

U.S. Department of the Interior
National Park Service

**A Protocol for Monitoring Allegheny Woodrats
(*Neotoma magister*) at Mammoth Cave National Park**

Prepared by:

Dr. Robert L. Woodman (USGS/BRD Ecologist)¹
Steven C. Thomas (NPS/CUPN Co-coordinator/Ecologist)²
Bill J. Moore (NPS/CUPN Data Manager/Ecologist)²

¹Gulf Coast Network
635 Cajundome Blvd.
Abdalla Hall, Suite 124
Univ. Louisiana-Lafayette
Lafayette, LA 70506

and

²National Park Service
Cumberland Piedmont Network
P.O. Box 8
Mammoth Cave, KY 42259

Prepared for:

Cumberland Piedmont Network
National Park Service, U.S. Department of the Interior
Version 3.1 (January 2007)

Important Note: This sampling protocol includes both this narrative section, and the nine accompanying Standard Operating Procedures (SOPs):

SOP 1: Training of Field Personnel
 SOP 2: Pre-Sampling
 SOP 3: Establishment and Location of Sampling Sites
 SOP 4: Collection of Field Data
 SOP 5: Post-Sampling
 SOP 6: Data Management
 SOP 7: Data Analysis
 SOP 8: Reporting
 SOP 9: Revising the Protocol

Table of Contents

I. Background and Objectives	2
Issues Being Addressed and Rationale for Allegheny Woodrat Monitoring.....	2
Historical Development of Allegheny Woodrat Monitoring at MACA	3
Measurable Objectives.....	3
II. Sampling Design.....	4
Rationale for Selecting this Sampling Design over Others	4
Site Selection	5
Allegheny Woodrat Sampling Locations.....	6
Sample Frequency and Replication	8
III. Field Methods.....	8
Field Season Preparations, Field Schedule, Site-Check, and Equipment Setup.....	8
Sampling Methods	9
IV. Data Management.....	10
Overview of Database Design	10
Data Entry	11
Data Verification and Editing.....	11
Metadata Procedures.....	12
Data Archival Procedures	12
V. Analysis and Reporting	12
Data Analysis	12
Reporting.....	13
VI. Personnel Requirements and Training.....	14
Roles and Responsibilities	14
Qualifications and Training	14
VII. Operational Requirements.....	15
Field Schedule and Annual Workload	15
Facility and Equipment Needs.....	16
Startup and Monitoring Costs	16
Procedure for revising the Protocol and Archiving Previous Protocol Versions.....	16
VIII. References	17
IX. Acknowledgements	18

I. Background and Objectives

Issues Being Addressed and Rationale for Allegheny Woodrat Monitoring

The Allegheny woodrat, *Neotoma magister*, is a native small mammal of interest on Mammoth Cave National Park (MACA) and across the Eastern USA, due, in part, to recent dramatic population declines. Woodrats are frequent visitors to the cave ecosystem and are important importers of organic matter, in the form of nesting materials, food caches, and fecal and urine deposition, into caves. These organic nutrients are known to support a specialized invertebrate cave community (Richards 1989, 1990). Cave management and visitor activity may impact or inhibit woodrat access into and use of caves through imposition of physical barriers, such as cave doors, and various disturbance factors (noise, lighting, etc.). Woodrats, as surface foragers feeding on a wide variety of plant materials and parts (e.g., fruit, nuts and seeds, fungi, leaves, etc.) also relate to the terrestrial ecosystem, and may reflect larger-scale changes in vegetation communities through long-term changes in population performance and structure. The combination of being relatively widespread, important to the cave ecosystem, potentially sensitive to cave management and visitation impacts, and a strong dependent relationship with surface vegetation-based ecosystem performance make woodrats a useful indicator for park-level monitoring.

Allegheny woodrats are an endemic forest-dwelling species associated with cliffs, rock outcrops, talus slopes, and caves. Because woodrats are limited to rocky habitats for dens and to forests for food (especially nuts and acorns), they are vulnerable to disturbance both within caves and in the surrounding forest. Due to dramatic population declines along the northern and western peripheries of the species' range over the past 30 years, they now occur on more state endangered and threatened species lists than any other rodent in the U.S. The Allegheny woodrat is currently monitored by the Natural Heritage Program as a G3/G4 species (i.e., “vulnerable”/“apparently secure”, and is considered a “species of concern” (formerly called “Category 2 candidate”) by the U.S. Fish and Wildlife Service.

Several hypotheses have been proposed to account for the decline, they include: 1) inbreeding (Beans 1992); 2) reduced winter forage (Hicks 1989, Beans 1992, McShea and Schwede 1993); 3) infection with the raccoon roundworm (*Baylisascaris procyonis*) (McGowan 1993, Stone et al. 1993); 4) increased exposure to an increasing number of predators (Hassinger et al. 1996); 5) habitat (forested) fragmentation (Hassinger et al. 1996); 6) climate/weather changes (Linzey 1990); 7) human disturbance (Linzey 1990); and 8) synergistic affects of two or more causes of decline (Linzey 1990).

Specific threats to woodrats at MACA include cave entrance modification, direct visitor disturbance, cave lighting impacts, raccoon roundworm parasite (lethal to woodrats), impacts to food resources [from pests/pathogens (hard mast species), ozone, acid deposition, and fire], habitat fragmentation/loss (adjacent land use), in-cave modifications, and an increase in predators (e.g., feral cats, skunks, owls) on the park.

Woodrat population parameters ranked third in the Cave Nutrients functional “pathway” (ecosystem “sub-model”) at the end of the MACA Prototype Long-term Ecological Monitoring program’s ecosystem attribute ranking and prioritization process. The Cave Nutrients pathway

ranked second in importance among 18 ranked pathways on the park. This ranking established the significance of monitoring woodrat park-wide abundance and population structure, and use of managed caves on MACA.

Historical Development of Allegheny Woodrat Monitoring at MACA

Recognizing the special management status (Category 2 species) and key role woodrats play in supporting cave invertebrate communities, long-term monitoring of woodrats at MACA was put forth as a component in a 1993 proposal which resulted in MACA being selected as a prototype monitoring park for the cave/karst biome (A Proposal 1993).

Development of the MACA Allegheny woodrat monitoring protocol is based on the preliminary five-year woodrat monitoring study initiated at MACA in 1997 and completed in 2002 (Thomas 2003). Limited methods testing continued through 2003. Design and sampling methods revision, field testing of revised design, and initial database development took place primarily in 2004. A pilot test of the sampling methodology and designs was performed on “managed” caves and “unmanaged” caves (on the South side of the Green River only—due to the ferry being out of operation) in November 2004. The data have been entered into a MS Access database and analysis will be performed in early 2006. The sampling methods described in the preliminary study are utilized in the MACA woodrat monitoring protocol.

Measurable Objectives

Two general questions will be simultaneously assessed in woodrat monitoring: (1) what are the trends in woodrat population structure, population estimate, relative abundance, and distribution among sampled caves on the park over time, and (2) are woodrats using “managed” and visited (tour) caves?

The specific **monitoring questions** that will be addressed by this protocol include:

- What is the status of Allegheny woodrat population [population and relative abundance estimates, distribution among sampled caves, and structure (age class ratios, mean weight, general health, ectoparasite load, sex ratios)] using “unmanaged” (i.e., natural) caves on the park?
- What is the trend over time in population estimate, abundance, distribution among sampled caves, and structure (age class ratios, mean weight, general health, ectoparasite load, sex ratio) of the Allegheny woodrat population associated with “unmanaged” caves across the park?
- How do trends in Allegheny woodrat population structure differ between “managed” (i.e., with lighting systems, cave doors, block houses, tours, etc.) and “unmanaged” caves on the park?
- What is the current pattern (status) in use of “managed” caves by Allegheny woodrats on the park?
- What is the change in the pattern (trend) of use of “managed” caves by Allegheny woodrats on the park?

The specific **monitoring objectives** for this protocol are:

1. Determine current population structure and cave-use status and long-term trends in Allegheny woodrat population in “unmanaged” caves on the park.

2. Establish current use-levels and determine trends in use of “managed” caves by Allegheny woodrats on the park.
3. Determine if trends in Allegheny woodrat population structure differ between “managed” and “unmanaged” caves within the park.

II. Sampling Design

Rationale for Selecting this Sampling Design over Others

Two general questions will be simultaneously assessed in woodrat monitoring: 1) Are woodrats using “managed” and visited (tour) caves? and 2) What are the status and trends in woodrat population structure and abundance on the park over time? Both questions will be assessed using a standard live trapping methodology which provides for collection of sex, body weight, reproductive and general health states, ectoparasite load, and tracking of marked individuals. Sampling will occur in two temporally-overlapping designs using the same sampling methodology. One sampling design will address assessment of woodrat use of “managed” caves, the other, assessment of population status and trends across the park over time. The differences between the designs include: 1) numbers of sites (caves) being sampled, 2) intensity of sampling at each site, and 3) frequency of sampling over the year. Both designs use the same exact trapping, handling and marking methods, and both base upon a standardized 3-day sampling **session** (setup on day 1, check traps in the morning of days 2 and 3, for two trapping-nights per session). In the “use of managed caves” design, up to nine (9) “managed” caves will be sampled bimonthly and the data combined for analysis into two 6-month periods per year. In the “park-wide” design, approximately 50 “unmanaged” caves will be sampled hemi-annually (2 sessions per year). Sampling for both designs will occur during the same month on the “unmanaged” caves’ schedule. Data from these temporally-overlapped sessions will be used in combined analysis that examines woodrat population status and trends using a “cave management-level” stratification factor. The “unmanaged” caves being sampled for “park-wide” population status and trends are distributed unequally on the North and South sides of MACA, as defined by a natural barrier, the Green River. Given sufficient sample size (n), this distribution pattern will be used as a geographic stratification factor in analysis of data from the “park-wide” design.

“Managed” caves will be sampled with higher intensity than are the “unmanaged” caves. Sampling within “managed” caves will be accomplished with 4 traps per cave per trapping-night, while “unmanaged” caves will be sampled with 2 traps per trapping-night. This reflects the fact that “managed” caves have a variety of entrance structures that may require trap locations to be distributed within partitioned or otherwise grossly modified entrance areas, as well as deeper into the cave entrance (≤ 50 m from outside), in order to adequately sample for woodrats. Unmanaged cave entrance areas, in contrast, are typically open to access by woodrats, and may be adequately sampled for visitation with only 2 traps per cave. Also, in terms of logistics, more traps can be placed in the limited number ($n=9$) of “managed” cave entrances than in the large number ($n=\pm 50$) of “unmanaged” caves]. Sampling sessions will run for 3 consecutive days (2 nights) each and will consist of several sampling trips (a sampling **trip** is defined as one project crew’s sampling on one date; roughly equivalent to the data collected and recorded by one crew on a field data form on one date).

This design provides maximum ability to assess use of “managed” caves by woodrats. The “unmanaged” cave component (~50 caves) provides unequal stratification across the park’s major natural barrier, the Green River. Using separate sampling schedules in “unmanaged” versus “managed” caves improves potential detection through enabling larger “unmanaged” cave n within the defined sampling session. Further efficiency is gained through use of a distance-from-road limit factor in selecting “unmanaged” caves—sampled caves will be located within 0.46 km of accessible roads to reduce hike-in site access times, which allows inclusion of more caves within the available time.

Site Selection

Following a review of cave location maps and park information, potential sampling sites (caves) were selected with respect to four selection criteria: (1) the question being assessed (Are woodrats using “managed” caves? or What are the status and trends in woodrat population abundance and structure on the park?), (2) location relative to the Green River (i.e., north or south), (3) distance from an accessible road, and (4) road distance (= travel time) from the staff office (i.e., sampling “hub”). The steps followed during the initial sample site selection process which used the four criteria, and rationale for each, are describe below:

- *Criterion #1.* All “managed” caves ($n=9$) on the park were auto-selected by definition as woodrat monitoring sites in order to provide maximum ability to assess use of “managed” caves by woodrats. “Managed” caves were defined as those having entrances with physical structures such as doors and block houses, or which have electric lighting, or which receive regular visits by tours.
- *Criterion #2.* To assess trends in woodrat population abundance and structure, approximately 50 “unmanaged” caves were selected, roughly equally distributed North and South of the Green River. This is because natural caves are distributed unequally across MACA, on the North and South sides, as defined by a natural barrier, the Green River. “Unmanaged” caves do not have doors (although some have bat-friendly, angle iron gates), block houses, lights, and are off limits to public visitation.
- *Criterion #3.* The approximately 50 “unmanaged” caves were initially selected from the group of South side caves ($n=108$) located within 0.3 km, and the group of North side cave ($n=36$) located within 0.5 km, from a vehicle-accessible road as determined by straight-line measurement using GIS. This design was chosen to reduce site access times, which allows inclusion of more caves within the available time. This group of caves was considered a semi-random sample of caves on the park because we have no evidence to assume the distribution of roads at MACA affects the distribution of caves. Since fewer caves naturally occur north of the Green River than south, the distance-from-road was expanded to provide a longer list of potential sampling sites. Consequently, all North side caves ($n=35$) that met the distance-from-accessible-road criterion were selected as potential sampling sites. The South side caves ($n=108$) were reduced in number by sorting them by distance from an accessible road, and then selecting the 70 caves closest to a road as potential sampling sites.
- *Criterion #4.* South side caves selected as potential sampling sites were further selected (from the 70 caves closest to a road) based on road distance (=travel time) from the staff

office. This serves to increase sampling efficiency by decreasing drive-time to/from caves. The most distal caves were later dropped due to being located a longer road distance from the sampling “hub” (i.e., the staff office).

The final list of “unmanaged” caves on both the north ($n=25$) and south ($n=25$) sides were selected from among the potential sites based on safety considerations. Caves which were either unsafe for sampling personnel (e.g., a vertical pit entrance requiring ropes and gear to safely access) or for woodrats (e.g., no safe/sheltered spot in entrance to place traps) were omitted from consideration.

Allegheny Woodrat Sampling Locations

Approximately 59 permanent sampling sites (caves) have been established as a one-time task with respect to the process described in the previous section. However, due to the sensitive nature of cave location data, no information that could be used to determine the location of any cave at MACA can be disclosed (Cave Resources Protection Act of 1988). Therefore, only a general sampling site locations (approximate) map is provided (Figure 1). Copies of the approved protocol for internal use only will contain detailed maps and cave location information. Map locations data are elements of the project database (locations tables) established within the Cumberland Piedmont Network (CUPN) Vital Signs Monitoring program’s Data Management System.

Co-location of Allegheny Woodrat Sampling Locations with other Protocols

Cave resource sampling (and analysis) can be integrated both spatially and temporally based on expected extensive co-location and co-visitation. Sampling of multiple caves for multiple protocols at MACA will be scheduled in a staggered-rotational-panel design. A multiple-protocol cave sampling design has been developed for the park. Sampling for each protocol will be performed in some set of caves (caves = sample units), with many caves being used for most or all sampling efforts (sampling co-location at the “two-dimensional surface” level). In particular, as there are only nine “managed” caves (out of over 270 known caves on the park), all managed caves will be included for sampling for all parameters under all protocols. The sampling plan among caves for four protocols (Allegheny woodrats, cave crickets, cave beetles, and cave air conditions) variably overlaps in space and time. Woodrat sampling spatially overlaps with the other three protocols in that it occurs in all of the managed caves and in some of the unmanaged caves that are used for cricket, beetle and cave air monitoring, but also occurs on different schedules than do the other protocols. Broad integration will be obtained in MACA’s cave ecosystem monitoring through combinations of multi-protocol co-location and co-visitation. The resulting integration in sampling supports statistical inter-class (unmanaged versus managed) comparisons for all parameters in a spatial and temporal context

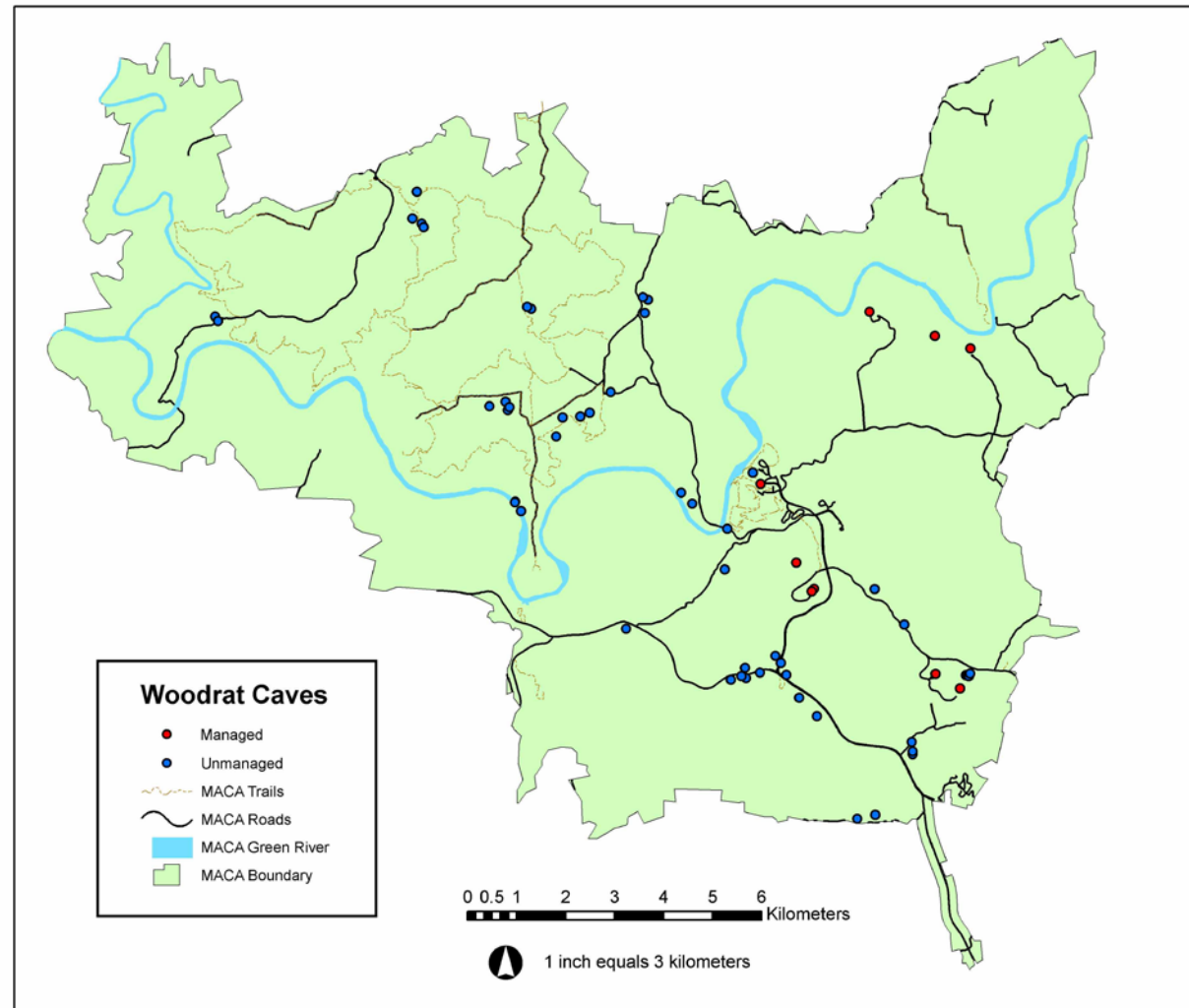


Figure 1. Locations of 50 “unmanaged” and 9 “managed” caves for long-term Allegheny woodrat monitoring at Mammoth Cave National Park, Kentucky. **Note:** Due to the sensitive nature of cave location data, cave names have been omitted and all points are approximate. In-house copies of the monitoring protocol contain information obscured here.

Sample Frequency and Replication

Annual monitoring of “unmanaged” caves will be accomplished using two three-consecutive-day sampling *sessions* (consisting of at least eight sampling *trips* total). *Sessions* are scheduled to occur during the first two weeks of May and November. If, after several years, the recommendation is made to decrease the number of sampling *sessions* per year to one, this single sampling *session* will likely occur during November. This is based on previous woodrat monitoring at MACA (Thomas 2003), where annual peaks in trapping success occurred in November four out of five years. The greatest number of juvenile woodrats was captured during May at MACA (Thomas 2003). Marking and recapturing juveniles can provide information on longevity and dispersal. Approximately 25 “unmanaged” caves will be sampled north of the Green River and about 25 caves will be sampled south of the Green River simultaneously during each *session*.

Sampling *sessions* in “managed” cave entrances are scheduled to occur within the first two weeks of every-other month beginning in January (between 01 and 14 January, March, May, July, September, and November). A maximum of nine caves, all south of the Green River, will be sampled. After a woodrat is captured in a given cave, that cave will not be sampled until the next May or November sampling *session*; thus, “managed” caves actually being used by woodrat(s) will only be sampled for one *session* during every 6-month period. “Managed” caves not being used by woodrats (as determined by trapping) will continue on a bimonthly trapping schedule during each 6-month period. “Managed” cave sampling will include a set of alternative follow-up actions that will depend on initial and year-long sampling outcomes for that cave (i.e., if no rats are captured within 1 year at initial trap sites, a new, deeper-in-cave array may be developed within the cave). “Managed” cave sampling will be scheduled to occur as close to “unmanaged” cave sampling as possible, to provide comparison within a similar time period and average seasonal condition.

III. Field Methods

Field Season Preparations, Field Schedule, Site-Check, and Equipment Setup

Prior knowledge of sampling procedures and locations is essential for efficient and consistent sampling efforts. Therefore, project crew leaders and crew members should be trained and refreshed (SOP #1 “Training of Field Personnel”), particularly if new personnel join the sampling crews or if intervals between sampling *sessions* are $\geq$ six months.

Three-consecutive-day sampling *sessions* will be scheduled by the project leader into 2-week blocks within given sampling months by 31 December for the upcoming calendar year. A two-week window allows for inclement weather, personnel workloads, etc. Woodrat sampling *sessions* in “unmanaged” caves are scheduled to occur during the first two weeks of May and November. Sampling *sessions* in “managed” cave entrances are scheduled for the first two weeks of every-other month beginning in January (between 01 and 14 January, March, May, July, September, and November). “Managed” cave sampling will be scheduled to occur as close to “unmanaged” cave sampling as possible. Sampling routes (the sampling order) for each crew will be finalized one or two days beforehand (incorporating information obtained during the site-check of caves described in the next paragraph) in order to maximize efficiency and minimize travel times.

A day or two before the scheduled sampling *session* a project crew leader and/or a crew member should conduct pre-sampling site-checks of all remote cave entrances (SOP#2 “Pre-Sampling”, Site-Check of Sampling Sites). The purpose of these checks is to confirm that all sampling sites can be located and accessed (i.e., no safety hazards or roads blocked). Also, particularly difficult to locate caves can be temporarily marked with a piece of colored survey ribbon placed in the vicinity ($\geq 15\text{m}$) of the cave entrance to enable easy location of the cave during sampling. Upon return from the field, the crew leader/member will give a copy of any written notes that may impact sampling logistics to the project leader, and discuss options with the project leader. Based on outcomes of the discussion, appropriate adjustments will be made prior to the upcoming sampling *session*.

In order to reduce lost time and perhaps lost data, a pre-trip checklist is provided (SOP #2 “Pre-Sampling”, Table 2.1). The crew leader must check each item on the list, particularly supplies, at least one week before sampling, in case supplies are needed, and again the day before the trip for final details. All of the equipment and supplies listed in this checklist should be organized and made ready for each trip into the field, and copies of the appropriate field data form (SOP #4 “Conducting Field Sampling”, Appendix A) should be made. Most equipment maintenance and repair/replacement is routinely performed as a post-sampling task—this check serves as an assurance of current readiness. As the crew leader prepares to depart for the field, the list should be checked again and reconciled against supplies and equipment being loaded up to assure nothing is being left behind.

Sampling Methods

Park-wide abundance and population structure will be assessed by live-trapping for woodrats in approximately 50 “unmanaged” caves distributed across the park. The sampling design will use a North-South stratification based on the rough bisection of the park by the west-running Green River, with approximately 25 caves on each side of the river. Two live traps will be placed within each cave for 2 consecutive nights in each sampling *session*, in 2 sampling *sessions* per year. Each sampling *session* will be performed by a minimum of two 2-person crews (one crew leader and at least one crew member). Day 1 of each *session* will consist of each crew locating approximately 25 caves (each site located within a 10-minute hike from a drivable road) and setting the two live traps in the entrance area. Beginning early in the morning of Day 2, each trap will be checked, all captured woodrats processed and released, and traps rebaited and reset as necessary. Starting early in the morning of Day 3, each trap will be checked, all captured woodrats processed and released, and traps removed and placed in the vehicle.

Use of “managed” caves will be assessed by placing four live traps within the first 50 m of each of up to 9 “managed” caves proximal to the main entrance. Trapping will be performed for 2 consecutive nights each sampling *session*, in up to 6 *sessions* in the sampling year. After a woodrat is captured in a given cave, that cave will not be sampled until the next May or November sampling *session*. “Managed” caves not being used by woodrats (as determined by trapping) will continue on a bimonthly trapping schedule during each 6-month period. “Managed” caves will be sampled by a single two-man crew (one crew leader and at least one crew member). Day 1 will consist of accessing each cave and setting the four live traps in the entrance area. Days 2 and 3 will proceed the same way as described for “unmanaged” caves (above).

Captured woodrats will be transferred from the trap to a cotton mesh handling bag for processing. A woodrat will be processed following these steps:

1. Visually inspect woodrat for presence of tattoo
2. Make-ready tattooing supplies and equipment if woodrat is unmarked
3. Zero scale
4. Transfer woodrat from trap to handling bag
5. Weigh woodrat
6. Determine sex
7. Determine age class
8. Determine reproductive condition
9. Determine ectoparasite load (e.g., fleas, ticks, bot fly larvae)
10. Assess physical condition
11. Tattoo previously unmarked woodrat
12. Release woodrat at site of trap

A detailed description of procedures, listed in the order they should occur, for: (1) operating live traps; (2) handling a woodrat; (3) weighing a woodrat; (4) differentiating between woodrat sexes; (5) assessing reproductive condition; (6) differentiating among woodrat age classes; (7) assessing woodrat measures of “health”; (8) marking a woodrat, and (9) filling in the field data form is provided in SOP #4 “Conducting Field Sampling”.

IV. Data Management

Overview of Database Design

Following the lead of the National Park Service (NPS) and the Inventory and Monitoring (I&M) Program, the CUPN Monitoring Program has adopted MS Access XP (2002) as its desktop database standard and ArcGIS as the GIS standard.

Rather than developing a single, integrated database system, CUPN relies upon modular, standalone project databases that share design standards based on the I&M Program’s Natural Resource Database Template [NRDT (v 3.0)] with links to shared lookup tables housed in a centralized database. This and other long-term monitoring protocol databases developed by CUPN share certain design standards. This is important given the often unpredictable ways in which datasets may be aggregated and summarized. Each monitoring protocol database is developed using the following primary components:

1. *Common lookup tables* – Links to entire tables that reside in a centralized database, rather than storing redundant information in each database. These tables contain information that is not project-specific (e.g., lists of parks, personnel, and species).
2. *Core tables and fields based on CUPN and national templates* – These tables and fields are used to manage the information describing the “who, where and when” of project data. Core tables are distinguished from common lookup tables in that they reside in each individual

project database and are populated locally. These core tables contain critical data fields that are standardized with regard to data types, field names, and domain ranges.

3. *Project-specific tables and fields* – The remainder of database objects can be considered project-specific, although there will typically be a large amount of overlap among projects. For example, a time field will require similar data types and domain values.

A noteworthy deviation from the NRDT for this and other cave-related protocols is the development of a “tlu_Cave_Locations” table. While this table’s structure is nearly identical to the NRDT’s tbl_locations, its functionality has changed in that it is a common lookup table shared among protocols, as opposed to being a core table within each protocol database. The decision to break out cave location information in this manner was largely due to its recognized sensitivity level. The project-specific data tables for this monitoring protocol database include:

- tbl_Event Details – Contains cave level observational information such as woodrat sign in the caves and cave notes.
- tbl_Trap – Contains trap level observational information such as trap condition and trap notes.
- tbl_Occupant – Contains observational information for each woodrat capture such as sex and weight of the trap occupant.

Refer to SOP # 6 “Data Management”, Appendix B for a complete list of tables, fields, and descriptions within the woodrat database.

Data Entry

Extensive use of programmatic data validation has been incorporated to greatly reduce the number of operator entry errors. Rather than direct database table entry, customized forms are being designed and tested that provide a natural flow of data entry into the database and validate the entered data before allowing them to be written to the database. Where possible, data are entered via the use of dropdown lists (i.e., built into the form or separate lookup tables) or by typing the beginning characters of the value, thus eliminating a large proportion of potential operator entry errors.

For other data fields, validation controls prevent impossible values to be entered (e.g., a negative number for woodrat weight) and data entry alert messages are provided any time a datum is entered that is not realistic (e.g., weight greater than 600 g). The user is offered a chance to reenter the data or keep the abnormal data.

Data Verification and Editing

In addition to data validation accomplished by the computer program, the data will also be manually verified shortly after data entry. This process involves checking the accuracy of computerized records against the original source.

The primary goal of data entry verification is to determine where errors are being introduced into the database. Each error found will, of course, be corrected, but will additionally be cataloged to find methods for eliminating that specific type of error during subsequent collection periods.

Metadata Procedures

The importance of metadata, or data about the data (e.g., who collected it, when, where, etc.), cannot be overemphasized. Because of the importance of metadata, much effort has been exerted both by the NPS and the developers of this project to insure data are properly documented. All geospatial data will be documented with appropriate Federal Geographic Data Committee (FGDC) and NPS metadata standards. In addition, the data manager will create a Dataset Catalog record to document the project database.

ArcCatalog (i.e., geospatial data) and Dataset Catalog records destined for upload to the NR-GIS Data Store will be edited with the NPS Metadata Tools and Editor prior to upload. Because this project contains information that can be considered protected or sensitive (i.e., cave locations), authorization must be obtained, beginning with the CUPN Co-coordinators, before any data products are released and/or posted in a location where the public may potentially gain access.

Data Archival Procedures

This and other monitoring protocols will have variable long-term data archiving requirements. Modifications to protocols may require complete datasets to be archived before modifications are implemented. Archived datasets or subsets destined for long-term archiving will be saved in their native formats. To ensure the capability of accessing the data the application software will be maintained. If it is not possible to archive or support the application software, the data will be stored as ASCII text files.

Versioning of archived datasets is handled by adding a three digit number to the file name, with the first version being numbered 001. Each subsequent version is assigned a sequentially higher number.

Tabular datasets destined for archiving will be stored locally within an object-oriented file structure established on the CUPN file server. Incremental or differential tape backups of all project databases on the server are regularly conducted. Backup copies of the data are maintained in a secure alternate location. Currently, GIS files are maintained and archived separately by the GIS specialist.

V. Analysis and Reporting

Data Analysis

The monitoring questions and subsequent analysis of the supporting data can be divided into two categories, based on time scale in analysis. The first category includes questions of status (population structure and relative abundance), distribution across sampled caves on the park, and

management—influence on population status and use of caves, measured at the within-year and annual scales. The second category includes these same questions, considered over multi-year scales. Both categories of questions will be addressed using a combination of summary and descriptive statistics, graphic analysis, and comparative regression and correlative analysis. Additional analytic approaches will be employed to evaluate woodrat population parameters in a comparative and correlative model with park-level weather trends and spatial dynamics and movement of woodrats among sampled caves.

With respect to use of managed caves by woodrats, data are collected in bimonthly sampling *sessions*. These data will be combined into two 6-month periods per year for analysis. Data collected during the May and November sampling *sessions* from all managed and unmanaged ($n = 59$) caves will be evaluated using a suite of metrics, and descriptive and summary statistics. Annual and longer-term trends analyses will use separate bimonthly datasets (for use of managed caves), hemi-annual, and derived, cumulative annual data to evaluate longer-period trends and patterns, both for managed and unmanaged caves.

The development of basic queries and summary reports in MS Access will be utilized to automate and thus streamline the data analysis and reporting workload, as appropriate. In consultation with the project leader, the data manager will develop queries that will address basic statistical questions. It is anticipated the results of these queries will be relied upon heavily for annual reporting.

In instances where the statistical questions become increasingly complex, data will need to be exported out of the relational MS Access database to commercial off-the-shelf statistical packages for higher level statistical analyses (i.e., t-tests, regression, and ANOVA). In general, these data will be formatted based on parameters provided to the CUPN data manager. The data manager will develop automated export routines based on parameter queries in MS Access to export the data in comma delimited ASCII text format for import into the selected statistical analysis software.

Reporting

Three primary elements or components (Annual Status, Graphic Cumulative Trend, and 5-Year Trend Analysis) of “formal” reports and will be generated to provide park management and other interested parties technical and interpretive information about the status and trends being detected in the monitored resource. The “Annual Status” and “Graphic Cumulative Trend” elements will be included in a report produced each March 31 following completion of the preceding year’s sampling efforts, data entry, and specified analysis. The “5-Year Trend Analysis” element will be developed at 3-year intervals, starting after at least 5 years of sampling have been completed. The 5-Year Trend Analysis element will be included in the March report of each scheduled submission year, in conjunction with the current Annual Status and Graphic Cumulative Trend elements. Each type of element will provide quantitative and “formal” data together with subjective interpretation and explanations and, if appropriate, recommendations for action by park management. Reports will be centered upon Allegheny woodrats, but may also

synthesize findings among several vital signs being monitored at MACA that display cross correlation.

Reports on woodrat monitoring will be written by the project leader, and/or crew leader(s) under the direction of the project leader. One or more internal reviews for grammatical soundness, clarity, and soundness will be sought prior to submitting the report to MACA resource management and CUPN management. Review by park staff and subsequent external reviews must be sought for new reports or those that deviate significantly from previously reviewed and distributed reports.

A brief (2-3 paragraphs) summary of sampling activities, preliminary results, and any public interest highlights that occurred during each federal fiscal year will be written by the CUPN Co-coordinators by October 15 for inclusion in the CUPN Monitoring program's Annual Administrative Report.

VI. Personnel Requirements and Training

Roles and Responsibilities

Implementation of this protocol requires an overall project leader and a minimum of two 2-person project crews. The project leader oversees and directs project operations, including training of personnel. Each crew consists of one project crew leader and at least one project crew member. The project crew leader has site familiarity, woodrat sampling/handling techniques expertise, and is responsible for team tasks. The project crew member has varied and less expertise, and is responsible for assisting the crew leader with data collection.

The project leader is the principal ecologist for implementing this monitoring protocol and is supervised by one of the CUPN Co-coordinators. The project leader will be responsible for training, data collection, filing *trip* reports with the data manager, some data entry, data verification, data validation, data summary, analysis, and reporting. Trained NPS scientists will serve as crew leaders and will be responsible for preparation of supplies/equipment, conducting pre-sampling site-checks, some training, project crew oversight, data collection, data recording, post-sampling equipment inspection and storage, and some data entry. Crew members, will be responsible for assisting with pre-sampling site-checks, some data collection and some data entry. Data management will be shared responsibilities among the project leader and data manager. The data manager and project leader will develop automated data entry forms and database features as part of the quality assurance process. The data manager is ultimately responsible that adequate QA/QC procedures are built into the database management system. The data manager, project leader, and CUPN Co-coordinators are jointly responsible for ensuring data handling procedures are followed.

Qualifications and Training

An essential component for the collection of credible, high-quality woodrat data is well-trained and experienced project crew leaders. Therefore, new crew leaders should be thoroughly familiar with SOP #4 "Conducting Field Sampling" and should be given hands-on training by the

project leader, or an experienced crew leader designated by the project leader, for each of the items detailed therein. Because of the time and effort required to fully train a crew leader, it is recommended that only permanent staff scientists be trained as crew leaders. The overall project leader should be a permanent staff member as well.

Special qualifications and training for crew members is not required because the tasks assigned to them can be easily taught and rehearsed in less than 1-hour during a pre-sampling “training and handling preparation” meeting on Day 1 of a sampling *session* (SOP #1 “Training of Field Personnel, Table 1.1). Due to the need for underground travel and in environments with some surface relief all project crew should be free of claustrophobia and relatively physically fit.

VII. Operational Requirements

Field Schedule and Annual Workload

Woodrat monitoring of “managed” caves will occur on a bimonthly basis beginning in January (between 01 and 14 January, March, May, July, September, and November). “Managed” caves where woodrats have been captured will be sampled for only 1 *session* during each 6-month period. Sampling of cave entrances is scheduled for the first two weeks of each sampling month. A two-week window allows for inclement weather, personnel workloads, etc. Monitoring efforts in “managed” caves will require one 2-person crew. Based on the pilot test, all nine “managed” caves can be sampled by one 2-person crew in less than five hours per day. Therefore, implementation of the protocol will involve two people doing about three half-days of field work six times a year (for “managed” caves) for a total of approximately 18 field-days per year.

Woodrat sampling *sessions* in “unmanaged” caves are scheduled to occur during the first two weeks of May and the first two weeks of November. Monitoring efforts in “unmanaged” caves will require at least two 2-person crews. Based on the pilot test, sampling “unmanaged” caves takes each two-person crew approximately eight hours per day to complete. Therefore, implementation of the protocol will involve four people doing four full days of field work twice a year (one day of pre-sampling site-check plus the 3-day sampling *session* of “unmanaged” caves) for a total of approximately 32 field-days per year.

Electronic entry of all field data will take approximately one eight-hour day per year for a crew member to complete. Data verification, editing, validation, archival, and metadata procedures are estimated to require approximately 11 office-days per year (7 days for data manager, 2 days for project leader, and 1 day each for GIS specialist and curatorial staff). With the aid of queries to automate the workload, data analysis is estimated to take approximately five office-days per year (3 days for project leader, and 1 day each for the data manager and another NPS scientist). Producing the annual status report is estimated to consume 5 office-days per year (4 days for project leader, and ½ day each for data manager and GIS specialist). Therefore, all data management, analysis, and reporting activities are estimated to involve a total of 22 office-days per year.

Facility and Equipment Needs

The nature of woodrat sampling work does not require special facilities beyond normal office space and equipment storage needs. Table 2.1 in SOP #2 “Pre-Sampling” contains a list of field equipment needs for one crew. Since two crews will work simultaneously, equipment requirements will increase accordingly.

Startup and Monitoring Costs

Personnel expenses for field work are based on two crews of two people—an NPS scientist to oversee the entire sampling *session* (project leader) and/or act as crew leader, plus a transient individual to act as a crew member. As detailed above, woodrat monitoring is estimated to require a maximum total of 50 field-days to implement. Field costs will vary somewhat from year to year based on the skill level and size of the crew. Data management-related personnel expenses will include staff time of student interns, the project leader, the data manager, and other NPS staff and is estimated to require a total of 21 office-days (30% of total time necessary to implement this protocol). Based on FY 2006 personnel costs, total personnel expenses for 71 work-days (50 field-days plus 21 office-days) are estimated to be \$20,000 per year (26 intern-days = \$2,000 plus 45 NPS staff-days = \$18,000). There are no anticipated startup costs for implementing this protocol, since all items on the list of supplies and equipment (SOP #2 “Pre-Sampling”, Table 2.1) have already been purchased. Annual supplies and equipment costs should be minimal ($\leq$ \$200), since the most expensive items on the list (i.e., two-way radio and GPS unit) are shared among multiple projects.

Procedure for revising the Protocol and Archiving Previous Protocol Versions

No protocol can be expected to remain unchanged over the long term. The Allegheny woodrat protocol, although well researched and defined, is no exception. We anticipate the foundation, the logic and rationale of program design, to remain as written over the term of the program. However, there will come a time when program logistics, such as sample locations, methods, and reporting criteria may require updating. Careful documentation of changes to the protocol are essential when people, years from now, are examining data trends for example, to know exactly what conditions the data were gathered. All woodrat monitoring data will be entered into a project-specific MS Access database, which contains a field that denotes the protocol version under which the data were collected. Each protocol version will be properly archived to ensure future retrieval.

The rationale for dividing a sampling protocol into a Protocol Narrative with supporting SOPs is based on the following:

- The Protocol Narrative is a general overview of the protocol that gives the history and justification for performing the work as well as sampling methods. It does not contain all methodological details which are found in the accompanying SOPs. The Protocol Narrative is changed only if major revisions are necessary.

- The SOPs, in contrast, are specific detailed instructions for performing given tasks and are expected to be revised more frequently than the Protocol Narrative.
- When a SOP is revised, in most cases, it will not require modification to the Protocol Narrative, unless they affect the Narrative direction or rationale.
- All versions of the Protocol Narrative and SOPs will be archived in the CUPN protocol library and referenced to the resulting Woodrat data.

Steps for changing the Protocol Narrative or SOPs are detailed in SOP #9 “Revising the Protocol”. The Protocol Narrative and each SOP contains a Revision History Log that will be filled out each time the Protocol Narrative or an SOP is changed.

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0
2.0	Dec. 2005	Steven Thomas	Revise Chapter V (Analysis and Reporting)	To reflect revisions made to SOPs 7 & 8	3.0
3.0	Jan. 2007	Steven Thomas	Minor changes on several pages.	To reflect merger of MACA Prototype & CUPN	3.1

VIII. References

- A Proposal for Designation of Mammoth Cave National Park as the Prototype Long-Term Ecological Monitoring Site for the Cave Biogeographic Category. 1993. Un-published document on file at Mammoth Cave National Park. 109 pp.
- Beans, B.E. 1992. Without a trace: The puzzling demise of the Allegheny woodrat. Audubon, January-February:32-34.
- Hassinger, J., C. Butchkoski, and D. Diefenbach. 1996. Fragmentation effects on the occupancy of forested Allegheny woodrat (*Neotoma magister*) colony areas. The State of Pennsylvania. Unpublished report. 2 pp.
- Hicks, A.P. 1989. Whatever happened to the Allegheny woodrat? The Conservationist, March-April:34-38.
- Linzey, A.V. 1990. Status of the Allegheny woodrat. Indiana University of Pennsylvania, Indiana, 11 pp.
- McGowan, E.M. 1993. Experimental release and fate study of the Allegheny woodrat (*Neotoma magister*). New York Department of Environmental Protection, Endangered Species Unit. Unpublished report.

McShea, W.J. and G. Schwede. 1993. Variable acorn crops: Responses of white-tailed deer and other mast consumers. *J. Mammal* **74**:999-1006.

Mengak, M. T. 1991. Woodrat population status and distribution. Virginia Fed. Aid Proj. EW-2-2, Study No. 1, Job No. I-A & I-B. 14 pp.

Richards, P. 1989. Predation in the cave rat fecal latrine. Cave Research Foundation Annual Report. pp. 45-47.

-----, 1990. The effects of predation on invertebrate community structure in the cave rat fecal latrine. Cave Research Foundation Annual Report. pp. 58-61.

Thomas, S. C. 2003. Allegheny woodrat monitoring in Kentucky final report. Cooperative Agreement No. G553002001 between the National Park Service, Mammoth Cave National Park and the Kentucky Department of Fish and Wildlife Resources. 76pp.

IX. Acknowledgements

This monitoring protocol was made possible through the National Park Service Natural Resource Challenge. The authors extend their gratitude to Steve Fancy and Larry West for the direction and guidance on developing monitoring protocols they have provided. We appreciate Paul Geissler, USGS-BRD Status and Trends Program, and Bill Palmisano and Ed Pendleton of USGS-BRD Leetown Science Center for their guidance and support with protocol development. We offer our sincere thanks to the management staff of the Mammoth Cave National Park; Ronald Switzer (Superintendent), Bruce Powell (Deputy Superintendent), Mark DePoy (Chief of SRM), for their support and various contributions towards the development of the protocol. We would like to offer our special thanks to Chris DeWildt, Douglas Foster, Tara Granke, Kurt Helf, Johnathan Jernigan, Maggie Mahan, Andy Nollman, Katie O'Neill, and Lillian Scoggins for their assistance with field work, data entry, and report organization. We wish to thank Rob Byrd and Mauricio Flores of the Computer Science Department at Western Kentucky University for assistance with database development.

**A Protocol for Monitoring Allegheny Woodrats
(*Neotoma magister*) at Mammoth Cave National Park**

Standard Operating Procedure (SOP) # 1

Training of Field Personnel

Version 2.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0
2.0	Jan. 2007	Steven Thomas	Added “Cumberland Piedmont Network” to page 1.	Address merger of MACA Prototype with CUPN	2.1

Implementation of this protocol requires an overall **project leader** and a minimum of two 2-person project crews. The project leader oversees and directs project operations, including training of personnel. Each crew consists of one **project crew leader** and at least one **project crew member**. The project crew leader has site familiarity, woodrat sampling/handling techniques expertise, and is responsible for team tasks. The project crew member has varied and less expertise, and is responsible for assisting the crew leader with data collection.

An essential component for the collection of credible, high-quality woodrat data is well-trained and experienced project crew leaders. This cannot be overemphasized. Therefore, new crew leaders should be thoroughly familiar with SOP #4 “Conducting Field Sampling” and should be given hands-on training by the project leader, or an experienced crew leader designated by the project leader, for each of the items detailed therein. Many procedures require little time to reach an adequate level of proficiency (e.g., locating sampling sites, operating traps, and sexing woodrats), while others may take several sampling sessions and handling several woodrats to become fully competent (e.g., assessing woodrat reproductive condition, determining age class, and properly marking a woodrat). Because of the time and effort required to fully train a crew leader, it is recommended that only permanent staff be trained as crew leaders. The overall project leader should be a permanent staff member as well. Several crew leaders should be trained (and should participate in sampling on a regular basis) from among permanent Cumberland Piedmont Network or Mammoth Cave National Park (MACA) staff in case primary crew leaders are unavailable for particular sampling *trips*. Proper adherence to SOP #2 “Pre-Sampling” should serve to refresh and “recalibrate” the crew leaders’ abilities to prepare for sampling; locate sampling sites; identify woodrat sex, reproductive condition, age class, and

measures of overall “health”; and properly record the information—which ensures integrity of the data being collected.

Transient personnel (e.g., student interns, short-term or seasonal employees, volunteers, etc.) should serve as project crew members (i.e., field assistants). While review of SOP #4 “Conducting Field Sampling” for crew members is encouraged, it is not essential because the tasks assigned to crew members can be easily taught and rehearsed in less than 1-hour during a pre-sampling “training and handling preparation” meeting on Day 1 (e.g., carrying traps, placing polyester fiber fill in traps, slicing apples, baiting traps, setting traps, checking traps, holding a woodrat, etc.). In this meeting, the project leader (or designated crew leaders) also reviews member roles, steps in the sampling process, the particular safety Job Hazard Analyses, and two-way radio use. A checklist to assist the training and preparation meeting facilitator is provided (Table 1.1).

Table 1.1. Pre-Sampling training and handling preparation meeting checklist for Woodrat Monitoring. Meeting conducted by either overall project leader or project crew leader(s) designated by the project leader.

Item	Description
Pre-Trip Training Meeting Checklist	
□ 1.	Demonstrate how to operate a live trap; including inspection, correct setup, baiting, placement of fiber fill, setting, and folding process (see SOP #4 “Conducting Field Sampling”).
□ 2.	Discuss risk of woodrat bites and describe how to handle a woodrat; including transfer of woodrat from trap to handling bag, and holding and releasing a rat (see SOP #4 “Conducting Field Sampling”).
□ 3.	Review roles of project crew leader and crew member(s) (see SOP #1 “Training of Field Personnel”).
□ 4.	Review steps in the field sampling process (see SOP #4 “Conducting Field Sampling”, Appendix B).
□ 5.	Review appropriate Job Hazard Analyses (JHA’s) (see SOP #4 “Conducting Field Sampling”, Appendix C).
□ 6.	Demonstrate proper use of the park’s two-way radios (including radio call #’s).

Since the Allegheny woodrat (*Neotoma magister*) is the only woodrat species known to occur at MACA and is easily distinguished from other rodents on the park, expertise in woodrat identification is not required for project crew.

**A Protocol for Monitoring Allegheny Woodrats
(*Neotoma magister*) at Mammoth Cave National Park**

Standard Operating Procedure (SOP) # 2

Pre-Sampling

Version 2.0 (September 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0

This SOP gives procedures for (1) general sampling preparation and (2) conducting pre-sampling site-checks of cave entrances, as well as (3) a brief description of how woodrat monitoring should be scheduled at Mammoth Cave National Park (MACA), and (4) how to organize supplies and equipment. In order to reduce lost time and perhaps lost data, a pre-trip checklist is provided (Table 2.1). All of the equipment and supplies listed in this checklist should be organized and made ready for each trip into the field, and copies of the field data form (SOP #4 “Conducting Field Sampling”, Appendix A) should be made. This SOP describes tasks to be performed prior to Day 1 of a sampling *session*. Therefore, the crew leader should not simply peruse the checklist the morning before the sampling *session*. The crew leader must check each item on the list, particularly supplies, at least one week before sampling, in case supplies are needed, and again the day before the *session* for final details (such as keys, road closures, batteries for lights/GPS units, etc). Finally, as the crew leader prepares to depart for the field, the list should be checked again and reconciled against supplies and equipment being loaded up to assure nothing is being left behind.

I. General Preparation And Review

Procedures:

1. It is assumed that a required NPS research/collecting permit to conduct this monitoring project will be maintained and an original copy kept in the project leader’s (“Principal Investigator”) vertical files. Each crew should carry a photocopy of the permit while in the field. It is recommended that a state collecting permit also be obtained and maintained by the project leader.

2. Copies of field data forms from recent sampling *trips* should be reviewed to identify any unique events or hazards that may be encountered. Trip reports are based on information recorded on field data forms, so it is imperative that they are clearly organized for ease of field note entry. Thus, uniform field data forms printed on “Rite-in-the-Rain” paper will be used by project crew leaders in an effort to standardized field data entries between sampling crews (SOP #4 “Conducting Field Sampling”, Appendix A).
3. Prior knowledge of sampling procedures and locations is essential for efficient and consistent sampling efforts. Therefore, project crew leaders and crew members should be trained and refreshed (SOP #1 “Training of Field Personnel”), particularly if new personnel join the sampling crews or if intervals between sampling *sessions* are greater than or equal to six months.

II. Site-Check of Sampling Sites

Procedures:

1. A day or two before the scheduled sampling *session*, a project crew leader should obtain a hard copy of the **map** (i.e., from the project leader’s file cabinet in the office, or print a new copy from the “Images” subfolder in the woodrat project folder on the shared drive on write-in-the-rain paper) with the appropriate cave locations and cave numbers. Also, obtain a hard copy of the appropriate **cave locations field list** (i.e., ordered route list) (i.e., from the project leader’s file cabinet in the office, or print a new copy from the “Docs” subfolder in the woodrats project folder on the shared network drive on write-in-the-rain paper) for “unmanaged” caves (e.g., SOP #3 “Establishment and Location of Sampling Sites”, Table 3.1) or for “managed” caves (e.g., SOP #3 “Establishment and Location of Sampling Sites”, Table 3.2) with written directions to the vehicle access parking location and to each cave from the vehicle, and geographic coordinates in Universal Transverse Mercator (UTM), utilizing the North American Datum 1983 (NAD83) projection, for parking and cave entrance locations. Review map and cave locations field list, and become familiar with route and directions to each cave prior to departing for the field.
2. The GIS specialist will download the most current geographic coordinates for each cave entrance scheduled for sampling into the GPS unit to be utilized by the respective field crews. *Note:* It is the responsibility of the project crew leader to schedule this task with the GIS specialist in advance and provide the GPS unit to the GIS specialist. If the waypoints have not been erased from the GPS unit since the last time the cave entrances were visited, simply confirm that the waypoint for each cave is there. *Note:* sampling site waypoints can be stored on GPS units between sampling *sessions*. However, if caves are added or removed from the list of sampling sites for monitoring, the waypoint list must be updated and unneeded cave entrance location information should be erased from the GPS unit.
3. Following the written directions in the appropriate cave locations field list (e.g., SOP #3 “Establishment and Location of Sampling Sites”, Table 3.1 or Table 3.2), and GPS unit if necessary, the crew leader and/or a crew member should drive a field vehicle to the designated parking spot (point on a road that is closest to the first cave entrance). Safely park the vehicle and locate the cave entrance on foot using the “Navigate” or “Go To” feature on

the GPS unit (see operations manual for unit) in conjunction with the written directions and the map.

4. Confirm the correct entrance has been found by locating the permanent numbered brass marker (“cap”) anchored to a rock in the entrance, and/or the cave entrance description information. *Note:* presently, not all cave entrances have been permanently marked. The current permanent mark status for each cave should be noted on the cave locations field list.
5. Visually inspect cave entrance for new hazards (e.g., recent entrance collapse, unstable rocks in entrance, tree blocking entrance, flooding, ice in entrance, access road blocked or impassible, etc.). Make written notes regarding any such hazards and initial recommendations for later discussion with the project leader.
6. Temporarily mark hard-to-locate caves with a piece of colored survey ribbon placed in the vicinity ($\geq 15\text{m}$) of the cave entrance to enable easy location of the cave during sampling. *Note:* special care should be exercised to remove the ribbon on the last day of the 3-day sampling session in order not to compromise site “security”.
7. Continue as above to the second cave on the route until all cave entrances have been located. *Note:* it is not necessary to conduct a pre-sampling site-check of the 5 “managed” cave entrances that receive daily visitation (i.e., Carmichael, Historic, Frozen Niagara, New, and Violet City); since all hazards will be reported by other NPS staff and resolved quickly.
8. Immediately give a copy of any written notes that may impact sampling session logistics to the project leader and discuss options with the project leader.
9. Based on outcomes of the discussion in procedure #8, adjustments [e.g., the sampling route (order), number of caves to sample, which caves to sample] will be made and a new cave locations field list (i.e., ordered route list) will be produced (on write-in-the-rain paper), necessary changes to the GPS waypoint list will be made, and the GPS unit and hardcopies will be placed with the rest of the supplies/equipment, assembled for the ensuing sampling session. *Note:* Caves on the cave locations field list should be arranged according to the order they will be encountered following the most time-efficient route.

III. Scheduling Field Work

Procedures:

1. Three-consecutive-day sampling sessions will be scheduled by the project leader into 2-week blocks within given sampling months by 31 December for the upcoming calendar year. A two-week window allows for inclement weather, personnel workloads, etc. Woodrat sampling sessions in “unmanaged” caves are scheduled to occur during spring (first two weeks of May) and fall (first two weeks of November). If the number of sampling sessions per year decreases, monitoring will likely be scheduled during November. Monitoring sampling sessions in “managed” cave entrances are scheduled for the first two weeks of every-other month beginning in January (between 01 and 14 January, March, May, July, September, and November). *Rationale:* Based on previous woodrat monitoring at MACA (Thomas 2003), annual peaks in trapping success occurred in November four out of five years. The greatest number of juvenile woodrats was captured during May at MACA (Thomas 2003). Marking and recapturing juveniles can provide information on longevity and dispersal. *Background Information:* Sampling routes (sampling order) for each crew will be finalized one or two days beforehand (incorporating information obtained during the

site-check of caves detailed in the previous section) in order to maximize efficiency and minimize travel times. Based on results from the pilot test, all nine “managed” cave entrances can be sampled by one 2-person crew in less than five hours per day, while sampling “unmanaged” caves takes each two-person crew approximately eight hours per day to complete.

IV. Organizing Supplies and Equipment

Procedures:

1. The crew leader should check each item on the supplies and equipment checklist (Table 2.1) to organize and make everything ready one week in advance of a sampling session. This allows time to make needed repairs, check batteries and purchase supplies, if necessary. The following is a list of field supplies and equipment needs for one sampling crew, along with a pre-trip logistical checklist. *Note:* most equipment maintenance and repair/replacement is routinely performed as a post-sampling task—this check serves as an assurance of current readiness.

Table 2.1. Logistical and field supplies/equipment checklist for Woodrat Monitoring.

Number Required	Description
Pre-Trip Logistical Checklist	
☐	1. Schedule monitoring crews with caves and ordered routes in advance
☐	2. Reserve appropriate number and type of vehicles in advance
☐	3. Go through supplies/equipment checklist
☐	4. Check all appropriate equipment for battery (including two-way radios) condition—replace as needed
☐	5. Pre-sampling “site-check” to locate & visually inspect each remote cave ent.
☐	6. Crew member(s) assemble, inspect, and place fiber fill in traps
☐	7. Fill out Cave Entrance Request Form for all non-artificially lighted caves and file one copy with Ranger Division---Project leader keeps originals in file
☐	8. Obtain keys to cave gates/doors and road gates (<i>list will be provided here, but it is hidden in this protocol for security purposes</i>)
☐	9. Perform general pre-trip vehicle inspection (check: first aid kit, fuel level, oil level, tires, spare tire and changing equipment, lights, and wipers)
☐	10. Establish surface watch
☐	11. Sign out crew with destination, vehicle, and approximate return time on dry erase board in office

- ☐ 12. Obtain copy of current NPS research/collecting permit from project leader, one for each field crew

Supplies/Equipment Checklist (Per Crew)

“Unmanaged” Caves Monitoring (per crew, 2 crews needed):

- ☐ 50 Live traps [Tomahawk brand #102 (rigid) or #201 (collapsible)]
- ☐ ~100 Cover boards (8” x 16” x 1/8”) for covering top and one side of each trap
- ☐ ~55 Apples

“Managed” Caves Monitoring (per crew, 1 crew needed):

- ☐ ≤ 36 Live traps [Tomahawk brand #102 (rigid) or 201 (collapsible)]; place 4 traps per cave, if all 9 caves scheduled to be trapped then 36 traps needed; if 8 caves, then 32 traps needed; 7 caves = 28 traps; and so on
- ☐ ≤ 72 Cover boards (8” x 16” x 1/8”) for covering top and one side of each trap (fewer boards needed if less than 36 traps set); use ~2 boards per trap
- ☐ ≤ 40 Apples (fewer apples needed if less than 36 traps set); calculations based on about 1.1 apples per trap

Both “Unmanaged” and “Managed” Caves Monitoring (per crew):

- ☐ 1 Pesola brand scale (500g or 600g)
- ☐ 1 Cotton mesh bag (the type found at natural food/produce stores for customers to carry fruit in works well) with a boot lace threaded through the holes around the perimeter of the bag’s mouth; tie around trap door for handling woodrats
- ☐ 1 Polyester fiber fill (5 lb bag/box)
- ☐ 1 Tattoo pliers (Model 3080 from Stone Mfg. and Supply Co., Kansas City, MO)
- ☐ 1 Container (pill box) with tattoo letters/numbers (#300 tattoo digit)
- ☐ 1 Bottle of black ink for marking male woodrats
- ☐ 1 Bottle of green ink for marking female woodrats
- ☐ 10 Disposable latex or vinyl gloves in ziplock bag for applying ink to woodrat ears
- ☐ 10 Alcohol wipes stored in ziplock bag to clean woodrat ears prior to tattooing
- ☐ 1 Copy of woodrat trapping history report from database (*optional, but useful*).
- ☐ 1 Covered clipboard for field data forms
- ☐ 1 Appropriate field data forms for two sampling *trips* (on write-in-the-rain paper)
- ☐ 2 Pencils and/or Permanent markers (“Sharpies”)
- ☐ 1 Backpack and/or “fanny” pack to hold equipment
- ☐ 2 Work gloves

- ☐ 2 Helmets with lights
- ☐ 2 Hand-held flashlights for backup
- ☐ ~10 Extra AA batteries for lights and GPS unit
- ☐ 1 Hard copy of map with cave locations (on write-in-the-rain paper)
- ☐ 1 Hard copy of appropriate (“unmanaged” or “managed”) cave locations field list with written directions to each cave (on write-in-the-rain paper)
- ☐ 1 GPS unit with all cave entrance waypoints pre-programmed
- ☐ 1 Needle-nose pier for adjusting and repairing traps
- ☐ 1 ~0.25 meter-long section of cotton string for repairing handling bag
- ☐ 1 Pocket knife for cutting string and apples
- ☐ 6 Trash bags to keep bedding dry while transporting to caves during rain and for soiled bedding and other trash (e.g., disposable gloves, used alcohol wipes)
- ☐ 1 Two-way radio (operational and fully charged)
- ☐ 1 First Aid kit

Crew Leader’s Signature:_____ Date:_____

IV. References

Thomas, S. C. 2003. Allegheny woodrat monitoring in Kentucky final report. Cooperative Agreement No. G553002001 between the National Park Service, Mammoth Cave National Park and the Kentucky Department of Fish and Wildlife Resources. 76pp.

A Protocol for Monitoring Allegheny Woodrats (*Neotoma magister*) at Mammoth Cave National Park

Standard Operating Procedure (SOP) # 3

Establishment and Location of Sampling Sites

Version 2.0 (September 2005)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0

This SOP explains the procedures used for establishing (i.e., selecting) and locating permanent sampling sites (i.e., cave entrances) that should be followed by all project crews both: (1) prior to sampling (if an additional site is to be added) and (2) during sampling *trips*.

I. Establishment of Sampling Sites

Approximately 59 permanent sampling sites (caves) have been established as a one-time task. If necessary, additional sites may be selected following the 4-step procedure outlined below. The distance from accessible road parameter should be incrementally increased by 0.1 km until a satisfactory list of potential sampling caves is obtained.

Procedures:

1. Cave location maps and park information was reviewed to locate sampling sites with respect to four selection criteria. Potential sampling sites (caves) were selected based on: (1) the question being assessed (Are woodrats using “managed” caves? or What are the status and trends in woodrat population abundance and structure on the park?), (2) location relative to the Green River (i.e., north or south), (3) distance from an accessible road, and (4) road distance (= travel time) from the staff office (i.e., sampling “hub”). *Rationale:* Criterion #1—All “**managed**” caves ($n=9$) on the park were auto-selected by definition as woodrat monitoring sites in order to provide maximum ability to assess use of “managed” caves by woodrats. Therefore, no additional such caves should be added to the list of monitoring sites unless park managers prescribe a management action like those contained in the definition which follows. “Managed” caves were defined as those having entrances with physical structures such as doors and block houses, or which have electric lighting, or which receive regular visits by tours. Criterion #2—To assess trends in woodrat population abundance and

structure, approximately 50 “**unmanaged**” or natural caves were selected, roughly equally distributed North and South of the Green River. *Rationale:* Unmanaged caves are distributed unequally across MACA, on the North and South sides, as defined by a natural barrier, the Green River. *Note:* “Unmanaged” caves do not have doors (although some have bat-friendly, angle iron gates), block houses, lights, and are off limits to public visitation. Criterion #3—The approximately 50 “unmanaged” caves were initially selected from the group of South side caves ($n=108$) located within 0.3 km, and the group of North side caves ($n=35$) located within 0.5 km, from a vehicle-accessible road as determined by straight-line measurement using GIS. *Rationale:* This design was chosen to reduce hike-in/out site access times, which allows inclusion of more caves within the available time. Since fewer caves naturally occur north of the Green River than south, the distance-from-road was expanded to provide a longer list of potential sampling sites. Consequently, all North side caves ($n=35$) that met the distance-from-accessible-road criterion were selected as potential sampling sites. The South side caves ($n=108$) were reduced in number by ordering them by straight-line distance from a vehicle-accessible road, and then selecting the 70 caves closest to a road as potential sampling sites (which effectively “squeezed” the distance-from-road boundary down from 0.3 km to 0.2 km). *Note:* we have no evidence to assume the distribution of roads at MACA affects the distribution of caves. Therefore, this group of caves was considered a semi-random sample of caves on the park. Criterion #4—South side caves selected as potential sampling sites were then further reduced (from the 70 caves closest to a road) based on road distance (=travel time) from the staff office. This serves to increase sampling efficiency by decreasing drive-time to/from caves. The most distal caves were later dropped due to being located a longer road distance from the sampling “hub” (i.e., the staff office).

2. The final list of “**unmanaged**” caves on both the north ($n=25$) and south ($n=25$) sides were selected from among the potential sites based on safety considerations. Caves which were either unsafe for sampling personnel (e.g., a vertical pit entrance requiring ropes and gear to safely access) or for woodrats (e.g., no safe/sheltered spot in entrance to place traps) were omitted from consideration. Caves which could not be located were also omitted from consideration.
3. The proposed list of sites was adjusted (as described in steps 1 and 2 above) to create the final list.
4. GIS was informed, and maps and tables were created for cave locations (e.g., Figure 3.1, Table 3.1, and Table 3.2).

II. Location of Sampling Sites during a Sampling Session

Procedures:

1. On Day 1 of a sampling session, obtain the current/revised sampling locations map and cave locations field list (i.e., ordered route list, with written driving and walking directions) on write-in-the-rain paper described in procedure #9 in “Site-Check of Sampling Sites” (SOP#2 “Pre-Sampling”). Review map and field list, and become familiar with route and directions to each cave prior to departing for the field. *Note:* Caves on the cave locations field list should be arranged according to the anticipated order they will be encountered following the most time-efficient predetermined route.

2. Following the written driving directions in the appropriate cave locations field list (e.g., Table 3.1 or Table 3.2), and GPS unit if necessary, the crew leader and crew member(s) should drive the field vehicle to the designated parking spot (point on a road that is closest to the first cave entrance). Safely park the vehicle and locate the cave entrance on foot using the “Navigate” or “Go To” feature on the GPS unit (see operations manual for unit) in conjunction with the written directions and the map. The temporary piece of colored survey ribbon placed in the vicinity (≥ 15 m) the previous day (or two) during the pre-sampling site-check (SOP #2 “Pre-Sampling”, Site-Check of Sampling Sites, procedure #6) should aid in locating the entrance.
3. Confirm the correct entrance has been found by locating the permanent numbered brass marker (“cap”) anchored to a rock in the entrance, and/or cave entrance description information. *Note:* presently, not all cave entrances have been permanently marked. The current permanent mark status for each cave should be noted on the cave locations field list.
4. Visually inspect cave entrance for new hazards (e.g., recent entrance collapse, unstable rocks in entrance, tree blocking entrance, flooding, ice in entrance, access road blocked or impassible, etc.) since the pre-sampling site-check a day or two earlier. Record notes regarding any such hazards in the “Cave Notes” field of the field data form (SOP#4 “Conducting Field Sampling”, Appendix A) for that cave.
5. Continue as above to the next cave on the route until all cave entrances have been located.
6. Repeat the above steps to locate sampling sites on Day 2 and Day 3 of the sampling session. *Note:* Remember to remove the temporary ribbon placed at selected hard-to-find cave entrances on Day 3 of the sampling session in order not to compromise the “sensitivity” of these locations.

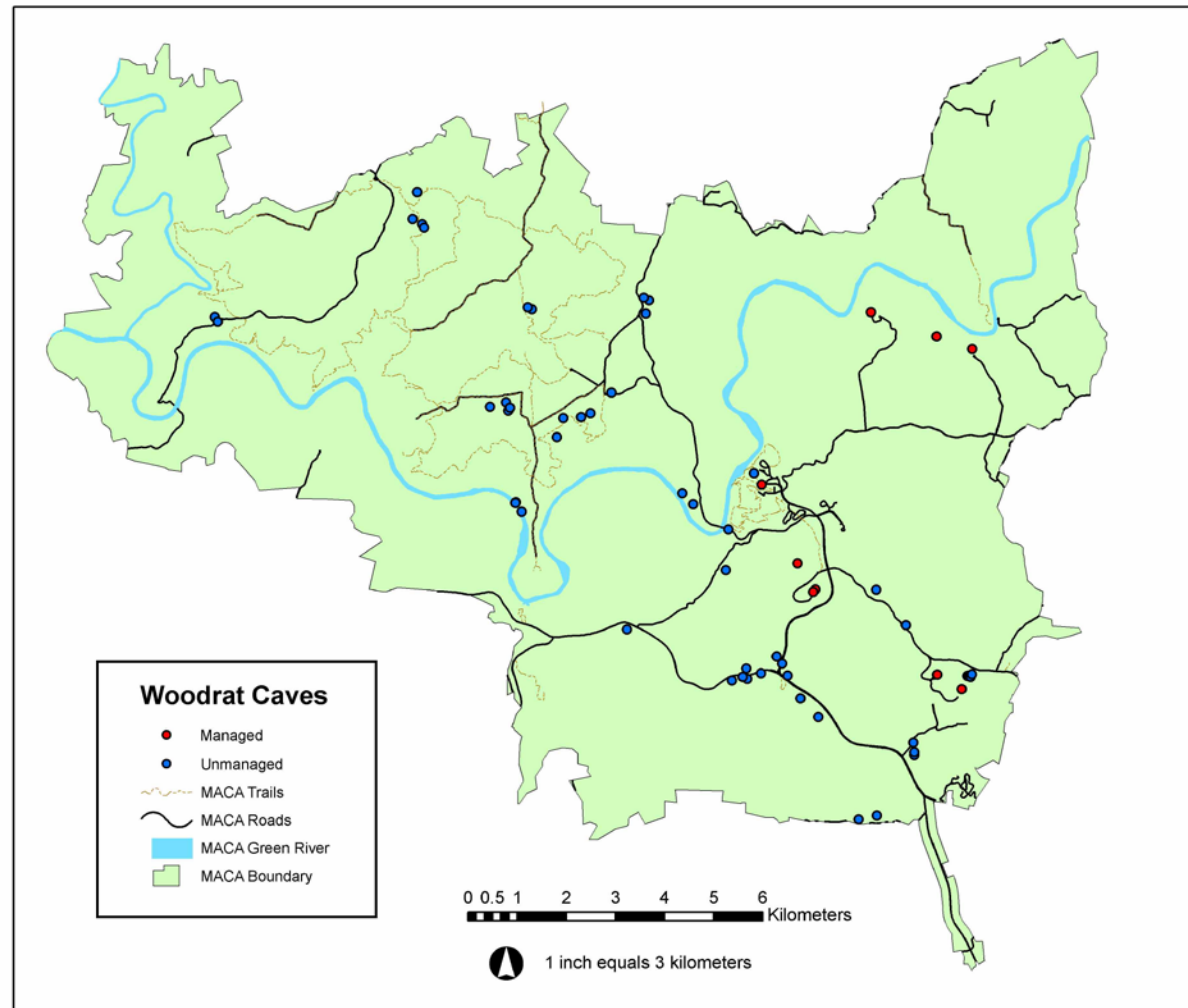


Figure 3.1 Locations of 50 "unmanaged" and 9 "managed" caves for long-term Allegheny woodrat monitoring at Mammoth Cave National Park, Kentucky. **Note:** Due to the sensitive nature of cave location data, cave names have intentionally been omitted and all points are approximate. In-house copies of the monitoring protocol contain information obscured here.

Table 3.1. Driving and walking directions, and UTM coordinates for woodrat monitoring of 50 “unmanaged” caves, at Mammoth Cave National Park, Kentucky. **Note:** Cave names, directions, and coordinates have intentionally been omitted from this table due to the sensitive nature of these data. In-house copies of the monitoring protocol contain information withheld here.

Cave #	Cave Name	Directions from SRM Office to Vehicle Parking Location	Vehicle Parking X Coordinate	Vehicle Parking Y Coordinate	Directions from Vehicle Parking Location to Cave Entrance	Cave Entrance X Coordinate	Cave Entrance Y Coordinate
<i>“Unmanaged” Cave Location List—<u>South</u> Side of Green River</i>							
025	Cave Name Hidden	<Example> Drive 3.5 miles to Little Hope Cemetery on South Entrance Road and park on N. side of road 0.1 miles west of cemetery.	000000.000000	0000000.0000000	<Example> Follow old road bed south for 95 meters. Cave entrance is on west side of road bed.	000000.0000000	0000000.0000000
040	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
041	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
043	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
077	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
080	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
102	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
104	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
105	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
143	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
149	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
156	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
170	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
197	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
202	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
212	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
214	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
216	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
217	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
265	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
266	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
278	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
280	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
281	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
286	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000

“Unmanaged” Cave Location List—North Side of Green River

009	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
010	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
024	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
027	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
028	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
033	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
057	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
059	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
117	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
172	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
173	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
176	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
177	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
178	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
224	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
248	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
293	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
298	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
310	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
334	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
335	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
336	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
339	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
346	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000
350	Cave Name Hidden	000000.0000000	0000000.0000000	000000.0000000	0000000.0000000

Table 3.2. Driving and walking directions, and UTM coordinates for woodrat monitoring of 9 “managed” caves, at Mammoth Cave National Park, Kentucky. **Note:** Cave names, directions, and coordinates have intentionally been omitted from this table due to the sensitive nature of these data. In-house copies of the monitoring protocol contain information withheld here.

Cave #	Cave Name	Directions from SRM Office to Vehicle Parking Location	Vehicle Parking X Coordinate	Vehicle Parking Y Coordinate	Directions from Vehicle Parking Location to Cave Entrance	Cave Entrance X Coordinate	Cave Entrance Y Coordinate
<i>“Managed” Cave Location List</i>							
0001	Cave Name Hidden	<Example> Drive 1.0 miles to service road behind hotel. Unlock gate and proceed down hill on paved road to entrance on right.	000000.0000000	0000000.0000000	<Example> N/A—Park vehicle at entrance and walk down stairs.	000000.0000000	0000000.0000000
001a	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
001b	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
001c	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
001d	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
001e	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
005a	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
0007	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000
0032	Cave Name Hidden		000000.0000000	0000000.0000000		000000.0000000	0000000.0000000

A Protocol for Monitoring Allegheny Woodrats (*Neotoma magister*) at Mammoth Cave National Park

Standard Operating Procedure (SOP) # 4

Conducting Field Sampling

Version 2.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0
2.0	Jan. 2007	Steven Thomas	Minor changes on field data forms.	To aid data entry.	2.1

This Standard Operating Procedure (SOP) gives step-by-step instructions that project **crew leaders** and **crew members** should follow to conduct a woodrat sampling **session** at Mammoth Cave National Park (MACA). The SOP describes procedures, listed in the order they should occur, for: (1) operating live traps; (2) handling a woodrat; (3) weighing a woodrat; (4) differentiating between woodrat sexes; (5) assessing reproductive condition; (6) differentiating between woodrat age classes; (7) assessing woodrat measures of “health”; (8) marking a woodrat, and (9) filling in the field data forms (Appendix A). A checklist summarizing the steps is provided in Appendix B.

Prior to conducting a woodrat monitoring *session* all personnel involved should review the related Job Hazard Analyses (JHA's) and follow all safety guidelines (Appendix C), and review SOP #2 “Pre-Sampling”.

General Sampling Approach

- **Monitoring “unmanaged” caves:** monitoring of “unmanaged” caves will be accomplished using two 3-consecutive-day sampling *sessions* (consisting of four sampling **trips** each *session*) scheduled to occur during spring (May) and fall (November) (see “Scheduling of Field Work” in SOP #2 “Pre-Sampling”). Approximately 25 caves will be sampled north of the Green River and 25 caves will be sampled south of the Green River simultaneously during each *session*. Each sampling *session* will be performed by a minimum of two 2-person crews (one crew leader and at least one crew member). Day 1 of each *session* will consist of each crew locating approximately 25 caves (each site located within a 10-minute hike from a drivable road) and setting two live traps in the entrance area and should take approximately eight hours. Beginning early in the morning of Day 2, each

trap should be checked, all captured woodrats processed and released, and traps rebaited and reset as necessary. Depending largely on the number of woodrat captures (especially unmarked individuals), Day 2 could take from five to eight hours to complete (each crew's work is considered a separate sampling *trip* on Day 2). Starting early in the morning of Day 3, each trap should be checked, all captured woodrats processed and released, and traps removed and placed in the vehicle (each crew's work is considered a separate sampling *trip* on Day 3). Like Day 2, Day 3 could take from five to eight hours to complete.

- **Monitoring “managed” caves:** three-consecutive-day sampling *sessions* (consisting of two sampling *trips*) are scheduled for every-other month of the year beginning in January (see “Scheduling of Field Work” in SOP #2 “Pre-Sampling”). A maximum of nine caves, all south of the Green River, will be sampled by a single two-man crew (one crew leader and at least one crew member). After a woodrat is captured in a given cave, that cave will not be sampled until the next spring (May) or fall (November) sampling *session*; thus, “managed” caves being used by woodrats will only be sampled for one *session* during every 6-month period. “Managed” caves not being used by woodrats (as determined by trapping) will continue on a bimonthly trapping schedule during each 6-month period. Day 1 of a sampling *session* will consist of accessing each cave and setting four live traps in the entrance area (within the first 50 meters) and should take less than five hours. In the morning of Day 2, each trap should be checked, all captured woodrats processed and released, and traps rebaited and reset as necessary. Depending on the number of caves sampled and the number of woodrat captures (especially unmarked individuals), Day 2 (the first sampling *trip*) could take from two to five hours to complete. In the morning of Day 3 (the second sampling *trip*), each trap should be checked, all captured woodrats processed and released, and traps removed and placed in the vehicle. Like Day 2, Day 3 could take from two to five hours to complete.

I. Operation of Live Traps

Procedures:

Pre-Departure Setup and Preparation (steps to be performed at the MACA-SRM office)

1. Rigid traps (e.g., Tomahawk brand #102) will require no assembly. Consult the instructions sheet (Appendix D) for proper setup of collapsible traps (e.g., Tomahawk brand #201). Inspect the trap for any damage which would prevent it from operating correctly (e.g., door bent so won't close fully, hook missing from rear of collapsible trap, trigger hook bent so door doesn't stay open, large hole in trap, etc.). Check the proper operation of the trap by setting and tripping it twice.
2. Hold the trap door open with one hand and place 3 slices of apples with skin up (to keep apple juices from soaking into bedding and to minimize chewing of bait by rodents from outside trap) in the back of the trap. *Note:* it is critical that bait remain beyond the trip pan (“treadle”) because the door will not close properly if an apple slice becomes lodged underneath the pan.
3. Set the trigger on the trap (Appendix D) so the door remains open. Place about a softball-sized ball (when gently squeezed) of clean polyester fiber fill in the back of the trap above

the apple slices. Close the trap door to ready for transport. The fiber fill is for use as bedding material by a woodrat during periods of cold weather (outside air temperatures predicted to be < 60 degrees Fahrenheit) or in breezy or “drippy” cave entrances. *Note:* When properly placed, the fiber fill will not interfere with proper operation of the treadle and will actually hold the apple slices in place.

4. Place checked and baited traps into vehicle for transport to cave sites.

At Sampling Site

1. Place each baited trap inside the cave entrance in the most sheltered spot available. Near woodrat sign (e.g., food cache, midden, latrine) is especially good. Don’t place a trap less than 1 meter from a fresh-looking nest, since woodrats tend to disturb traps placed too close to their nests. Ideally the spot should be free from water sources (e.g., dripping from overhead, flooding, flowing along floor of cave, blowing in from outside), especially if there is a chance of rain during the sampling *trip*. Since woodrats are primarily nocturnal, spots that offer shelter from light sources (i.e., electric lights in “managed” caves or sunlight in “unmanaged” caves) should reduce stress on the captured animal. The use of 1 to 3 “cover boards” (8” x 16” x 1/8” hardboard) per trap is strongly recommended, and when placed on top and along side a trap, can provide shelter from water and light, as well as discourage accessing the bait from outside of the trap rather than through the door. When used, cover boards should be placed in a way which will not prevent the trap door from operating correctly. If available, a flat rock can be placed on top of the cover board placed on top of the trap, and another rock leaned against the cover board alongside the trap to stabilize both the trap and boards. *Note:* before placing cover boards on the trap, make sure the fiber fill and apple slices do not interfere with the treadle.
2. Properly set the trap (Appendix D). Make sure that: a) the trap door is open, b) the back door on a collapsible trap is secured with the hook provided, and c) nothing is likely to prevent the door from closing properly (e.g., an obstacle such as a stick, nut, rock or cover board is in the way of the door; an apple slice or stick is underneath the treadle; or the trigger hook which holds the door open is wedged against the rock wall). See Figure 4.1 for example of a correctly set trap.

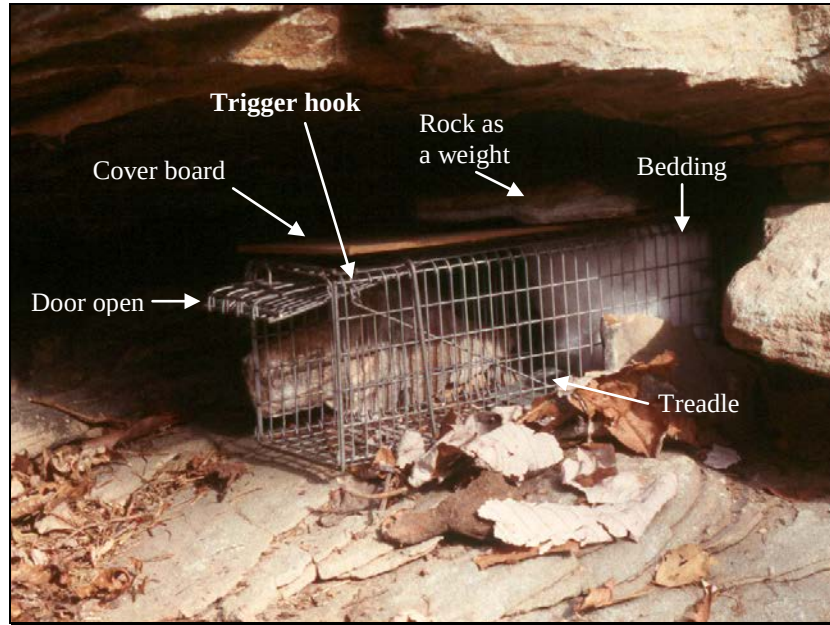


Figure 4.1. A set live trap. Board covering side has been temporarily removed to show position of bedding. Apples are underneath fiber fill bedding material towards rear of trap. Ideally, traps should be placed further back in cave entrance for added shelter from outside elements.

Trap Inspection

When checking a set trap on day 2:

1. Note whether or not the door is shut and any disturbance that is evident.
2. Use a light source to check the condition of the bait and fiber fill.
3. If the bait appears to have been chewed by a rodent (or is missing), replace the chewed/missing apple slices and reset trap. Reposition any fiber fill that has been moved.
4. If the bait and fiber fill appear to be undisturbed, leave the trap alone for the second night.
5. Carefully release any non-target species captured, replace the bait and fiber fill and reset the trap. It is not necessary to replace the trap with another trap because woodrats have been captured in traps the day following capture and release of skunks and other species, as well as conspecifics (other woodrats). **If a woodrat is captured**, process the animal following section “II. Handling a Woodrat” (below), and replace the bait and fiber fill, and reset the trap. *Note:* prior experience indicates several (non-target) species may be captured, including skunks, snakes, chipmunks, opossums, juvenile raccoons, gray squirrels, weasels, and pregnant mice (too large to escape).
6. Before leaving the baited, set, and covered trap, visually check it (see procedure #2 in “At Sampling Site”, above).

When checking traps on Day 3 of a sampling session, steps 1, 2, and 5 (above) apply. After recording trap condition, retrieve trap, bedding, bait, and cover boards.

II. Handling a Woodrat

Procedures:

Notes about Risk of Bites

Even though woodrats are hardy and relatively easy to handle, care should be used not to add unnecessary stress to the animal and not to be bitten by the animal. Whether or not to use gloves while handling a woodrat is a matter of preference. It is difficult to find a glove that provides both the dexterity needed for holding and manipulating a woodrat and protection from a full force bite. With practice, an observer can learn how to avoid being bitten by using the handling bag to direct a woodrat's mouth away from his hand. Being rather docile animals, woodrats only tend to bite when greatly provoked.

Notes about Euthanasia

Although unlikely, it is possible that a woodrat will be found dead or near death in a trap. The decision whether or not to euthanize a critically injured or sick woodrat will ultimately be left to the discretion of the crew leader. Generally, if the crew leader believes trapping did not contribute to the condition of the animal, then the woodrat should be released unaided to either live or die on its own. However, if the crew leader feels strongly that trapping either caused or was a major contributing factor in the animal's demise, then perhaps aid may be given (e.g., warming the woodrat, limited care at the office) or the animal may be euthanized. Cervical dislocation and thoracic compression are commonly used methods because they are quick and impart little pain; and are approved by the Animal Care and Use Committee of the American Society of Mammalogists (*ad hoc* Committee on Acceptable Field Methods in Mammalogy 1998). All dead woodrat specimens should be preserved according to curatorial guidelines for deposit in the MACA museum collection to serve as vouchers.

Processing a Woodrat

1. To process a captured woodrat, use the cotton mesh handling bag provided to receive the woodrat from the trap and to control the animal during measurement and assessment. Before transferring a woodrat from the trap to the handling bag, the scale must be zeroed with the empty bag attached (see procedure #1 in section III. "Weighing, Sexing, Aging, and Assessing Reproductive Condition of a Woodrat" below). *Note:* Before using the bag, thoroughly inspect it to ensure there are no holes large enough to allow escape. Repair any enlarged holes with cotton string and re-zero the scale before using the bag.
2. Look at the woodrat while still in the trap to determine if it has been tattooed. If not, assemble all tattooing supplies and equipment prior to transferring the unmarked woodrat from the trap to the handling bag (see procedure #1 in section V. "Marking a Woodrat").
3. Open the bag and place it over the trap entrance and secure the bag with the attached boot lace. Reach through the handling bag and hold the door open with one hand and spread the bag out with the other hand. Forcefully blow on the woodrat and direct it out of the trap and into the bag. Once the woodrat is entirely out of the trap, close the door and use the hand that was holding the bag out to cinch the bag closed near the trap entrance to contain the woodrat in the bag. Next, use the hand that once held the trap door open to untie the boot lace and carefully remove the bag from around the trap. Finally, tie the handling bag mouth shut with the boot lace using an overhand knot and a bow for security. *Note:* while transferring a

woodrat from trap to handling bag, place the bag on a clean, dry surface (e.g., a cover board) so the bag does not pick up moisture, dirt, leaves, sticks, etc. which can affect its weight.

4. A woodrat in a handling bag is best held by tightly pinching the fur and skin behind the neck and between the shoulder blades right through the handling bag. A woodrat can be further immobilized, such as when tattooing the animal (see section V. “Marking a Woodrat”), by wrapping it up in the handling bag. *Note:* woodrats tend to be less active, and therefore easier to handle, when the bagged woodrat doesn’t come into contact with the ground or a rocky surface. Either suspend the bag in the air, such as when weighing the animal, or place the bag and woodrat on your lap.
5. Once a woodrat has been fully processed, it should be released at the point of capture (i.e., by the trap) by untying the boot lace and opening the handling bag mouth. Shake any dirt and debris out of the bag. *Note:* always hold on to the handling bag while releasing a woodrat because sometimes a hind foot can become entangled in the mesh and the animal might take the bag with it.

III. Weighing, Sexing, Aging, and Assessing Reproductive Condition of a Woodrat

Procedures:

For each Woodrat:

1. Zero the scale. Attach the handling bag to the hook at the bottom of the scale, and hold the scale up and suspend it from the ring at the scale top. If available, use a fixed object (e.g., cave wall or ceiling, tree branch) to steady your hand while zeroing or using the scale. Check the scale for a “zero” reading while the empty handling bag is attached. Adjust or reset zero, if needed. After zeroing the scale proceed to transfer the woodrat from the trap to the handling bag for weighing (see above procedures for “Processing a Woodrat” in section “II. Handling a Woodrat”).
2. **Weigh** the woodrat while it is in the handling bag. Woodrats should be weighed to the nearest 1 gram. Since the Pesola scale only displays in 5-gram increments, you will need to interpolate to achieve the 1-gram level. Wait until the woodrat has stopped moving before reading the scale. Re-weigh the animal at least once or until the same weight is obtained twice consecutively.
3. Determine the **sex** of the woodrat in the handling bag. An adult woodrat is much easier to sex than a juvenile. The elongated penis sheath and lack of mammae (teats) are readily apparent on an adult male woodrat. The relatively shorter urethral papilla (projection) and mammae (normally 4) visible in the inguinal (groin) region are usually obvious on an adult female—especially around a period of lactation (Figure 4.2). First, part the fur in the inguinal region by blowing or using a finger or other probe and search for small mammae. Second, assess the distance from the sheath/papilla to the anal opening. This distance is greater in males (approximately same as length of penis sheath) than in females.
4. Assess the **reproductive condition**, if possible. Juvenile woodrats usually have nonscrotal testes (males) or imperforate vaginal openings (females). **Adult male woodrats** can have either nonscrotal testes or scrotal testes, depending on breeding condition. During the breeding season, the enlarged testes lie in a shallow body cavity depression (temporary scrotum) on either side of the anus (Swartz and Swartz 1981). Testes of woodrats generally

are less-prominent than those of typical laboratory rats (*Rattus rattus*). Thus, visual assessment alone is usually insufficient to determine scrotal status, and palpation of the testes is required. Only with experience will an observer develop the ability to distinguish between the two categories. **Adult female woodrats** can have either imperforate (closed) or perforate (open) vaginal openings, depending on breeding condition. During breeding season, a perforate vaginal opening will appear as a fleshy (moist and swollen during estrus) vertical slit at the base of the urethral papilla. At other times, the slit will be closed and usually will have a crusty or flaky appearance. Imperforate juvenile females do not have this crusty appearance. Pregnant females usually have enlarged bellies and pups can often be felt by palpation. Lactating females have elongated, baggy, often pinkish mammae that are missing hair around the bases of one or more, so they are highly visible (Figure 4.2). The mammae of post-lactating females are often orange and crusty (dried). They may be elongated and hair may be missing around the bases, but they are not baggy and pink. After the breeding season (February-September), adult mammae tend to decrease in size, remain “crusty”, and hair grows around the bases of each one...partially obscuring them. Juvenile female mammae are small and are often obscured by hair, thus you must part the fur in the inguinal region to locate them.

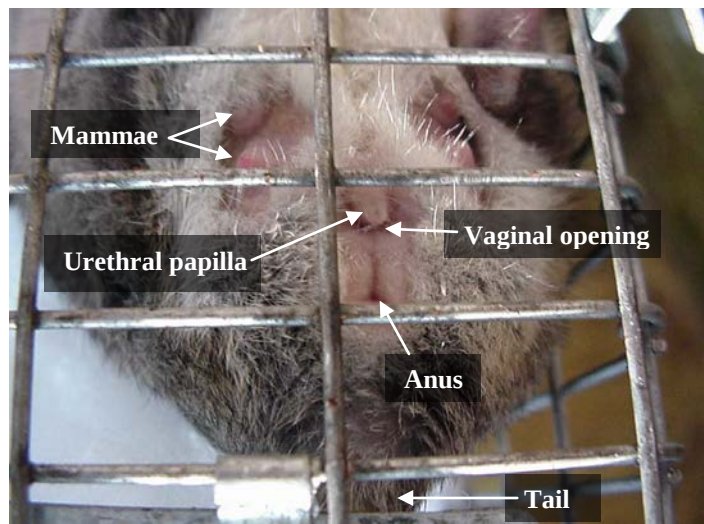


Figure 4.2. Lactating adult female Allegheny woodrat. Note pink, baggy mammae with hair missing around their bases. Mammae have similar appearance during late stages of pregnancy.

5. To increase certainty and decrease subjectivity, this protocol will initially differentiate only two **age classes**; adults and juveniles. A woodrat will be considered an adult if one of the following primary criteria is met: (a) at least six months has passed since the woodrat was first captured (thus ensuring that, unless captured as a neonate, the woodrat is at least 7 to 8 months old) (Rainey 1956); or (b) the woodrat displays evidence of sexual maturity, namely, it is a scrotal male, or a female with a perforate vaginal opening or shows signs of lactation or pregnancy. In the future, use of secondary criteria, such as weight and pelage (fur) color, will be used [and possibly third age class reliably differentiated (e.g., subadults)] as additional keys to age class determination are developed specifically for the MACA population (e.g., Figure 4.3). These characteristics must be evaluated on a local basis for

effective use. *Rationale:* Differentiating among woodrat age classes can be difficult. The difficulty lies not in obtaining the information upon which to make a determination, but the high degree of variability associated with some of the data. It is a particular challenge to discern age at the border between age classes. Generally, three age classes have been recognized: (1) adult, (2) subadult, and (3) juvenile. For Allegheny woodrats, these have traditionally been distinguished mainly by weights reported from Virginia by Mengak (1991) (i.e., adult: ≥ 225 g; subadult: 175-224g; juvenile: <175 g). However, in a five-year study of woodrats in Kentucky, Thomas (2003) found average weights of adult woodrats were almost 50 grams less for males and nearly 30 grams less for females than reported from Virginia by Mengak (1999). Thomas (2003) also captured known adult (based on capture history or known to have produce a litter) woodrats that weighed less than 200 grams, as well as woodrats with very little gray pelage (i.e., subadult-like pelage) that weighed less than 175 grams.

Key to Determine Age Class at Mammoth Cave National Park, Kentucky

(Note: under evaluation)

Primary Criteria:

1. a). If time between 1st capture and recapture is ≥ 6 months, then it is considered an adult.
b). If this is 1st capture or if time between 1st capture and recapture is < 6 months, then see #2.
2. a). If **male** woodrat is scrotal, or if **female** has a perforate vagina or is lactating, post-lactating, or pregnant, then it is considered an adult.
b). If woodrat does not show signs of sexual maturity as in a), then see #3.

Secondary Criteria:

3. a). If **male** woodrat weighs ≥ 250 grams, then it is considered an adult.
a'). If **female** woodrat weighs ≥ 225 grams, then it is considered an adult.
b). If **male** woodrat weighs less than 250 grams, then see #4.
b'). If **female** woodrat weighs less than 225 grams, then see #4.
4. a). If woodrat weighs less than 175 grams, then see #5.
b). If woodrat weighs between 175 and 224 grams, then see #6.
5. a). If woodrat weighs less than 175 grams and has predominately ($\geq 75\%$) soft gray pelage on sides and dorsal, then it is considered a juvenile.
b). If woodrat weighs less than 175 grams and has some ($< 75\%$) soft gray pelage (but fur is mostly, gray-brown—sides and gray-black—dorsal), then it is considered a subadult.
6. a). If **male** woodrat weighs 175 – 249 grams, then it is considered a subadult.
b). If **female** woodrat weighs 175 – 224 grams, then it is considered a subadult.

Figure 4.3. Key to determine Allegheny woodrat age class (under evaluation).

IV. Assessing the “Health” of a Woodrat

Procedures:

Several measures can be used to assess the relative health of a woodrat. These include: a) injuries, b) general physical appearance, and c) ectoparasite load, and are collected while the woodrat is in the handling bag and being held by the nape of the neck.

1. Search the woodrat for any evidence of major or obvious injuries. Examples of injuries include large gashes; open wounds; missing or severely torn ear; blind or damaged eye; some or all of tail missing; missing digit or limb; and broken limb.
2. Visually assess the general physical appearance of the woodrat. Look for evidence of disease or malnutrition such as eye infection, large patches of fur missing, disorientation, lethargy, a growth or tumor, and emaciation.
3. Visually scan the woodrat for ectoparasites. **Fleas** found on MACA woodrats have been identified as *Orchopeas sexdentatus pennsylvanicus*, a subspecies that specializes in woodrats as hosts. Obviously, the longer a woodrat is handled, the more likely a flea is to be observed, if it is present. Only record fleas observed during this assessment period (for consistency between marked and unmarked woodrats)—DO NOT record fleas seen later, as in tattooing step. **Ticks** (*Ixodes woodi* or *I. kingi*) can be found on the ears and muzzle of woodrats and occur less frequently than fleas. Subcutaneous **bot fly larvae** can be found on the cervical (throat) region of a woodrat (Figure 4.4) and leave a **scar** that is visible for several weeks following emergence. *Rationale:* During a five-year study at MACA, the flea infestation rate (total # of infested woodrats/total # of captures x 100) was over 22% with little intra-annual variation (Thomas 2003). Tick infestation rates at MACA were just below 3%, and didn't vary by season (Thomas 2003). Bot fly larvae (*Cuterebra americana*) were found to occur less frequently than ticks, with an infestation rate of less than 1% at MACA over 5-years (Thomas 2003). Thomas (2003) found as many as five larvae present on a woodrat at one time (the two woodrats found this way were recaptured months later with no visible deleterious effects).



Figure 4.4. Woodrat with four subcutaneous bot fly larvae (*Cuterebra* sp.) in cervical region.

V. Marking a Woodrat

Tattooing will occur after weight, sex and age class has been determined, and general “health” assessed. Woodrats are marked for permanent recording and tracking over time. Woodrats in this monitoring project will be permanently marked on their first capture with a letter or number (except zero, 9 and W) tattoo in one ear. *Rationale:* During two years of a capture-recapture study in Kentucky, almost 24% of woodrats marked with two Monel brand #1 ear tags lost one or more tags, and almost 10% lost more than one ear tag (Thomas 2003). Subsequently, all individual woodrats marked with tattoos were able to be identified.

Each woodrat will be given a unique 3-digit identifier that will follow a code based on the tattoo mark applied (Appendix E). *Rationale:* The first digit refers to the ear that is marked. The capital letter “R” for right ear and the letter “L” for left. The second digit refers to the color ink used. The capital letter “B” for black ink and the letter “G” for green. The third and final mark refers to the particular mark itself; either a capital letter or number (except zero, 9 and W). For example, the woodrat identified as “RBA”; its Right ear has a Black letter “A” in it. To increase the possible combinations in the future, either introduce another ink color (e.g., red), or tattoo both ears using the same color and capital letter or number initially. If the latter is done, the identification code could remain 3-digits long if a B” (for Both ears) was used in the first digit. Obviously, after a reasonable length of time since the last capture, say eight years, an individual woodrat can be assumed dead and the identification code reused.

All male woodrats will be marked using black ink and all females with green ink. *Rationale:* For ease of distinguishing sex of individual woodrats inside a trap, or if a marked individual is sighted outside a trap, as well as increasing the possible number of unique marks. This also follows the marking convention used during the woodrat study at Mammoth Cave National Park from 1999-2003 (Thomas 2003).

Procedures:

For each Woodrat:

1. Assemble all tattooing supplies and equipment prior to transferring an unmarked woodrat from the trap to the handling bag. Specifically, a disposable glove should be put on one of the observer’s hands; the correct letter or number (Appendix E) should be placed in the tattoo pliers and secured with the rotating bar and thumb screw; an alcohol wipe packet should be opened and the tattoo letter/number prongs cleaned; and the correct color (black = male, green = female) tattooing ink should be removed from its ziplock bag, the top removed and the ink flow started (for roll-on applicator this can be accomplished by holding the bottle upside down, squeezing it, and rolling the ball along your thumb covered with the disposable glove or along a cover board). Proceed to section III. “Weighing, Sexing, Aging, and Assessing Reproductive Condition of a Woodrat”, and section IV. “Assessing the ‘Health’ of a Woodrat” before tattooing a woodrat (detailed in the steps below).
2. Prepare the weighed, sex, aged, and reproductive condition- and “health”-assessed woodrat for tattooing by having a crew member “immobilize” the animal by wrapping it up in the handling bag and tightly pinching the fur and skin behind the neck and between the shoulder

blades through the handling bag. Gently pull the appropriate ear to be marked (Appendix E) through one of the holes in the handling bag. Apply alcohol from the wipe packet to both sides of the ear and allow it to dry. Drying time can be shortened by blowing on the ear. Apply tattooing ink to thumb and index finger of gloved hand and gently rub ink on to both sides of ear. Before the ink dries, spread the ear out with gloved hand and position pliers with letter or number in the middle of the wide, flat portion on the front side of the ear. *Note:* it is important not to miss some of the ear with the tattoo or to have the ear folded when tattooing because the resulting mark may not be readable. Quickly squeeze and release the pliers making sure the pins on the letter or number made contact with the cork on the pliers on the back side of the ear. It is not necessary to completely puncture the ear with the pins, only the outer layer of skin must be penetrated for ink to enter. It is better to squeeze too hard with the pliers than not hard enough. *Note:* an ear tattoo must be applied only one time otherwise the mark will be indiscernible. If a tattoo is later found to be unreadable, mark the other ear and consider it an individual new to the marked population.

3. After squeezing the pliers to mark the woodrat, apply fresh ink to thumb and index finger of gloved hand and gently rub ink into both sides of ear by taking the ear between the thumb and index finger and massaging with a circular rubbing motion. Continue rubbing ink into the marked area on the ear for 15 to 20 seconds, up to 1 minute if the ear is bleeding.
4. Alternately tattoo ears of same sex woodrats marked the same day in close proximity (≤ 1 km) to each other or (if too many unmarked individuals of a particular sex are captured in close proximity) mark the untattooed ear with a permanent marker using the same capital letter or number placed in the tattooed ear to distinguish recaptured woodrats on Day 3 of the sampling session. *Rationale:* Because the tattoo will not be legible for a month or two, you will not be able to read the mark on any woodrats marked on Day 2 if recaptured on Day 3 of the sampling session.
5. Unwrap the woodrat from the handling bag and the woodrat is ready to be released (see procedure #3 in section II. “Handling a Woodrat”).

VI. Filling in the Field Data Forms

Procedures:

One type of field data form will be used in woodrat monitoring for “unmanaged” caves and another for “managed” caves (Appendix A). The data fields on both forms are arranged into the following 4 levels that proceed from general to specific: (1) sampling *trip* data, (2) cave (*event*) data, (3) individual trap data, and (4) individual woodrat data.

1. Make sure you have a sufficient number of blank copies of the appropriate form before leaving the office on Days 2 and 3 of the sampling session.
2. On Day 3 of the session, make sure you take a photocopy of the data form completed on Day 2 for making field comparisons for quality control. Only “blind” comparisons should be made in order to minimize bias. That is, only compare what was recorded for any particular field on Day 2 with Day 3 after recording the Day 3 data. **For example**, on Day 2 the observer recorded that a particular woodrat had two ticks. If the same woodrat is recaptured (indicated by entering a “Y” for “Yes” in the “Caught Yesterday?” field) on Day 3, do not look at the data form from Day 2, instead process the woodrat normally, but before releasing it, compare the two data forms to see if they differ. If, continuing the example, only one tick

was recorded on the Day 3 form, then re-examine the woodrat to see if there is only one tick (the other may have fallen off) or if there are two (indicating the observer missed the second tick the during initial exam).

3. When the sampling crew arrives at the first trap on Day 2 the individual assigned to record data (usually the crew leader, for consistency) should record the following information on the form:

Sampling Trip Level Data

Trip Date (mm/dd/yyyy): Record the month (2 digits), day (2 digits), and year (4 digits) in the format shown. Include the forward slash. An example is 05/02/2002.

Area: For “unmanaged” caves only, record the side of the Green River the crew is sampling this *trip*. Enter *s* for south side and *n* for north side. Since all “managed” caves are located on the south side, an “M” (for “Managed”) is pre-printed on the form in this field.

Weather: Write a narrative description of the general weather conditions starting with last night’s weather and including the conditions during the day (this may need updating if the conditions change dramatically as the day progresses). An example is “Clear but windy overnight, low in the mid 40s; cloudy and upper 60s while checking traps”. Detailed weather parameters can be obtained electronically from the park’s weather station during future analysis if necessary. Thus, this entry is not intended to be exhaustive, but rather, provide a brief snapshot.

Trip Notes: Record any special notes regarding the sampling *trip* (day). For example, crew leader WSM got sick in the middle of the *trip* and was replaced by crew leader SCT.

Start Time (hhmm): Enter the time the crew departed the office to begin the sampling *trip* (day). 24-hours format should be used. Fill in all four digits. Examples are 0630 (6:30 am) and 1350 (1:50 pm). Only use central time zone.

End Time (hhmm): Enter the time the crew returned to the office after completing the sampling *trip* (day). 24-hours format should be used. Fill in all four digits. Examples are 0630 (6:30 am) and 1350 (1:50 pm). Only use central time zone.

Crew Leader and Crew Member(s): List the initials of the crew leader and the primary crew member. If there is more than one crew member, then list the full names of all additional crew member(s). In the database these, initials will correspond to the full name and contact information for that person. Examples are SCT for Steven C. Thomas or BJM for Bill J. Moore.

Cave (Event) Level Data

Cave #: Record the unique 3-digit cave identification number in the space provided. *Note:* a few caves are identified by a 3-digit number followed by a lowercase letter (e.g., “001a”) instead. *Note:* it is critical that the correct number be recorded for each cave. Before recording

cave number, double-check the map, written descriptions, and locate the permanent numbered brass marker (“cap”) anchored to a rock in the entrance, if one exists.

Arrival Time at Cave (hhmm): Record the time to the nearest minute when you arrived at the cave entrance using the hour and minute format shown. 24-hours format should be used. Fill in all four digits. Examples are 0630 (6:30 am) and 1350 (1:50 pm). Only use central time zone.

Visible Sign: Using the codes provided, circle any woodrat sign observed at the cave that has not been previously recorded this sampling session [**on** = old nest, **fn** = fresh nest, **ov** = old vegetation, **fv** = fresh vegetation (greenery), **ol** = old latrine, **fl** = fresh latrine, **wb** = woodrat bones/skull/teeth, **lw** = live woodrat]. *Note:* can select more than one. Additional notes related to woodrat sign (e.g., species of fresh vegetation observed, number of fresh nests, etc.) should be recorded in the “Cave Notes” field (see below).

Cave Notes: Record any notes related to the cave itself [e.g., new hazards such as recent entrance collapse, unstable rocks in entrance, tree blocking entrance, flooding, ice in entrance, access road blocked or impassible), visible woodrat sign, etc.

Individual Trap Level Data

Trap #: Record the trap number. Follow numerical sequence for the next record (e.g., 1...2...3...4). The trap numbers have been pre-printed on the form for each cave. *Note:* traps are numbered as they are encountered while entering from outside. The first trap encountered is #1, the second is #2, and so on. If two traps are encountered simultaneously (i.e., they are equidistant to the outside), the one on the right while facing into the cave is given the lower number and the one on the left is given the higher number. **For example**, you enter a “managed” cave entrance and encounter a single trap on your left; this is trap #1. You continue on and encounter two traps approximately the same distance from the outside, one on your right and one on your left; the trap on your right is trap #2 and the trap on your left is trap #3. The last one you encounter is #4.

Trap Cond.: In the space provided, record the condition the trap was in when you encountered it. Use the following codes: **ud** = trap undisturbed; **udch** = trap not sprung, but bait was chewed by a rodent (or bedding pulled on/out) or piece of bait missing; **sp** = trap sprung, but bait and bedding not disturbed by a rodent; **spch** = trap sprung and bait was chewed by a rodent (or bedding pulled on), but no animal in trap; **ns** = trap not set; **mal** = malfunction of trap (e.g., apple under treadle so door couldn’t shut, door caught on rock which prevented closure, door didn’t close completely or at all when treadle was depressed, etc.); **malch** = malfunction of trap and bait was chewed by a rodent (or bedding pulled on), but no animal in trap; **miss** = trap set but was missing when checked; **rat** = woodrat(s) in trap; **chipmunk** = chipmunk in trap; **opossum** = opossum in trap; **skunk** = skunk in trap; **gray squirrel** = gray squirrel in trap; **weasel** = weasel in trap; or **mouse** = mouse caught in trap. *Note:* record one of the above codes for each trap in every cave.

Trap Notes: Record any special notes regarding the trap (e.g., trap was flipped upside down, trap moved outside cave, trap missing, cover boards removed from trap, all bedding pulled outside of trap, all bait gone, apple under treadle, Peromyscus droppings).

Individual Woodrat Level Data

Weight (g): Record the weight of the woodrat (not including the weight of the handling bag) to the nearest 1.0 gram.

Sex: Record the determined sex of the woodrat. Use **m** for male and **f** for female. Use **u** for unknown. A comment should be made in the “Woodrat Notes” field if code **u** is utilized.

Age Class: Record the age class of the woodrat as determined by the crew leader. Use **a** for adult, **j** for juvenile, and **u** for unknown. A comment should be made in the “Woodrat Notes” field if code **u** is utilized.

Repro.: Record the reproductive condition of the woodrat as determined by the crew leader. For females use a 3-digit code. The first digit refers to the state of the vaginal opening, either **i** for imperforate vaginal opening, **p** for perforate vaginal opening, or **u** for unknown. The second digit refers to the state of the mammae regarding lactation; enter **n** for nonlactating, **l** for lactating, **p** for post-lactating, or **u** for unknown. The third digit refers to whether or not the woodrat is pregnant; enter **n** (no) for not pregnant, **y** (yes) for pregnant, and **u** for unknown. For male woodrats, use **n** for nonscrotal, **s** for scrotal, or **u** for unknown.

Tag #: Record the unique 3-digit identification code for the woodrat. The tattoo should be read by the crew leader and the identification code determined by the crew leader. The first digit refers to the ear that is marked; the capital letter “R” for right ear, the letter “L” for left, and the letter “B” for both. The second digit refers to the color ink used; the capital letter “B” for black ink and the letter “G” for green. The third and final mark refers to the particular mark itself; either a capital letter or number (except zero, 9 and W). For example, the woodrat identified as “RBA”; its Right ear has a Black letter “A” tattooed in it (Appendix E).

Caught Yesterday?: Always enter **n** (no) on Day 2 of a 3-day sampling session for each woodrat captured. On Day 3, enter either **n** (no), **y** (yes), or **u** (unknown) depending on whether the woodrat was captured (anywhere) the previous day of the sampling session.

Injured?: Circle the correct letter to indicate whether or not the woodrat shows any sign of injury **n** = no injury observed, **y** = injury observed, or **u** = unknown. Examples of injuries include large gashes; open wounds; missing or severely torn ear; blind or damaged eye; some or all of tail missing; missing digit or limb; and broken limb. *Note:* describe any injury observed in the “Woodrat Notes” field.

General Physical Condition: Record the general physical condition of the woodrat using the following four choices: **good** = no visible diseases or injuries, or evidence of only very slight injury; **fair** = several signs of injury but not severe, or some hair missing, or signs of mild illness or disease; **poor** = many signs of injury or serious injury, or much hair missing, or very sick, or

disease-ridden; **dead** = dead; or **unknown**. A comment should be made in the “Woodrat Notes” field if code **u** is utilized.

Ectoparasites:

- (1) **Fleas** [circle one: **0** = none observed, or **f** = few (1-5), or **m** = many (>5)]
- (2) **Ticks** [write in: **0** = none observed, or **1** = one, or **2** = two, or...**6** = six]
- (3) **Bot fly larvae (BFL=)** [write in: **0** = none observed, or **1** = one, or **2** = two, or...**6** = six]
- (4) **Bot fly larval scars (BFS=)** [write in: **0** = none observed, or **1** = one, or **2** = two, or...**6**=six]

Woodrat Notes: Record any special notes regarding an individual woodrat [e.g., pelage (fur) is predominately ($\geq 75\%$) gray on sides and dorsal, pelage is mostly ($\geq 75\%$) gray brown on sides and gray black on dorsal, missing tail, collected tissue sample from right ear, animal appeared disoriented, left ear split in two, explanation of “unknown” being recorded in another field, etc.].

VIII. References

- ad hoc* Committee on Acceptable Field Methods in Mammalogy. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. *Journal of Mammalogy*, 79:1416-1431.
- Mengak, M. T. 1991. Woodrat population status and distribution. Virginia Fed. Aid Proj. EW-2-2, Study No. 1, Job No. I-A & I-B. 14 pp.
- , 1999. Status and distribution of the Allegheny woodrat (*Neotoma magister*) in Virginia. Final Report. Nongame and Endangered Wildlife Program Research Contract: ED0918MM_078, 4 pp.
- Rainey, D. G. 1956. Eastern woodrat, *Neotoma floridana*: Life history and ecology. University of Kansas Publications of the Museum of Natural History **8**:535-646.
- Schwartz, C. W. and E. R. Schwartz. 1981. The wild mammals of Missouri. University of Missouri Press, Columbia.
- Thomas, S. C. 2003. Allegheny woodrat monitoring in Kentucky final report. Cooperative Agreement No. G553002001 between the National Park Service, Mammoth Cave National Park and the Kentucky Department of Fish and Wildlife Resources. 76pp.

Appendix A. Field data forms for recording data for Allegheny woodrat monitoring of “unmanaged” and “managed” caves at Mammoth Cave National Park. (*next two pages*)

Unmanaged Caves

Field Data Form -- Allegheny Woodrat Monitoring of Cave Entrances at Mammoth Cave National Park

Trip Date (mm/dd/yyyy): ____/____/____ Area: N or S (circle one)

Weather: _____

Trip Notes: _____

Start Time (hhmm): _____ End Time (hhmm): _____

Crew Leader: _____ Crew Member(s): _____

Arrival				Caught				Age				Caught				Woodrat Notes			
Cave #	Time	Visible Sign	Cave Notes	Trap #	Trap Cond.	Trap Notes	Wt(g)	Sex	Class	Repro.	Tag #	Yesterday?							
		on	fn		1								Injured?: n y u Physical Cond:_____						
		ov	fv									Fleas: 0 f m Ticks: __ BFL:__ BFS:__							
		ol	fl		2								Injured?: n y u Physical Cond:_____						
		wb	lw								Fleas: 0 f m Ticks: __ BFL:__ BFS:__								
		on	fn		1								Injured?: n y u Physical Cond:_____						
		ov	fv									Fleas: 0 f m Ticks: __ BFL:__ BFS:__							
		ol	fl		2								Injured?: n y u Physical Cond:_____						
		wb	lw								Fleas: 0 f m Ticks: __ BFL:__ BFS:__								
		on	fn		1								Injured?: n y u Physical Cond:_____						
		ov	fv									Fleas: 0 f m Ticks: __ BFL:__ BFS:__							
		ol	fl		2								Injured?: n y u Physical Cond:_____						
		wb	lw								Fleas: 0 f m Ticks: __ BFL:__ BFS:__								
		on	fn		1								Injured?: n y u Physical Cond:_____						
		ov	fv									Fleas: 0 f m Ticks: __ BFL:__ BFS:__							
		ol	fl		2								Injured?: n y u Physical Cond:_____						
		wb	lw								Fleas: 0 f m Ticks: __ BFL:__ BFS:__								

KEY:

Area: <u>N</u>orth or <u>S</u>outh of Green R.	Visible Sign: <u>on</u> = old nest <u>fn</u> = fresh nest <u>ov</u> = old veg. <u>fv</u> = fresh veg. <u>ol</u> = old latrine <u>fl</u> = fresh latr. <u>wb</u> = woodrat bones or teeth <u>lw</u> = live woodrat	Trap Condition: <u>ud</u> = undisturbed <u>udch</u> = not sprung yet bait or bedding was disturbed, chewed, or missing <u>sp</u> = trap sprung but bait and bedding not disturbed <u>spch</u> = trap sprung and bait was chewed by a rodent (or bedding pulled on) but no animal in trap <u>ns</u> = not set <u>mal</u> = mechanical malfunction of trap <u>malch</u> = malfunction of trap and bait chewed by rodent (or bedding pulled) <u>miss</u> = trap set but missing or write in specific animal(s): <u>rat</u>, <u>chipmunk</u>, <u>opossum</u>, <u>skunk</u>, <u>squirrel</u>, <u>weasel</u>, <u>mouse</u>	Sex: <u>M</u>ale, <u>F</u>emale, or <u>U</u>nknown Age Class: <u>A</u>ddult, <u>J</u>uvenile, or <u>U</u>nknown Reproductive Condition: Females have 3-digits: 1) vaginal opening: <u>I</u>mperviate, <u>P</u>erviate, or <u>U</u>nknown. 2) <u>N</u>onlactating, <u>L</u>actating, <u>P</u>ost-lactating, or <u>U</u>nknown, 3) Pregnant? <u>Y</u>es, <u>N</u>o, or <u>U</u>nknown Males: <u>N</u>onscrotal, <u>S</u>crotal, or <u>U</u>nknown	Tag #: has 3-digit code: 1) ear marked: <u>R</u>ight, <u>L</u>eft or <u>B</u>oth ; 2) ink: <u>B</u>lack or <u>G</u>reen); 3) capital letter or number of the mark (not 0, 9 or W) Caught Yesterday?: was woodrat captured yesterday (anywhere)? <u>Y</u>es, <u>N</u>o, or <u>U</u>nknown	Physical Condition: <u>good</u> = no visible diseases, no injuries, or evidence of only very slight injury, <u>fair</u> = injuries but none severe, some hair missing, signs of mild illness or disease <u>poor</u> = many signs of injury, serious injury, much hair missing, very sick, or disease-ridden <u>dead</u> = dead <u>unknown</u> = unknown	Fleas: <u>0</u> (zero), <u>F</u>ew(1-5), <u>M</u>any(>5), For Ticks, Bot fly larvae (BFL), and Bot fly larval scars (BFS) use actual counts of <u>0</u>, <u>1</u>, <u>2</u>, ... <u>6</u>. BEFORE LEAVING CAVE ENTRANCE CHECK FIELD FORM FOR COMPLETENESS AND ACCURACY.
--	---	--	--	--	--	---

Managed Caves

Field Data Form -- Allegheny Woodrat Monitoring of Cave Entrances at Mammoth Cave National Park

Trip Date (mm/dd/yyyy): ____/____/____ Area: M
Weather: _____
Trip Notes: _____
Start Time (hhmm): _____ End Time (hhmm): _____
Crew Leader: _____ Crew Member(s): _____

Arrival		Cave Notes		Trap #		Trap Cond.		Trap Notes		Wt(g)	Sex	Age Class	Repro.	Tag #	Caught Yesterday?	Woodrat Notes	
		on ov ol wb	fn fv fl lw		1											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
					2											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
					3											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
					4											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
		on ov ol wb	fn fv fl lw		1											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
					2											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
					3											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	
					4											Injured?: n y u Physical Cond:_____ Fleas: 0 f m Ticks: __ BFL:__ BFS:__	

KEY:

Managed Cave #s: 001 SomeCave 001a SomeCave 001b SomeCave 001c SomeCave 001d SomeCave 001e SomeCave 005a SomeCave 007 SomeCave 032 SomeCave	Visible Sign: <u>on</u> = old nest <u>fn</u> = fresh nest <u>ov</u> = old veg. <u>fv</u> = fresh veg. <u>ol</u> = old latrine <u>fl</u> = fresh latr. <u>wb</u> = woodrat bones or teeth <u>lw</u> = live woodrat	Trap Condition: <u>ud</u> = undisturbed <u>udch</u> = not sprung yet bait or bedding was disturbed, chewed, or missing <u>sp</u> = trap sprung but bait and bedding not disturbed <u>spch</u> = trap sprung and bait was chewed by a rodent (or bedding pulled on) but no animal in trap <u>ns</u> = not set <u>mal</u> = mechanical malfunction of trap <u>malch</u> = malfunction of trap and bait chewed by rodent (or bedding pulled) <u>miss</u> = trap set but missing or write in specific animal(s): <u>rat</u> , <u>chipmunk</u> , <u>opossum</u> , <u>skunk</u> , <u>squirrel</u> , <u>weasel</u> , <u>mouse</u>	Sex: <u>Male</u> , <u>Female</u> , or <u>Unknown</u> Age Class: <u>Adult</u> , <u>Juvenile</u> , or <u>Unknown</u> Reproductive Condition: Females have 3-digits: 1) vaginal opening: <u>Imperforate</u> , <u>Perforate</u> , or <u>Unknown</u> . 2) <u>Nonlactating</u> , <u>Lactating</u> , <u>Post-lactating</u> , or <u>Unknown</u> , 3) Pregnant? <u>Yes</u> , <u>No</u> , or <u>Unknown</u> Males: <u>Nonscrotal</u> , <u>Scrotal</u> , or <u>Unknown</u>	Tag #: has 3-digit code: 1) ear marked: <u>Right</u> , <u>Left</u> or <u>Both</u> ; 2) ink: <u>Black</u> or <u>Green</u> ; 3) capital letter or number of the mark (not 0, 9 or W) Caught Yesterday?: was woodrat captured yesterday (anywhere)? <u>Yes</u> , <u>No</u> , or <u>Unknown</u>	Fleas: <u>0</u> (zero), <u>Few</u> (1-5), <u>Many</u> (>5), For Ticks , Bot fly larvae (BFL), and Bot fly larval scars (BFS) use actual counts of <u>0</u> , <u>1</u> , <u>2</u> , ... <u>6</u> . BEFORE LEAVING CAVE ENTRANCE CHECK FIELD FORM FOR COMPLETENESS AND ACCURACY.
				Physical Condition: <u>good</u> = no visible diseases, no injuries, or evidence of only very slight injury, <u>fair</u> = injuries but none severe, some hair missing, signs of mild illness or disease <u>poor</u> = many signs of injury, serious injury, much hair missing, very sick, or disease-ridden <u>dead</u> = dead <u>unknown</u> = unknown	

Appendix B

Sequence of Steps for Woodrat Monitoring at Mammoth Cave N.P.

Step	Procedure
1.	Read and follow SOP #1 “Training of Field Personnel” and SOP #2 “Pre-Sampling” procedures.
2.	One week prior to sampling <i>session</i> , crew leader(s) check each item on pre- <i>event</i> checklist and purchase any supplies/equipment. (see SOP #2 “Pre-Sampling”)
3.	One week prior to sampling <i>session</i> , GIS Specialist is assigned task to load all site location waypoints for appropriate sampling <i>session</i> on GPS unit(s) if necessary. (see SOP #3 “Establishment and Location of Sampling Sites”)
4.	One or two days prior to sampling <i>session</i> , conduct sampling “site-check” to locate & visually inspect each remote cave entrance. (see SOP #3 “Establishment and Location of Sampling Sites”) (crew leader and/or crew member)
5.	One day prior to sampling <i>session</i> : Crew member(s) assemble, inspect, and place fiber fill in traps. (see SOP #2 “Pre-Sampling”)
6.	Day 1: Crew member(s) cut bait and place it underneath fiber fill in traps. (see SOP #4 “Conducting Field Sampling”)
7.	Day 1: Conduct a ≤1-hour long pre-sampling “training and handling preparation” meeting (see SOP #1 “Training of Field Personnel”)
8.	Day 1: Crew leader(s) check each item on pre- <i>event</i> checklist before departing to the field. (see SOP #2 “Pre-Sampling”)
9.	Day 1: Locate sampling caves using map, directions, and/or GPS. (see SOP #3 “Establishment and Location of Sampling Sites”)
10.	Properly place, cover, set, and inspect live traps (2 per cave for “unmanaged” caves and 4 each for “managed” caves). (see SOP #4 “Conducting Field Sampling”)
11.	Day 2: Check traps, process woodrats, rebait and reset traps as needed. (see SOP #4 “Conducting Field Sampling”)
---	<i>All following steps are described in SOP #4 “Conducting Field Sampling”:</i>
12.	Woodrat in trap: visually inspect woodrat for presence of tattoo
13.	Woodrat in trap: make ready tattooing supplies and equipment if unmarked
14.	Woodrat in trap: zero scale
15.	Woodrat in trap: transfer woodrat from trap to handling bag
16.	Woodrat in bag: weigh woodrat
17.	Woodrat in bag: determine sex
18.	Woodrat in bag: determine age class
19.	Woodrat in bag: determine reproductive condition
20.	Woodrat in bag: determine ectoparasite load
21.	Woodrat in bag: assess physical condition
22.	Woodrat in bag: tattoo previously unmarked woodrat
23.	Woodrat in bag: release woodrat at point of capture
24.	Upon return to office review field data forms for completeness and accuracy
25.	Day 3: Check traps, process woodrats (steps 12 - 23 above), and retrieve traps.
26.	Upon return to office review field data forms for completeness and accuracy
27.	Day 3 or 4: Project crew leader and member(s) check and repair/replace all needed supplies and equipment prior to storage.(see SOP #5 “Post-Sampling”)
28.	Project Leader is responsible for filing a field report with the Data Manager. (see SOP #5)
29.	Follow SOP #6 “Data Management” for data flow following sampling <i>session</i> .

Appendix C

Job Hazard Analyses (JHAs) Related to Conducting Woodrat Monitoring

JOB HAZARD ANALYSIS
MAMMOTH CAVE NATIONAL PARK

DATE: 9/20/2002 JOB TITLE: Field work in backcountry JOB LOCATION: Backcountry FILENAME: fldbackcountry.jha.doc		PREPARED BY: Kurt Helf TITLE: Invertebrate Ecologist	
APPROVED BY: (Division Chief) Mark DePoy		DATE:	DATE WORK IS PLANNED TO START: CONCURRED BY: DATE:
SAFETY ITEM	PROCEDURE	RESPONSIBILITY	
Biological Hazards (e.g., ticks, stinging insects, poisonous plants and animals)	Be aware of surroundings, be able to identify and avoid contact with hazardous organisms. Carry small first aid kit with proper treatments. Bring medication if severely allergic to hazardous organisms.	Individual and immediate supervisor.	
Accidents	Observe speed limits at all times. Assemble backcountry gear including boots, required specialized gear, park radio or cell phone, compass, water, food, and maps. Ensure ranger activities and surface watch is aware of activity location. No 'self rescue' or assist is allowed; all transport must be performed by responding medical service.		
Rough terrain (e.g., excessive slope, etc.)	Wear proper footwear.		
Hazardous Weather	Check weather forecast for expected time involved. Wear proper clothing against expected weather.		
Getting Lost	Ensure some knowledge of orienteering of group member. Know area to be traveled and bring maps.		

JOB HAZARD ANALYSIS
MAMMOTH CAVE NATIONAL PARK

DATE: 9/20/2002 JOB TITLE: Driving in backcountry JOB LOCATION: Backcountry FILENAME: drbackcountry.jha.doc		PREPARED BY: Kurt Helf TITLE: Invertebrate Ecologist DATE WORK IS PLANNED TO START:	
APPROVED BY: (Division Chief) Mark DePoy		DATE:	CONCURRED BY: DATE:
SAFETY ITEM	PROCEDURE	RESPONSIBILITY	
Vehicle Failure	Check vehicle's oil, water, spare tire, tire pressure, and fuel level.	Driver and immediate supervisor.	
Deer and other animals in front of vehicle. Other Drivers and Vehicles.	Observe posted speed limits at all times. Be aware of surroundings.		
Hazardous Weather	Check weather forecast for expected time involved.		
Getting Lost and Injury	Know the area to be traveled and carry map. Ensure vehicle has first aid kit and emergency equipment (i.e., fire extinguisher, flashlight, blanket, radio). Set up a surface watch.		

JOB HAZARD ANALYSIS
MAMMOTH CAVE NATIONAL PARK

DATE: 9/20/2002 JOB TITLE: Field work in caves JOB LOCATION: Caves FILENAME: fldwrkcv.jha.doc		PREPARED BY: Kurt Helf TITLE: Invertebrate Ecologist DATE WORK IS PLANNED TO START:	
APPROVED BY: (Division Chief) Mark DePoy		DATE:	CONCURRED BY: DATE:
SAFETY ITEM	PROCEDURE	RESPONSIBILITY	
Loss of light and hypothermia	Bring at least three separate sources. An LED flashlight will outlast you. Carry an extra layer of wool or high tech material, and a balaclava in your helmet liner. A garbage bag, a small piece of foam pad, and chemical heater you are ready for a bivouac.	Individual and immediate supervisor.	
Accidents	Far from entrances or developed trails, cave in teams of at least four people. Team members must be reasonably matched in skills and fitness. In case of accident leave one party member with affected person, and send other two for help. Ensure ranger activities and surface watch is aware of activity location. No 'self rescue' or assist is allowed. All transport must be done by responding medical service. Carry compact first aid kit.		
Passages with vertical exposure	Inspect ropes and slings for wear; replace sooner than you think is absolutely necessary (all fibers in webbing are exposed to abrasion, unlike kernmantle ropes). Inspect teeth of mechanical ascenders for wear; keep a prussik 'quick draw' in case of ascender failure. Cross a drop unsecured only if you are sure that the moves needed are well within your skill level; make sure nobody is below.		
Flooding/storms	Check weather forecast. Base level passages, shaft drains, and even shafts can become impassable or unlivable in a matter of minutes to hours. Consider soil saturation levels in concert with weather forecast. Take note of upper level refuges from flood along lower level routes. Cave entrances can be prone to lightning; if waiting out a storm then stay hundreds of feet in and periodically check storm status.		
Fatigue	People in good physical condition need less water and are less prone to injury. Push your endurance limit in gradual increments. Avoid overloading your pack; be creative to reduce weight and bulk.		

Appendix D

Woodrat Live Trap Assembly and Setting Instructions

Assembly instructions are for collapsible Tomahawk brand (model #201) live traps only.

1. Release roll hook which holds trap in collapsed position. Open to square position.
2. Important: If it does not open fairly easily do not force it, but look for something that may be catching.
3. Swing the U-bar down over the front of the live trap to a straight up and down position.
4. Secure the rear door by clipping roll hook over lower cross wire of door.
5. It is important not to force the live trap in any way. If it is not caught on itself, it opens and sets up easily.
6. To fold trap place trap before you with roll hook located at top, nearest you. Swing U-bar back to folding position. Raise both end doors up against roof and fold away from you. Hook roll hook over one leg of U-bar to hold trap closed.
7. When folding, be sure to fold the trap so the trigger mechanism is in the middle of the collapsed trap.
8. Important: Do not force trap to collapse. If it doesn't collapse easily, check carefully for something left hooked or you are possibly folding it the wrong way.

Setting a Trap:

Place trap before you with trip rod on the side nearest you. Press safety door (spring) back and raise complete door unit up against the top. Press trigger forward so small brass roller on door rests on trigger.

Mammoth Cave National Park

Example: "RBA" = Right ear marked, Black ink used, letter "A" is mark.

RGA	LGA
RGB	LGB
RGC	LGC
RGD	LGD
RGE	LGE
RGF	LGF
RGG	LGG
RGH	LGH
RGI	LGI
RGJ	LGJ
RGK	LGK
RGL	LGL
RGM	LGM
RGN	LGN
RGO	LGO
RGP	LGP
RGQ	LGQ
RGR	LGR
RGS	LGS
RGT	LGT
RGU	LGU
RGV	LGV
RGX	LGX
RGY	LGY
RGZ	LGZ
RG1	LG1
RG2	LG2
RG3	LG3
RG4	LG4
RG5	LG5
RG6	LG6
RG7	LG7
RG8	LG8

**A Protocol for Monitoring Allegheny Woodrats
(*Neotoma magister*) at Mammoth Cave National Park**

Standard Operating Procedure (SOP) # 5

Post-Sampling

Version 2.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0
2.0	Jan. 2007	Steven Thomas	Changed established protocol file structure	Update file storage pathway	2.1

This Standard Operating Procedure explains procedures that all field observers using the Allegheny Woodrat Monitoring Protocol for Mammoth Cave National Park (MACA), Kentucky should be familiar with and follow after the field sampling is completed.

Procedures:

1. Organize field data forms and check that they have been filled out completely. As a rule, all data forms need to be reviewed for completeness and accuracy by the crew leader immediately upon returning from the field (SOP #6 “Data Management”, Data Flow). However, because of the number of caves involved and crew members, some deficiencies in data recording may not be identified until all data forms have been organized and reviewed as a group (e.g., when arrival time for a particular cave has inadvertently been missed by a sampling crew). Once the data forms have been reviewed, and the data entered into the database, verified and validated, the project leader will make photocopies to serve as backups, and have originals submitted to the appropriate archive (SOP #6 “Data Management”; Data Entry, Data Verification, and Data Validation).
2. Check and repair/replace all non-consumable supplies and equipment prior to returning them to their proper storage areas in the attic of the Maple Springs Research facility house (traps and cover boards), each NPS staff member’s office (helmet with light, GPS unit), and the Science and Resources Management (SRM) biology laboratory (all supplies and equipment not previously mentioned). Inspect each trap for any damage which would prevent it from operating correctly (e.g., door bent so won’t close fully, hook missing from rear of collapsible trap, trigger hook bent so door doesn’t stay open, large hole in trap, etc.). Check the proper operation of each trap by setting and tripping it twice. Use needle-nose pliers to adjust trigger hook if door either won’t stay open or won’t close. If trap condition is questionable, repair or replace the damaged ones.

3. All reference manuals should be re-shelved on their appropriate bookshelf. Other reference materials (e.g., field maps, field sampling locations lists and directions) and extra field data forms need to be filed in their appropriate filing cabinet. Clean the insides and outsides of all vehicles used in the field.
4. Identify and obtain ancillary data. It is of critical importance that these data be incorporated into the woodrat monitoring efforts. First and foremost, knowledge of management efforts inside and outside caves for that year (e.g., controlled burns) will be used to assess the effects of these efforts on woodrat population structure and dynamics. Second, because cave woodrats obtain food from outside caves, the quality and quantity of their food supply can be affected by surface weather patterns. For example, drought conditions limit plant growth and thus reduce food availability for woodrats. Therefore, annual climate data will be obtained from the park weather station or from the National Park Service Air Resources Division.
5. At the end of each field sampling session, crew leaders complete a narrative trip report outlining hours worked, field crew members and their responsibilities on the project, and any unique situations/hazards encountered. This information will be used to document the dataset and may be important for data analysis (i.e., it may be the only source of information identifying causes for discrepancies and inconsistencies in the data). The project leader is responsible for ensuring field trip reports are completed and filed in the appropriate folder within the established protocol file structure (i.e., Z:\Vital_Signs\Vital_Signs_Prj\Woodrats).

Post-Trip Logistical Checklist

- ☐ 1. Inform surface watch of return
- ☐ 2. Erase crew sign out from dry board in office
- ☐ 3. Return keys to appropriate individuals
- ☐ 4. Review field data forms for completeness and accuracy
- ☐ 5. Remove apples from traps and discard at least 0.5 km from cave entrances
- ☐ 6. Remove soiled bedding from traps and discard in trash; remove clean bedding and store for future use if/when dry; traps do not need to be hosed out nor sanitized (*hantavirus* not a concern at present)
- ☐ 7. Examine all non-consumable supplies and equipment for damage or loss; repair or order replacements
- ☐ 8. Remove all batteries from battery-operated equipment if storage will be ≥ 6 mos
- ☐ 9. Store equipment in proper place (see SOP#5 “Post-sampling”, procedure #2)
- ☐ 10. Photocopy field data forms to serve as backups
- ☐ 11. Project Leader is responsible for filing a field report with the Data Manager
- ☐ 12. Designated personnel enter data from field forms into database using data entry forms

Crew Leader's Signature: _____ Date: _____

A Protocol for Monitoring Allegheny Woodrats (*Neotoma magister*) at Mammoth Cave National Park

Standard Operating Procedure (SOP) # 6

Data Management

Version 2.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas and Bill Moore		Address peer reviewer comments and update due to new NRDT v3.0	2.0
2.0	Jan. 2007	Steven Thomas	Minor changes on several pages	To reflect merger of MACA Prototype and CUPN	2.1

I. Introduction

Purpose

This SOP provides instructions for the development, maintenance and distribution of monitoring data associated with the protocol for monitoring Allegheny woodrats in Mammoth Cave National Park (MACA). The woodrat protocol is one of 17 identified vital signs monitoring protocols currently slated for development by the Cumberland Piedmont Network (CUPN) Vital Signs Monitoring program.

Per the National Park Service's (NPS) Inventory and Monitoring (I&M) Program, Microsoft Access XP (2002) is the primary software environment being utilized for desktop database applications. All data handling practices from production to distribution and archival should be conducted in accordance with the guidance contained in the CUPN Data Management Plan (DMP) (Moore et al. 2005). It is the responsibility of the data manager to be thoroughly familiar with the standards and procedures within the DMP and ensure this SOP is updated to reflect any substantive changes made in the DMP. At minimum, it is assumed that individuals involved in the various phases of this project are familiar with the data stewardship roles and commensurate responsibilities contained in Chapter II and Appendix B, of the above referenced DMP. Appendix A of this SOP contains a list of pertinent data stewardship roles for this protocol as defined in the DMP.

All proposed changes to this SOP must be routed through the data manager for approval.

Expected Audience

This SOP is written primarily for data technician(s), the project leader, and the data manager. In all cases, it is intended that this SOP will reduce the overall time required to accomplish the required responsibilities for each of the assigned roles. To accomplish this goal:

- Protocol data managers will want to read the entire SOP like a text book and be familiar with all aspects of the document. Data managers should be looking for ways to improve the system, but must first know the system being used.
- Protocol project leaders should also be familiar with this SOP, paying particular attention to the data flow and handling procedures. Project leaders are responsible for understanding and fulfilling the data stewardship responsibilities assigned their role, as well as ensuring that anyone under their supervision understands and fulfills their assigned responsibilities.
- Data Technicians need not be familiar with all aspects of this SOP but should instead focus on sections related to their area(s) of responsibility (e.g., data entry, verification).

II. Woodrat Database - Metadata

Metadata, or data about the data, include two basic categories: (1) the data structure information or data dictionary, and (2) data that describe the environment surrounding the purpose of the study. The data dictionary includes information such as field name, field type, field length, etc. (see Appendix B). The second category of metadata includes, for example, the contact information of the sample collector (name, address, phone number, etc.), or information about the location where the woodrat was captured. These are metadata. The “real” data may be, for example, the attributes of the captured woodrats—that are of no value whatsoever unless accurate metadata are associated with the woodrat capture data. Thus, the importance of accurate metadata cannot be overemphasized.

Because of the importance of metadata, much effort has been exerted both by the NPS and the developers of this project to insure data are properly documented. The project leader will complete a basic metadata survey form for inclusion in the data manager’s project file. The data manager will utilize this information to create a Dataset Catalog record to document the project database. It is the shared responsibility of the project leader and data manager to ensure this record remains accurate and up to date. Shapefiles generated for the project will be referenced in the Dataset Catalog record under “related data.” The shapefiles will also be documented with ArcCatalog and the Dataset Catalog record referenced in Section 1.2, Supplemental Information. All geospatial data will be documented with appropriate Federal Geographic Data Committee and NPS metadata standards.

ArcCatalog and Dataset Catalog records destined for upload to the NR-GIS Data Store will be edited with the NPS Metadata Tools and Editor prior to upload. Because this project contains information that can be considered protected or sensitive (i.e., cave locations), authorization must be obtained, beginning with the CUPN Co-coordinators, before any data products are released and/or posted in a location where the public may potentially gain access. Refer to Chapter IX of the CUPN Data Management Plan (Moore et al. 2005) for further guidance regarding the release of information.

III. Woodrat Database - Data Model

The general data model for Allegheny woodrat monitoring consists of: (1) metadata (described above) and (2) field collection data. Proper linking of the two is critical to effective long-term monitoring and analysis of woodrat population abundance and structure and use of “managed” caves, and provides park managers and policy makers with information necessary to make correct decisions regarding the use and conservation of the park’s natural resources.

Standardized Naming Convention

To aid in consistency within this data model and others, CUPN is adhering to the recommended database naming conventions developed by the I&M Program (Washington Support Office, I&M Program 2004a).

Woodrat Data Model

A relationships diagram of the woodrat monitoring protocol is given in Figure 6.1. This structure is based on the Natural Resource Database Template (NRDT) version (3.0).

The I&M Program developed the NRDT as a standard Microsoft Access database core for natural resource inventory and monitoring project datasets. It is comprised of a set of relational database tables that parks and networks can use as a standardized yet flexible database core to develop applications to capture, manage and share natural resource inventory and monitoring data. For more information on the NRDT the reader is referred to the NRDT Version 3 documentation (Washington Support Office, I&M Program 2004b).

At its core, NRDT establishes a one-to-many relationship between locations and *events*. This created some difficulty when attempting to adapt this woodrat protocol to the NRDT because a sampling *session* (and in most cases a sampling unit) for “unmanaged” caves is comprised of multiple crews, visiting multiple locations, on multiple days. “Managed” cave *sessions* are similar except they can typically be conducted with a single crew. Several approaches were considered, but the selected database model was developed per the following:

- **Location** – Location is defined as the cave entrance where trapping took place. Each cave entrance has a globally unique identifier established in the `tlu_cave_locations` table, which is also linked to other various cave protocol databases.
- **Event** – A sampling *event* is defined as one visit (to check traps) to one cave, by one field crew, on one day. For example if a field crew checks traps at nine caves over the course of the day, within the database model, this would comprise nine separate *events*. When entered in the database each sampling *event* receives a globally unique identifier.
- **Event Group** – Event Group is synonymous with a *trip*. Using the previous example where a crew checked traps in nine caves over the course a day, the nine *events* comprise a single event group. These are “grouped” in the database via a shared, globally unique identifier.

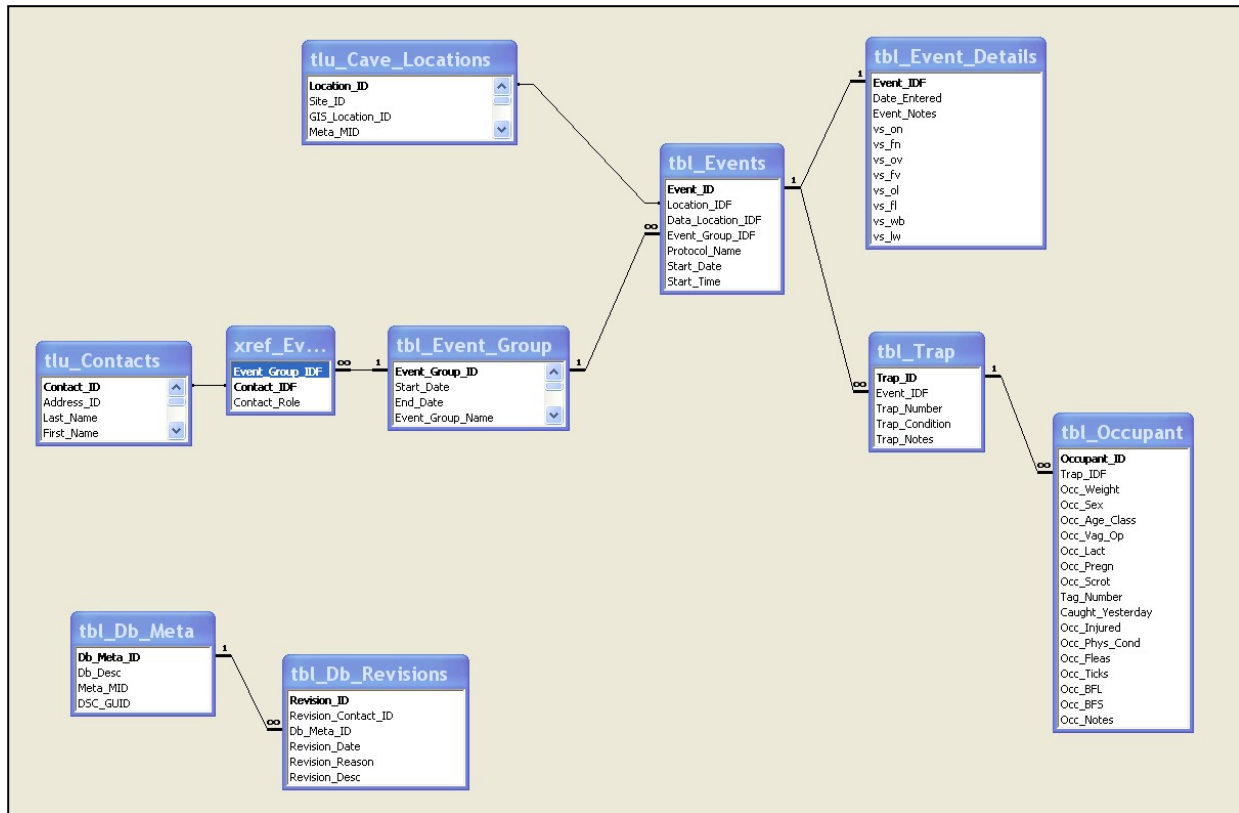


Figure 6.1. Allegheny Woodrat Data Model

In addition to the event and location tables, this database contains three protocol specific tables. Each record within these tables is automatically assigned a globally unique identifier upon data entry.

tbl_Event_Details – A decision was made to place protocol specific *event* details (e.g., woodrat sign in caves) in a separate table and not in tbl_Events. This means that only those fields, which are shared across all protocols, will be present in tbl_Events. This approach should result in greater efficiency in programming and data roll-ups. Tbl-Event_Details is linked to tbl_Events via a one-to-one relationship.

tbl_Trap – This table is synonymous with tbl_Field_Data in the NRDT. It contains trap-specific information (i.e., trap number, condition, and notes). It is linked to tbl_Events via a one-to-many relationship due to the fact that more than one trap is usually set per *event*.

tbl_Occupant – This table contains information on woodrats or other species captured. It is linked to tbl_trap via a one-to-many relationship due to the fact a single trap may, on rare occasions, contain more than one occupant.

Refer to Appendix B for a complete list of tables, fields, and descriptions within the woodrat database.

IV. Data Flow and Data Entry

Data Flow

Periodically observers will set woodrat traps within specified cave entrances and on the next two consecutive days, return to check the traps (refer to SOP #4 “Conducting Field Sampling”, for detailed field methodologies). Immediately upon returning from the field, the field crew leader will recheck the field data forms for completeness and accuracy. After rechecking the data forms for accuracy, field data are entered into an MS Access database form. The data will then be checked by the data technician (verification) and project leader (validation) using queries, forms and reports designed to find erroneous entries. After certifying the validity of the data content for each sampling *trip* (i.e., Event Group), the project leader will contact the data manager who will certify the format and overall reliability of the data, prior to appending the records to the master, validated dataset, which is located in the project’s Validated_Data folder. A summary of the data flow and associated QA/QC is presented in Appendix C.

Data Entry

Prior to commencement of database use, a user (e.g., data technician, project leader, crew leader, crew member, etc.) must receive hands-on training from the data manager in the use of the protocol-specific database and demonstrate a level of competency and understanding of the data processing steps.

Use of programmatic data verification and validation has been incorporated into the data entry forms to greatly reduce the number of operator entry errors (Appendix D). Rather than direct database table entry, customized forms (Figure 6.2), which mimic the field data forms have been designed and tested. These forms provide a natural flow of data entry into the database and incorporate some validation checks to the entered data before allowing them to be written to the database. Where possible, data are entered via the use of dropdown lists or by typing the beginning characters of the value, thus eliminating the possibility of operator entry error. Look-up tables contain project-specific data and prohibit entry of data into a field if a corresponding value is not included in the lookup table. For these fields, only valid names or measures may be entered and spelling mistakes are eliminated.

Figure 6.2 “Unmanaged” Cave Data Entry Form

For the remaining data fields, validation controls prevent impossible values to be entered (e.g., a negative number for woodrat weight) and data entry alert messages are provided when a datum is entered that is not realistic (e.g., weight greater than 650 g). The user is offered a chance to reenter the data or keep the abnormal data. If the user accepts the abnormal data (after double-

checking the field data sheet), the user records the abnormal value on a standardized form that is submitted to the project leader prior to validation.

V. Data Verification

In addition to data validation accomplished by the computer program, the data will also be manually verified shortly after data entry. This process involves checking the accuracy of computerized records against the original source (i.e., the paper field forms). While the goal of data entry is to achieve 100 percent correct entries, this is rarely accomplished every time. To minimize the possibility of carrying entry errors forward into analysis, a data verification process has been established for this protocol that involves multiple checks.

1. During the data entry process, the data technician will double check all field entries prior to advancing to the next record. The data technician will make note of discrepancies and correct prior to moving to next step.
2. Once all records for a sampling *trip* have been entered, the data technician will run the “Records Verification Query” which can be executed from the main switchboard of the database. This query provides a means to check for duplicate, missing, or incomplete records by providing record counts organized by *trip*. The data technician will make note of discrepancies and correct prior to moving to next step.
3. Open the Record Verification and Validation Form, which can be executed from the main database switchboard. This form displays *trip*-level information with all woodrat records contained in a subform. The data technician should review each *trip* to ensure accurate woodrat data have been entered. The data technician will make note of discrepancies and correct. Inform project leader that data verification is complete and forward data entry and verification processing notes to the project leader.

The primary goal of data entry verification is to determine where errors are being introduced into the database. Each error found will, of course, be corrected, but will additionally be cataloged to find methods for eliminating that specific type of error during subsequent sampling periods. For example, if data entry of a certain field is more prone to entry errors, a more stringent computer validation method will be created to eliminate that error from occurring. Once the computerized data are verified as accurately reflecting the original field data and validation is complete, the project leader can submit original field forms for archival. The electronic version of the data is used for all subsequent data activities.

VI. Data Validation

In addition to the computerized data validation process described above, the project leader must also review and validate the data after verification is complete. Validation procedures seek to identify data values that are not logical. For example a uniquely tagged woodrat that was recorded as a female in the spring and a male in the fall. The primary question throughout the validation process should be “Do these data make sense?” As such, data validation will be conducted by the project leader, who is an authority on the methodologies and species involved.

Prior to commencing the validation process, the project leader should obtain the master cave and woodrat summary reports produced from the previously validated data, as well as the data entry and verification processing notes from the data technician. Once these items are obtained, the

project leader will proceed by opening the “Record Verification and Validation Form” and compare the data in question with data in the current master database (validated data). In addition, the project leader is responsible for reconciling any out-of-range values noted by the data technician. Once satisfied with the quality of the data, the project leader will validate records at the *trip*-level, via a field established for this purpose on the above referenced form.

During the entry, verification, and validation phases, the project leader is responsible for the data. The project leader must assure consistency between field data forms and the database by noting how and why any changes were made to the data on the original field forms. In general, changes made to the field forms should not be made via erasure, but rather through marginal notes (preferred) or attached explanations. Once validation is complete, the dataset is turned over to the data manager for archiving and storage.

VII. Database Administration

Data Maintenance

Datasets are rarely static. They often change through additions, corrections, and improvements made following the archiving of a dataset. There are three main caveats to this process:

1. Only make changes that improve or update the data while maintaining data integrity.
2. Once archived, document any changes made to the dataset.
3. Be prepared to recover from mistakes made during editing.

Any editing of archived data is accomplished jointly by the project leader and data manager. Every change must be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions.

Data Organization

CUPN has established a template directory structure, composed of seven folders and four subfolders for each vital sign monitoring project (Figure 6.3). Project files which are being modified, considered draft, and/or certain files currently in use (e.g., a copy of the field data form) should reside within this directory. A similar directory structure will contain archived files (CUPN_Archive\). Both the working and archive directories will be accessible via the MACA Local Area Network (LAN), with access permissions maintained by the data manager(s) and/or MACA Information Technology (IT) Staff.

The data tables utilized for data entry and validation reside within the “Working_Data” folder. Once data in these tables are validated by the project leader, the data manager will append the records to the data tables in the “Validated_Data” folder and the “working” data tables will be emptied. As indicated, the data tables containing the master protocol-specific data for the project are contained in the “Validated_Data” folder. These data have been validated and are available as read-only except to CUPN data managers.

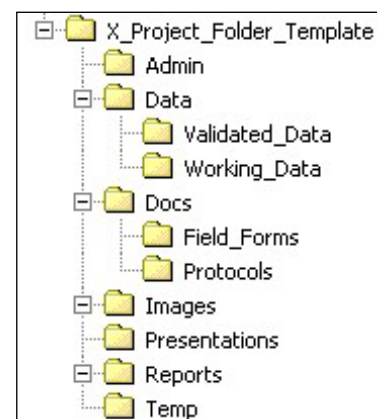


Figure 6.3. CUPN Project Directory Structure

Data Security and Integrity

As many different users will be accessing the database, it is imperative that the data remain secure. Although MS Access provides a means for allowing User-Level Securities to different groups of users, the data managers have determined that it will be more effective to create user groups within the local area network operating system that will have different security levels. Generally, three levels of users will be given different sets of permissions. CUPN data managers will have all permissions, including insert, delete, and modify for all folders in the folder structure. Project leaders/program coordinators, will have the same permissions as program data managers except for read-only permission to the shared data tables and archived data. Those entering the data will have insert and modify permission to the observation data and read-only permission to the lookup and shared data tables.

Version Control

Prior to any major changes of a dataset, a copy is stored with the appropriate version number. This allows for the tracking of changes over time. With proper controls and communication, versioning ensures that only the most current version is used in any analysis. Versioning of archived datasets is handled by adding a three digit number to the file name, with the first version being numbered 001. Each new version is assigned a sequentially higher number. Frequent users of the data are notified of the updates, and provided with a copy of the most recent archived version.

Data Logs and Backups

Once the data are archived, any changes made to the data must be documented in an edit log. From this point forward, original field data forms should not be altered. Field forms can be reconciled to the database through the use of the edit log. Secure data archiving is essential for protecting data files from corruption. Once a dataset has passed the specified QA/QC procedures, the data manager will make a formal entry in the I&M Dataset Catalog. Subsequently, an electronic version of the dataset is maintained in a read-only format on the program server. Incremental or differential tape backups of all project databases are regularly conducted. Backup copies of the data are maintained in a secure alternate location.

VIII. Data Availability

In addition to the “standardized” data dissemination strategies noted in Chapter IX of the DMP, data will be made available for research and management applications on request (per the framework established in the DMP). Data requests should be directed to the CUPN Co-coordinators.

IX. Literature Cited

- Moore, W. J., R. Byrd, and T. Leibfreid. 2005. Data management plan for the Cumberland Piedmont Network and Mammoth Cave National Park Prototype monitoring program. USDI National Park Service. Mammoth Cave, KY. 81pp.
- Washington Support Office, Inventory and Monitoring Program. 2004a. Recommended naming standards for inventory and monitoring databases. Version 3, February 2005. USDI National Park Service, Online

(http://science.nature.nps.gov/im/apps/template/IM_DB_Naming_Recs_v3.pdf).
Accessed 05 August 2005.

Washington Support Office, Inventory and Monitoring Program. 2004b. Natural Resource Database Template Version 3 Documentation. National Park Service. Fort Collins, CO. 21 pg.

Appendix A

Data Stewardship Roles for Woodrat Monitoring at Mammoth Cave National Park

This appendix contains a list of pertinent data stewardship roles for this protocol as defined in the DMP. For a comprehensive list of responsibilities assigned to each role refer to Appendix B, “Data Stewardship Roles and Responsibilities”, of the CUPN Data Management Plan (DMP) (Moore et al. 2005).

Role	Individual(s)/Entities	Duty Station / Title	Contact
Project Crew Member	Kurt Helf	MACA / CUPN Ecologist	(270) 758-2145
	Lillian Scoggins	MACA / CUPN GIS Specialist	(270) 758-2149
	Johnathan Jernigan	MACA / CUPN Physical Scientist	(270) 758-2146
	TBD	MACA / WKU Biology Dept. Student Intern #1	(270) 745-4856
	TBD	MACA / WKU Biology Dept. Student Intern #2	(270) 745-4856
Project Crew Leader	Bill Moore	MACA / CUPN Data Manager/Ecologist	(270) 758-2161
	Steve Thomas	MACA / CUPN Co-coordinator	(270) 758-2144
Data Technician	Variable (dependent on availability and training). Ideally this individual will be someone who was involved in the collection of the data they will be processing.	MACA / Variable	Multiple
Information Technology Specialist	Pat Price	MACA / Supervisory IT Specialist	(270) 758-2130
Project Leader/Resource Specialist	Steve Thomas	MACA / CUPN Co-coordinator	(270) 758-2144
GIS Specialist	Lillian Scoggins	MACA / CUPN GIS Specialist	(270) 758-2149
Data Manager	Bill Moore	MACA / CUPN Data Manager	(270) 758-2161
Curator	Brenda Wells	MACA / Ecological Assistant	(270) 758-2134
CUPN Co-coordinator	Steve Thomas	MACA / CUPN Co-coordinator	(270) 758-2144
Data Manager (National Level)	Margaret Beer	Fort Collins, CO / NRP Data Manager	(970) 267-2168
End Users (managers, scientists, publics)	Multiple Entities	Multiple	Multiple

Appendix B

Table and Field Descriptions

Woodrat Protocol DB (v1.0)

Database Dictionary

Woodrats_v1.0_be.mdb

Documentation Date: 9/28/2005

* Refer to Appendix D of the CUPN Data Management Plan (DMP) (Moore et al. 2005) for descriptions of linked tables.

Table	<i>tbl_Db_Meta</i>		
Description	<i>M. Database description and links to I&M metadata tools.</i>		
FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Meta_MID	M. Link to NR-GIS Metadata Database (Meta_MID)	dbGUID	16
DSC_GUID	M. Link to I&M Dataset Catalog desktop metadata tool (DSC_GUID)	dbGUID	16
Db_Meta_ID	M. Local primary key (Db_Meta_ID)	dbGUID	16
Db_Desc	M. Description of the database purpose (Db_Desc)	dbMemo	0

Table	<i>tbl_Db_Revisions</i>		
Description	<i>M. Database revision history data.</i>		
FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Revision_ID	M. Database revision (version) number or code (Rev_ID)	dbText	50
Revision_Contact_ID	MA. Link to tlu_Contacts (Rev_Cnt_ID)	dbGUID	16
Db_Meta_ID	M. Link to tbl_DB_Meta (Db_Meta_ID)	dbGUID	16
Revision_Date	M. Database revision date (Rev_Date)	dbDate	8
Revision_Reason	M. Reason for the database revision (Rev_Reason)	dbMemo	0
Revision_Desc	M. Revision description (Rev_Desc)	dbMemo	0

Table *tbl_Event_Details*
Description *MA. Sampling event details (visible rat sign in caves)*

FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
vs_fn	Visible Sign: fresh nest	dbBoolean	1
vs_ol	Visible Sign: old latrine	dbBoolean	1
Event_IDF	M. Event ID (Event_ID)	dbGUID	16
Date_Entered	Date when data was entered	dbDate	8
vs_on	Visible Sign: old nest	dbBoolean	1
vs_fv	Visible Sign: fresh veg.	dbBoolean	1
vs_fl	Visible Sign: fresh latrine	dbBoolean	1
vs_wb	Visible Sign: woodrat bones or teeth	dbBoolean	1
vs_lw	Visible Sign: live woodrat	dbBoolean	1
vs_ov	Visible Sign: old veg.	dbBoolean	1
Event_Notes	MA. General notes on the <i>event</i> (Ev_Notes)	dbMemo	0

Table *tbl_Event_Group*
Description *MA. Event aggregations (e.g., seasons, trips).*

FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Start_Time	Time when sampling <i>trip</i> begins	dbDate	8
Event_Group_ID	M. An identifier for the event group (Ev_Gp_ID)	dbGUID	16
Start_Date	M. Starting date of the event group (Start_Date)	dbDate	8
Ver_Val_Date	Timestamp when <i>trip</i> has been verified and validated	dbDate	8
Event_Group_Name	MA. Event group (e.g. season, <i>trip</i>) name (Ev_Gp_Name)	dbText	100
Event_Group_Notes	MA. Event group notes (Ev_Gp_Note)	dbMemo	0
Event_Group_Report	MA. <i>Trip</i> report, link to <i>trip</i> report or <i>trip</i> report name (Ev_Gp_Rept)	dbText	255
Weather	Description of the weather at the moment of the <i>trip</i>	dbText	100
Verified_Validated	If <i>trip</i> has been verified and validated	dbBoolean	1
End_Time	Time when <i>trip</i> ends	dbDate	8
End_Date	M. Ending date of the event group (End_Date)	dbDate	8
Area	North or South of Green River OR “Managed” Caves	dbText	1
Event_Group_Desc	MA. Event group description (Ev_Gp_Desc)	dbText	255

Table *tbl_Events*
Description *M. Sampling events.*

FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Event_ID	M. Event identifier (Event_ID)	dbGUID	16
Location_IDF	M. Link to tbl_Locations (Loc_ID)	dbGUID	16
Data_Location_IDF	MA. Optional link to tbl_Data_Locations (Data_Loc_ID)	dbGUID	16
Event_Group_IDF	MA. Link to tbl_Event_Group	dbGUID	16
Protocol_Name	M. The name or code of the protocol governing the <i>event</i> (Protcl_Nam)	dbText	100
Start_Date	M. Starting date for the <i>event</i>	dbDate	8
Start_Time	MA. Starting time for the <i>event</i> (Start_Time)	dbDate	8

Table *tbl_Occupant*
Description *Rat (Occupant) Capture Data (weight, sex, etc.)*

FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Occupant_ID	Occupant Identifier (record ID)	dbGUID	16
Occ_Vag_Op	Woodrat's reproductive condition. Female: vaginal opening: Imperforate, Perforate, or Unknown	dbText	1
Occ_Age_Class	Woodrat's age classification: Adult, Juvenile, or Unknown	dbText	1
Occ_Sex	Woodrat's sex: Male, Female, or Unkonwn	dbText	1
Occ_Weight	Woodrat's weight in grams	dbDouble	8
Occ_Pregn	Woodrat's reproductive condition. Female: pregnancy: Pregnant Yes, No, or Unknown	dbText	1
Occ_BFL	Bot fly larvae (BFL) use actual counts (0,1,2...)	dbInteger	2
Caught_Yesterday	was woodrat captured yesterday (anywhere)? Yes, No, or Unknown	dbText	1
Trap_IDF	Link to tbl_Trap	dbGUID	16
Tag_Number	ear marked: Right, Left, or Both. ink: Black or Green. capital letter or number of the mark (0-9, A-Z)	dbText	3
Occ_Scrot	Woodrat's reproductive condition. Male: genitalia: Nonscrotal or Scrotal	dbText	1
Occ_BFS	Bot fly larval scars (BFS) use actual counts (0,1,2...)	dbInteger	2
Occ_Ticks	Ticks use actual counts (0,1,2...)	dbInteger	2
Occ_Fleas	Fleas: 0 (zero), Few (1-5), Many (>5)	dbText	1
Occ_Phys_Cond	Physical Condition: good, fair, poor, dead, unknown	dbText	10
Occ_Injured	Occupant injured? No, Yes, or Unknown	dbText	1
Occ_Notes	Woodrat Notes	dbMemo	0

Occ_Lact	Woodrat's reproductive condition. Female: lactation: Nonlactating, Lactating, Post-lactating, or Unknown	dbText	1
----------	--	--------	---

Table *tbl_Trap*
Description *U. Trap observations*

FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Trap_ID	Trap Identifier (Trap ID)	dbGUID	16
Event_IDF	Link to tbl_Events	dbGUID	16
Trap_Number	Trap number in cave (1,2,3,4)	dbInteger	2
Trap_Condition	Condition of Trap when checked (ud=undisturbed, rat=woodrat in trap, etc.)	dbText	20
Trap_Notes	Trap specific notes	dbMemo	0

Table *xref_Event_Group_Contact*
Description *O. Cross-reference table between event groups and contacts.*

FIELD NAME	FIELD DESCRIPTION	FIELD TYPE	FIELD WIDTH
Event_Group_IDF	Link to tlu_Event_Group	dbGUID	16
Contact_IDF	Link to tlu_Contacts	dbGUID	16
Contact_Role	Role of contact for specified Event Group	dbText	20

Appendix C

QA/QC Process Flow for Woodrat Monitoring at Mammoth Cave National Park

<u>QA/QC Procedure Name</u>	<u>Schedule</u>	<u>Description of Procedure</u>	<u>Responsible Entity</u>	<u>Response</u>
Immediate Verification	Before releasing occupant or leaving trap	Crew leader and crew members will verify all data on their field forms pertaining to the current occupant or trap before releasing the animal or proceeding to the next location	Crew Leader	If there are blank or incorrect entries they will be corrected immediately. If a procedural change or new datasheet format could prevent future mistakes, the suggestion will be annotated in the notes.
Field Notes Review	Immediately after returning from the field	After the crew returns from the field the crew leader will assure that all field data forms are accounted for and complete.	Crew Leader	Make sure all data have been entered and all data sheets are accounted for.
Field Notes to Computer Form verification	As entered	The person who enters the data into the computer from the field datasheets explicitly compares the paper datasheet with the data on the computer screen to verify correct data entry	Data Technician	Make corrections immediately and, if the errors could have been prevented by changing a process or computer form tell the data manager.
Hardcopy-to-Digital Verification	As soon as practicable, following previous step	Run Record Count Verification Query, compare cave and woodrat summary reports with field data sheets, review records in data verification and validation form with field data sheets	Data Technician	Record any data entry errors, abnormal values, or other discrepancies found in dataset via a standardized form. Make appropriate corrections at time of check, and submit form to project leader.
Data Validation	As soon as practicable, following previous step	Compare cave data and woodrat data with master woodrat and cave summary reports. Mark records (i.e., Event Groups as validated. Once validation is complete move to projects "Validated_Data" folder.	Project Leader and Data Manager	Record any inconsistencies and import error messages. Correct problems and/or change process as needed. Provide feedback to data technicians and crew members as appropriate.
Data Documentation and Dissemination	At least annually, but prior to any data releases	Ensure dataset is fully documented and sensitive information is flagged	Data Manager, GIS Specialist and Project Leader	

Appendix D Data Verification/Validation Controls within Data Entry Forms

Field Data Form - Allegheny Woodrat Monitoring of Unmanaged Cave Entrances at Mammoth Cave National Park

Allegheny Woodrat Monitoring Protocol

Trip Date: 4/1/2005 April 2005 Area: N Unmanaged caves

Weather: It was a cold dreary night

Trip Notes: Remember to bring lunch next time

Start Time (hhmm): 6:30 End Time (hhmm): 16:30

Person: Harry Rat Role: Crew Leader

Person: Role: Crew Member

Person: Role: Crew Member

Caves (Info only): 001b New Entrance, 298 Cade Cave, 350 Crumbling Rock Cave, 310 Fishtrap Spring Cave, 059 Johnson Spring Cave, 334 Beech Tree Sink, 335 Squeeze Cave, 178 Salamander Cave

Cave #	Arrival Time	Visible Sign	Cave Notes	Trap #	Trap Cond.	Trap Notes	Wt(g)	Sex	Age Class	Repro.	Tag #	Caught Yesterday?	Woodrat Notes
999	12:00	on fn ov fv ol fl wb lw	Open Notes	1	rat	Open Notes	300	M		vaq lact pregn scrot	ear link letter	N	Injured? N Physical Cond: good Fleas: F Ticks: 9 BFL: 6 BFS: 3
				2	jud	Open Notes	0			vaq lact pregn scrot	ear link letter		Injured? Physical Cond: Fleas: Ticks: 0 BFL: 0 BFS: 0

Previous Trip Next Trip Add Trip Delete Trip

Previous Event Next Event Add Event Delete Event

1. Trip Date - Combo box populated with values from today's date to 180 days prior.
2. Event Group Name - autopopulated based on trip date
3. Area - combo box restricted according to form (e.g., "managed" caves form = "M" only)
4. Event Group Desc - autopopulated dependent on form (i.e., "managed" or "unmanaged")
5. Contact - Combo box limited to values in tlu_contacts
6. Contact Role - Combo box limited to values in list, only 1 crew leader can be assigned
7. Cave # - Combo box limited to values in tlu_Cave_Locations
8. Time - All times formatted hh:mm; End time must be after start time
9. Trap # - Set on form; 1-2 on "unmanaged" form, 1-4 on "managed" form
10. Trap Condition - Limited to values in combo box
11. Weight - Warning message appears when value entered is <25 or >650
12. Sex - Limited to values in combo box
13. Age Class - Limited to values in combo box
14. Reproductive Condition - All controls limited to values in combo box; male/female controls enabled based on value entered in Sex
15. Input values limited to specified values (e.g., ear = R or L)
16. Remaining controls limited to values in combo box, message box appears if user attempts to advance to next record without entering values in these fields.

A Protocol for Monitoring Allegheny Woodrats (*Neotoma magister*) at Mammoth Cave National Park

Standard Operating Procedure (SOP) # 7

Data Analysis

Version 2.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Dec. 2005	Steven Thomas	Major revisions throughout document	Address peer reviewer comments	2.0
2.0	Jan. 2007	Steven Thomas	Minor changes on several pages	To reflect merger of MACA Prototype and CUPN	2.1

This SOP outlines the data flow and expected analyses of Allegheny woodrat monitoring data collected within Mammoth Cave National Park (MACA). The monitoring questions and subsequent analysis of the supporting data can be divided into two categories, based on time scale in analysis. The first category includes questions of status (population structure and relative abundance), pattern of cave use by woodrats amongst sampled caves, and management—influence on population status and use of caves, measured at the within-year (*sessional*) and annual scales. This category focuses on detection of salient natural patterns in population characteristics, and detection of significant or dramatic influence on use of caves by woodrats due to both planned management activities, such as cave modification, and variable disturbance from cave tours. The sampling design provides: 1) a bimonthly assessment of management impact as reflected in cave use and population parameters, and 2) a hemi-annual assessment of park-wide population status. Data are collected on a bimonthly basis in managed caves to assess putative management impact on cave-use by woodrats and on population parameters (Table 7.1). Data are collected on a hemi-annual (6-month) basis at unmanaged caves to assess park-wide population status (Table 7.1). The second category includes these same questions (using the same two sampling designs), considered over multi-year scales. This category focuses on detection of multiple-year trends and natural patterns in woodrat populations, and on detection of possible cumulative management effects on cave use levels and patterns that may manifest themselves only after many years. Both categories of questions will be addressed using a combination of summary and descriptive statistics, graphic analysis, and multivariate comparative and correlative analysis. Management impact classes (managed and unmanaged) are a key factor in short-term (1–year scale) analyses. Both management impact and time are the key grouping and stratification factors in the long-term, repeated-measures analyses of the several categories of woodrat data (age and sex structure in the population, relative health and ectoparasitism levels, cave-use, distribution among sampled caves, and abundance). Additional analytic approaches will be developed in future years to evaluate

woodrat population parameters in a comparative and correlative model with park-level weather trends and spatial dynamics, and movement of woodrats among sampled caves.

With respect to use of managed caves by woodrats, data are collected in bimonthly sampling sessions. These data will be combined into two 6-month periods per year for analysis. Data collected during the May and November sampling sessions from all managed and unmanaged ($n = 59$) caves will be evaluated using a suite of metrics, and descriptive and summary statistics. [Note: data collected during the months between May and November sessions (i.e., January, March, July, and September) **will not** be used for quantitative analyses (i.e., to estimate: population structure, relative abundance, population size). Annual and longer-term trends analyses will use separate bimonthly datasets (for use of managed caves), hemi-annual, and derived, cumulative annual data to evaluate longer-period trends and patterns, both for managed and unmanaged caves.

Table 7.1. Sampling schedule for Allegheny woodrat monitoring at Mammoth Cave National Park. “b” indicates bimonthly sampling in 9 “managed” caves for assessing cave use. “h” indicates hemi-annual (6-month) sampling in 50 “unmanaged” caves to assess population parameters. Sampling for “b” and “h” caves follows 2 overlapped (May and November) schedules using the same methodology.

Cave Type	Jan	Feb	Mar	Apr	May ^{1,2}	June	July	Aug	Sept	Oct	Nov ^{1,2}	Dec
managed (9)	b		b		b		b		b		b	
unmanaged (50)					h						h	

¹“b” and “h” data collected in May and November are combined for “all-caves = 59” assessment of park-wide population parameters.

²“b” data for May, July, and September are pooled to assess use of “managed” caves in the 6-month period beginning in May of each year. “b” data for November, January, and March are pooled to assess use of “managed” caves in the 6-month period beginning in November of each year.

The protocol was designed to answer the following monitoring questions:

1. What is the status of Allegheny woodrat population [population and relative abundance estimates, distribution among sampled caves, and structure (age class ratios, mean weight, general health, ectoparasite load, sex ratios)] using “unmanaged” and “managed” (all 59) caves on the park?
2. What is the trend over time in population estimate, abundance, distribution among sampled caves, and structure (age class ratios, mean weight, general health, ectoparasite load, sex ratio) of the Allegheny woodrat population associated with “unmanaged” and “managed” (all 59) caves across the park?
3. How do trends in Allegheny woodrat population structure differ between “managed” (i.e., with lighting systems, cave doors, block houses, tours, etc.) and “unmanaged” caves on the park?
4. What is the current pattern (status) in use of “managed” caves by Allegheny woodrats on the park?
5. What is the change in the pattern (trend) of use of “managed” caves by Allegheny woodrats on the park?

I. Data Analysis

A. General Data Structure for Analysis: Data are collected from woodrats in traps in caves in sampling *sessions*. Sampling occurs in 9 “managed” caves in a bimonthly *sessions* schedule and in “unmanaged” caves in a 6-month *sessions* schedule. For analysis, data will be delivered at 6-month intervals (May and November) (see also Table 7.1). Note that “managed cave data” has an internally pooled structure for cave-use analysis.

A sampling *session* consists of 2 or more sampling *trips*, where a sampling *trip* consists of 1 sampling team visiting all of its assigned traps in 1 sampling day. For managed caves, all 9 caves are sampled by 1 team on each of 2 days—thus, each “managed *session*” will consist of 2 sampling *trips*. For unmanaged caves, 2 sampling teams are used, and the “unmanaged *session*” will consist of 4 sampling *trips*. (See SOP #4 for details on sampling for managed and unmanaged caves).

For qualitative analytical purposes (i.e., woodrat use of managed caves), data will be pooled into sets representing 3 managed sampling *sessions* for each 6-month period of every sampling year (per Table 7.1). Each set will include the managed caves in which at least one woodrat was captured during the 6-month period. Frequency of managed cave use will be reported as “# managed caves with woodrats out of the 9 managed caves sampled” for the 6-month pooled sampling period.

For quantitative analytical purposes, data will come as sets representing 1 managed *session* and 1 unmanaged *session* in each May and November of every sampling year. Each set will include all woodrats captured in the *session* by individual ID (ear code) x location (cave ID number) x trap night 1, or trap night 2, with corresponding age class (1 or 2), sex (M or F), weight (value in grams), parasitism loads (fleas = 3 infestation classes, ticks = count, bot fly larvae and bot fly scars = count), physical condition score (4 classes), and injury score (2 classes). Note: cave ID number incorporates a potential stratification or grouping factor (locations north of versus locations south of the Green River) that can be used in descriptive metrics and statistical calculations and in trend analysis and comparison over time. Sex and age class can serve as grouping factors in descriptive, comparative and trend analyses (e.g., mean weight of females, or a comparison of mean weights of adult males versus adult females).

Descriptive and summary metrics and statistics will be developed on a hemi-annual basis each May and November for selected population descriptive parameters.

“Descriptive Statistics” will be taken to mean a calculated value, such as a mean weight or mean age, which represents a sample value that may be reported with a variance term and/or standard deviation. A “Metric” will be taken to mean any other value, such as a sum (e.g., the number of females in the sample collected in the *session*), which is reported as a finite number and without any calculated variance or standard deviation term. Metrics are frequently used in computing a statistic. Note: in general, while descriptive statistics can be calculated for any desired sample structure or data subset,

such as for “caves by side-of-the Green River”, etc., it is strongly recommended that most sample subdivision be avoided, owing to the small sample *n* expected.

B. Data Transforms: For analytical purposes, some data types will need to be transformed prior to use in computation of statistics. Specifically, all “class” data entered as text (“yes” or “no”, “some”, “A”, etc.) will be converted to ranked numerical scores stated as integers. Converted class data will be denoted with a T, as shown below. Data to be converted include:

- **AgeT** = Transformed age class (2 classes) = values of 1 or 2 for increasing age, from 1 = “Juvenile” to 2 = “Adult”
- **PhysConT** = Transformed physical condition class (4 classes) = values ranging from 0 – 3, from 0 = “dead” to 3 = “good”
- **FleaT** = Transformed flea infestation class (3) = values ranging from 0 – 2 for increasing flea load, from 0 = zero to 2 = “many”

Note: For data conversion and analysis purposes, individuals with an entry of “U” (Unknown) for a given data type (sex, age class, etc.) will be deleted or dropped from that specific analysis. For example; a sampling session yields 13 unique individuals. 12 are assigned to age classes, while 1 is classified as “age is U”. Calculating the mean age class for the session will use the transformed data for the 12 age-classified individuals. The “U” individual, and its unique ID code, will not be included in this calculation.

C. Descriptive Metrics and Statistics: A set of descriptive metrics and statistics will be developed and reported for each of the 2 (May and November) pooled managed and unmanaged *sessions*. These metrics and statistics will be reported in tabular form for each *session* for each sampling year (2 values per year for each metric or statistic) in the Annual Status report element, and will be presented in graphic form over time in the Cumulative Trend and 5-Year Trend report elements. These metrics will be presented as appropriate labeled sums or ratios (e.g., “the total number of individuals recorded this *session* was 19”, or “the ratio of males to females this *session* was 11:3”). Descriptive statistics will appear, in general, in the form of labeled sample means with associated variance terms [e.g., “The mean weight of north side females is 221.6 +/- 19.5 grams (*n*=15)”].

1. **Descriptive Sums and Metrics:** A comprehensive set of descriptive metrics will be generated from the protocol database through use of the query set to be developed. Metric values will be reported in a general labeled table or list in the Annual Status report element, and will be exported in comma delimited ASCII text format for transfer (download) to SigmaPlot for graphic manipulation and reporting in the Cumulative Trend report element. The descriptive metrics set will include:

- a) A set of “counts” based on “trapped bodies” and on “unique individuals defined by ID code”. Counts of woodrats will be labeled in the general format of **RatN**. One or more additional letters will be added as a suffix to denote specific structures and sub-divisions of the total, as shown in the following examples. In general, counts may be calculated for 1 or both (2) trap-nights, separately for the north or south side (for “unmanaged caves”), and in combination with sex.

Likely subsets and combinations are noted below. Others may be defined as needed by the project leader, and should be labeled in a similar convention.

- RatN = Total number of woodrats (“bodies”) caught in a *session*, **including non-same cave recaptures**. RatN may be computed for either “managed” or “unmanaged” caves separately, or combined for a total “park-wide” count for the *session*. **Note:** this approach accounts for possible sources of variation in capture probabilities due to heterogeneity among individuals (e.g., territoriality) and behavioral response to capture (e.g., trap happy).
- RatN_M or RatN_F = RatN by sex
- RatN_S or RatN_N = RatN by side-of-the Green River
- RatNid = Total number of unique individuals caught (all rat ID codes recorded in a *session*). **Note:** recaptures in the *session* do not show up here. RatNid may be computed for either “managed” or “unmanaged” caves separately, or combined for a total “park-wide” count for the *session*.
- RatNid_M or RatNid_F = RatNid by sex
- RatNid_S or RatNid_N = RatNid by side-of-the Green River
- RatnNid_tn1 or _tn2 = Number of unique individuals caught in trapping-night 1 or 2 (all rat ID codes seen in 1 night in a cave class).
- RatNid_tn_N or RatNid_tn_S = RatNid-tn1 or -tn2 by side-of-the Green River

a) A set of ratios and proportions for specified (by project leader) parameters within the sample of woodrats (RatN) or of unique individuals (RatNid) collected within a *session*. The calculated ratios and proportions are the “sample ratio or proportion estimates” for the ratio or proportion in the population in the specified class of caves on the park. For example; a sex ratio calculated from the numbers of male and female unique individuals collected in a given *session* on the north side of the Green River is the sample estimate of the sex ratio expected in woodrats on the north side of the Green River. In general, ratios will be calculated by using specified summary class data “a” divided by the appropriate summary class data “b”, and stated as “the ratio $x = a / b$ ”, where “x” = the parameter, such as “sex” in the population, and “a” and “b” are the appropriate class sums, such as number of female unique individuals in the specified sample (RatNid_F for the park, RatNid_S_F for females on the south side of the Green River, etc.). In general, proportions will be calculated using the appropriate *n* of woodrats (RatN_“x”) or the appropriate *n* of unique individuals (RatNid_“x”) for the specified class “x”, divided by the appropriate total count of woodrats (RatN) or unique individuals (RatNid) for the selected sample. For example, the proportion of individuals that are injured in the population of woodrats on the north side of the Green River would be estimated by the sample proportion calculated as $\text{RatNid_N_injured=yes} / \text{RatNid_N}$. [(Note: using the RatNid will eliminate all recaptures from the count- the count (and associated rat-specific data) will thus include only the “first time the individual is captured” in a *session* data. In the case of estimated injury

rates (proportion injured), use of only the first-time-captured data is appropriate, as this parameter may change for a recaptured individual)]. General-format ratios and proportions are presented below. The project leader may define any desired proportion by requesting the Cumberland Piedmont Network (CUPN) data manager develop the appropriate database queries.

- TCR = Total Capture Rate (estimate of relative abundance) = RatN / TN for the desired sample, where TN = the appropriate number of trap-nights. TN = trap-nights = adjusted count of traps (trap *n*) available for the night = traps deployed – traps not available [(not-available includes: failed traps, other species in traps, as defined on field data form (see SOP #4, Appendix A)]. TCR can be computed for any subset of the *session* data: by side-of-the Green River, by sex, etc.
 - IDCR = Unique Individuals Capture Rate (alternate estimate of relative abundance) = $\text{RatNid} / \text{TN}$ for the desired sample. IDCR can be computed for any subset of the *session* data: by side-of-the Green River, by sex, etc. IDCR is a conservative measure of trap efficiency or trapping success, as it excludes all recaptures in the *session*.
 - M:F = The sex ratio for the desired sample = $\text{RatNid_M} / \text{RatNid_F}$ for the sample.
 - A:J = The age class ratio for the desired sample = $\text{RatNid_age = A} / \text{RatNid_age = J}$ for the sample. A:J can be computed for any subset of the *session* data: by side-of-the Green River, by sex, etc.
 - IR = Injury Rate in the defined population, estimated by the proportion of injured in the sample = $\text{RatNid_injury=yes} / \text{RatNid}$ in the sample. Note: drop all ID codes from injury calculations where injury is “U” (unknown) for the individual. IR can be computed for any subset of the *session* data: by side-of-the Green River, by sex, etc.
2. **Descriptive Statistics:** A set of descriptive statistics will be generated and reported for each of the 2 (May and November) managed and unmanaged *sessions* with +/- 1 standard deviation (SD) in the Annual Status report element (2 data points or values per variable per year). Typical descriptive statistics will include the sample mean, sample SD, and sample median. Descriptive statistics will be generated by queries in the database. Resulting values will be exported in comma delimited ASCII text format for transfer (download) to SigmaPlot for graphic plotting and long-term analysis for reporting in the Cumulative Trend and 5-Year Trends Analysis report elements. Note: for all descriptive statistics, computation will normally be performed separately for managed and unmanaged *sessions* (and can be performed for “all woodrats combined for both managed and unmanaged caves” in the sampling timeframe), by using appropriate sub-sets of descriptive sums and metrics—for example, to calculate a mean age in the managed caves population, use transformed managed caves ages (AgeT_managed) and the corresponding RatNid-

managed value. Finally, Note: statistics will not ordinarily be computed for females and males separately in managed *sessions*, owing to small *n* in these samples. North-side / south-side do not apply to the managed *session* and will not be used in such computations.

Descriptive Statistics will include:

- MAge = mean age of unique individuals in the sample = sum of appropriate individual transformed ages (AgeT) / appropriate RatNid. Note: it is not necessary to drop all ID codes from injury calculations where age is “U” (unknown) for the individual, because transformed age values already have eliminated “U” records.
- MedAge = the median AgeT in the sample. Compute by sorting for median value among appropriate AgeT for the sample.
- MWt = mean weight of unique individuals in the sample = sum of appropriate weights / appropriate RatNid. Note: drop all ID codes from MWt calculations where weight is “U” for the individual, and, for recaptured woodrats, use only the first-night data for MWt calculation.
- MedWt = the median weight in the sample. Compute by sorting for median value among appropriate weights for the sample.
- MFlea = mean flea score among unique individuals in the sample = sum of appropriate transformed FleaT / appropriate RatNid. Note: for recaptured woodrats, use only the first-night data for MFlea calculation.
- MedFlea = the median flea score in the sample. Compute by sorting for median value among appropriate FleaT for the sample.
- MBotfly = mean bot fly larvae + bot fly scars among unique individuals in the sample = sum of appropriate bot fly and bot fly scar counts / appropriate RatNid. Note: for recaptured woodrats, use only the first-night data for MBotfly calculation.
- MedBotfly = the median bot fly count in the sample. Compute by sorting for median value among appropriate bot fly larval and scar counts for the sample.
- MTick = mean tick count among unique individuals in the sample = sum of appropriate tick counts / appropriate RatNid. Note: for recaptured woodrats, use only the first-night data for MTick calculation.
- MedTick = the median tick count in the sample. Compute by sorting for median value among appropriate tick counts for the sample.
- MPC = mean physical condition score among unique individuals in the sample = sum of appropriate transformed PhysConT / appropriate RatNid. Note: drop all ID codes from MPC calculations where physical condition is “U” for the individual, and, for recaptured woodrats, use only the first-night data for MPC calculation.
- MedPC = the median physical condition in the sample. Compute by sorting for median value among appropriate physical condition scores for the sample.

D. Trend Analysis using Graphic Methods: The descriptive metrics and statistics will be presented in graphic format over time (at 6-month intervals) in the Cumulative Trend

report element. This presentation will be accomplished through the general route of creating automated export routines based on parameter queries in the MS Access database to export the descriptive metrics and statistics data in comma delimited ASCII text format for import SigmaPlot for graphic depiction. Graphic analysis presentation should include data over a minimum of ten (10) *sessions*. Graphic analysis may be developed for any desired sample structure or subset, and can use any desired summary metric, mean, proportion, or ratio. Graphic analysis will provide a non-statistical method for presenting cumulative data, and will provide initial viewing of potential trends in the selected parameters. Specifically, graphic presentation will allow initial detection of apparently large and sudden changes in a parameter, which changes may serve as the first warning of a large change in the population. Graphic analysis will be reported in the Cumulative Trend report element; along with a text summary of trend interpretation developed by the project leader or other designated vertebrate ecologist. In addition to the Cumulative Trend report element interpretive text portion, it is highly recommended that the project leader or other designated vertebrate ecologist meet with representatives from park resource management to discuss and evaluate apparent trends observed in the data on an annual basis.

- E. Trend Analysis using Linear Regression over Time:** Apparent trends in parameters over time will be evaluated to detect statistically-significant departures from stasis or stability by using simple linear regression analysis performed on “least-squares-best-fit” models. The general best-fit model is represented by a straight line through the data with the slope and y-intercept defined as $a = mx + b$. Stability in the population parameter is best indicated by a slope of zero over time in the best-fit model (meaning that the mean or ratio or proportion is not systematically changing—either increasing or decreasing as a trend over time). For general regression analysis purposes, a minimum of five (5) years, or 10 *session* data-points, will be used, with re-analysis being performed in each subsequent sampling year to include the new year’s data in the cumulative dataset. The general regression test is “is the slope of the best-fit line equal or not equal to zero?” The general “null hypothesis” (H_0) is “slope = 0.0 over time”: a statistical departure would be indicated if regression analysis reveals that the best-fit line has a slope statistically not equal to zero. Comparison for parameter trends over time between managed and unmanaged cave-classes will be through use of multiple-slope comparison testing, where H_0 : “all regression models have the same slope”. Multiple-slopes testing is performed using standard routines in SigmaPlot, which will generate appropriate ANOVA tests, calculate df and provide F-test values.

All regression analysis will be performed on summary metrics and descriptive statistical values exported in comma delimited ASCII text format from the MS Access database to SigmaPlot. Regression analysis will be performed in SigmaPlot using the established (“canned”) routines, which will generate least-squares-best-fit models, perform the relevant Analysis of Variance (ANOVA), compute appropriate degrees-of-freedom (df), normality and F-statistics, and provide a report detailing the analysis and associated statistics (see Section I. F. following). Statistical tests will initially be performed at the 95% confidence limit for detection of a $\pm 30\%$ change, unless otherwise determined by the project leader. A power analysis will be performed after 5 years to assess the efficacy of the sampling. Performance of regression analysis will be the duty of any designated individual who has appropriate familiarity with SigmaPlot manipulations and

operations (individuals could include the CUPN physical scientist, designated ecologists, trained students or SCA personnel, or the project leader).

Note: for reporting and evaluation purposes, any statistically significant departure from a slope = 0 (rejecting H_0 ;) should be evaluated by the project leader and/or other vertebrate ecologist. In general, an “increasing” or “decreasing” trend over time will need to be carefully interpreted with respect to the specific parameter being considered. For example; a “decrease in Mflea over time” may be considered to be a positive event, while a “decrease in MWt over time” may be an indicator of potential food limitation in the population.

We anticipate that analyses will explore the behavior of woodrat sample parameters over time. Of particular interest are variability in sex ratios, age class ratios, relative health, and ectoparasite levels. The CUPN data manager will provide automated export routines based on parameter queries in MS Access to export the data. These data will be imported into SigmaStat or SigmaPlot for higher level statistical analyses (i.e., t-tests, regression, and ANOVA). An example of a time-series graph of capture rates is shown in Figure 7.1.

F. Use of Statistical Analysis Software:

Data in comma delimited ASCII text format are readily imported into statistical analysis software used at CUPN (e.g., SigmaStat and SigmaPlot). The sequence of steps for data import within SigmaStat and SigmaPlot are:

1. Launch SigmaStat or SigmaPlot.
2. Click on File to view the File menu.
3. Select Import from the File menu.
4. A window will open in which the user can select the appropriate file type and the file to be imported. There will be a drop-down list from which the appropriate file type may be selected. Select “Plain Text.” Then, navigate to the appropriate folder and select the desired file.
5. Now, a new window is launched in which the field format must be indicated. Select “Delimiter” and the comma from the associated drop-down list. Click on “Import.”

G. Estimation of Park Population Size based on Lincoln-Petersen Mark-Recapture

Analysis: Each *session* will generate a number of uniquely-identified individuals collected in a sample on each of 2 consecutive trapping nights. As all woodrats caught will be assigned a unique identifier mark (i.e., ear tattoo), individuals are readily identified in subsequent recaptures, and may be effectively tracked over time and across the sampling space on the park, based on use of location by date by RatNid. A Lincoln-Petersen estimate of the park woodrat population size can be calculated based on mark-recapture frequencies observed between night 1 and night 2 in any *session*, where either the “unmanaged”, or the combined “managed” and “unmanaged” data are used. The general model for calculating a Lincoln-Petersen population estimate with approximate variance estimate and confidence interval is provided below, as derived from Pollock et al. (1990)

Variables and definitions:

The first night's count of caught individuals = $n1$, where $n1$ = RatNid for the first night
The second night's count of caught individuals = $n2$, where $n2$ = RatNid for the second night

The count of marked recaptures = $m2$, where $m2$ = RatNid for the second night minus the new individuals not seen in RatNid for the first night.

The population estimate (Chapman estimate), "N-hat c", =
$$\frac{(n1 + 1)(n2 + 1)}{(m2 + 1)}$$

The variance estimate = "var-hat N-hat c" =
$$\frac{(n1 + 1)(n2 + 1)(n1 - m2)(n2 - m2)}{((m2 + 1)(m2 + 1))(m2 + 2)}$$

The 95% confidence interval (assuming normality for N-hat c) =
$$N\text{-hat } c \pm 1.96 (\text{var } N\text{-hat } c)^{0.5}$$

Reporting and interpretation of this population estimate involves the general assumption of "population closure" and "un-restricted within-population area movement". For the limited area of the park, closure may be approximated by assuming that no woodrat is likely to travel further than about 1.0 km within one 24-hour period (between sampling night 1 and sampling night 2 of the *session*). From this, it may be assumed that most woodrats encountered within the park on any one sampling night are unlikely to have moved outside of the park or sampling area within one 24-hour period. Population estimation calculation will be performed using SigmaStat by the project leader after each sampling *session*, and will be reported in the Annual Status and Cumulative Trend (graphic presentation over time) report elements. After a minimum of 5 sampling years (10+ *sessions*), N-hat c will be statistically evaluated for trend-over-time by performing a linear regression and associated tests. For this analysis, N-hat c values may be calculated by transferring the appropriate RatNid values in comma delimited ASCII text format imported from the database into SigmaPlot, followed by performing the regression analysis using established SigmaPlot routines, as noted in previous section.

II. Data Flow

The CUPN data manager will work with the project leader to ensure that data are regularly verified and rolled up into a master copy of the dataset in the "DBMS_Master" folder for this protocol (i.e., X\CUPN IM Projects...\Woodrats\DBMS_Master). This folder is reserved for datasets that have already been validated, will no longer change, and with the exception of the data manager, is available to Cumberland Piedmont Network staff with read-only access privileges. This ensures that once data are validated, the dataset remains accessible to staff while being secure from accidental or undocumented changes. This copy of the dataset, which is in .mdb format, should be utilized by CUPN staff for all analyses.

The development of basic queries and summary reports in MS Access will be utilized to automate and thus streamline the data analysis and reporting workload, as appropriate. In consultation with the project leader, the data manager will develop queries (and

accompanying summary reports) that will address basic statistical questions. Results of these queries will be used for development of reports for park resource managers, as well as internal reports generated for CUPN staff and cooperators. The data manager will construct these queries and reports within the front-end of the current version of the protocol's MS Access database stored in the X:\CUPN IM Projects . . . \Woodrats\DBMS_Forms folder, which can be linked to the appropriate data tables on the CUPN server. Note: this front-end database can be copied to the project leader's workstation in order to increase performance. However, the working and master back-end databases should remain on the CUPN server in their respective folders at all times.

In instances where the statistical questions become increasingly complex, such as the long-term effects of management actions on park woodrat population structure and dynamics, data will need to be exported out of the relational MS Access database to commercial off-the-shelf statistical packages. CUPN staff primarily utilize SigmaStat, Systat, and SigmaPlot for frequency distribution plots, test for normality, analysis of variance, time series analysis, etc. In these instances, the data manager will work with the project leader and other CUPN staff to format data for export. In general, these data will be formatted based on parameters provided to the data manager via a make-table query in MS Access. The generated table will be exported in comma delimited ASCII text format.

III. Literature Cited

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical inference for capture-recapture experiments. *Wildlife Monographs* **107**:1-97.

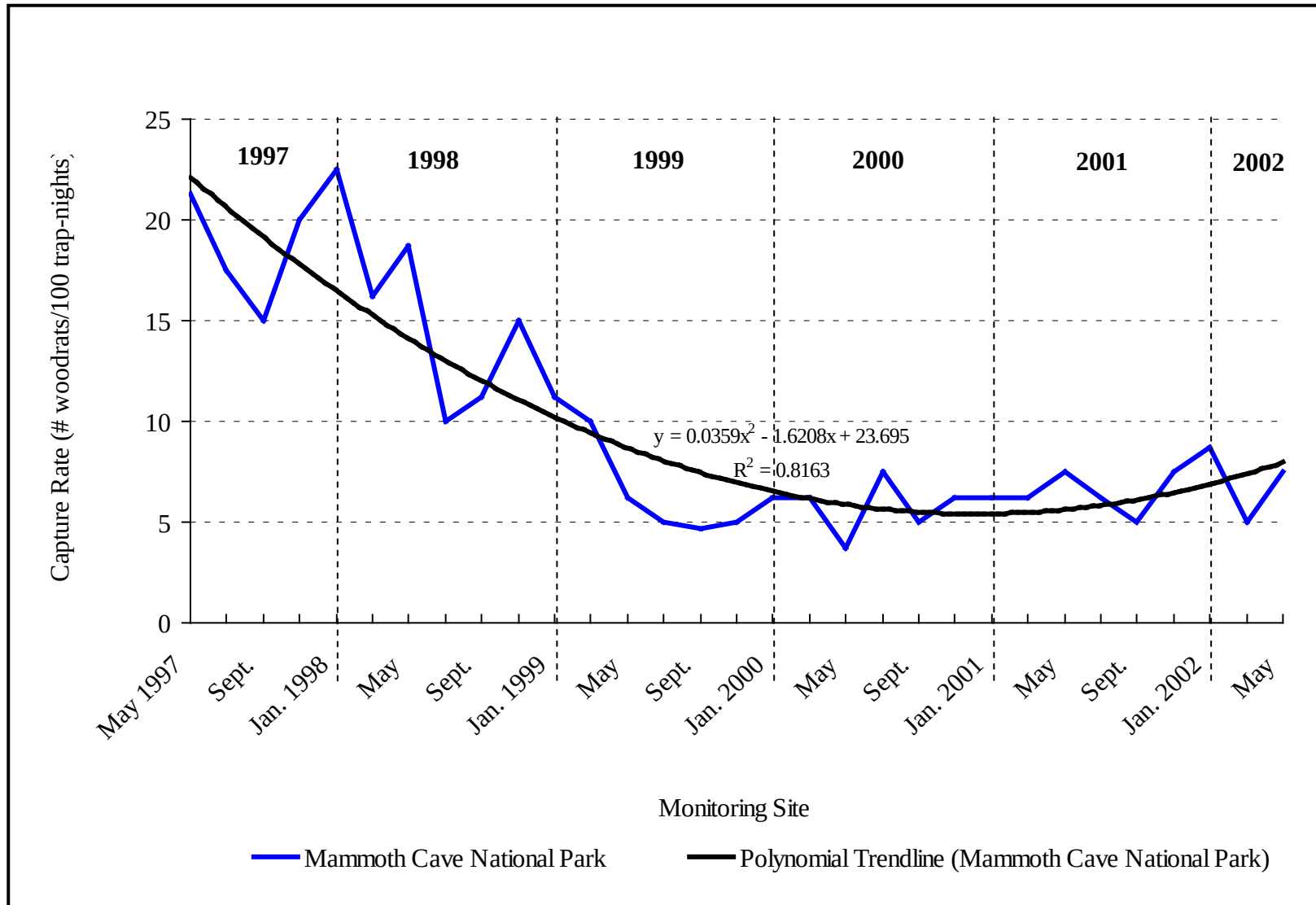


Figure 7.1. Example of a time-series graph of woodrat capture rates over time (fitted with a polynomial trend line) from bimonthly sampling at a series of trapping sites along a transect on Mammoth Cave National Park, May 1997- May 2002.

**A Protocol for Monitoring Allegheny Woodrats
(*Neotoma magister*) at Mammoth Cave National Park**

Standard Operating Procedure (SOP) # 8

Reporting

Version 3.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0
2.0	Dec. 2005	Steven Thomas	Added Section I on elements of reports	Elements of reports not adequately described in previous versions	3.0
3.0	Jan. 2007	Steven Thomas	Minor changes on several pages	To reflect merger of MACA Prototype and CUPN	3.1

This SOP gives step-by-step instructions for reporting on Allegheny woodrat population abundance and structure, and woodrat use of “managed” caves data collected at Mammoth Cave National Park (MACA). This SOP describes the elements of “formal” reports that will be generated, the procedure for formatting a report, the report review process, and distribution of completed reports. Efficient reporting on monitoring results is critical in assisting park resource managers with management decisions. Therefore, a reporting schedule is given with key reporting dates identified. Timely production of appropriate reports is the responsibility of the project leader and the Cumberland Piedmont Network (CUPN) Co-coordinators. Several types of reporting venues will be used to circulate information from implementation of this monitoring protocol (e.g., CUPN Annual Administrative Report, oral presentations, journal articles, newsletters, park information highlights, brochures, website), however only formal internal reports are detailed in this SOP.

I. Report Elements

- **Three Major Elements of Reports Will be Generated by this Monitoring Project:** Three primary elements or components (Annual Status, Graphic Cumulative Trend, and 5-Year Trend Analysis) of “formal” reports and will be generated to provide park management and other interested parties technical and interpretive information about the status and trends being detected in the monitored resource. The “Annual Status” and “Graphic Cumulative Trend” elements will be included in a report produced each March 31 following completion of the preceding year’s sampling efforts, data entry, and

specified analysis. The “5-Year Trend Analysis” element will be developed at 3-year intervals, starting after at least 5 years of sampling have been completed (see Table 8.1). The 5-Year Trend Analysis element will be included in the March report of each scheduled submission year, in conjunction with the current Annual Status and Graphic Cumulative Trend elements. Each type of element will provide quantitative and “formal” data together with subjective interpretation and explanations and, if appropriate, recommendations for action by park management. Preparation of the quantitative (data) parts for all reports will be the responsibility of the project leader working in collaboration with the CUPN data manager and other designated staff. Interpretative and explanatory content for all reports will be provided by the project leader, who will be responsible for final assembly and formatting of reports, and submission of reports to the CUPN Co-coordinators. The CUPN Co-coordinators will review and discuss reports with the project leader, will follow the review procedure described in Section III, and will be responsible for forwarding reports to MACA resource managers and other stakeholders as described in Section IV. A brief (2-3 paragraphs) summary of sampling activities, preliminary results, and any public interest highlights that occurred during each federal fiscal year will be written by the CUPN Co-coordinators by October 15 for inclusion in the CUPN Vital Signs Monitoring program’s Annual Administrative Report.

Note: “Interim Reports” which include Status and Graphic Cumulative elements may be developed at any time during the sampling year, to provide a “quick glance” view of the current status and short-term shifts of any parameter(s) of the resource. These “interim” reports may include any 1 or more sampling trips or sessions for that year, and can be used to quickly examine incidental questions-of-interest posed by program staff or park management (i.e., to report outcomes of management-directed “discretionary sampling”) (see also remarks in reports sections below, and in the general Sampling Design discussion in Chapter II of the protocol narrative).

- **Annual Status** element will typically be prepared and included in the report submitted annually in March after the last (November) sampling session and data-entry and analysis processes have been completed for that year. (Additional “interim reports” that include the Status element may be requested at any time for discretionary sampling trips/sessions). This report element will present in tabular and/or graphic form the descriptive metrics and statistics developed for the key woodrat parameters (see metrics and statistics listed in SOP # 7, Section I.C.) for the sampling year, together with appropriate interpretive text and summary. The purpose of this report element is to provide information reflecting the current status of the resource. Its content and structure is intended to provide managers and other viewers a quick “at-a-glance” focus on identifying key items of interest and highlighting potential significant changes or conditions that have occurred in this sampling year. For example, the population of woodrats in all sampled managed caves has apparently vanished in mid-year, whereas populations in other sampled unmanaged caves remained relatively constant. This could be reported to park management as a “flag” or indicator of a possible resource-shift which merits additional attention in the next sampling year. The report element’s quantitative content will be generated through automated (programmed) queries developed within the CUPN Vital Signs Monitoring

program's data management system, with initial report generation being performed by the project leader in collaboration with the CUPN data manager.

- **Graphic Cumulative Trend** element will, in general, be prepared and included in the report submitted in March of each year in conjunction with the Annual Status element. Additional reports that include the Graphic Cumulative Trend element may be developed for “discretionary” sampling (short-term monitoring) being performed to address specific management questions in selected caves as needed. The Graphic trend report element will present cumulative data (all years collected) in a graphic format (variable x over time in 6-month increments for all parameters, variable y plotted as a function of variable x, over time, etc.), as a “running cumulative report element” reflecting observed trends in parameters. (Note: in year 1 of monitoring, the Cumulative Trend element will be the graphic parts of that year's Annual Status report element. In subsequent years, the Cumulative Trend element will include “all” years of monitoring.) The purpose of this report element is to provide park resource managers and other viewers a readily-accessible visual portrayal of resource status-over-time; where inspection of trends graphics will support easy detection of large and rapid changes in resource condition. Interpretive content will focus on explaining possibly-salient visual trends, such as an apparent decrease in percent-juveniles over time, and will identify “flags” (subjectively important-appearing changes) that call for possible management action. Development of the graphic content will be performed by down-loading descriptive statistics and metrics (the Annual Status content) into SigmaPlot, where these data will be plotted as graphic time-series. Development of this graphic content will be the general responsibility of the project leader and/or designated other staff.
- **5-Year Trend Analysis** element will be developed and submitted at 3-year intervals starting in Year Five of monitoring. Each Trend report element will present time-series analyses in 5-year analytical segments, and will provide the current and all previous 5-year analyses, in both graphic and tabular (slope model equation and statistical test summary) formats. The graphical record of each parameter over time (in 6-month increments) will be presented with a “best-fit, least-squares linear regression” model line (generally a linear model with slope of $a = mx + b$) superimposed on the graphed data set, along with a model equation. Statistical tests for slope equal/not equal zero will be presented in a cumulative (all parameters considered) table following the graphs. The best-fit model and slope test will use 5 years of data in each analytic segment. (For multi-year trend-analysis purposes, 5+ years is considered to be the reasonable minimum time to encompass both inter-year system variation and longer-term trend detection, as organism longevity may exceed one year. For statistical purposes, power of slope-over-time analysis of trends improves with number of data points used.) For the slope test, the general null hypothesis being tested will be $H_0 = \text{slope} = \text{zero}$. A zero slope would indicate a no-change in the parameter over time. A departure in slope from zero would indicate a trend of either increase or decrease in the parameter. In addition, this 5-Year Trend report element will include “Class comparison tests” for the preceding all-years cumulative data for selected parameters x class structure [i.e., trend in mean weights or in sex-ratio may be compared between North-side and South-side woodrats using a comparison-of-slopes test with H_0 : “all slopes = zero”, or H_0 : “Slope A – Slope B = zero

(a difference test)"]. The 5-Year Trend element will be submitted in conjunction with the Annual Status and Cumulative Trend report elements being submitted in those prescribed 5-Year Trend report element years. Development of the Trend report element will be performed by downloading the appropriate descriptive statistics and metrics into SigmaPlot, where graphic depiction and statistical analysis will be performed. Development of graphics and statistical analysis within SigmaPlot, interpretation of analysis, and recommendations to management, will be the responsibility of the project leader.

II. Report Format

General

Reports should be produced on high quality white paper, 215 x 280 mm (8.5 x 11 in) in size. Font size of all text should be 12 point unless smaller font aids in fitting information on tables. Times New Roman font should be the standard font utilized. However, other text fonts are acceptable if used consistently throughout the document. Text is left justified with 3-cm margins on all sides. Words should not be hyphenated on the right side of text.

Page numbers and headers should be placed in the upper-right corner of each page starting with page two of the report. One exception to page numbering and headers is with figures (including pictures and illustrations), if a separate figure title page is used, place number and heading on these pages and leave them off pages containing the figures. Headers should contain an abbreviated version of the report title.

Bolding and underlining should be used minimally in the body of the text unless used on section headings and subheadings. Use italic font for scientific names of species. When using both common and scientific names, list scientific name with first mention of common name only.

Three levels of section headings may be used. First-level headings are all upper-case letters, bolded and left-justified with a sequenced whole number to its left. Second-level headings are bolded and left justified similar to first-level headings with sequenced numbers to the first decimal place. However, only the first letter in each word is capitalized. Third-level headings are indented five spaces and the first letter in each word is capitalized. Third-level headings are not bolded, underlined or numbered. Third-level headings may be italicized followed by a period and two hyphens or bulleted.

Reports should be direct and concise, avoiding superfluous wording. Refer to CBE Style Manual (CBE Style Manual Committee 1994) or Writing with Precision, Clarity and Economy (Mack 1986) for aids in writing. Also see Strunk and White (1979), Day (1983), and "Notes on Writing Papers and Theses" (Lertzman 1995) for help in structuring sentences and paragraphs for clarity.

Tables

Tables should be placed within the text of a report or immediately following the literature cited section. Tables should be numbered in sequence regardless of where they are located. Table headers are placed at the top of a table. Horizontal lines are used to separate the table heading

from column headings, column headings from the table and to signify the end of the table. Generally, vertical gridlines lines should not appear on a table.

Figures

Figures should be placed within the text of a report or immediately following tables behind the literature cited sections. Figures should be numbered in sequence regardless of where they are located. Figure captions are placed below the figure if it is included in the text or on a separate sheet of paper preceding the figure if included after the literature cited section. Both tables and figures should contain information not presented in the body of the text. Also, tables and figures should not duplicate information already presented in the body of the text.

Pictures

Treat as figures.

Report Outline

TITLE PAGE

- Title
- Author(s)
- Institutions
- Prepared for
- Date

TABLE OF CONTENT PAGE (optional)

EXECUTIVE SUMMARY PAGE (abstract)

1.0 INTRODUCTION

1.1 Background

1.2 Justification for Study

1.3 Objectives

2.0 METHODS

2.1 Study area(s)

2.2 Field method(s)

2.3 Analytical method(s)

3.0 RESULTS

4.0 DISCUSSION

5.0 MANAGEMENT IMPLICATIONS

6.0 ACKNOWLEDGEMENTS

7.0 LITERATURE CITED

(See Section V, Literature Cited for format examples and
http://science.nature.nps.gov/im/monitor/doc/Literature_Cited_Style.doc)

APPENDICES (optional)

III. Review Procedure

Internal Review

Reports on woodrat monitoring will be written by the project leader, and/or crew leader(s) under the direction of the project leader. One or more internal reviews for grammatical soundness will be sought prior to submitting the report to MACA resource management and CUPN management. Internal review by CUPN personnel skilled in technical writing for clarity and directness should fulfill this review requirement. Internal reviews will be conducted by CUPN staff and/or other persons sought out for their language skills.

If reports are written to update findings only and they do not deviate significantly from previously reviewed and distributed reports then the review process may stop here. However, review by park staff and subsequent external reviews must be sought for new reports or those that deviate significantly from previously reviewed and distributed reports. Also, if management activities within a park are not clearly understood, then park review should be sought for a report to clarify results and management implications.

Park Review

Park staff, generally Resource Managers, are in a unique position in that they can supply details about management activities that may influence findings presented in a report. Also, they will be the ones applying management recommendations to their park. Therefore, review by park staff is vital to the interpretation of findings and the assessment of proposed management implications. Review by park staff should be conducted before a report is submitted for external review.

External Review

External review by two or more experts in woodrat monitoring should be sought for the first report in a series of reports. In addition, analytical methods employed on data presented in the report need to be reviewed by one or more statisticians. If a report updates a previously reviewed and distributed report then external review is not required. However, external reviews must be sought for new reports or those that deviate significantly from previously reviewed and distributed reports. In order to conserve reviewer time, external reviews must follow the internal and park review process.

All review comments must be addressed, be it there inclusion in the report or reason for excluding them from the report. The responsibility to edit a report falls to the senior author of the report or their designee.

IV. Distribution Procedure

Identifying Stakeholders

The primary stakeholder in our woodrat monitoring efforts is the National Park Service management staff at MACA. Additional stakeholders include other parks in the CUPN, any of the national park units with cave/karst resources and/or woodrat populations, and MACA interpretive staff. Potential stakeholders include state and federal wildlife agencies, universities, and the general public. Although this particular monitoring project is not part of any national or regional effort, natural resource specialist conducting (or considering conducting) Allegheny woodrat monitoring anywhere throughout the species' range should be interested in project results. Initial implementation of this protocol will be carried out with assistance from several student interns provided to CUPN through a cost-sharing (50/50 of personnel and administrative costs) agreement with Western Kentucky University.

Distributing Reports

Reports will be provided to resource managers at MACA, where woodrat monitoring was performed. Additionally, a copy will be kept on file with the CUPN office of the National Park Service, Mammoth Cave, Kentucky and made available to all interested parties upon request. Copies (electronic and/or paper) of all reports will be archived per program data management and records-archiving policies and procedures (to be developed in the near future).

All data collected by CUPN are of course, public property and are subject to requests under the Freedom of Information Act (FOIA). The data management plan for the CUPN Vital Signs Monitoring program (Moore et al. 2005) describes appropriate procedures to respond to FOIA requests, including the protection of sensitive data such as cave and endangered species locations. Reports containing non-sensitive data will be disseminated through the CUPN Vital Signs Monitoring program's website. Through the website, those requesting information will be asked to provide information to document by whom and for what purpose the report is being used. By documenting requests, users can be informed when updated reports are available. Users requesting paper copies will have their requests documented as well.

Table 8.1. Proposed reporting schedule for the three primary report elements to be generated from Allegheny woodrat monitoring.

Report Element	2007	2008	2009	2010	2011	2012	2013	2014	2015
Annual Status	X	X	X	X	X	X	X	X	X
Graphic Cumulative Trend	X	X	X	X	X	X	X	X	X
5-Year Trend Analysis					X			X	

V. Literature Cited

Moore, W. J., R. Byrd, and T. R. Leibfreid. 2005. Data management plan for the Cumberland Piedmont Network and Mammoth Cave National Park Prototype Monitoring Program. USDI National Park Service. Mammoth Cave, KY. 81pp.

CBE Style Manual Committee. 1994. Scientific style and format: the CBE manual for authors, editors, and publishers. Sixth edition. Council of Biology Editors, Cambridge University Press, New York, New York, USA.

Day, R. A. 1983. How to write and publish a scientific paper. Second edition. ISI Press, Philadelphia, Pennsylvania, USA.

Lertzman, K. 1995. Notes on writing papers and theses. Bulletin of the Ecological Society of America **76**:86-90.

Mack, R. N. 1986. Writing with precision, clarity, and economy. Bulletin of the Ecological Society of America **67**:31-35.

Strunk, W. Jr., and E. B. White. 1979. The elements of style. Third edition. Macmillan, New York, New York, USA.

**A Protocol for Monitoring Allegheny Woodrats
(*Neotoma magister*) at Mammoth Cave National Park**

Standard Operating Procedure (SOP) # 9

Revising the Protocol

Version 2.1 (January 2007)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	Sept. 2005	Steven Thomas		Address peer reviewer comments	2.0
2.0	Jan. 2007	Steven Thomas	Minor changes	To reflect merger of MACA Prototype and CUPN	2.1

This Standard Operating Procedure explains how to make changes to the Allegheny woodrat monitoring Protocol Narrative for Mammoth Cave National Park (MACA) and accompanying SOPs, and how to track these changes. Any changes in the Allegheny woodrat monitoring protocol will adhere to the guidelines contained in this SOP. Observers asked to edit the Protocol Narrative or any one of the SOPs need to follow this outlined procedure in order to eliminate confusion in how data is collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies, and should see the revision history log attached to each SOP.

Procedures:

1. The woodrat monitoring protocol for MACA and (Narrative and accompanying SOPs) has attempted to incorporate the most sound methodologies for collecting and analyzing data. However, all protocols regardless of how sound require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken.
2. All edits require review for clarity and technical soundness. Oversight of the revision process for all protocols is the responsibility of the Cumberland Piedmont Network (CUPN) Co-coordinators. When a potential modification to a protocol is identified, the project leader consults with the CUPN Co-coordinators, who then decide whether the change should be considered “small” or “significant”. Small changes or additions to existing methods will be reviewed in-house by CUPN staff designated by the Co-coordinators. However, if a substantial change, such as a change in methods is sought, then an outside review may be required. The need will be determined by the CUPN Co-coordinators and project leader. Reviewers will be selected based on the type of change (i.e., changes in sampling sites versus

changes in sampling design or sampling analysis). Regional and National staff of the National Park Service, as well as the U.S. Geological Survey-Biological Resource Discipline, with familiarity in ecological research and data analysis will be utilized as reviewers. Also, experts in small mammal monitoring, research, and statistical methodologies outside of the National Park Service will be utilized in the review process, as needed.

3. Document all edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...etc). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
4. Depending upon the magnitude and nature of a proposed change, it could have significant implications for data management. The database may have to be edited by the data manager to accompany changes in the Protocol Narrative and SOPs. The database may have to be edited by the data manager to accompany changes in the Protocol Narrative and SOPs. Thus the data manager must be consulted prior to implementing changes to protocols. Immediately after the changes to the Protocol Narrative or SOP(s) have been made, inform the data manager, so the new version number can be incorporated in the metadata of the project database.
5. Post new versions on the Internet and in the “Narratives” or “SOP” subfolder for the project. Forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP. Archive a copy of each previous version in the MACA curatorial facility.