes. For example, Butt Mountain had a peak capture index in 1990 and 1997, a span of 7 years. Star Chapel had a peak capture index in 2000 but generally had a low fall population. Devil's Marbleyard had a peak in 1994 and 1995 but a low of zero in 1999, a span of only 4 years. Neither the peak nor the low coincided with peaks or lows at other sites. The Stacks had its peak year in 1996 and a low 3 years later in 1999 again not coinciding with other sites.

I calculated the relative abundance of woodrats at each LTM using the Lincoln-Peterson (L-P) estimator. Trends, as expected, were similar to catch per 10 trap night data. Close examination of Table 6 (actual number of woodrats caught during each monitoring period) and Table 8 (L-P estimator of woodrat abundance) reveals very close correlation between the values. Correlation coefficients were 0.987 for Butt Mountain; 0.945 for Star Chapel; 0.947 for Rocky Mountain; 0.991 for Devil's Marbleyard; 0.938 for Elizabeth Furnace; 0.943 for Bluff's Trail; 0.705 for The Stacks

Table 6. Total number of Allegheny woodrats (*Neotoma magister*) captured during annual fall monitoring at long-term monitoring (LTM) sites in Virginia, 1990-2001.

Monitoring Site Name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Butt Mountain	20	3	9	7	9	16	16	20	1	2	3	
Star Chapel Cave	5	6	8	3	4	2	3	4	8	8	12	
Elizabeth Furnace	5	3	2	3	2	4						
Bluff's Trail	4	5	5	3	5	3						
Rocky Mountain					2	2	1	2	5	3	1	
Devil's Marbleyard					10	10	4	6	1	0	4	2
Sulphur Springs Gap						6	6	3	6	2	0	0
The Stacks						6	14	12	5	3	5	7
Osbourne Ridge										4	6	2
TOTAL	34	17	24	16	32	49	41	47	26	22	31	12

Table 7. Capture index (animals caught per 10 trap nights effort) of Allegheny woodrats (*Neotoma magister*) captured during annual fall monitoring at long-term monitoring (LTM) sites in Virginia, 1990-2001.

Monitoring Site Name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Butt Mountain	2.52	0.38	1.27	0.92	1.24	2.05	2.11	2.70	0.13	0.26	0.41	
Star Chapel Cave	0.63	0.75	1.06	0.39	0.51	0.38	0.52	0.41	1.02	1.03	1.60	
Elizabeth Furnace	0.64	0.38	0.26	0.39	0.25	0.50						
Bluff's Trail	0.83	0.64	0.68	0.40	0.67	0.78						
Rocky Mountain					0.30	0.26	0.13	0.54	0.63	0.39	0.13	0.26
Devil's Marbleyard					1.27	1.31	0.51	0.81	0.13	0.00	0.52	0.27
Sulphur Springs Gap						0.79	0.38	0.83	0.25	0.00	0.00	
The Stacks						0.75	1.57	1.87	0.65	0.75	0.62	0.89
Osbourne Ridge										0.52	0.77	0.25

Table 8. Allegheny woodrat abundance estimates (± SE) using the Lincoln-Peterson estimator and mark-recapture data from 9 long term monitoring sites in Virginia, 1990-2001.

Site Name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Butt Mountain	21.4	3.0	9.0	7.8	8.8	20.7	17.2	20.9	1.0	2.0	5.0	
	(2.2)	(0.0)	(0.0)	(1.1)	(1.10	(3.8)	91.40	(1.2)	(0.0)	(0.0)	(1.4)	
Star Chapel	3.0	7.3	8.8	3.0	4.0	3.0	4.0	3.0	8.6	8.0	17.0	
	(0.0)	(1.7)	(1.1)	(0.0)	(0.0)	(0.0)	(0.0)	(3.0)	(1.0)	(0.0)	(4.2)	
Elizabeth Furnace	9.0	3.0	3.0	3.0	2.0	[1]						
	(4.5)	(0.0)	(0.0)	(0.0)	(0.0)							
SNP-Bluff Trail	7.0	7.0	7.0	3.5	6.5	[2]						
	(3.5)	(2.3)	(2.3)	(0.9)	(1.9)							
Rocky Mountain					2.0	2.0	1.0	2.0	5.7	5.0	1.0	1.0
					(4.2)	(0.0)	(0.0)	(0.0)	(1.1)	(1.4)	(0.0)	(0.0)
Devil's Marbleyard					11.6	9.9	5.0	6.5	1.0	0.0	4.0	2.0
					(1.8)	(0.0)	(1.4)	(0.9)	(0.0)	(0.0)	(0.0)	(0.0)
Sulpher Springs Gap						9.0	1.4	6.5	2.0	0.0		
						(4.5)	(0.4)	(0.9)	(0.0)	(0.0)		
The Stacks						7.3	9.8	19.0	6.5	6.5	5.7	7.4
						(1.7)	(1.2)	(4.9)	(1.9)	(0.9)	(1.1)	(0.7)
Osbourn Ridge									2.0	4.0	6.5	3.0
									(0.0)	(0.0)	(0.9)	(1.4)

[1] No recaptures; no estimate

[2] One night of trapping.

and 0.462 for Sulphur Springs Gap. These values suggest that the monitoring protocol was very successful in catching the majority of the woodrats present at the site.

I used Program CAPTURE to estimate population size of LTM sites during years when absolute number of captures was $\geq$ 10 individuals. Seven LTM observations fit the criteria (Table 6). This analysis revealed that the estimated woodrat population size varied from 15 to 20 individuals again agreeing closely with number of actual captures. The 95% confidence intervals ranged from 11 to 33 individuals (Table 9). Only at Butt Mountain in 1990 did the actual catch exceed the population estimate. Confidence interval estimates were generally narrow expect at The Stacks in 1997 and Star Chapel Cave in 2000. In both cases, 12 individual woodrats were caught in two nights of trapping but only 4 and 3 woodrats were recaptured on the second night at The Stacks and Star Chapel Cave, respectively. This resulted in the high standard error estimates and wide confidence intervals.

Woodrat populations showed a declining trend at Butt Mountain, Devil's Marbleyard and The Stacks (Figure 3a and 3b). The trend was increasing at Star Chapel Cave largely on the strengh of the 2000 sample year. The overall trend in abundance was flat at the other LTM sites (Table 6). The regression coefficient was significant only at Devils Marbleyard ($F=12.56$, $P = 0.012$, d.f. =1,6).

Site Occupancy

I used survey site data (Appendix A.1) and the number of individuals captured at each site in Program PRESENCE to estimate a detection probability and to determine the sample size needed to detect a change in site occupancy rates. Simulation results indicated that the overall detection probability of a woodrat in a trap was 0.0942 or 9.42%. The average simulation based estimate of site occupancy was 85.5% compared to the observed site occupancy of 64.1% (Table 2). The minimum sample sized needed to observe a change in the number of sites occupied would be 27 sites in order to detect a 10% change in mean occupancy rates with the error rates set at 0.05 and 0.1 for Type I and Type II errors, respectively. Changing the error rates and the minimum detectable change in mean occupancy levels increases or decreases the sample size (Table 10).

Table 9. Allegheny woodrat population estimates (N) and model estimates for other parameters for selected site and year combinations based on models in Program CAPTURE.

Site	Year	Model[1]	Actual Catch	$\hat{N}$	s.e.[2]	$\hat{p}$[3]	$\hat{c}$[4]	95%Confidence Interval Lower	Upper
Butt Mountain	1990	Zippen	20	19	1.14	0.82	0.600	12	26
Butt Mountain	1995	M_t	16	18	2.16	0.50	----[5]	17	27
Butt Mountain	1996	M_t	16	16	0.70	0.79		16	20
Butt Mountain	1997	Zippen	16	20	0.49	0.91	0.67	20	20
Star Chapel	2000	M_t	12	17	4.26	0.42	----	14	33
Devils Marbleyard	1994	M_t	10	11	1.06	0.56	----	11	15
The Stacks[6]	1996	M_o	14	15	2.64	0.43	----	14	26
The Stacks	1997	Zippen	12	15	6.61	0.51	0.57	13	51

[1] See Otis et al. (1978) for model explanation.

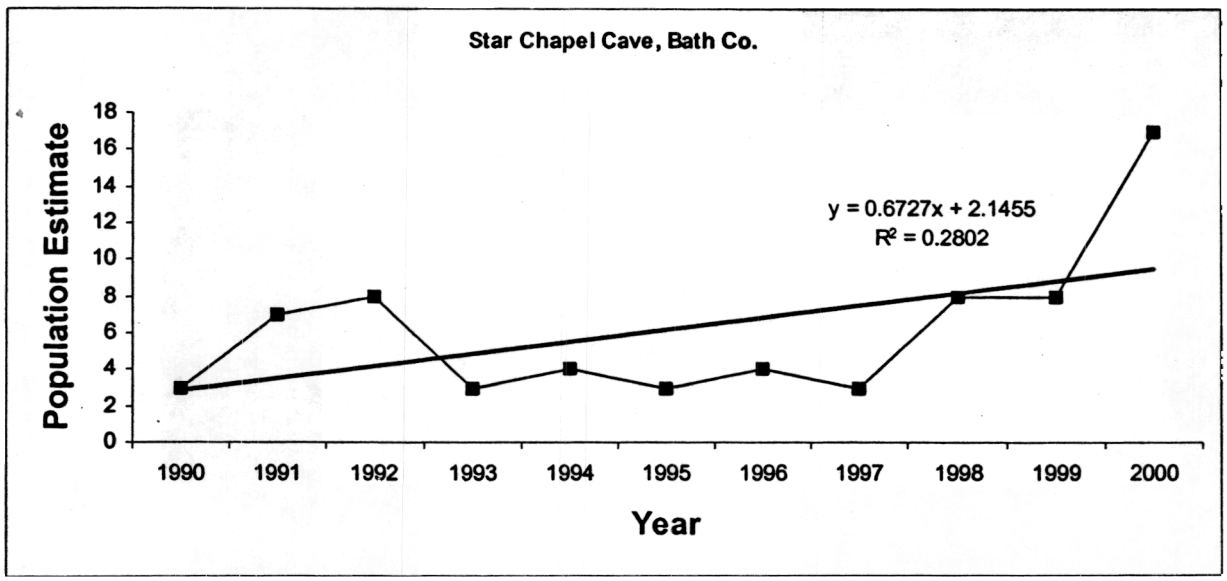
[2] Estimate of standard error.

[3] Probability of capture.

[4] Probability of recapture.

[5] Model does not calculate probability of recapture

[6] The Stacks was trapped for 3 consecutive nights in 1996. Parameter estimates are based on 3 nights trapping.



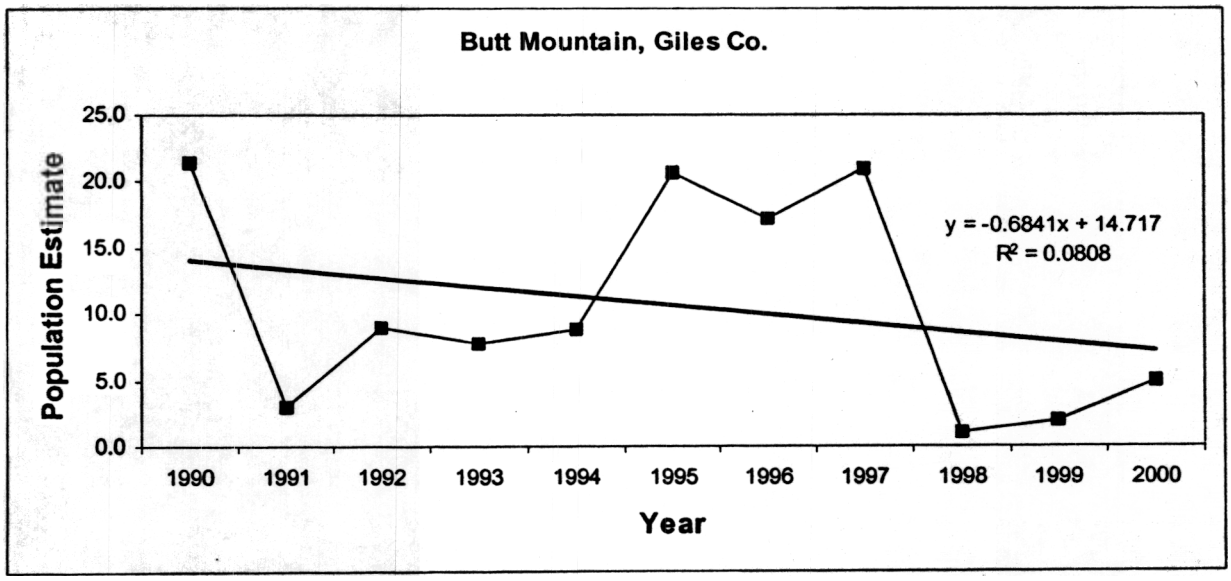
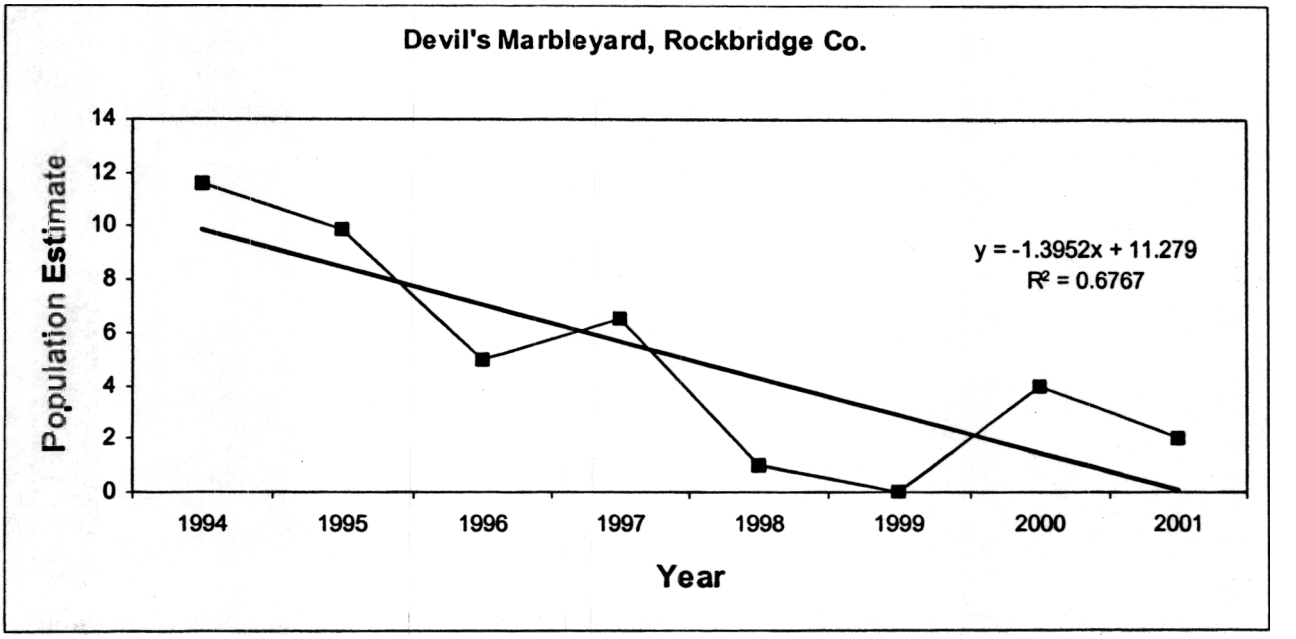


Figure 3a. Population estimates and trendline for woodrat at two long-term monitoring sites in Virginia.



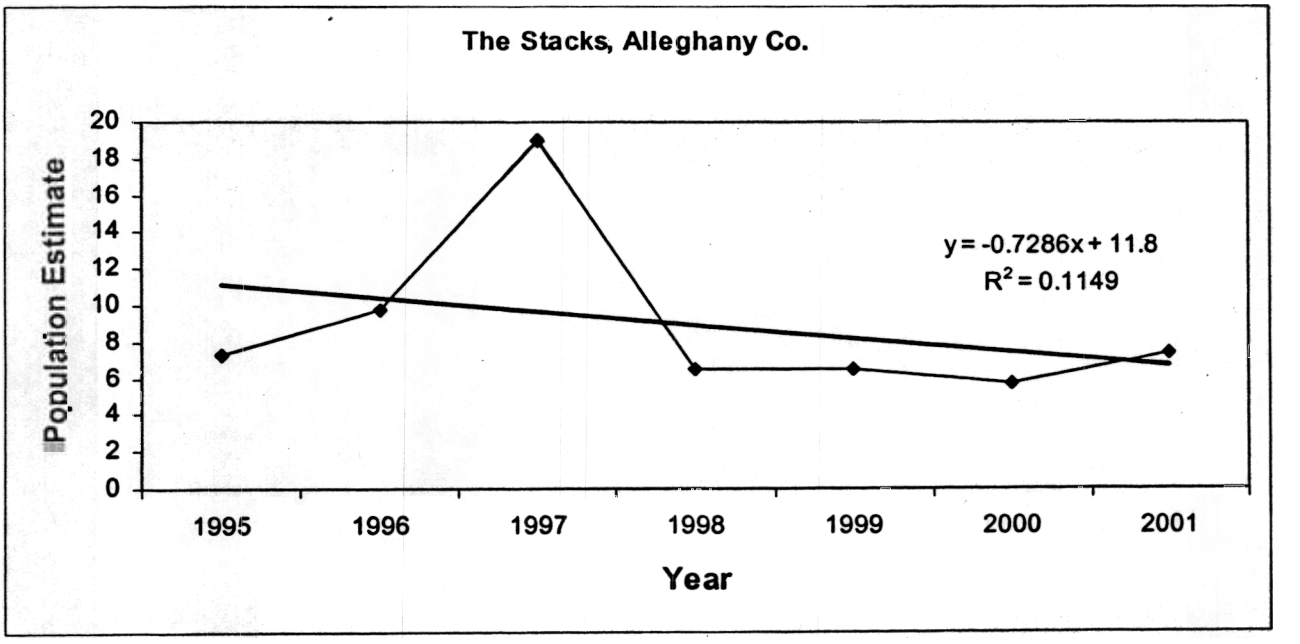


Figure 3b. Population estimates and trendline for woodrat at two long-term monitoring sites in Virginia.

Table 10. Comparison of the effects of changing the Type I (alpha) and Type II (Beta) error rates on the required number of survey sites to sample in order to detect a specifed change in detectable occupancy.

Minimum Detectable Change in Mean Occupancy Rates (%)	Apha	Beta = 0.2	Beta = 0.1	Beta = 0.05
5	0.05	78	108	
10	0.05	19	27	34
15	0.05	9	12	15
20	0.05	5	7	9
25	0.05	3	4	5
5	0.1	57	83	108
10	0.1	14	21	27
15	0.1	6	9	12
20	0.1	4	5	7
25	0.1	2	3	4
5	0.2	36	57	78
10	0.2	9	14	19
15	0.2	4	6	9
20	0.2	2	4	5
25	0.2	1	2	3

Two LTM sites were trapped at times other than the annual monitoring periods. Butt Mountain, Giles Co. was trapped 24 times over 11 years including three to four times per year from 1996-1999. The Butt Mountain.population fluctuated from a high population in 1990 to a low in 1991 followed by another high in 1996 through 1997 and a total collapse in 1998 (Table 11). Of particular interest is the period 1996-1998. During the period, the population was at its highest level

for 2 years and completely disappeared in a span of 6 months. In 1997, 32 different individuals were regularly trapped at this site. Six months later (April 1998) not a single woodrat was caught. This situation persisted for 3 trap sessions in 1998 until a lone, unmarked male was collected in October 1998. The population began a slow recovery to 5 individuals in May 2000 when all trapping ceased.

The second intensively trapped site was Star Chapel Cave in Bath County. This site was trapped 30 times in 11 years including monthly in fall 1993 and bi-monthly for most of 1998 and 1999 (weather permitting). The population size was generally low (i.e., 2 to 6 animals) but increased to 15 animals in June 1999 (Table 12). The fluctuation and collapse seen at Butt Mountain was not seen at Star Chapel.

DISCUSSION

Lindzey (1998) indicated the entire western mountain region of Virginia as well as a portion of the Piedmont within the Allegheny woodrats' range but he did not list individual counties with actual woodrat colonies. Linzey's (1998) map indicated that all or portions of 51 counties are within the Virginia range of the Allegheny woodrat including counties with no museum records. Furthermore, Linzey (1998) shows a map of North America with the range of both the eastern and the Allegheny woodrat combined but labels the map as Allegheny woodrat. Clearly, errors in Linzey's state and national maps indicate that revisions are warranted. Results from my project are the most complete summary of the county-by-county range of the Allegheny woodrat in Virginia currently available. Additional trapping is necessary to complete the distribution map for Virginia.

Since survey sites were often trapped for two nights if no woodrats were collected on the first night, it is reasonable to assume that the survey site data in Appendix A.1 are an accurate reflection of the actual site occupancy. Howerver, I acknowledge that even with two nights of trapping a woodrat may not be caught leading to the false conclusion that the site is unoccupied. Further trapping would then be required but this must be balanced with time and cost limitations.

Of the 22 survey sites I trapped more than once, only one (Chimney Run-Bath Co.) was not occupied on either trap occasion. The other 21 survey sites were occupied on at least two trap visits. However, the fact that some sites appeared unoccupied at a visit indicates that either a woodrat was present but not caught or woodrat occupancy changes over time. Therefore, multiple visits may be required to be certain that woodrats have disappeared from a site. Given that, in most instances,

Table 11. Population estimates (Lincoln-Peterson estimator) based on results of all trapping sessins at Butt Mountain, Giles Co. an intensively studied site. This table lists woodrat captures during both the annual fall monitoring and the many periodic sampling visits that occurred between monitoring visits between June 1990 and July 2000. Sampling protocal included 40 live traps set for 2 nights.

Date	Population Estimate (N)	S.E.	95% Confidence Interval Upper	Lower
Oct 6-7 1990	21.4	2.2	25.7	17.1
Jun 18-19 1991	4.0	0.0	4.0	4.0
Sep 7-8 1991	3.0	0.0	3.0	3.0
Oct 2-3 1992	9.0	0.0	9.0	9.0
Jun 3-4 1993	7.8	1.1	10.0	5.5
Oct 17-18 1993	7.8	1.1	10.0	5.5
Apr 17-18 1994	6.0	0.0	6.0	6.0
Oct 1-2 1994	8.8	1.1	11.0	6.6
Oct 14-15 1995	20.7	3.8	28.1	13.2
Apr 20-21 1996	25.4	6.1	37.3	13.5
Jun 18-19 1996	20.0	2.0	23.8	16.2
Aug 24-25 1996	17.2	1.4	20.0	14.4
Apr 4-5 1997	15.3	0.6	16.3	14.2
May 29-301997	17.0	4.2	25.3	8.7
Aug 25-26 1997	18.7	1.0	20.6	16.8
Oct 11-12 1997	20.9	1.2	23.3	18.6
Apr 25-26 1998	0	0	0	0
May 26-27 1998	0	0	0	0
Aug 22-23 1998	0	0	0	0
Oct 15-16 1998	1.0	0.0	1.0	1.0
Apr 24-25 1999	1.0	0.0	1.0	1.0
Aug 3-4-1999	1.0	0.0	1.0	1.0
Oct 2-3 1999	2.0	0.0	2.0	2.0
May 10-11 2000	5.0	1.4	7.8	2.2

Table 12. Population estimates (Lincoln-Peterson estimator) based on results of all trapping sessins at Star Chapel Cave, Bath Co. an intensively studied site. This table lists woodrat captures during both the annual fall monitoring and the many periodic sampling visits that occurred between monitoring visits between June 1990 and July 2000. Sampling protocal included 40 live traps set for 2 nights.

Date	Population Estimate (N)	S.E.	95% Confidence Interval Upper	Lower
Oct 6-7 1990	3.0	0.0	3.0	3.0
Sep 1-2 1991	7.3	1.7	10.6	4.1
May 29-30 1992	17.7	5.6	28.6	6.7
Sep 19-20 1992	8.8	1.1	11.0	6.6
May 27-28 1993	2.0	0.0	2.2	2.0
Sep 18-19 1993	3.0	0.0	3.0	3.0
Oct 9-10 1993	3.0	0.0	3.0	3.0
Nov 13-14 1993	3.0	0.0	3.0	3.0
Dec 4-5 1993	4.0	0.0	4.0	4.0
Apr 1-2 1994	4.0	0.0	4.0	4.0
Jun 15-16 1994	5.0	2.4	9.8	0.2
Oct 3-4 1994	4.0	0.0	4.0	4.0
May 15-161995	4.0	0.0	4.0	4.0
Oct 7-8 1995	3.0	0.0	3.0	3.0
Jun 20-21 1996	5.0	1.4	7.8	2.2
Aug 17-18 1996	4.0	0.0	4.0	4.0
Oct 17-18 1996	4.0	0.0	4.0	4.0
May 15-16 1997	2.0	0.0	2.0	2.0
Nov 23-24 1997	3.0	0.0	3.0	3.0
Apr 10-11 1998	2.0	0.0	2.0	2.0
Jun 20-21 1998	2.0	0.0	2.0	2.0
Sep 6-7 1998	6.5	0.9	8.2	4.8
Nov 11-14 1998	8.6	1.0	10.5	6.7
Feb 13-14 1999	5.0	0.0	5.0	5.0
Apr 5-6 1999	7.0	0.0	7.0	7.0
Jun 19-20 1999	15.0	0.0	15.0	15.0
Aug 6-7 1999	14.0	0.0	14.0	14.0
Oct 17-18 1999	8.0	0.0	8.0	8.0
Apr 21-22 2000	9.5	0.9	11.2	7.8
Jul 15-16 200	17.0	4.2	25.3	8.7

only one or two woodrats were caught at a survey site, it would be easy for the site to become vacant due to a random death from predation, disease or accident. The source of recolonization of previously occupied sites was not investigated in this study although that would be vital information for future management and protection activities involving woodrat populations.

Four measures of population abundance were available – actual number of woodrats caught, catch per 10 trap nights, Lincoln-Peterson estimator and CAPTURE output. As expected, results from each of these measures were in close agreeement. Further, each measure revealed that the overall abundance of woodrats at a LTM site is low (i.e. captures varied between 0 and 20).

I trapped 145 sites (Appendix A.1) and cooperators trapped an additional 35 sites (Appendix A.2) throughout this study. Many sites – including LTM sites – were trapped multiple times. This gives us an accurate picture of woodrat occurrence in Virginia. Woodrats are known to occur in 27 counties. They are likely to occur in the 11 counties of southwest Virginia where no trapping occurred but where reliable records area vailable. It is doubtful if woodrats occur in nine counties just east of the Blue Ridge – Prince William, Fauquier, Culpeper, Orange, Louisa, Fluvanna, Buckingham, Appomattox and Campbell. Subtracting these nine counties from the 51 counties on Linzey's (1998) map leaves 42 counties in the Allegheny woodrat's range. This study documented woodrat occurrence in 27 (65.8%) counties and suggested their occurrence in 11 additional counties or 91% of their potential range. It now seems certain that woodrat have been extirpated from counties along the Potomac River.

While the extensive distribution of woodrats in Virginia is not in doubt, their long-term survival prospects are not certain. They occur in isolated locations with few individuals per location. They commonly disappear from individual locations (Table 4). Even sites with high population levels (i.e. several LTM sites) saw the population decline to zerop within a short time (Tables 6-8). Population estimates confrim that woodrats are not abundant within a site (Tables 8 and 9) and the monitoring protocal used in this study was succesful at detecting the woodrats that are present at LTM sites.

It is very unlikely that the monitoring protocol detected significantly fewer woodrats than were acutally present. I acknowlege the possibility that not all woorats present at a LTM site were caught every monitoring period. However, repeated trapping at two sites – Butt Mountain and Star Chapel Cave – clearly shows that over time most or all woodrats at a site will be captured (Tables 11

and 12). When the standard error of the Lincoln-Peterson estimate is 0 and the confidence bounds equal the estimate (N), then all the animals marked on night 1 are recaptured on night 2. Of course, this does not prove that all animals are caught but when repeated trapping fails to produce any untagged individuals one may assume all trappable animals are being collected.

Clearly, woodrat populations are not high or dense at the intensively trapped sites (Tables 11 and 12). Only once in 11 years did the Lincoln-Peterson population estimate exceed 20 indiviudals (Butt Mtn., April 1996, Table 11). Low abundance of woodrats at LTM sites (presumably the most extensive habitat available, hence their inclusion as an LTM site) and the presence of only one or two individuals at survey sites along with the geographically sepearated survey sites clearly indicates the sparse nature of woodrat distribution. This further complicates management efforts and increases the likelihood that individual colonies will become devoid of woodrats. Recolonization of these colonies is problematic and requires a source population within the travelling range of the woodrat. This argument leads to the conclusion that woodrats in the Ridge and Valley and Blue Ridge Provences of Virginia are functioning as isolated colonies and the entire woodrat complex is acting as a metapopulation. The corresponding source and sink populations were not identified in this study but presumably exist since both survey and LTM sites lost woodrats and were then recolonized (Tables 4 and 6).

The total collapse of the most abundant woodrat population in Virginia (Butt Mtn., Oct 1997 to April 1998) raises further questions about long term survival, recolonization, source-sink dynamics, population bottlenecks, founder effects and other conservation biology questions. Unfortunately, no answers are available to these very interesting questions. Only further study, including manipulative research, could answer these questions. That the two intensively studied populations behaved so differently over the same time period indicates that woodrats are responding to some stimulus unknown from this study.

Taken together, these two sites further support the conclusion that woodrats do not occur in high numbers at a site. Also, the trapping protocal was successful in capturing most, if not all, individuals at a site. Intensive and repeated trapping provided information on reproduction (Mengak 2002a), home range (Mengak 2002b), longeviety (Mengak 1997 and 2000), and reproduction, survival and growth rates (Mengak 2002a).

A recent study has examined woodrat population structure using microsatellite DNA analysis (Castleberry et al., 2002c). This analysis suggests that across the woodrats range in Virginia and West Virginia, isolation by distance is occurring. The relationship between genetic distance and geopraphic distance across the central Appalachians was significant. Castleberry et al. (2002c) state that all statistical tests indicated significant genetic subdivision at both the population and subpopulation levels. Not suprisingly, Castleberry et al. (2002c) found frequent gene flow among individuals inhabiting rock outcrops within subpopulations. Castleberry et al. (2002c) found, however, that the isoloation-by-distance effect is more pronounced at a large scale suggesting gaps in gene flow across the species distribution. They concluded that forested dispersal corridors are critical to maintaining gene flow and genetic structure within subpopulations.

Low population abundance (Tables 6,7 and 8), frequent loss of a colony at individual sites (Tables 4 and 6), declining abundance at monitoring sites (Table 8, Figures 3a and 3b), absence of woodrats at 34% of historic sites, and loss of some historic sites to development (Appendix A.2) clearly suggests that the long term survival of the Allegheny woodrat in Virginia is in doubt.

Colony isolation, predation, paaraasitism and disease (suspected but as yet undocumented in Virginia), habitat alteration from timber management, lack of a natural fire regime, oak regeneration, and development indicate the tenuous survival prospects facing this species.

The low survival rates (Mengak 2002a; J. Edwards, WVU, pers. comm.), low reproductive rates (Mengak 2002a), colony isolation (this study; Castleberry et al. 2002c) and life history characteristics (Mengak et al. 2002) suggest that woodrats are at increased risk of extirpation throughout their range. Slow reproductive rate and long potential lifespan suggest this species is functioning like a K-selected species (Mengak et al. 2002). Traditonal conservation strategies for rodents may not be applicable to woodrats.

Strategies such as habitat manipulation (e.g. creation of early successional habitat), nest box construction (as for songbirds, waterfowl, bats and flying squirrels), and traditional habitat protection (such as bat gates on caves) may have no impact on woodrats. New strategies such as maintaining sufficient old growth mast producing canopies (Beck 1977; McShea 2000), maintenance of continuously forested corridors, predator control, public education, maintenance of course woody debris such as large

snags and fallen logs, and more may be required to insure the long-term survival of the Allegheny woodrat. It is currently unclear which, if any, of these strategies would improve the survival probability of the Allegheny woodrat. With this background, the following actions are recommended.

Recommendations

Recommendation #1--Continue annual monitoring for 10-20 years at selected sites. This is inexpensive and provides valuable data on long-term changes in population status along with valuable life history information that is currently unavailable. Eight to ten sites should be monitored annually in summer or fall.

Recommendation #2 –Continue to survey additional outcrops, caves and other suitable habitat for presence/absence of woodrats. Fifteen to 30 new sites should be sureyed annually to extend our understanding of woodrat distribution. This would be especially valuable information to incorporate into a GIS spatial model to understand colony distribution, potential areas of woodrat concentrations and potential threats to survival.

Recommendation #3 – Conduct annual presence/absence surveys at 25-30 known woodrat sites. This is a reasonable number of sites for detecting a 10% change in occupancy rate with a 5% Type I error rate (rejecting the null hypothesis when it is in fact true). One night of trapping (two nights if no rats are caught on night 1) with 15 traps requires only 2-man hours of effort per night for a maximum of 108 hours (27 sites x 2 nights x 2 hours per site).

Both recommendations #2 and #3 could be easily assigned to a seasonal intern with wildlife experience at a minimal cost (cost estimate = $2,000 to $3,000 for salary, vehicle and supplies like bait and ear tags). Combining recommendations #2 and #3 would require 2 people, a vehical and approximately $5,000 per year – presumably during summer. Sufficient training would be required to insure competance in handling and tagging live animals.

Annual monitoring is more costly than presence/absence surveys because more trapping effort is involved (40 traps vs. 15 per night and 2 night vs. presumably 1 night or 2 at most).

Recommendation #4 – Secure funding from federal, state, and private grant sources to initiate 2 studies to determine the importance of racoon roundworms, predator impact (a predator removal and predator food habits study), mapping actual and potential colony sites on a GIS platform, habitat

characteristics at coloy sites and intercolony dispersal. This would involve university graduate students (M.S. and Ph.D.) and costs could exceed $150,000.00. Time required for these studies would approach 3 years.

Recommendation #5 – It is time for regional wildlife resource agencies at both the state and federal level to get serious about woodrat research. Non-game studies have, for too long, taken a distant back seat to studies of game species (often for political rather than biological reasons). Scientifically rigorous studies with testable hypothesis are critically needed to address questions such as (1) the role of mammalian and avian predators in woodrat ecology, (2) the role of parasites in woodrat ecology including the actual prevelance of raccoons and *B. procyonis* infected raccoons in the Southern Appalachian mountians, (3) the role of short rotation timber management and loss of mature timber in woodrat ecology, (4) the role of gypsy moth defoliation and loss of oak mast in woodrat ecology, (5) survival and dispersal of woodrats, and (6) general woodrat ecology including food habits, distribution, home range, behavior, reproduction and more.

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Appendix A.1. Activity summary of 145 survey sites trapped by year and occupancy status (0=inactive; 1=active) during surveys for Allegheny woodrats in Virginia, 1990-2000. Table includes occupancy status of LTM sites for comparison.

SITE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ATT TOWER-LOUDEN CO		0									
BACK CREEK MTN - RIGHT									0		
BALD KNOB ROAD - COVINGTON		0									
BARNEYS RUN									0		
BARNEYS RUN UPSTREAM									0		
BOYER FURNACE						0					
BROADTREE SITE							0				
BRP-FLAT TOP	0										
BRP-JOHNSON FARM	0										
BRP-SHARP TOP SUMMIT				0							
BRP-SHARP TOP TRAIL	0										
CAMP ROCK							0				
CAMP TODD									0		
CASCADES I									0		
CASCADES II									0		
CEDAR CLIFFS ON APP. TRAIL							0				
CELLAR MTN TRAIL							0				
CLIFTON FORGE RESERVIOR CAVE									0		
CMB UNIT 22									0		
COBBLER MTN TRAIL								0			
DEMPSEY'S MARLBROOK				0							
DIFFICULT RUN						0					
ELISHA LICK GAP									0		
FAIRYSTONE WMA		0									
FOREST ROAD # 125							0				
FS 512 TRAIL							0				
GOSHEN PASS		0									
HAMILTON CAVE		0									
HARPERS FERRY		0									
HODGES DRAFT							0				
HONE QUARRY									0		
JACKSON RIVER					0						
LIME KILN - BATH CO							0				
LINKS CAVE		0									
LITTLE MOUNTAIN CAVE					0						
LOWER RAWLEY									0		
MARES RUN									0		
MINE MTN RUN						0					
MOOMAW LEFT							0				
MT WEATHER ROAD		0									
MTN GROVE SALTPETER CAVE		0									
NEIL RUN						0					
NEW CASTLE WORKCENTER									0		
NEWPORT TAWNEYS CAVE		0									
NPS-CABIN JOHN BRIDGE									0		
NPS-FAIRFAX CO									0		
NPS-GREAT FALLS									0		
NPS-OPP HOG ISLAND									0		
NPS-OPP PLUMMER'S ISLAND									0		
NPS-POTOMAC RIVER									0		
OLD GROWTH FOREST							0				
OLD MILL CAVE					0						
PAINT BANK									0		
POINT OF ROCKS		0									

Appendix A.1. Continued	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RAINBOW ROCK NORTH							0				
RICH HOLE WILDERNESS									0		
ROAD HOLLOW TRAIL									0		
RT. 733 #1							0				
RT. 733 #2							0				
SHORT HILL MTN											
SIDELING HILLS							0				
SNP-BYRD'S NEST NO. 4					0						
SNP-RATTLESNAKE			0								
SNP-SOUTH MARSHALL			0								
SNP-UPPER HAWKSBILL	0										
STAUNTON AQUEDUCT		0									
UNION SPRINGS I									0		
ARBOGAST SALTPETER CAVE	1										
BALD KNOB											
BARNEYS WALL		1									
BIG SPY MOUNTAIN							1				
BIRCH GAP #2											1
BRP-MP 12.0							1				
BRP-MP 7.6L							1				
BRP-MP 7.6R							1				
BRP-ROCK CASTLE GORGE							1				
CARVENS COVE RESERVIOR		1									
CASCADES III									1		
CHESTNUT RIDGE									1		
CHIMNEY ROCKS CAVE							1				
CLARKS CAVE			1								
CLAYTON MILL SPRING							1				
CLINCH MOUNTAIN WMA						1					
COVINGTON CAVE									1		
DRAGON'S TOOTH		1									
FLAT TOP MOUNTAIN											
FORE MOUNTAIN							1				
FOREST ROAD 181 - LEFT									1		
FROZEN KNOB							1				
GREENSTONE OVERLOOK							1				
HOOP HOLE LOOP									1		
HUMPBACK ROCKS							1				
IRISH CREEK #1							1				
IRISH CREEK #2							1				
LIMEKILN BRIDGE SINKHOLE				1							
LITTLE HUMPBACK							1				
LOCHER TRACT							1				
MACHINE CREEK							1				
MAPLE SPRINGS							1				
MCGRAW GAP									1		
MILL CREAK									1		
MILL HILL CAVE					1						
MOOMAW RIGHT							1				
NEW RIVER CAVE		1									
NICHOLS KNOB		1									
PADDY GAP						1					
PANTHER GAP DRAFT									1		
PHOEBE NEEDLES COMM CTR										1	
PUNCH BOWL RIDGE											
RAINBOW ROCK SOUTH							1				
RAMSEY DRAFT							1				

Appendix A.1. Continued	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
SHERANDO LAKE-TORRY RIDGE							1				
SHORT CUT ROAD						1					
SNP-GRAVEL SPRING HUT					1						
SOUTH BATTLE RUN				1							
SPRUCE RUN MOUNTAIN CAVE		1									
STATE LINE DUMP						1					
TINKER MOUNTAIN		1									
UNION SPRINGS II									1		
VINING TRACT	1										
VPI SITE							1				
WILLIAMSVILLE CABIN		1									
CHIMNEY RUN						0	0				
BACK CREEK MTN - LEFT								0	1		
BATHER'S CAVE				1						0	
DISMAL FALLS		1								0	
FORTNEY BRANCH							0	1			
BIG HELLGATE CR. QUARRY										1	1
BRADY'S CAVE				1						1	
MASSANUTTAN MTN	1				1						
SNP-BIG DEVILS STAIRS	1				1						
HANGING ROCK		0					1		0		
CASTLE ROCK		1			1					0	
SNP-FRANKLIN CLIFFS			1		1				0		
WIND ROCK		1			1					0	
CAMPBELL RUN-COURSEY SPRINGS								1	1		1
CLIFF DALE CHURCH							1		1		1
SNP-BEARFENCE			1		1				1		
SNP-BIG MEADOWS	1				1				1		
SNP-CRESENT ROCK			1		1				1		
SNP-LITTLE STONY MAN TRAIL			1		1				1		
SNP-BROWNTOWN OVERLOOK			1		0	1			0		
SNP-PINNACLES PICNIC AREA	0		1		1				0		
SNP-NORTH MARSHALL		1			0	1			1		
OSBORNE RIDGE								1	1	1	1
SULPHUR SPRINGS GAP						1	1	1	1	0	0
ELIZABETH FURNACE	1	1	1	1	1	1					
RON STEPHENS		1	1	1	1	1	1				
SNP-BLUFFS TRAIL	1	1	1	1	1	1					
THE STACKS						1	1	1	1	1	1
DEVIL'S MARBLEYARD					1	1	1	1	1	0	1
ROCKY MOUNTAIN					1	1	1	1	1	1	1
BUTT MOUNTAIN	1	1	1	1	1	1	1	0	1	1	1
STAR CHAPEL	1	1	1	1	1	1	1	1	1	1	1
COUNT BY YEAR	14	31	14	11	26	21	47	11	51	16	11
RATS PRESENT	9	17	12	9	20	16	31	8	24	10	10
PERCENT	64%	55%	86%	82%	77%	76%	66%	73%	47%	63%	91%
RATS ABSENT	5	14	2	2	6	5	16	3	27	6	1
PERCENT	36%	45%	14%	18%	23%	24%	34%	27%	53%	38%	9%

Appendix A.2. Activity summary of 34 survey sites trapped by cooperators and occupancy status (0=inactive; 1=active) during the Allegheny woodrat project in Virginia 1990-2000.

	YEAR											
SITE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	COOPERATOR
REDDISH KNOB FIRETOWER	1											B.GLASGOW-USFS
COFFIN CAVE							1					C.HOBSON-Va. Nat. Hertage
JACK CAVE		1										C.HOBSON
LIGNITE												SITE DESTROYED
ROCKBRIDGE ALUM SPRINGS												SITE DESTROYED
SNP-PARK HEADQUARTERS												SITE DEVELOPED
ATT TOWER - FRENZEL						1						F. FRENZEL-VDGIF
WOODSTOCK TOWER					1							F. FRENZEL-VDGIF
ROARING RUN FURNACE								1				H.HARVEY-USFS
BRUSHY MTN-JERRY'S RUN							1					E. HAVERLACK-USFS
COLES POINT						1						E. HAVERLACK
RHODODENDRON WAYSIDE					1	0						W. HAVERLACK
SKYLINE						1						E. HAVERLACK
THOMAS SPRINGS					1							E.VHAVERLACK
TOP DR/SCENIC DR AT OVERLOOK					1	1						E. HAVERLACK
BEAR CLIFF												J.CRANFORD-VA TECH
BOONSBORO									1			J.JEFFERIES-VDGIF
CLEAR CREEK FALLS											0	LISA NUTT-USFS
MULLINS POND											0	LISA NUTT
PINE MOUNTAIN											1	LISA NUTT
BIRCH GAP #1											0	LISA NUTT
BIRCH GAP #3											0	LISA NUTT
SKIDMORE FORK												M.FIES-DGIF
CONSERVATION & RESEARCH CTR								1				W. McSHEA-CONS & RES CENTER
SNP-KAISER RUN TRAIL					1							W. McSHEA
SNP-OVERALL RUN TRAIL					1							W. McSHEA
SNP-PINEY RIDGE					1							W. McSHEA
SNP-RANGE VIEW CABIN					1							W. McSHEA
AMLITE MINES							1					PEDLAR DIST-USFS
BIG MARYS CREEK						1						PEDLAR DIST
DICKIE HAMILTONS							1					PEDLAR DIST
BOYCE VA	1											PHONE CALL TO MENGAK
RAVEN WOOD FARM								1				PHONE CALL TO MENGAK
FOOL'S CAVE	1											ROY POWERS-MT.EMPIRE CC
SNP-WHITEOAK CABIN						1						SNP-WATSON-NAT.PARK SERVICE

Appendix A.3. Summary of location information for woodrat sites trapped in Virginia during Allegheny woodrat project, 1990-2000.

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
	SNP-PINEY RIDGE TRAIL	ACTIVE	1994							WASHINGTON
ALLEGHANY	*** THE STACKS	ACTIVE	1995	37 44 20	80 07 00	4176756	577744	3260	E	JORDON MINES
ALLEGHANY	BALD KNOB ROAD	INACTIVE	1996	37 50 4	79 53 35	4187744	597422	2001	NE	COVINGTON
ALLEGHANY	BRUSHY MTN. - JERRY'S RUN	INACTIVE	1996							JERRY'S RUN
ALLEGHANY	CHESTNUT RIDGE	ACTIVE	1998	37 51 03	79 50 47	4189698	601495	1513	W	CLIFTON FORGE
ALLEGHANY	CLIFTDALE CHURCH	ACTIVE	1994	37 40 55	80 01 20	4170780	586537	1700	SW	JORDAN MINES
ALLEGHANY	CLIFTON FORGE RESERVIOR CAVE	INACTIVE	1998	37 51 07	79 50 51	4189793	601488	1440	SE	CLIFTON FORGE
ALLEGHANY	COLE'S POINT	ACTIVE	1995	38 56 46	37 54 48	4200244	590939	1620	SE	FALLING SPRING
ALLEGHANY	COVINGTON CAVE	ACTIVE	1998	37 46 52	79 55 57	4181939	594183	1280	S	COVINGTON
ALLEGHANY	FORE MOUNTAIN	ACTIVE	1996	37 49 57	79 53 14	4187620	597942	2566	W	COVINGTON
ALLEGHANY	FOREST ROAD 125	INACTIVE	1996	37 50 04	79 53 35	4187813	597416	2001	W	COVINGTON
ALLEGHANY	FROZEN KNOB	ACTIVE	1996	37 39 32	80 11 40	4168081	571065	3045	N	ALLEGHANY
ALLEGHANY	McGRAW GAP	ACTIVE	1998	37 51 17	79 51 40	4190122	600190	1987	NE	CLIFTON FORGE
ALLEGHANY	MOOMAW - RIGHT	ACTIVE	1996	37 56 57	79 57 8	4200445	592008	1502	E	FALLING SPRING
ALLEGHANY	MOOMAW LEFT	ACTIVE	1996	37 57 01	79 57 08	4200620	592006	1545	E	FALLING SPRING
ALLEGHANY	MOOMAW - LEFT N. MTN. OVERLOOK - TOP DRIVE	ACTIVE	1994	37 49 34	79 37 45	4187207	620817	3000	SE	LONGDALE FURNACE
ALLEGHANY	NICHOLS KNOB	ACTIVE	1991	37 39 47	80 01 09	4168680	586120	3561	SE	JORDON MINES
ALLEGHANY	PETER'S MOUNTAIN	INACTIVE	1994	37 42 26	80 08 55	4173481	575062	3295	NE	ALLEGHANY
ALLEGHANY	RAINBOW ROCK - NORTH	INACTIVE	1996	37 48 42	79 47 46	4185404	605971	1126	SW	CLIFTON FORGE
ALLEGHANY	RAINBOW ROCKS - SOUTH	ACTIVE	1996	37 48 42	79 47 46	4185404	605971	1126	SW	CLIFTON FORGE
ALLEGHANY	RHODODENDRON WAYSIDE	ACTIVE	1994	37 52 24	79 36 18	4192463	622890	2800	NE	COLLIERSTOWN
ALLEGHANY	RICH HOLE WILDERNESS	INACTIVE	1998	37 52 16	79 38 01	4192168	620184	3064	SE	LONGDALE FURNACE
ALLEGHANY	SKYLINE	ACTIVE	1995							UNKNOWN
ALLEGHANY	THOMAS SPRINGS	ACTIVE	1994	37 42 27	80 08 45	4173512	575061	3320	S	ALLEGHANY
AMHERST	***ROCKY MOUNTAIN ELECTRONICS	ACTIVE	1995	37 47 42	79 10 48	4184458		4000	s	MONTEBELLO
AUGUSTA	BIG SPY MOUNTAIN	ACTIVE	1996	37 54 27	79 08 29	4197045	663378	2868	SW	VESUVIUS QUAD
AUGUSTA	BRP MP 12.0	ACTIVE	1996							SHERANDO
AUGUSTA	BRP MP 7.6 LEFT	ACTIVE	1996	37 57 44	78 54 24	4203448	683917	2502	E	SHERANDO
AUGUSTA	BRP MP 7.6 RIGHT	ACTIVE	1996	37 57 49	78 54 29	4203630	683799	2367	W	SHERANDO

Appendix A.3. Continued

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
AUGUSTA	CAMP TODD	INACTIVE	1998	38 21 56	79 16 02	4247574	651382	2463	SW	WEST AUGUSTA
AUGUSTA	CEDAR CLIFFS ON APP. TRAIL	INACTIVE	1996	37 56 54	78 56 37	4201879	680693	2200	N	SHERANDO
AUGUSTA	CELLAR MTN. TRAIL	INACTIVE	1996	37 56 32	79 06 50	4200930	665756	3461	W	BIG LEVELS
AUGUSTA	CLAYTON MILL SPRING	ACTIVE	1996	38 25 45	79 25 45	4222374	637599	1925	SE	DEERFIELD
AUGUSTA	HODGES DRAFT	INACTIVE	1996	38 17 15	79 23 46	4238705	640280	3365	SE	MCDOWELL
AUGUSTA	RAMSEY DRAFT	ACTIVE	1996	38 18 26	79 21 42	4040998	643259	2395	W	WEST AUGUSTA
AUGUSTA	ROAD HOLLOW TRAIL	INACTIVE	1998	38 18 49	79 22 15	4241703	642428	2552	SW	WEST AUGUSTA
AUGUSTA	SHERANDO LAKE-TORREY RIDGE TRAIL	ACTIVE	1996	37 55 38	79 00 17	4199419	675370	2036	SE	BIG LEVELS
AUGUSTA	STAUNTON AQUEDUCT	INACTIVE	1991	38 19 58	79 11 50	4243960	656740	2040	NW	STOKESVILLE
BATH	*** STAR CHAPEL CAVE	ACTIVE	1990	38 10 15	79 45 11	4225300	609240	2160	E	SUNRISE
BATH	BACK CREEK MOUNTAIN LEFT	INACTIVE	1997	38 08 13	79 49 55	4221379	602363	3373	W	SUNRISE
BATH	BACK CREEK MOUNTAIN RIGHT	INACTIVE	1998	38 08 07	79 49 52	4221219	602449	3486	E	SUNRISE
BATH	BARNEY RUN	INACTIVE	1998	38 01 57	79 45 17	4209925	609305	2049	E	WARM SPRINGS
BATH	BARNEY RUN UPSTREAM	INACTIVE	1998	38 01 27	79 45 26	4209014	609077	2018	E	WARM SPRINGS
BATH	CAMPBELL RUN HOLLOW	ACTIVE	1997	38 09 19	79 35 59	4223769	622682	1606	E	WILLIAMSVILLE
BATH	CHIMNEY ROCKS CAVE	ACTIVE	1996	38 05 26	79 41 54	4216427	614329	2320	E	BATH ALUM
BATH	CHIMNEY RUN	INACTIVE	1995	38 05 44	79 48 34	4216963	604549	1860	W	WARM SPRINGS
BATH	CHIMNEY RUN	INACTIVE	1996	38 05 44	79 48 34	4216963	604549	1860	W	WARM SPRINGS
BATH	CLARKS CAVE	ACTIVE	1992	38 05 06	79 39 30	4215951	617707	1600	N	BATH ALUM
BATH	FORTNEY BRANCH	ACTIVE	1997	37 55 29	79 58 54	4197725	589519	1610	E	FALLING SPRING
BATH	JACKSON RIVER-FIRST FORD	INACTIVE	1992	38 07 57	79 46 36	4221020	607218	1911	NE	SUNRISE
BATH	LIME KILN	INACTIVE	1996	38 06 43	79 48 26	4218684	604566	2009	SE	WARM SPRINGS
BATH	LITTLE MOUNTAIN CAVE	ACTIVE	1994	38 08 14	79 46 38	4221601	607157	1957	E	SUNRISE
BATH	MARES RUN	INACTIVE	1998	38 01 20	79 46 15	4208787	607887	2507	E	WARM SPRINGS
BATH	MILL HILL CAVE	ACTIVE	1994	37 59 14	79 57 38	4200472	591220	1700	NE	FALLING SPRING
BATH	MT.GROVE SALTPETER CAVE	INACTIVE	1991	38 06 34	79 52 23	4218354	598768	2000	NW	WARM SPRINGS
BATH	NEIL RUN	INACTIVE	1995	38 06 38	79 49 13	4218610	603683	1840	NE	WARM SPRINGS
BATH	NORTH MOUNTAIN	ACTIVE	1994							UNKNOWN
BATH	PANTHER GAP DRAFT	ACTIVE	1998	38 01 10	79 32 47	4208469	627966	1937	S	GREEN VALLEY

Appendix A.3 Continued

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
BATH	WILLIAMSVILLE CABIN	ACTIVE	1991	38 09 14	79 36 10	4223585	622646	1600	S	WILLIAMSVILLE
BEDFORD	BOONSBORO	ACTIVE	1998	37 27 30	79 15 00	4147000	653000	840	E	BOONSBORO
BEDFORD	BRP-PEAKS OF OTTER-FLATTOP MTN	INACTIVE	1990	37 27 06	79 34 53	4145606	625620	3994	S	PEAKS OF OTTER
BEDFORD	BRP-PEAKS OF OTTER-JOHNSON FARM	INACTIVE	1990	37 27 15	79 36 13	4145972	623518	2590	E	PEAKS OF OTTER
BEDFORD	BRP-PEAKS OF OTTER-SHARP TOP MTN	INACTIVE	1993	37 25 59	79 36 20	4143720	623840	3600	E	PEAKS OF OTTER
BEDFORD	BRP-PEAKS OF OTTER-SHARP TOP TRAIL	INACTIVE	1990	37 26 13	79 36 33	4144069	623044	2721	W	PEAKS OF OTTER
BLAND	HAMILTON CAVE	INACTIVE	1991	37 08 25	80 53 15	4110220	510110	2200	NW	MECHANICSBURG
BOTETOURT	CARVEN'S COVE RES.	ACTIVE	1991	37 22 42	80 56 21	4137160	594256	2274	N	DALEVILLE
BOTETOURT	HOOP HOLE LOOP	ACTIVE	1998	37 40 27	79 56 07	4170016	593896	1799	E	STORM
BOTETOURT	RAVEN'S WOOD FARM	ACTIVE	1998							UNKNOWN
BOTETOURT	TINKER MOUNTAIN	ACTIVE	1991							
CLARKE	TINKER MOUNTAIN BOYCE, VA	INACTIVE	1987	39 00 42	78 01 17	4322146	757061	600	NW	BOYCE
CLARKE	MT. WEATHER RD.	INACTIVE	1991	39 00 59	77 57 46	4322646	243553	1140	SW	ASHBY GAP
CRAIG	FS ROAD 181	ACTIVE	1998	37 35 02	80 03 59	4159872	582417	1871	E	NEW CASTLE
CRAIG	NEW CASTLE WORK CENTER	INACTIVE	1998	37 30 21	80 06 29	4151069	578807	1294	E	NEW CASTLE
CRAIG	PAINT BANK	INACTIVE	1998	37 33 33	80 12 51	4156981	569422	2625	NW	POTTS CREEK
CRAIG	ROARING RUN FURNACE	ACTIVE	1997	37 42 27	79 53 35	4173718	597576	1325	SE	STROM
DICKENSON	BIRCH GAP - SITE #1	INACTIVE	2000	37 14 20	82 26 58	4122163	371436	2590	W	CLINTWOOD
DICKENSON	BIRCH GAP - SITE #2	ACTIVE	2000	37 14 20	82 26 58	4122163	371436	2590	W	CLINTWOOD
DICKENSON	BIRCH GAP - SITE #3	INACTIVE	2000	37 41 20	82 26 58	4122163	371436	2590	W	CLINTWOOD
DICKENSON	MULLINS POND	INACTIVE	2000	37 13 50	82 28 40	4121254	368915	2605	SW	CLINTWOOD
DICKENSON	PINE MOUNTAIN	ACTIVE	2000	37 13 30	82 30 00	4121000	368500	2360	N	CLINTWOOD
FAIRFAX	CABIN JOHN BRIDGE	INACTIVE	1998	39 28 29	77 14 05	4316228	306732	140	NE	FALLS CHURCH
FAIRFAX	DIFFICULT RUN	INACTIVE	1995	39 28 29	77 14 05	4316234	306252	140	NE	FALLS CHURCH
FAIRFAX	FAIRFAX CO.	INACTIVE	1998	39 28 29	77 14 05	4316228	306732	140	NE	FALLS CHURCH
FAIRFAX	GREAT FALLS	INACTIVE	1998	39 28 29	77 14 05	4316228	306732	140	NE	FALLS CHURCH
FAIRFAX	OPP. HOG ISLAND	INACTIVE	1998	39 28 29	77 14 05	4314897	313650	140	NE	FALLS CHURCH
FAIRFAX	OPP. PLUMMER'S ISLND	INACTIVE	1998	39 28 29	77 14 05	4315242	311352	140	NE	FALLS CHURCH
FAIRFAX	POTOMAC R.	INACTIVE	1998	39 28 29	77 14 05	4316228	306732	140	NE	FALLS CHURCH

Appendix A.3 Continued

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
FRANKLIN	PHEOBE NEEDLES COMMUNITY CENTER	ACTIVE	1998	36 58 02	80 05 43	4091423	580533	1531	NE	FERRUM
FRANKLIN	RON STEPHENS	ACTIVE	1991	37 06 13	80 02 34	4106620	584920	1500	N	CALLAWAY
FREDERICK	ATT TOWERS-FRENZEL	ACTIVE	1995	29 06 04	78 29 50?	4330500	716500	2425	W	MOUNTAIN FALLS
FREDERICK	PADDY GAP	ACTIVE	1995	39 03 21	78 30 55	4325415	717695	1320	SW	MOUNTAIN FALLS
FREDERICK	STATE LINE DUMP	ACTIVE	1995	39 05 09	78 30 48	4329049	716536	2060	SE	WARDENSVILLE
GILES	BEAR CLIFF	ACTIVE	1989	37 21 43	80 30 43	4134860	542960	3700	SE	EGGLESTON
GILES	*** BUTT MOUNTAIN FIRETOWER	ACTIVE	1990	37 22 10	80 37 27	4135720	533100	4200	W	EGGLESTON
GILES	BALD KNOB	ACTIVE	1991	37 21 03	80 24 24	4133640	540800	4300	NW	EGGLESTON
GILES	BARNEYS WALL	ACTIVE	1991	37 22 00	80 35 03	4135400	536800	3300	S	EGGLESTON
GILES	CASCADES I II III	ACTIVE	1998	37 21 23	80 35 42	4134262	535884	2475	S	EGGLESTON
GILES	CASTLE ROCK	INACTIVE	1991	37 18 35	80 38 31	4129080	531190	1700	E	PEARISBURG
GILES	DISMAL FALLS	ACTIVE	1991	37 08 33	80 53 46	4115100	508440	2250	SE	MECHANICSBURG
GILES	FLAT TOP/SUGAR RUN MOUNTAIN	ACTIVE	1999	37 14 51	80 51 29	4122109	512854	4087	TOP	WHITEGATE
GILES	LINKS CAVE	INACTIVE	1991	37 18 38	80 30 41	4129256	543439	1900	NW	EGGLESTON
GILES	LITTLE STONY CR.-CASCADES	ACTIVE	1994	37 21 27	80 35 30	4134378	536232	2380	SE	INTERIOR
GILES	NEW RIVER CAVE	ACTIVE	1991	37 16 03	80 36 10	4124427	535488	1940	SW	EGGLESTON
GILES	NEWPORT TAWNEYS'CAVE	INACTIVE	1991	37 18 49	80 30 36	4129920	543240	1925	SE	EGGLESTON
GILES	OLD GROWTH FOREST - MTN LAKE	INACTIVE	1996	37 23 26	80 30 09	4137711	541189	3606	W	EGGLESTON
GILES	SPRUCE RUN MTN CAVE	ACTIVE	1991	37 17 49	80 31 31	4127720	542420	2140	N	EGGLESTON
GILES	WIND ROCK	ACTIVE	1991	37 24 57	80 31 10	4140960	542960	4128	N	INTERIOR
GREENE	VINING TRACT	ACTIVE	1990	38 19 30	78 30 54	4244620	717120	1800	SE	SWIFT RUN GAP
GREENE	SNP-BEARFENCE MOUNTAIN	ACTIVE	1992	38 26 46	78 27 46	4258100	721540	3450	SE	FLETCHER
HIGHLAND	ARBOGAST SLTPTR CAVE	ACTIVE	1990	38 25 20	79 25 08	4254140	638060	3220	N	DOE HILL
LEE	COFFIN CAVE	ACTIVE	1996							BIG STONE GAP
LOUDOUN	ATT TOWERS-LOUDEN CO	INACTIVE	1991							UNKNOWN
LOUDOUN	HARPER'S FERRY	INACTIVE	1991	39 19 09	77 43 13	4355625	265564	500	NE	HARPER'S FERRY
LOUDOUN	POINT OF ROCKS	INACTIVE	1991	39 16 11	77 33 25	4349662	279519	440	NW	POINT OF ROCKS
LOUDOUN	SHORT HILL MTN	INACTIVE	1991	39 11 17	75 44 15	4341055	263765	1010	SE	PURCELLVILLE
MADISON	SNP-LITTLE STONY MAN	ACTIVE	1992	38 36 13	78 23 03	4275817	729110	3400	N	OLD RAG MTN

Appendix A.3 Continued

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
MADISON	SNP-WHITEOAK CANYON	ACTIVE	1995	38 33 36	78 21 36	4271046	730030	2317	E	OLD RAG MTN
MONTGOMERY	OLD MILL CAVE	INACTIVE	1994	37 15 58	80 20 20	4124341	558378	1600	SE	McDONALDS MILL
NELSON	GREENSTONE OVERLOOK	ACTIVE	1996	37 56 50	78 55 41	4201760	682068	2998	N	SHERANDO
NELSON	HANGING ROCKS	ACTIVE	1996	37 51 50	78 59 36	4192402	676514	3371	B	HORSESHOE MTN
NELSON	HUMPBACK ROCKS	ACTIVE	1996	37 56 56	78 53 59	4202049	684569	3600	E	SHERANDO
NELSON	LITTLE HUMPBACK ROCKS	ACTIVE	1996	37 56 41	78 54 27	4201531	683849	3566	E	SHERANDO
NELSON	MILL CREEK	ACTIVE	1993	37 53 00	79 07 00	419500	666000	2760	E	BIG LEVELS
NELSON	WINTERGREEN RESORT	ACTIVE	1990	37 54 56	78 56 10	4198378	681659	2820	SW	SHERANDO
PAGE	MASSANUTTEN MTN.	ACTIVE	1990	38 38 23	78 36 40	4280180	708280	2047	SE	HAMBURG
PAGE	SNP-BIG MEADOWS	ACTIVE	1990	38 40 29	78 26 36	4267620	723300	3450	N	BIG MEADOWS
PAGE	SNP-CRESCENT ROCKS	ACTIVE	1992	38 33 40	78 15 21	4271100	728200	3400	W	BIG MEADOWS
PAGE	SNP-FRANKLIN CLIFFS	ACTIVE	1992	38 32 13	78 25 11	4268325	724864	3020	W	BIG MEADOWS
PAGE	SNP-HAWKSBILL MTN	INACTIVE	1990	38 33 44	78 23 41	4270610	727378	3580	NE	BIG MEADOWS
PAGE	SNP-PARK HEADQUARTERS	INACTIVE	1990	38 39 42	38 37 07	4282463	729024	1200	S	THORNTON GAP
PAGE	SNP-PINNACLES RANGER STN	ACTIVE	1990	38 36 59	78 23 46	4277260	730820	3200	NW	OLD RAG MTN
PAGE	SNP-RATTLESNAKE	INACTIVE	1992	38 45 07	78 17 32	735320	429254	3055	E	BENTONVILLE
PATRICK	FAIRYSTONE FARMS WMA	INACTIVE	1991	36 47 58	80 07 23	4072780	578280	1300	W	PHILPOTT RESERVOIR
PATRICK	BRP-ROCK CASTLE GORGE	ACTIVE	1998	36 47 45	80 21 39	4071849	556246	2689	SE	WOOLWINE
RAPPAHANNOCK	*** SNP-BLUFF'S TRAIL	ACTIVE	1990	38 45 37	78 13 23	4293520	741000	2500	S	CHESTER GAP
RAPPAHANNOCK	SNP-BYRD'S NEST No. 4 SHELTER	INACTIVE	1992	38 42 05	78 19 31	4287084	732199	2727	E	THRONTON GAP
RAPPAHANNOCK	SNP-DEVILS STAIRS TRAIL	ACTIVE	1990	38 45 37	78 12 48	4293520	741000	2200	S	CHESTER GAP
RAPPAHANNOCK	SNP-GRAVEL SPRINGS HUT	ACTIVE	1992	38 45 49	78 14 14	4293939	740378	2480	SE	CHESTER GAP
RAPPAHANNOCK	SNP-KAISER RUN TRAIL	ACTIVE	1994							BENTONVILLE
RAPPAHANNOCK	SNP-N MARSHALL	ACTIVE	1991	38 46 23	78 12 30	4294940	742640	3240	SW	CHESTER GAP
RAPPAHANNOCK	SNP-RANGE VIEW CABIN	ACTIVE	1994	38 44 35	78 17 39	4291527	735165	2850	E	THORNTON GAP
ROANOKE	DRAGON'S TOOTH	ACTIVE	1991	37 21 45	80 10 17	4135220	573380	3050	SW	GLENVAR
ROCKBRIDGE	GOSHEN PASS	INACTIVE	1991	37 56 01	79 27 31	4199349	635459	1398	E	GOSHEN
ROCKBRIDGE	*** DEVIL'S MARBLEYARD	ACTIVE	1994	37 34 54	79 28 21	4160273	634906	2000	SW	SNOWDEN
ROCKBRIDGE	AMLITE MINES	ACTIVE	1996					1200		BUENA VISTA

Appendix A.3 Continued

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
ROCKBRIDGE	BATHERS CAVE	ACTIVE	1993	37 49 52	79 26 24	4186098	637671	1100	NW	LEXINGTON
ROCKBRIDGE	BIG HELLGATE CREEK QUARRY	ACTIVE	1999	37 36 16	79 28 27	4162903	634714	1240	NE	SNOWDEN
ROCKBRIDGE	BIG MARYS CREEK	ACTIVE	1995	37 51 59	79 11 44	4192330	658719	2000	e	MONTEBELLO
ROCKBRIDGE	BRADY'S CAVE	ACTIVE	1993	37 46 27	79 25 21	4186085	637610	1100	NW	LEXINGTON
ROCKBRIDGE	DEMPSEY'S MARLBROOK CAVE	INACTIVE	1993	37 50 45	79 16 19	4189939	652207	1260	NW	CORNWALL
ROCKBRIDGE	DICKIE HAMILTON'S	ACTIVE	1996					900		GLASGOW
ROCKBRIDGE	FS 512 TRAIL	INACTIVE	1996	37 37 03	79 25 35	4164334	638877	1497	SW	SNOWDEN
ROCKBRIDGE	IRISH CREEK NO. 1	ACTIVE	1996	37 48 21	79 17 35	4185428	650266	1492	S	CORNWALL
ROCKBRIDGE	IRISH CREEK NO. 2	ACTIVE	1996	37 48 17	79 17 26	4185321	650486	1499	S	CORNWALL
ROCKBRIDGE	LIMEKILN BRIDGE SINKHOLE	ACTIVE	1993	37 46 26	79 25 21	4185939	637000	1100	NW	LEXINGTON
ROCKBRIDGE	LOCHER TRACT - SHALE MINE	ACTIVE	1996	37 36 50	79 28 12	4163743	936085	882	NW	SNOWDEN
ROCKBRIDGE	PUNCH BOWL RIDGE	ACTIVE	1994	37 48 17	79 17 26	4185321	650486	1499	S	BUENA VISTA
ROCKBRIDGE	RT. 733 NO. 1	INACTIVE	1996	37 45 40	79 18 47	4180467	648616	2078	S	CORNWALL
ROCKBRIDGE	RT. 733 NO. 2	INACTIVE	1996	37 45 40	79 18 13	4180467	649417	2374	S	CORNWALL
ROCKBRIDGE	SHORT-CUT ROAD	ACTIVE	1995	37 53 54	79 18 37	4177178	648893	2092	NE	BUENA VISTA
ROCKBRIDGE	SIDELING HILLS	INACTIVE	1996	38 04 24	79 29 32	4214826	632255	2796	SE	CRAIGSVILLE
ROCKBRIDGE	SOUTH BATTLE RUN	ACTIVE	1994	37 38 21	79 25 21	4166646	639268	1200	E	GLASGOW
ROCKINGHAM	HONE QUARRY	INACTIVE	1998	38 27 07	79 07 31	4257367	663585	1915	SE	REDDISH KNOB
ROCKINGHAM	LOWER RAWLEY	INACTIVE	1998	38 30 30	79 08 24	4284050	662118	2162	SW	RAWLEY SPRINGS
ROCKINGHAM	REDDISH KNOB FIRETWR	ACTIVE	1990	38 27 46	79 14 26	4258390	653621	4350	N	REDDISH KNOB
ROCKINGHAM	SKIDMORE FORK	ACTIVE	1987	38 30 47	79 12 10	4264049	656598	3360	N	BRANDYWINE
ROCKINGHAM	UNION SPRINGS I	INACTIVE	1998	38 28 56	79 05 23	4260854	666617	2154	E	BRIERY BRANCH
ROCKINGHAM	UNION SPRINGS II	ACTIVE	1998	38 28 38	79 05 11	4260290	666942	1976	SW	BRIERY BRANCH
SCOTT	*** OSBORNE RIDGE	ACTIVE	1998	36 51 00	82 32 15	4079344	363509	3005	N	FT BLACKMORE
SCOTT	BROADTREE SITE	INACTIVE	1996	36 51 00	82 32 37	4079090	362378	2998	N	FT BLACKMORE
SCOTT	FOOL'S CAVE	ACTIVE	1990							CLINCHPORT
SCOTT	JACK CAVE	ACTIVE	1991							CLINCHPORT
SCOTT	MAPLE SPRING	ACTIVE	1996	36 52 20	82 36 14	4081689	357052	3177	W	FT BLACKMORE
SCOTT	VPI SITE	ACTIVE	1996	36 52 28	82 36 13	4081941	357091	3244	W	FT BLACKMORE

Appendix A.3 Continued

COUNTY	LOCATION	STATUS	YEAR	LATITUDE	LONGITUDE	UTM NORT	UTM EAST	ELE-VATION	ASPECT	TOPO_QUAD
SHENANDOAH	*** ELIZABETH FURNACE	ACTIVE	1990	38 56 21	78 20 09		732451	900	E	STASBURG
SHENANDOAH	*** SULPHER SPRINGS GAP	ACTIVE	1995	38 59 38	78 36 14	4318866	710903	1800	N & S	WOODSTOCK
SHENANDOAH	BOYER FURNACE	INACTIVE	1995	38 52 30	78 24 09	4308349	725561	1100	S	TOM'S BROOK
SHENANDOAH	MINE MOUNTAIN RUN	INACTIVE	1995	38 52 30	78 24 09	4308349	725561	1100	S	TOM'S BROOK
SHENANDOAH	WOODSTOCK TOWER	ACTIVE	1994	38 52 12	78 26 34	4305171	721207	1820	NW	RILEYVILLE
WARREN	CONSERVATION & RESEARCH CENTER	ACTIVE	1997	38 53 23	78 09 51	4308170	745940	1021	S	FRONT ROYAL
WARREN	SNP-BROWNTOWN OVERLOOK	ACTIVE	1992	38 47 04	78 11 26	4290240	743260	2900	NW	CHESTER GAP
WARREN	SNP-OVERALL RUN TRAIL	ACTIVE	1994							BENTONVILLE
WARREN	SNP-SOUTH MARSHALL	INACTIVE	1992	38 46 22	78 16 21	4294920	741480	3170	NW	CHESTER GAP
WASHINGTON	CLINCH MTN. WMA	ACTIVE	1995	36 54 26	81 51 33	4085300		2160	W	SALTVILLE
WISE	CAMP ROCK	INACTIVE	1996	36 52 56	82 37 02	4083762	355845	3787	SW	WISE
WISE	CLEAR CREEK FALLS	INACTIVE	2000	36 55 43	82 35 50	4087942	357770	2898	NE	WISE
WISE	CMB UNIT #22	INACTIVE	1998	36 55 52	82 33 06	4088148	361798	2001	N	WISE
WISE	ELISHA LICK GAP	ACTIVE	1998	36 49 06	82 45 46	4075921	342743	3077	NW	BIG STONE GAP
WISE	MACHINE CREEK	ACTIVE	1996	36 55 13	82 33 51	4086979	360677	2492	SW	WISE

Appendix A.4. Sites identified as potential woodrat occupancy but not trapped in this study due to insufficient location information or resou

COUNTY	LOCATION	STATUS	LANDOWNER	LATITUDE	LONGITUDE	UTM-NORTH	UTM-EAST	ELEVATION	ASPECT	TOP
ALLEGHANY	CARTER'S CAVE	NEED TO TRAP	PRIVATE	37 39 28	80 09 38	4168000	574024	1880	S	ALLEGHANY
ALLEGHANY	RAINBOW GAP	NEED TO TRAP	PRIVATE							COVINGTON
BATH	SLEEPING SKUNK CAVE	NEED TO TRAP	USFS							FALLING SP
BATH	BREATHING CAVE	NEED TO TRAP	UNKNOWN	38 11 54	79 38 07			2400	SE	BURNSVILLE
BATH	WITHEROS CAVE	NEED TO TRAP	PRIVATE?							WILLIAMSVI
BEDFORD	DEVIL'S RACE PATH	NEED TO TRAP	UNKNOWN							UNKNOWN
BEDFORD	POPLAR FOREST	NEED TO TRAP	PRIVATE							FOREST
BLAND	NEWBERRY BANES CAVE	NEED TO TRAP	PRIVATE	37 06 50	81 01 02			2550	NW	LONG SPUR
BLAND	HOLLY BROOK	NEED TO TRAP	PRIVATE?	37 11 15	81 57 45	4115476	504024	2200	SW	MECHANICSBURG
BOTETOURT	STYNE CAVE	CAN NOT FIND	UNKNOWN							UNKNOWN
BOTETOURT	RAT TRAP CAVE	CAN NOT FIND	UNKNOWN							UNKNOWN
BOTETOURT	LIGNITE	DESTROYED	USFS	37 37 38	80 00 12	4164707	588000	1720	SE	JORDON MINES
BUCKINGHAM	BUCKINGHAM CO.	CAN NOT FIND	UNKNOWN							UNKNOWN
CLARKE	DUKE'S HOLLOW	CAN NOT FIND	PRIVATE							ASHBY GAP
CRAIG	SHIRE'S CAVE	NEED TO TRAP	UNKNOWN	37 33 39	80 12 48			2520	SW	POTT'S CREEK
CRAIG	PINES CAMPGROUND	NEED TO TRAP	USFS	37 36 55	80 02 15	4163344	584963	3462	N	JORDAN MINES
FLOYD	BUFFALO MOUNTAIN	NEED TO TRAP	PRIVATE	36 47 44	80 28 49	4072134	546634	3971	TOP	WILLIS
GILES	MTN LAKE SMITHSONIAN #2	CAN NOT FIND	USFS							EGGLESTON
GILES	STAY HIGH CAVE	CAN NOT FIND	PRIVATE							UNKNOWN
GILES	DOE CREEK	CAN NOT FIND	USFS	37 21 13	80 33 41	4133939	539048	3140	SW	EGGLESTON
GILES	STRALEYS # 2 CAVE	NEED TO TRAP	PRIVATE							STAFFORDSVILLE
GILES	STARNES CAVE	NEED TO TRAP	PRIVATE	37 16 57	80 46 36	4126000	519300	2300	SE	NARROWS
GILES	PIG HOLE CAVE	NEED TO TRAP	PRIVATE	37 19 03	80 31 56	4130400	504780	2280	SE	EGGLESTON
GREENE	JONES MTN.	NEED TO TRAP	NPS-SNP							CROZET/CHARLOTTESVILLE
HIGHLAND	COLD SPRINGS	NEED TO TRAP	USFS	38 33 44	79 36 11	4268927	621704	3000	W	SNOWY MOUNTAIN
HIGHLAND	LAUREL FORK	NEED TO TRAP	USFS	38 33 20	79 36 46	4268168	620899	2977	W	SNOWY MOUNTAIN
HIGHLAND	HUPMAN'S SALTPETER CAVE	NEED TO TRAP	PRIVATE	38 14 01	79 31 04			2400	NE	WILLIAMSVILLE
HIGHLAND	CHRISTIAN RUN	NEED TO TRAP	USFS	38 32 25	79 35 48	4266459	622303	3725	SE	SNOWY MOUNTAIN
HIGHLAND	COLUMBIA UNION COLLEGE	NEED TO TRAP	PRIVATE							UNKNOWN

Appendix A.4. Continued

COUNTY	LOCATION	STATUS	LANDOWNER	LATITUDE	LONGITUGE	UTM-NORTH	UTM-EAST	ELEVATION	ASPECT	TOPO QUAD
LEE	RAWHIDE, VA	CAN NOT FIND	USFS	36 49 26	82 55 59	4076861	327613		SW	KEOKEE
LEE	ROSEDALE CHURCH CAVE	NEED TO TRAP	VDOT							ROSEHILL
LEE	NEGRO HEAD ROCK SLTR	NEED TO TRAP	UNKNOWN							PENNINGTON GAP
LEE	INDIAN CAVE	NEED TO TRAP	NPS-CUMBERLAND							MIDDLESBORO SOUTH
LEE	PENNINGTON GAP	NEED TO TRAP	RAILROAD							PENNINGTON GAP
NELSON	SHIPMAN VA	DESTROYED	PRIVATE							LOVINGSTON
PAGE	RILEYVILLE CAVE	CAN NOT FIND	PRIVATE	38 46 04	78 22 39			800	N	RILEYVILLE
PULASKI	HOLE-IN-WALL CAVE	CAN NOT FIND	UNKNOWN							UNKNOWN
PULASKI	CLAYTOR L.	NEED TO TRAP	PRIVATE	37 03 49	80 39 29	4104780	529500	2000	NE	DUBLIN
ROANOKE	DIXIE CAVERNS	ACCESS DENIED	PRIVATE	37 15 09	80 11 20	4122963	573000	1300	N	GLENVAR
ROANOKE	MILLER'S COVE CAVE	CAN NOT FIND	UNKNOWN							GLENVAR
ROCKBRIDGE	GLASGOW VA.	CAN NOT FIND	PRIVATE	37 40 51	79 24 58	4171451	639805	900	NW	GLASGOW
ROCKBRIDGE	LIMEKILN BRIDGE SINKHOLE	DESTROYED	PRIVATE	37 46 27	79 25 21	4185939	637000	1100	NW	LEXINGTON
ROCKBRIDGE	ROCKBRIDGE ALUM SPR	DESTROYED	PRIVATE	37 51 52	79 35 28	4197000	621060	1800	NE	MILLBORO
ROCKBRIDGE	BRANCH'S POLECAT TRAP CAVE	NEED TO TRAP	PRIVATE	37 37 00	79 28 00	4165000	636000	800	N	SNOWDEN
ROCKBRIDGE	NORTH MOUNTAIN	NEED TO TRAP	USFS							UNKNOWN
ROCKINGHAM	ISLAND FORD CAVE	NEED TO TRAP	UNKNOWN	38 20 49	78 41 02	4246500	702695	1080	NW	McGANEYSVILLE
ROCKINGHAM	MASSANUTTEN CAVERNS	NEED TO TRAP	UNKNOWN							UNKNOWN
ROCKINGHAM	BIG MOUTH CAVE	NEED TO TRAP	UNKNOWN							UNKNOWN
ROCKINGHAM	SLATE LICK RUN	NEED TO TRAP	USFS	38 35 12	79 01 04	4272549	672655	2407	NE	RAWLEY SPRINGS
ROCKINGHAM	BALD KNOB-FEEDSTONE MTN	NEED TO TRAP	USFS	38 35 18	79 03 45	4272693	668741	3402	E	RAWLEY SPRINGS
ROCKINGHAM	SECOND MOUNTAIN TRAIL	NEED TO TRAP	USFS	38 31 05	79 02 15	4264987	671106	2493	SE	RAWLEY SPRINGS
ROCKINGHAM	COW KNOB CAVE	NEED TO TRAP	USFS	38 41 41	79 04 25	4284373	667551	3011	E	COW KNOB
RUSSELL	DAUGHERTY'S CAVE	NEED TO TRAP	UNKNOWN	36 55 55	82 03 46	4086170	405756	2160	N	LEBANON
RUSSELL	CLINCH AND LITTLE R.	NEED TO TRAP	UNKNOWN							HONAKER
RUSSELL	HURT CAVE	NEED TO TRAP	UNKNOWN							UNKNOWN
SCOTT	PETER'S CAVE	CAN NOT FIND	UNKNOWN							UNKNOWN
SHENANDOAH	COW KNOB/NORTH MTN?	CAN NOT FIND	UNKNOWN							UNKNOWN

Appendix A.4. Continued

COUNTY	LOCATION	STATUS	LANDOWNER	LATITUDE	LONGITUDE	UTM-NORTH	UTM-EAST	I		TOPO QUAD
SHENANDOAH	NEW MARKET VA.	NEED TO TRAP	PRIVATE	38 40 02	78 40 11	4282320	702800	1000	NE	NEW MARKET
TAZEWELL	RICH MT/SUMMIT E END	NEED TO TRAP	UNKNOWN	37 05 47	81 30 00	4105537	455524	4273	S	TAZEWELL SOUTH
TAZEWELL	WOLF RUN CR BURKE'S GARDEN	NEED TO TRAP	UNKNOWN							BASTIAN
TAZEWELL	TAZEWELL PEAK	NEED TO TRAP	UNKNOWN							TAZEWELL SOUTH/HUTCHSO
WISE	GUEST RIVER GORGE	CAN NOT FIND	UNKNOWN							UNKNOWN
WISE	ROCKY HOLLOW CAVE	NEED TO TRAP	UNKNOWN							NORTON