

# Cumberland Piedmont Network

National Park Service  
Inventory and Monitoring Division

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## Standard Operating Procedure 5

### *Cave Meteorological Sampling—Version 1.2*

Please cite this as:

Cumberland Piedmont Network. 2023. Cave meteorological sampling—Version 1.2. Cumberland Piedmont Network Standard Operating Procedure NPS/CUPN/SOP—5. Cumberland Piedmont Network, Mammoth Cave, Kentucky.

## Summary

This standard operating procedure (SOP) provides direction on collecting cave meteorological data (i.e., temperature and relative humidity) as possible correlative information for use in data analyses.

This SOP gives step-by-step instructions that project crew leaders and crew members should follow to conduct cave meteorological sampling at four parks in the Cumberland Piedmont Network (CUPN) that have caves in which several species of bats consistently roost.

Two methods will be used to collect cave meteorological data to determine the status and trends of key habitat parameters within selected caves used by bats in the four CUPN parks. The first method uses handheld sensors to measure cave air/rock temperature and relative humidity (RH) adjacent to concentrations of bats during biennial winter censuses. The second method uses automated data loggers to continuously collect cave air temperature and RH measurements in both summer and winter bat roost.

## Revision Log

| Revision Date | Author        | Changes Made                                       | Reason for Change                                                                | New Version # |
|---------------|---------------|----------------------------------------------------|----------------------------------------------------------------------------------|---------------|
| December 2015 | Steven Thomas | Minor edits made primarily to the field data form. | Minor edits made following external peer review and during database development. | 1.1           |
| April 2020    | Steven Thomas | Minor edits—multiple throughout document.          | Minor edits made following annual review of protocol.                            | 1.2           |
|               |               |                                                    |                                                                                  |               |
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## Overview

This SOP gives step-by-step instructions that project crew leaders and crew members should follow to conduct cave meteorological sampling at four parks in the Cumberland Piedmont Network (CUPN) that have caves in which several species of bats consistently roost. These parks include Chickamauga and Chattanooga National Military Park (CHCH), Cumberland Gap National Historical Park (CUGA), Mammoth Cave National Park (MACA), and Russell Cave National Monument (RUCA).

To address Monitoring Objective 3 of *A Protocol for Monitoring Bats at Cave Roosts in the Cumberland Piedmont Network* (Thomas et al. 2016), two methods will be used to collect cave meteorological data to determine the status and trends of key habitat parameters (cave temperature and relative humidity) within selected caves used by bats in the four CUPN parks. The first method, opportunistic grab sampling, uses handheld sensors to measure cave air/rock temperature and relative humidity (RH) adjacent to concentrations of bats during biennial winter censuses. The second method, continuous sampling, uses automated data loggers to continuously collect cave air temperature and RH measurements in both summer and winter bat roost caves following methods outlined in Woodman et al. (2011). Additional details related to these methods are included in the “Opportunistic Grab Sampling” and “Continuous Sampling” sections of this SOP. All monitoring field work associated with both cave meteorological sampling methods will occur during the winter.

## Step by Step Instructions

The status of continuous sampling cave meteorological information and recommended sampling schedule will be provided in the Field Information Sheet (see template in Figure 1 in SOP 2 *Pre-field Sampling and Safety*—Version 1.3 [CUPN 2023a] or example in Appendix E in a Supplemental Materials package which is available on the Cumberland Piedmont Network internal server, or by request to the network) for each cave scheduled for summer or winter bat monitoring. For the opportunistic grab sampling methodology see the Step by Step Instructions section in SOP 4 *Winter Cave Roost Sampling*—Version 1.2 (CUPN 2023b; because these data are collected in conjunction with bat hibernacula monitoring). For the continuous sampling methodology, cave meteorological field sampling activities broadly include data logger: (1) deployment, (2) data collection, (3) replacement, and (4) removal. Instructions for launching, programming, offloading, and battery replacement for the two models of data loggers (and their corresponding data shuttles) used in this protocol are provided in Appendix F in a Supplemental Materials package which is available on the Cumberland Piedmont Network internal server and are available at:

<http://www.onsetcomp.com/support/manuals?page=2>. Below is a sequential list of major tasks a field crew should follow during each continuous sampling *event*.

1. Project leader or designated field crew leader will file a trip plan with a CUPN contact (i.e., someone in the office during the trip) and the park (Figure 3 in SOP 2 [CUPN 2023a]) before the trip.
2. Project leader or designated field crew leader will establish a surface contact person (“surface watch”), what time to expect the crew to return (or call-in), and whom/when to notify (i.e., the response lead) in the event the crew does not return (or call-in) on time after attempting to contact the crew. The contact person will be given a copy of the detailed trip plan, the Field Information Sheet(s), travel route map(s), and a list of all team members and emergency contact phone numbers. The contact person will also be instructed to monitor weather channels/radar for approaching severe weather and to alert the field crew with adequate time to take safe action.
3. Project leader or designated field crew leader will conduct a pre-field sampling briefing for crew member(s) to cover such things as the sampling plan, any potential safety hazards/concerns (e.g., weather, check-in time, particular hazards expected), and gauge how the crew is doing (SOP 1 *Training Sampling Crew*—Version 1.2 [CUPN 2023c]).
4. Before leaving office, field crew leader should review the Field Information Sheet and supplies/equipment checklists (Tables 8, 9, and 10 in SOP 2 [CUPN 2023a]) to help alleviate any confusion in the field. Selected photos of data logger in situ and permanent landmarks should be printed on a supplemental Field Information Sheet(s) to help locate these items in the field.
5. If necessary, use the GPS unit and field map included with the Field Information Sheet to navigate to the entrance of the cave to be monitored.

6. Near the entrance, suit up with caving gear and prepare the monitoring equipment, data form(s), Field Information Sheet, and Cave Section Map.
7. Refer to the Field Information Sheet (see template at Figure 1 in SOP 2 [CUPN 2023a] and example in Appendix E in a Supplemental Materials package which is available on the Cumberland Piedmont Network internal server, or by request to the network) and Cave Section Map (Figure 2 in SOP 2) to navigate through the cave to the data logger(s).
8. The data recorder completes the fields “Park Code,” “Cave Name,” “Crew Member,” “Date,” “Time,” “Cave Section Number,” and “Data logger Location Name” on the HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form.
9. Enter the cave, moving cautiously and staying as quiet as possible.
10. Normally the project leader or designated field crew leader will handle data loggers and shuttles. Field crew members may serve as data recorder, data logger/shuttle handler, data logger spotter, measurer, or photographer (of data loggers and landmarks). It is important for the project leader or field crew leader to establish roles in advance and maintain good communication in the cave to ensure efficient and accurate work. If bats are present, talking should occur only when absolutely necessary. Using clear, agreed upon hand signals is helpful. When talking, use a low voice but avoid whispering, which can produce high frequency sounds that may increase disturbance potential.
11. If bats are present during the winter in a cave where bats are only monitored during the summer, then quickly attempt to confirm species identification (use binoculars or photography, if necessary), estimate numbers per species, estimate approximate distance between extant data logger(s) and bat(s), and record results in the “Notes” section of the data form. Describe the location of relatively large (> 25 bats) clusters of bats in the “Notes” section of the data form. Plot the approximate location of large clusters on the field copy of the Cave Section Map and label species and estimated number of bats next to each plot on the map. Record the location, approximate distance from data logger location, and size of fresh concentrations of bat guano in the “Notes” section of the data form. Plot (and label) the approximate location of fresh guano piles on the field copy of the Cave Section Map. Remember: this is NOT a bat monitoring sampling event, so it is best to minimize time spent on collecting bat information and minimize corresponding disturbance of bats.
12. Banded bats that are easily accessible should only be handled long enough to read their band numbers and only then if this can be done in a timely manner without disturbing a large number of additional bats. Note that it is sometimes possible to read band numbers without touching the bat. All individuals who directly handle bats must have an up-to-date rabies pre-exposure prophylaxis (vaccination) and must adhere to all current bat handling and decontamination protocols.
13. If in the unlikely event a bat mortality or serious injury to a bat occurs, this must be reported to the project leader immediately following completion of the field sampling event. As

previously mentioned, all people handling live and freshly dead bats must have up-to-date rabies pre-exposure inoculations and use gloves that will prevent penetration of bites. A freshly dead bat should be double-bagged (placed in two labeled plastic bags) for transport to the office where it should be refrigerated while the project leader decides what should be done with it. A mortally injured bat should be euthanized in the field by the project leader. Anyone performing euthanasia must have received NPS training to humanely euthanize bats. Mortality or injury to a federally listed species must be reported to the U. S. Fish and Wildlife Service (USFWS) within five calendar days.

14. If you locate a previously deployed data logger, skip to Step 15. Deploy initial pre-launched (in the office and programmed to record data once every two hours) automated temperature/RH data loggers (HOBOS) at locations in caves in which data loggers were not previously deployed. Data logger deployment should follow guidance from Woodman et al. (2011) provided in the Continuous Sampling section below. Record required metadata on the HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form, including assigning a unique data logger location name, transcribing the unique HOBO serial number from the data logger, determining the model type, describing the data logger location, and photographing the data logger in situ (record the frame number[s] of the photo[s]). After the data logger has been initially deployed, select a permanent landmark (e.g., a distinct cave rock formation, survey station) to use as a reference point for relocating the data logger. It is acceptable for a landmark to be used as a reference point for more than one HOBO data logger, as long as the data logger locations are in the same cave section. On the field data form record siting information from the landmark (i.e., azimuth, inclination, distance) to the data logger; assign it a unique name; describe its location relative to the data logger; and photograph the landmark in situ (record the frame number[s] of the photo[s]). Plot and label the approximate location of each data logger and corresponding landmark on the field copy of the Cave Section Map. Also use the “Deploying” activity if a pre-launched data logger is scheduled to be re-deployed in a permanent location at which a data logger had previously collected data in the past. In this case siting information and a data logger location description may be left blank (since it should have been previously collected). For more detail see the “Continuous Sampling” section of this SOP below.
15. Collect data from each previously deployed HOBO Temp/RH data logger located in the cave (Appendix F in a Supplemental Materials package which is available on the Cumberland Piedmont Network internal server, or by request to the network). This includes: (a) battery changing, (b) data uploading to the appropriate model of re-launched data shuttle (as per checklists in Tables 8 and 10 in SOP 2 *Pre-field Sampling and Safety*—Version 1.3 [CUPN 2023a])...this should be done in office beforehand in order to update the shuttle’s date and time to a computer that is set to local standard time), (c) re-deploying (i.e., restarting automatic data collection), (d) examining, (e) cleaning, and (f) returning the HOBO to its location. Record required metadata on the HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form. Location information for previously deployed data loggers and established landmarks should have been included on the cave’s Field Information

Sheet and should have been plotted on the cave's Cave Section Map to assist with relocating the data logger. For more detail see the "Continuous Sampling" section of this SOP below.

16. Replace a previously deployed HOBO Temp/RH data logger with a spare pre-launched data logger when there is some doubt about the reliability of the previously deployed data logger (e.g., data transfer was not successful, data logger did not re-deploy, LED not blinking after replacing battery, evidence of data logger having been submerged in flood, signs of external damage to the data logger). Record required metadata on the HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form, including metadata listed under "Collecting data from existing (above) data logger"—even if data from the HOBO will be uploaded in the office. For more detail see the "Continuous Sampling" section of this SOP below.
17. Remove (and do **NOT** replace) a previously deployed HOBO Temp/RH data logger from a location when: (a) there is some doubt about the reliability of the previously deployed data logger and no spare pre-launched replacement data logger is available, (b) it is no longer safe or prudent for a data logger to be placed in that location (e.g., repeated theft/vandalism of data loggers, flooding of data loggers, change in stability of cave ceiling/walls/floor), or (c) previously instructed to do so by the Project Lead. Record required metadata on the HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form including applicable metadata listed under "Collecting data from existing (above) data logger"—even if data from the HOBO will be uploaded in the office. For more detail see the "Continuous Sampling" section of this SOP below.
18. When the work is complete, exit the cave quickly, and move cautiously (in a safe manner).
19. Secure all cave gates and locks as required.
20. Inform surface contact person of party exiting cave ASAP (e.g., via cell phone, radio, or satellite communicator).
21. Before leaving cave entrance area, all data forms will be reviewed by someone (usually the project leader or field crew leader) other than the individual who filled them out, if possible. Review the Field Information Sheet and suggest any changes to be considered by the project leader.
22. Follow all applicable gear decontamination procedures as described in the White-nose Syndrome section of SOP 2 *Pre-field Sampling and Safety*—Version 1.3 (CUPN 2023a).
23. For a remote cave: upon arrival at the vehicle, office or place of lodging, immediately contact the designated surface contact person via cell phone, radio, or satellite communicator.

## Opportunistic Grab Sampling

Opportunistic grab (or spot) sampling of cave temperature and RH measurements will follow methods described here (for additional detail see Step by Step Instructions in SOP 4 *Winter Cave Roost Sampling*—Version 1.2 [CUPN 2023b]). This method uses handheld sensors to measure cave air/rock temperature and RH adjacent to concentrations of bats during winter censuses. Because winter hibernacula bat censuses will occur only once every two years at each selected cave and opportunistic grab sampling will be done in conjunction with hibernacula censuses, these cave meteorological datasets will only be collected biennially at each selected cave. Cave meteorological and associated data collected in each section will be recorded on page 2 (SOP 4 *Winter Cave Roost Sampling*—Version 1.2 [Figure 3; CUPN 2023b])—of the field data form. Descriptions of fields on the data form are provided in Table 1 in SOP 4.

### Equipment

Temperature of rock (e.g., ceiling, wall) adjacent to the most substantial concentrations of bats of each species per section of cave will be obtained via laser thermometer (exercise caution to avoid touching bats with the laser). Air temperature adjacent to the most substantial concentrations of bats of each species per cave section will be obtained via digital thermometer, thermo-hygrometer, temperature and RH probe, or similar instrument held away from observers' bodies to avoid artificial temperature increase due to body heat. Percent RH of air (again, as close as possible to the most substantial concentrations of bats of each species per section of cave) will be measured via thermo-hygrometer, temperature and RH probe, or similar instrument held away from observers' bodies (to avoid artificial humidity increase due to exhalation and vaporization). The specific make and models of each instrument is variable. All instrument sensors will be calibrated per the manufacturer's recommendations prior to **each** sampling event.

### Site Selection and Frequency

When possible, opportunistic grab (or spot) sampling of temperature and RH will occur in each CUPN bat hibernaculum during each bat census. In a few sections within a cave (e.g., Dixon Cave at Mammoth Cave National Park [MACA], Russell Cave at Russell Cave National Monument [RUCA]) bats typically roost out of reach of handheld meteorological instruments, and thus it may not be possible to conduct opportunistic grab sampling in those sections. When possible, rock/air temperature and percent RH will be measured adjacent the most substantial concentrations of bats (i.e., all bats do not need to be in physical contact) of each species (at as many separate concentrations as is practicable) in each section within each hibernaculum. If a section within the cave only contains bats roosting singly (i.e., not in physical contact), then measure each parameter adjacent to individually-roosting bats that are located as close as possible to the majority of other bats of that species in that section of the cave. Visually estimate the relative concentration (high, medium, or low) of bats at which temperature and RH measurements are being taken relative to other concentrations of bats of that species observed in that section of the cave during that sampling event. Specific sample locations will vary within each cave from sampling event to sampling event. Each opportunistic grab sample measurement will be collected in association with bats and since bats may

roost in different locations within a cave from sampling event to sampling event, the opportunistic grab sample measurement locations may differ over time as well.

## Continuous Sampling

Continuous sampling of cave air temperature and RH measurements in both summer and winter bat roost caves will follow methods outlined in Woodman et al. (2011). Data collection will be automated and data logger driven. This approach streamlines data collection, largely eliminates the need for data entry from data forms to a database, and significantly improves data quality since the possibility of human error is largely removed. However, associated metadata will be collected by use of a field data form. Generally, data loggers were chosen for their reliability, ease of use, and ability to collect data of interest.

### Equipment

The data loggers we use are: (1) HOBO® H8 Pro (H08-032-08), and (2) HOBO® Pro v2 (U23-001) Temperature/RH systems by Onset Computer Corporation. These data loggers include integrated air temperature and RH sensors. The HOBO H8Pro series model is no longer available, but we will use our current supply and replace them with the newer HOBO Pro v2 model when necessary. Prior to each field event, data loggers will be calibrated per the manufacturer's recommendations.

### Site Selection, Sampling Frequency/Interval, and Replication

An attempt was made to conduct continuous sampling of air temperature and RH at each of the 40 caves selected for summer bat monitoring and at each of the 29 hibernacula selected for winter bat monitoring in the Cumberland Piedmont Network. However, one cave (i.e., Neeld's Well at Chickamauga and Chattanooga National Military Park [CHCH]) selected for summer bat monitoring exclusively will not receive continuous sampling of temperature and RH because it is not humanly accessible in order to deploy a data logger. Therefore, continuous sampling of temperature and RH will take place at 49 of 50 selected summer and winter bat roost caves in the Cumberland Piedmont Network. In each selected cave at least one HOBO data logger was placed (following procedures in Woodman et al. [2011] given below) in a convenient location that was likely representative of the locations where bats roost (attaching data loggers to the end of sections of CPVC/PVC pipe or a telescoping pole when necessary). This was determined by the project leader or physical scientist based on written or photographic documentation from past inventory, monitoring or research efforts, coupled with direct observation of bats or bat sign (e.g., fresh guano pile) at the time of initial deployment. In the few selected bat roost caves which are relatively large and contain more than one large section within the variable temperature zone, a data logger was placed within each of those sections, when possible. The location of each data logger was clearly marked on the Cave Section Map (Figure 2 in SOP 2 *Pre-field Sampling and Safety*—Version 1.3 [CUPN 2023a]) for each cave, if available. A detailed written description (including distance, inclination, and azimuth [i.e., compass bearing] from an obvious permanent landmark [e.g., a distinct rock formation, survey station]) of the specific location of each data logger was recorded on the HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form. Photographs of the deployed data logger and corresponding permanent landmark were taken, and the frame (i.e., image) numbers recorded on

the field data form. No other means of marking locations in bat roost caves will be used in this protocol.

The following guidance on deployment of HOBO model H8 Pro data loggers is taken from Woodman et al. (2011). Note, most of the concern about heat conductance mentioned below can be addressed by using the newer HOBO model Pro v2 data logger and mounting clamp provided. The placement of the HOBO data logger that is stationed in a cave room of interest should [edited] be done so in one of three ways. The easiest way is to simply place the data logger on the floor. If this option is chosen, the data logger should be turned upside-down (to avoid having water collect on the logger's humidity sensor) and suspended between two small rocks or boards to avoid contact with the cave floor. If the data logger is in direct contact with a cave surface, heat may conduct into or out of the data logger, thereby distorting the air temperature measurement. Please note that in caves with woodrats or other opportunistic biota, this placement may not be optimal as the data logger may be dragged into other parts of the cave or damaged through chewing. A stand may also be built, onto which the data logger may be mounted. If this option is selected, the data logger should be thermally isolated from the stand, particularly if the stand is a good conductor of heat (as is metal). A third option for mounting the data logger is direct attachment to a cave wall or the ceiling. This option uses toggle bolts or nails (or rust-resistant wire) [edited] through appropriately sized crevices in the cave surface of choice. Please note that this method can damage the cave surface and should be avoided in areas with delicate formations. If this option is chosen, the data logger will need to be thermally isolated from the cave surface. We suggest that the HOBO should not be allowed to touch the surface so that no conduction can take place. This separation may be accomplished by putting spacers (or modeling clay) between the back of the HOBO and the cave surface. The toggle bolts or nails should pass through the spacers.

Each data logger was initially deployed during a time when the summer-roosting bats are not present (i.e., mid-November–mid-March), or during a scheduled winter bat census, depending on the time of year bats mainly use the cave. Some CUPN hibernacula are also used in the summer as a bat roost. In these instances data loggers were deployed, data will be collected, or will be replaced during scheduled winter bat counts. Data from each data logger will be collected once every two years after deployment. However, if there is evidence (i.e., the LED under the jack cap or communications window is not blinking, or if the upload indicator LED flashes for only a few seconds during upload to a data shuttle) that a data logger may have stopped collecting data, then the data logger will be replaced (if the data logger is not able to re-deploy after replacing the battery).

Initial cave air temperature and RH data have been collected at all 27 summer bat roost caves at Mammoth Cave National Park and at all five summer bat roost caves at Cumberland Gap National Historical Park. Data collection in summer bat roost caves has been initiated in all five (humanly accessible) summer bat caves at Chickamauga and Chattanooga National Military Park and at both summer bat caves at Russell Cave National Monument. Initial temperature and RH data have been collected at all 12 hibernacula at Mammoth Cave NP and at all eight hibernacula at Cumberland Gap NHP (park personnel at CUGA maintain in-cave continuous monitoring weather stations in two hibernacula). Data collection in hibernacula has been initiated at all six CHCH caves and at all three

RUCA caves. Collectively, continuous cave air temperature and RH data have been collected in all 39 (humanly accessible) selected summer bat caves and at all 29 selected hibernacula for all four parks. A list of bat roost caves, at each CUPN park in which continuous sampling of cave air temperature and RH data has been initiated, is provided in Table 1 below.

HOBO data loggers are programed to continuously record temperature and RH measurements **once every two hours**. This sampling interval should permit a new battery with full charge to last for two years, and the internal memory storage capacity should not be exceeded. This approach allows data from certain data loggers (i.e., those located in censused hibernacula) to be efficiently collected in conjunction with scheduled biennial winter bat censuses. The remaining data loggers, those deployed in caves which receive regular use by bats only during the summer, require special sampling events for servicing (10 caves are done in even years and another 10 are done in odd years) when the summer-roosting bats are not present (i.e., mid-November–mid-March).

**Table 1.** List of CUPN park, cave name, season of bat use, year continuous sampling of cave air temperature and relative humidity (RH) data was initiated, # of loggers and year logger data are collected.

| <b>Park Name</b>     | <b>Cave Name</b>                            | <b>Season of Bat Use:<br/>Summer, Winter, Both</b> | <b>Year Temp &amp; RH Data Collection Initiated [#<br/>of HOBOS]; year data are collected</b> |
|----------------------|---------------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
| CHCH<br>(7<br>caves) | 27 Spiders Cave (TN)                        | Both                                               | 2014 [1]; even year                                                                           |
|                      | Chambliss Cave (GA)                         | Both                                               | 2013 [1]; even year                                                                           |
|                      | Ha-Ha Cave (GA)                             | Winter                                             | 2014 [1]; even year                                                                           |
|                      | Lapp Hole (GA)                              | Both                                               | 2014 [1]; even year                                                                           |
|                      | Lookout Mountain<br>Battlefield Pit #1 (TN) | Both                                               | 2014 [1]; even year                                                                           |
|                      | Lookout Mountain<br>Battlefield Pit #2 (TN) | Both                                               | 2012 [1]; even year                                                                           |
|                      | Neeld's Well (TN)                           | Summer                                             | N/A (not humanly accessible)                                                                  |
| CUGA<br>(9<br>caves) | Big Salt Cave                               | Both                                               | Late '90s [2 CUPN + 1 more maintained by<br>CUGA staff]; odd yr                               |
|                      | Cliff Cave                                  | Winter                                             | 2013 [1]; odd year                                                                            |
|                      | Gap Cave                                    | Both                                               | Late '90s [1 CUPN + more maintained by<br>CUGA staff]; odd yr                                 |
|                      | Grassy Springs Cave                         | Both                                               | 2015 [1]; odd year                                                                            |
|                      | Indian Cave                                 | Winter                                             | 2015 [1]; odd year                                                                            |
|                      | Little Saltpeter Cave                       | Winter                                             | 2015 [1]; odd year                                                                            |
|                      | Olde Formation Pit                          | Both                                               | 2015 [1]; odd year                                                                            |
|                      | Skylight Cave                               | Winter                                             | 2015 [1]; odd year                                                                            |

| <b>Park Name</b>      | <b>Cave Name</b>                        | <b>Season of Bat Use:<br/>Summer, Winter, Both</b> | <b>Year Temp &amp; RH Data Collection Initiated [#<br/>of HOBOS]; year data are collected</b> |
|-----------------------|-----------------------------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
|                       | Taylor Cave                             | Summer                                             | 2017 [1]; odd year                                                                            |
| MACA<br>(31<br>caves) | Bat Cave                                | Both                                               | 2002 [4]; odd year                                                                            |
|                       | Colossal Entrance                       | Both                                               | 2015 [3]; odd year                                                                            |
|                       | Dixon Cave                              | Both                                               | 2002 [2]; odd year                                                                            |
|                       | Historic Entrance                       | Both                                               | Mid '90s [4 CUPN + several more maintained<br>by MACA staff]; odd yr                          |
|                       | Lee Cave                                | Both                                               | 2015 [2]; odd year                                                                            |
|                       | Long Cave                               | Both                                               | 1994 [3]; odd year                                                                            |
|                       | Wilson Cave                             | Winter                                             | 2002 [2]; odd year                                                                            |
|                       | Currie Cave                             | Both                                               | 2004 [2]; even year                                                                           |
|                       | Haunted Cave                            | Winter                                             | 2006 [2]; even year                                                                           |
|                       | Hickory Flat Cave                       | Both                                               | 2009 [2]; even year                                                                           |
|                       | J.T. Cave                               | Winter                                             | 2013 [1]; even year                                                                           |
|                       | Wildcat Hollow Sink                     | Winter                                             | 2004 [1]; even year                                                                           |
|                       | Anarchy Shelter                         | Summer                                             | 2018 [1]; even year                                                                           |
|                       | Blight Cave                             | Summer                                             | 2007 [1]; odd year                                                                            |
|                       | Blood Cave                              | Summer                                             | 2006 [1]; odd year                                                                            |
|                       | Blue Spring Hollow<br>Sandstone Shelter | Summer                                             | 2017 [1]; odd year                                                                            |
|                       | Boundary Cave                           | Summer                                             | 2017 [1]; odd year                                                                            |
|                       | Cathedral Cave                          | Summer                                             | 2007 [1]; odd year                                                                            |
|                       | Coke Cave                               | Summer                                             | 2018 [1]; even year                                                                           |
|                       | Deceptive Cave                          | Summer                                             | 2018 [1]; odd year                                                                            |
|                       | Dynamite Rock Cave                      | Summer                                             | 2012 [1]; odd year                                                                            |
|                       | Evening Cave                            | Summer                                             | 2018 [1]; even year                                                                           |
|                       | Hemlock Cave                            | Summer                                             | 2018 [1]; even year                                                                           |
|                       | Larkin Davis Cave                       | Summer                                             | 2018 [1]; odd year                                                                            |
|                       | Luna Cave                               | Summer                                             | 2008 [1]; even year                                                                           |
|                       | Misty Hole Cave                         | Summer                                             | 2008 [1]; even year                                                                           |

| <b>Park Name</b>     | <b>Cave Name</b>    | <b>Season of Bat Use:<br/>Summer, Winter, Both</b> | <b>Year Temp &amp; RH Data Collection Initiated [#<br/>of HOBOS]; year data are collected</b> |
|----------------------|---------------------|----------------------------------------------------|-----------------------------------------------------------------------------------------------|
|                      | Mossy Root Cave     | Summer                                             | 2018 [1]; even year                                                                           |
|                      | Saucer Cave         | Summer                                             | 2008 [1]; even year                                                                           |
|                      | Stacked Rock Cave   | Summer                                             | 2018 [1]; even year                                                                           |
|                      | Temple Hill Shelter | Summer                                             | 2018 [1]; even year                                                                           |
|                      | Wilson Hollow Pit   | Summer                                             | 2017 [1]; odd year                                                                            |
| RUCA<br>(3<br>caves) | Main Entrance       | Both                                               | 2013 [2]; even year                                                                           |
|                      | Picnic Entrance     | Both                                               | 2014 [1]; even year                                                                           |
|                      | Ridley Cave         | Winter                                             | 2014 [1]; even year                                                                           |

## Filling in the Field Data Form

A detailed list of descriptions for each field in the HOBO Temp/RH Data logger field data form (Figure 1) is given in Table 2 below.

**HOBO Temp/RH Data logger – Site Setup and Maintenance Field Observer Form****General Information**

Park Code: \_\_\_\_\_ Cave Name \_\_\_\_\_

Crew Member \_\_\_\_\_

Date \_\_\_\_/\_\_\_\_/\_\_\_\_ Time (hhmm, 24-hr format) \_\_\_\_\_ (LST)  
mm dd yyyy

Cave Section Number \_\_\_\_\_

Data logger Location Name \_\_\_\_\_

HOBO Serial Number \_\_\_\_\_ Model \_\_\_\_\_

Initial Install or Resurvey Only

Data logger Location Description \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Data logger Photos \_\_\_\_\_

Landmark Name \_\_\_\_\_

Landmark Description \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Landmark Photos \_\_\_\_\_

Siting information:

Azimuth \_\_\_\_\_ degrees

Inclination \_\_\_\_\_ degrees (+ or -)

Distance \_\_\_\_\_ meters

**Data Logger Activities and Accompanying Notes (check all that apply):**

\_\_\_\_ Deploying (above) data logger today.

LED blinking on departure? Y N

\_\_\_\_ Collecting data from existing (above) data logger.

Data logger undisturbed? Y N

LED blinking on arrival? Y N

Changed battery? Y N

If Y:

Cleaned o-ring? Y N

Greased o-ring? Y N

Cleaned o-ring groove? Y N

Replaced dessicant? Y N

Data transfer successful? Y N

Data logger re-deployed? Y N

LED blinking on departure? Y N

\_\_\_\_ This (above) data logger is being replaced today by:

HOBO Serial Number \_\_\_\_\_

Model \_\_\_\_\_

LED blinking on departure? Y N

\_\_\_\_ This (above) data logger is being removed, but **NOT** replaced today.**Notes:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Data recorder initials \_\_\_\_\_ Reviewed by: \_\_\_\_\_

**Office Use Only:**

Protocol Version #: \_\_\_\_\_

Raw data file uploaded to server by \_\_\_\_\_

on \_\_\_\_/\_\_\_\_/\_\_\_\_

Renamed raw data file filename: \_\_\_\_\_

Raw data file processed &amp; validated by \_\_\_\_\_

on \_\_\_\_/\_\_\_\_/\_\_\_\_

Final data file completeness:

Temp: \_\_\_\_\_% RH: \_\_\_\_\_%

Notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Entered into DB by \_\_\_\_\_ on \_\_\_\_/\_\_\_\_/\_\_\_\_

Scan made by \_\_\_\_\_ on \_\_\_\_/\_\_\_\_/\_\_\_\_

**Figure 1.** Field data form for HOBO relative humidity (RH) and temperature automated data logger deployment and maintenance for CUPN caves (based on Woodman et al. 2011).

**Table 2.** Data form field descriptions for HOBO Temp/RH data logger deployment and maintenance.

| Field Name                       | Field Description                                                                                                                                                                                                                                                                                         |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Park Code                        | Unique 4-letter park acronym (i.e., CHCH, CUGA, MACA, RUCA).                                                                                                                                                                                                                                              |
| Cave Name                        | The unique name of the cave being sampled.                                                                                                                                                                                                                                                                |
| Crew Member                      | First and last name of the primary crew member who carries out the data logger deployment or maintenance.                                                                                                                                                                                                 |
| Date                             | The date that data are being collected in mm/dd/yyyy format (e.g., 05/17/2011 for May 17, 2011).                                                                                                                                                                                                          |
| Time                             | The time, to the nearest minute, when new data logger was deployed, or the existing data logger was re-deployed or removed. Use 24-hours format. All four digits should be filled in. Examples: 0630 (6:30 am) and 1350 (1:50 pm). Use local standard time (LST)—make sure to use correct time zone.      |
| Cave Section Number              | Unique ID number of the cave section in which the data logger location lies. Record “99” for all caves that <u>only</u> are monitored for bats during the <u>summer</u> (99 is a placeholder in the database).                                                                                            |
| Data logger Location Name        | Unique name assigned (in the field) to a permanent location where a data logger was initially deployed. Within a cave, each specific HOBO data logger location will be assigned a name beginning with “H1,” followed by “H2,” and so forth.                                                               |
| HOBO Serial Number               | Record the serial number printed on the side of the existing data logger, or if no data logger is present, record the # of the new data logger being deployed.                                                                                                                                            |
| Model                            | Record the HOBO data logger model type. The old model is the <b>H8 Pro</b> (the general shape of a hockey puck), and the new model is the <b>Pro v2</b> (the general shape of a toilet paper roll cylinder).                                                                                              |
| Data Logger Location Description | A detailed description of the permanent location where the newly deployed HOBO data logger is placed.                                                                                                                                                                                                     |
| Data logger Photos               | Record frame (i.e., image) number(s) of photos taken of newly deployed HOBO data logger <i>in situ</i> .                                                                                                                                                                                                  |
| Landmark Name                    | Unique name assigned (in the field) to a permanent landmark that will be used as a reference point in the cave for relocating the specific location where a data logger was initially deployed. Within a cave, each landmark will be assigned a name beginning with “L1,” followed by “L2,” and so forth. |
| Landmark Description             | A detailed description of the permanent landmark and its location.                                                                                                                                                                                                                                        |
| Landmark Photos                  | Record frame (i.e., image) number(s) of photo(s) taken of the landmark.                                                                                                                                                                                                                                   |
| Siting Information: Azimuth      | Record the compass bearing in degrees (0°– 360°) from the permanent landmark to the data logger using a compass or disto.                                                                                                                                                                                 |
| Siting Information: Inclination  | Record the inclination obtained by a clinometer or Disto from the permanent landmark to the data logger. Record as a positive or negative whole integer.                                                                                                                                                  |
| Siting Information: Distance     | Record the distance in meters obtained by a measuring tape, laser range finder, or disto from the permanent landmark to the data logger.                                                                                                                                                                  |

| Field Name                                           | Field Description                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Data Logger Activities and Accompanying Notes        | <header only>                                                                                                                                                                                                                                                                                                                                                                                                   |
| Deploying (above) Data Logger Today                  | Place an "X" or "√" on this line if there was no data logger at this location upon arrival today.                                                                                                                                                                                                                                                                                                               |
| LED Blinking Upon Departure?                         | Circle Y if the red LED under the jack cap (HOBO H8 Pro) or LED in communications window (HOBO Pro v2) was blinking when finished.<br>Circle N if the LED was <u>not</u> blinking when finished.                                                                                                                                                                                                                |
| Collecting Data from Existing Data Logger            | Place an "X" or "√" on this line if data are being collected from an existing data logger today (e.g., battery changed, data transferred, data logger re-deployed).                                                                                                                                                                                                                                             |
| Data Logger Undisturbed?                             | Circle Y if the data logger was undisturbed when the crew arrived today. Circle N if the data logger was disturbed when the crew arrived today.                                                                                                                                                                                                                                                                 |
| LED Blinking Upon Arrival?                           | Circle Y if the red LED under the jack cap (HOBO H8 Pro) or LED in communications window (HOBO Pro v2) is blinking when field crew arrived. Circle N if the LED was <u>not</u> blinking when field crew arrived.                                                                                                                                                                                                |
| Changed Battery?                                     | Circle Y if the data logger battery was changed today.<br>Circle N if the data logger battery was <b>not</b> changed today.                                                                                                                                                                                                                                                                                     |
| Cleaned O-ring?                                      | Circle Y if the o-ring in the data logger was cleaned today.<br>Circle N if the o-ring in the data logger was <b>not</b> cleaned today.                                                                                                                                                                                                                                                                         |
| Greased O-ring?                                      | Circle Y if the o-ring in the data logger was greased today.<br>Circle N if the o-ring in the data logger was <b>not</b> greased today.                                                                                                                                                                                                                                                                         |
| Cleaned O-ring Groove?                               | Circle Y if the o-ring groove in the data logger was cleaned today.<br>Circle N if the o-ring groove in the data logger was <b>not</b> cleaned today.                                                                                                                                                                                                                                                           |
| Replaced Desiccant?                                  | Circle Y if the desiccant in the data logger was replaced today.<br>Circle N if the desiccant in the data logger was <b>not</b> replaced today.                                                                                                                                                                                                                                                                 |
| Data Transfer Successful?                            | Circle Y if the data transfer was successful today.<br>Circle N if the data transfer was <b>not</b> successful today.                                                                                                                                                                                                                                                                                           |
| Data Logger Re-deployed?                             | Circle Y if the data logger successfully re-deployed today.<br>Circle N if the data logger did <b>not</b> successfully re-deploy today.                                                                                                                                                                                                                                                                         |
| LED Blinking Upon Departure?                         | Circle Y if the red LED under the jack cap (HOBO H8 Pro) or LED in communications window (HOBO Pro v2) was blinking when finished.<br>Circle N if the LED was <u>not</u> blinking when finished.                                                                                                                                                                                                                |
| This (above) Data Logger is Being Replaced Today By: | Place an "X" or "√" on this line if an existing data logger is being replaced today. Record: 1) the serial number of the data logger being deployed today, and 2) the HOBO data logger model type of the data logger being deployed today. The old model is the <b>H8 Pro</b> (the general shape of a hockey puck), and the new model is the <b>Pro v2</b> (the general shape of a toilet paper roll cylinder). |

| Field Name                                                               | Field Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LED Blinking Upon Departure?                                             | Circle Y if the red LED under the jack cap (HOBO H8 Pro) or LED in communications window (HOBO Pro v2) was blinking when finished.<br>Circle N if the LED was <u>not</u> blinking when finished.                                                                                                                                                                                                                                                                                                                             |
| This (above) Data Logger is Being Removed, But <b>Not</b> Replaced Today | Place an "X" or "√" on this line if an existing data logger is being removed from the permanent data logger location and <u>not</u> being replaced by another data logger <u>today</u> (it may be replaced in the future).                                                                                                                                                                                                                                                                                                   |
| Notes:                                                                   | Record notes related to the data logger deployment and maintenance event.<br>May include: damage to data logger, shuttle problems, missing or moved data logger, evidence of recent flooding near data logger, proximity of data logger to roosting bats (including estimated distance and numbers & species of bats), proximity of data logger to fresh concentrations of bat guano (including estimated distance and approximate size of guano concentrations), other notes about bats, disturbance at cave entrance, etc. |
| Data Recorder Initials                                                   | Initials of individual filling-out the data form in the field. Occasionally, one (or more) persons will call out data, while another records.                                                                                                                                                                                                                                                                                                                                                                                |
| Reviewed by                                                              | Initials of individual who reviewed the completed data form for HOBO Temp/RH data logger deployment and maintenance elements. Ideally this should be someone other than the individual who filled-out the data form and is someone intimately familiar with the data form.                                                                                                                                                                                                                                                   |

## Literature Cited

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