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Protocol for Surveying Bat Use of Lava Tube Caves During Winter in Craters of the Moon National Monument and Preserve, Version 1.0

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

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Natural Resource Report NPS/UCBN/NRR—2017/1377

ON THE COVER
Long-eared myotis (*Myotis evotis*) exiting a lava tube cave in Craters of the Moon National Monument and Preserve, Idaho
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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal, high-level peer review based on the importance of its content, or its potentially controversial or precedent-setting nature. Peer review was conducted by highly qualified individuals with subject area technical expertise and was overseen by a peer review manager.

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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

1. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …). 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.

2. Notify the UCBN Project Lead and Data Manager of any changes to the Protocol Narrative so that the new version number can be incorporated in the Metadata of the project database.

3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative. A list will be maintained in the protocol revision SOP.

Executive Summary

The mission of the National Park Service (NPS) is “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring (I&M) networks.

The Upper Columbia Basin Network Inventory and Monitoring Program (UCBN) and Craters of the Moon National Monument and Preserve (CRMO) are collaborating to inventory and monitor winter bat use of selected lava caves in CRMO following common methods described in this document that have also been implemented in Lava Beds National Monument (LABE). Collaboration among these two parks and the UCBN will help the National Park Service as an agency move toward more efficient and effective conservation of bat resources. Winter surveys of bat use in CRMO lava tubes and other volcanic cave features will be implemented by CRMO staff. The UCBN will also assist CRMO with data management, analysis, and reporting at annual and 5-year intervals. Bats at CRMO are at risk of contracting the fungal disease white-nose syndrome, and also face elevated risk of fatal collisions with large commercial wind turbines which are increasingly common in southern Idaho. An additional concern to bats in the region over time is the threat of increasing aridification associated with accelerated climate change, which is predicted to stress female bats during reproduction and possibly cause some hibernacula to become unsuitable for prolonged torpor. CRMO actively manages visitor use in all caves and the methods outlined in this protocol will provide much needed baseline information about bats that will be used to guide cave management.

This protocol details the why, where, how, and when of the CRMO bat cave use survey program for its lava tube caves. As recommended by Oakley et al. (2003), it consists of a protocol narrative and a set of standard operating procedures (SOPs) which detail the steps required to collect, manage, and disseminate the data representing the status and trend of bat use in select caves that are safely accessed in winter, and that are at risk of undesirable human impacts on bats. The SOPs are published in a separate document (Rodhouse et al. 2017), but references to individual SOPs will not be cited in the protocol narrative. An important and highly dynamic aspect of this protocol is the decontamination procedures required to prevent accidental introduction of the fungus *Pseudogymnoascus destructans* that causes white-nose syndrome. Decontamination procedures are updated by the US Fish and Wildlife Service (USFWS) as new information becomes available about effectiveness of cleaning agents. As part of the preparation for field work, the CRMO Project Lead and crew lead will review the most recent decontamination guidelines and train assisting field staff in its implementation. At this time, this protocol does not support the collection of bats under any circumstances. The intent of the protocol is to ensure that the park has the ability to safely and responsibly collect qualitative and quantitative information about the use of CRMO caves by bats during winter.

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Servicewide Inventory and Monitoring Program, the Upper Columbia Basin Network Inventory and Monitoring Program, Craters of the Moon National Monument and Preserve, and the National Park Service's Biological Resources Management Division. John Apel, Kevin Castle, and Devin Stucki provided time and material support that greatly facilitated the development of this protocol. Kelly Kozar and Kirk Sherrill performed database development and contributed to the data management portion of this protocol. Editing was provided by Paulina Starkey. Additional editorial comments and suggestions were provided by John Apel and Kevin Castle.

Introduction

Bats are the second most species-rich group of mammals in the world, and provide critical ecosystem services including insect control (Jones et al. 2009, Boyles et al. 2011). They are long-lived and can exhibit high fidelity to roosting and hibernation sites (Wackenhut 1990, Sherwin et al. 2003, Rodhouse and Hyde 2014), returning to the same locations at regular intervals. As such, they are good bioindicators of ecosystem decline (Jones et al. 2009). Many of the 15 bat species in the Upper Columbia Basin Network (UCBN) are facing serious and immediate threats from white-nose syndrome (WNS; Blehert 2012), an emerging infectious disease, as well as from fatal collisions with turbines at wind energy development facilities in the region (Arnett et al. 2008). Climate change will also likely affect many of these species in the intermountain west (Humphries et al. 2002, Adams 2010). Surveying wintertime bat use in the lava tube caves of Craters of the Moon National Monument and Preserve (CRMO) can provide insight into how these important components of park biodiversity are faring in the park and across the region. While the lava tubes are an important natural resource that draws many visitors to CRMO, this also allows for human disturbance of bats, potentially affecting their welfare. There is also a possibility that humans will inadvertently introduce the WNS causing fungus *Pseudogymnoascus destructans* into CRMO caves. Because different portions of CRMO are managed by the NPS, BLM, the state, and by private owners, there are differing levels of cave resource protection within the monument as a whole (Figure 1). A better understanding of the patterns of winter bat use in caves will help CRMO staff manage these risks.

Winter bat use at CRMO was first documented in 1985; after that, informal and intermittent surveys of one cave, Arco Tunnel, occurred until 2012. During the 90s several maternity colony and day roost surveys occurred in a small selection of caves on the monument, but no directed research into winter use of caves occurred prior to 2012. The UCBN identified bats as a vital sign during its planning phase (Garrett et al. 2007) and developed a conceptual model for bats as a focal resource for all 9 of its parks. The emphasis at that time was on the broader role of bats in park ecosystems, particularly in riparian areas in which they routinely forage (Pierson 1998, Jones et al. 2009). The outbreak of WNS, the emergence of wind power development, and recognition of the effects of climate change as additional emerging stressors on North American bat populations occurred after publication of the UCBN monitoring plan in 2007. These issues have brought even greater attention to bat conservation in the National Park Service (NPS; Rodhouse et al. 2016), and particular emphasis has been placed on cave management policies (e.g., NPS *unpublished* a). CRMO is the only UCBN unit with cave resources and this protocol will provide the groundwork for making informed cave management decisions, which has become even more pertinent since WNS was found in nearby Washington State in March of 2016. It will also add to the overall knowledge of bat ecology in southeast Idaho and in the west, where the need for baseline data has been cited to improve conservation efforts in light of wind energy development in the region (Whiting and Bybee 2011). Since there are no other cave monitoring efforts in CRMO or other UCBN parks, this protocol utilizes a methodology similar to what is employed to survey for and monitor Townsend's big-eared bats (*Corynorhinus townsendii*) in the lava tubes of Lava Beds National Monument (LABE) in northern California, in the Klamath Network (KLMN; Krejca et al. *forthcoming*). It will also complement the servicewide NPS cave resources monitoring program developed by the NPS

Geologic Resources Division (Baker et al. 2015). There is an effort to develop a continent-wide coordinated bat monitoring program (Loeb et al. 2015) and this protocol will serve as one of the many building-blocks for that effort as well. Finally, it is noteworthy that the US Fish and Wildlife Service (USFWS) began a review of the status of three species of bats in 2013, including the little brown myotis (*Myotis lucifugus*), which is widespread across North America and occurs in CRMO. Though this protocol is currently limited in its ability to detect which *Myotis* species specifically are overwintering at CRMO, the potential for CRMO to gather diagnostic data, such as photographs and preferred hibernacula data of *Myotis* bats, will help inform management decisions if the species is listed in the future. This is also true for other species of concern in the western US such as the Townsend's big-eared bat.

Objectives

The UCBN I&M program and CRMO are collaborating to monitor winter bat use in Arco Tunnel, which is a safely accessed cave in the northern portion of the monument that consistently has been found with the largest number of bats (~30/year) among the set of caves recently inventoried (Stefanic and Rodhouse 2013, 2015, Slocum et al. 2016). The methods documented here will also be used to periodically inventory other caves within the monument and surrounding preserve as park resources and safety (winter environmental and accessibility) conditions permit.

This protocol addresses the following survey objective:

- Regularly count bats in Arco Tunnel during winter (January-March) and in other caves as environmental conditions and staff resources allow.

Between 2013 and 2016 (Stefanic and Rodhouse 2013, 2015, Slocum et al. 2016), 25-42 caves were surveyed each winter season, finding 38-84 bats/year in total. Arco Tunnel's population of bats accounted for 50-87% of the total bats found per season, and it was decided after four seasons that the yield per effort was not worth the exposure of employees to hazardous winter conditions. It was determined that focusing on Arco Tunnel as a study site would better focus efforts and better fit the current capacity of the park staff and resources. At this time this protocol does not support quantitative estimation of status and trend parameters. Rather, it will allow park managers to stay in touch with relative levels of use in Arco Tunnel, and will support on-going inventory questions pertaining to bat use in other caves in the park. CRMO has developed a WNS response plan in response to the 2010 request by the NPS Deputy Director of Operations (NPS *unpublished* a,b). The plan identifies steps to reduce the risk of transmission of WNS by humans by implementing a screening process for visitors, identifies steps to be taken in the event that *P. destructans* is found on bats in the monument, and indicates that changes to cave management may occur as new information about hibernacula emerges through monitoring. A general knowledge of how bats use the cave resource will allow for more informed decisions as WNS spreads further west. Because no bats will be handled by park staff during this survey, opportunities for research in the presence of *P. destructans* will be made when resources are available. Potential partners that have the ability to collect and process this data, such as Idaho Fish and Game, will be consulted as information regarding WNS spread into the region develops.

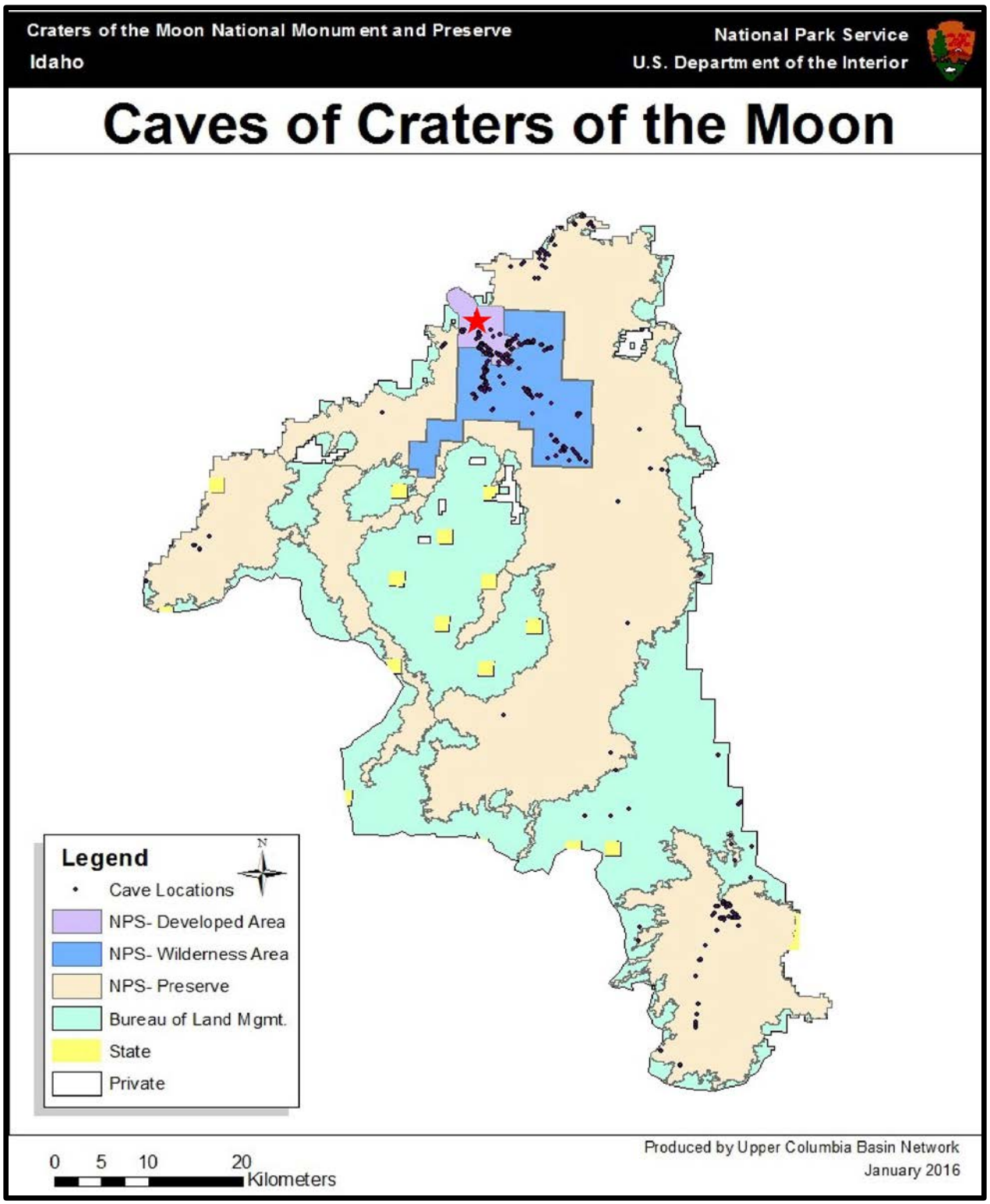

Figure 1. The approximate location of the 500+ known caves within Craters of the Moon National Monument and Preserve (CRMO). The NPS, BLM, state, and private inholdings cooperatively manage the approximately 750,000 acre area. These areas are almost entirely comprised of rugged lava flows. The approximate location of Arco Tunnel is indicated with a red star.

Sampling Design

This protocol targets the hibernating populations of bats of 7 species that are known to use or that might use lava tube caves in the NPS managed portion of the monument and preserve for winter hibernation (Genter 1986, Stefanic and Rodhouse 2013, 2015, Slocum et al. 2016). Currently, Townsend's big-eared bats, western small-footed bats, and little brown myotis (*Myotis lucifugus*) have been confirmed to hibernate in caves in CRMO. However, Yuma myotis (*Myotis yumanensis*), long-eared myotis (*Myotis evotis*), long-legged myotis (*Myotis volans*), and the big brown bat (*Eptesicus fuscus*) may also hibernate in CRMO according to range maps (Genter 1986, Stefanic and Rodhouse 2013, 2015, Slocum et al. 2016). Although identification of individual *Myotis* species will be attempted, it is not an expectation of this protocol; several species are morphologically cryptic (Constantine 1998, Weller et al. 2007, Rodhouse et al. 2008) and difficult to differentiate during hibernacula surveys, particularly when they are found on high cave ceilings or wedged into cracks. Therefore, the population of all *Myotis* also defines a target population that will be included as a reportable entity of interest (i.e., as a generic group).

Due to extreme limitations to accessibility of caves in CRMO during winter and the low-yield (very high cost per unit effort) of surveys (Stefanic and Rodhouse 2013, 2015, Slocum et al. 2016), the program will not employ a formal statistical sampling design to guide site selection. Rather, Arco Tunnel will be treated as a type of "index" site for repeated annual surveys. Other caves surveyed using the methods outlined here will be selected opportunistically as resources and conditions permit.

Selection of Arco Tunnel for Long-Term Monitoring

Arco Tunnel was first documented by park staff in 1958, and was first confirmed as a hibernaculum in 1985. There were 9 informal observations of hibernating bats until 2012, when serious attempts at yearly hibernacula surveys began (Stefanic and Rodhouse 2013). While there are over 500 documented caves on the NPS managed portion of CRMO, very few have been surveyed, and even fewer assessed for their suitability as winter hibernacula. Arco Tunnel is unique within the landscape not only because it is the longest known cave on the monument (5805' of passages), but also has consistently yielded the largest counts of bats during winter surveys; Arco Tunnel have accounted for 50-88% of all of the bats found in 2013-2016 surveys..

Due to the limited knowledge of the cave resource and the immense number of features considered "caves" at CRMO, lack of understanding of the total population of caves, and inability to access most caves safely in the winter, a larger sampling frame of caves that creates a statistically sound sampling population is unrealistic at this time. The NPS managed portion of CRMO is comprised of ~500,000 acres of recent and rugged lava flows (~16,000-~2,000 ya), very little of the area has been surveyed for caves. While there are over 500 documented caves, it is not known how much of the total cave population this figure represents. Attempts to inventory other caves in the winter will occur by park staff using these same methods when time and resources allow.

Interestingly, in the Big Desert area on Bureau of Land Management (BLM) lands 15 miles east of CRMO there are reports of very large (e.g., >500 animals) clusters of Townsend's big-eared bats and *Myotis* bats hibernating in larger, older lava tubes; this type of large and regionally significant

hibernacula may exist in the NPS-managed lands of CRMO (the Preserve), but remains undocumented. Such a resource could be included in a more formal monitoring program in the future if found. However, most of the access roads to the middle and southern portions of the monument are rendered inaccessible due to mud during most winters, and if there is snow, typically there is not enough snow to permit cross country travel over the sagebrush and broken lava terrain.

We note that a study by Bat Conservation International investigated features of lava tube caves in southeast Idaho that affect winter occupancy of Townsend's big-eared bats (Gillies et al. 2014). The study found that occupied caves were more likely to have a constriction within the cave, be longer, have higher minimum relative humidity, and have lower ceiling heights than caves that were unoccupied (Gillies et al. 2014). This study supports our current emphasis on Arco Tunnel for repeat surveys.

Sampling Frequency and Timing

Arco Tunnel will be surveyed annually during the first week of February. This is consistent with the timing of annual surveys in Lava Beds National Monument (LABE). It also is typically during the coldest part of the year at CRMO, which will limit surveyor disturbance of bats and increases the likelihood that all bats that will be hibernating at CRMO are present and discoverable. This is described as an "always-revisit" survey design, notated as [1-0], following McDonald (2003), with Arco Tunnel serving as a type of "index" sampling unit to be surveyed once each winter. If auxiliary winter surveys occur as time and resources permit in other caves, this will be performed between January 1 and March 15.

Response Design

CRMO will draw from methods developed for use in the lava tube caves of LABE (Krejca et al. *forthcoming*), and be consistent with methodologies recommended for cave roosting bats in general (Kunz 1988). Humidity, air temperature, and ceiling temperature will be recorded in each zone of the surveyed cave as well as near each individual cluster to provide ancillary information about thermal profiles of caves. When bats are found, they will be identified to species if possible, or species group if not (e.g., *Myotis* spp.). If bats are found singularly they will be counted as individuals; if two or more bats are found in physical contact, they will be considered a cluster. Bats hibernating near each other but not in physical contact are not considered a cluster. Clusters can contain more than one species of bat. In these cases, each identifiable species will be denoted as a separate species within the cluster. In CRMO, bats have been found hibernating in clusters that range from 2 to many bats, and most contain <3 bats (Stefanic and Rodhouse 2013, 2015, Slocum et al. 2016); elsewhere in the west, bats are commonly found hibernating individually and in small numbers (Pierson et al. 1999, Hendricks 2012).

Field Methods

Survey Preparation and Field Schedule

The first step in survey preparation is for the CRMO Project Lead and other field staff to review procedures outlined in the protocol, the SOPs (Rodhouse et al. 2016), and in the FWS decontamination protocol (http://whitenosesyndrome.org/topics/decontamination; USFWS 2016). The cave map of Arco Tunnel (or other cave) should be studied as well as the associated notes that include information about access challenges, as well as previous use by bats. These preparations should begin in November and December preceding each winter survey window. Hiring of field personnel, if necessary, must be initiated no later than September. Staff must be physically capable and willing to hike and snowshoe over rugged terrain in harsh winter weather, as well as be comfortable in small, tight spaces encountered while caving. The locations, species, and bats observed during prior years should be reviewed. Training of assistants should be conducted during this review period and in "real time" during surveys, directed by the CRMO Project Lead. Practice of bat identification will be included in training, as well as a review of personal protective equipment which includes suitable clothing for harsh winter weather, and WNS decontamination. Snowmobile training is required for any staff that will operate or be a passenger on a snowmobile. Snowmobile training will be directed by the CRMO safety officer according to current CRMO safety protocols. Prior to leaving for the field, cave maps for the day's surveys need to be printed on waterproof paper (e.g., rite in the rain) and GPS units need to be loaded with cave entrance location coordinates and other helpful waypoints. Isolation of exposed gear will happen before leaving the field, and decontamination of caving gear will happen immediately upon returning; more detailed instructions are provided in SOP #3. All practices listed are compliant with standards for working within designated Wilderness areas.

Traveling and Locating Arco Tunnel

Traveling to Arco Tunnel involves snowmobiling the loop road, hiking during snow-free periods, and snowshoeing when snowpack is present. The exact locations of all known caves, including Arco Tunnel, are archived at CRMO and UCBN offices. Cave locations are sensitive information, not to be distributed publicly according to the Federal Cave Protection Act of 1988. Notes about caves with access challenges and safety concerns are stored in the caves database and in hard-copy cave files stored at CRMO and UCBN. Digitized cave maps for all caves are stored at CRMO and UCBN offices, and are linked to cave records within the project database.

Conducting Cave Surveys

Field training will be conducted prior to each survey. Training will include a review of decontamination procedures as well as counting and bat identification procedures. The CRMO Project Lead will direct training on site. Arco Tunnel will be surveyed during the first week of February. All other auxiliary cave surveys will be completed between January 1 and March 14. Because Arco Tunnel has varying internal environments, it has been divided into zones based on natural features or breaks in the cave. Many CRMO caves have zones which are indicated on the cave map and are linked with each cave record in the database. Zone breaks in CRMO caves indicate a change in light impact or significant temperature or humidity differences (Baker et al. 2015). Zones

are delineated by the CRMO cave program manager/CRMO Project Lead based on recorded temperatures/humidity, features, and personal experience. Air temperature, ceiling/wall temperature and humidity are recorded one to three times per zone, regardless of whether bats are present. If bats are found, temperatures and humidity should be taken as close to the bats as possible. Limiting disturbance to bats is a priority over temperature measurement and species identification. No bats will be handled. Grounded bats should be noted as such during data collection but not disturbed. Bats are photographed to aid in identification and for use in counting bat clusters with a computer, but unnecessary photographing should be avoided. Even with photos, identification of hibernating bats is imprecise and most *Myotis* bats will be classified as *Myotis* spp. or as "unknown bat". Counts and species identifications should be attempted during surveys and confirmed during follow-up analyses of photographs. The CRMO Project Lead will review all photographs of clusters and assign species identities. Bats touching each other are considered as a cluster. Bats separated but hibernating near each other are recorded as individuals. If a cluster of bats contains more than 1 species, the difference in species will be recorded in the database, but the cluster will be counted as a single mixed-species cluster. Bats within the cluster will be identified to species if possible. Keeping track of clusters is important since the fungus causing white-nose syndrome was shown to be transmitted from direct contact between bats (Lorch et al. 2011). All observations will be recorded directly on water proof data sheets and/or on the cave map. In the office, data will be transcribed into the project Microsoft Access database during office review of photographs, datasheets, and cave maps. There will be an area to further describe observations, such as mixed species clusters, or bats hibernating within zones impacted by light. A template data entry sheet form is included in SOP #1. Digital copies of cave maps are stored in the project directory with the database in UCBN and CRMO offices.

Safety Procedures

Before leaving the office, all pertinent SOPs should be reviewed and discussed. Arco Tunnel, like all CRMO caves requires a minimum of 2 surveyors to enter the cave, but 6 surveyors splitting into parties of 2 is the recommended number for an efficient survey. All parties must carry a map and create a plan for dividing the group before entering the cave. Conducting cave surveys requires careful, cautious movement and communication among team members. Communicate all known hazards before entering the cave environment. Observers must communicate with the CRMO Project Lead or other team lead about independent movement within the cave. For example, if a 4-person team, directed by the CRMO Project Lead, splits into two groups to survey Arco Tunnel, the CRMO Project Lead will coordinate and direct those movements. Communication can be aided with a white board, dry erase markers, and laminated arrows indicating which passage was taken, the direction of travel (into or out of the passage) and the time. These specific strategies must be planned for and included in training and guidance provided by the CRMO Project Lead.

Decontamination Procedures

Before each survey, gear will be decontaminated. During the course of the survey day, steps will be taken to isolate items taken into the cave environment so they do not come into contact with other non-exposed gear. All gear exposed to the cave environment (e.g. coveralls, helmets, lights, pens, cameras, etc.) will be kept separate from non-exposed gear during the survey day, and will be decontaminated upon returning to the field according to the latest USFWS decontamination protocols

(USFWS 2016). Gear selection will also be made with regard to ease of decontamination, such as more water-resistant flashlights.

Collection of Bat Specimens Exhibiting Signs of White-Nose Syndrome

This protocol does not support the collection of bats under any circumstances. Handling bats requires pre-exposure rabies vaccination. Guidance on collection and submission of dead, sick, and injured bats is continuously being updated as the disease progresses across the continent. The US Geological Survey National Wildlife Health Center website is a source for current information (http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/). Any bats found in CRMO caves during winter surveys that are exhibiting signs and symptoms of white-nose syndrome should be photographed, documented, and reported immediately to the CRMO Project Lead. CRMO staff will execute park-specific response plans and will contact the NPS wildlife health branch in Ft. Collins, Colorado for further guidance. The website for the NPS white-nose syndrome response can be found at http://www.nature.nps.gov/biology/WNS/index.cfm. The CRMO WNS Response Plan (NPS *unpublished* b) provides park-specific guidance on collection and submission of sick or dead bats to the USGS National Wildlife Health Center for diagnostics.

Data Entry and Management

This protocol is set up for recording data using paper data entry. The form can be found in SOP #1. This should be printed on water proof Rite-in-the-Rain paper. The top of the form allows for entering of the cave name, number of zones, survey date, start time, and stop time, names of observers, and survey notes; the remainder of the form is set up for recording cluster counts and species. Each observation of environmental conditions or bats is entered on separate rows. Notes can be added to clarify unusual situations. In particular, notes should be provided that can help future survey participants cope with safety and accessibility challenges.

Data forms must be completely filled out and reviewed prior to concluding a survey and exiting a cave unless concerns have arisen about safety or disturbance to bats. This is a key step in the quality assurance and quality control process (QA/QC). Data forms are quick and easy to fill out, and given the relative sparsity of bat encounters and the small size of clusters, this in-field data entry and review requirement is not burdensome. Once back in the office, the CRMO Project Lead should expedite transcription of the data form(s) into the project database. Delaying this process will increase the risk of errors and memory lapses of key notes and observations that may not have been captured on the form and an accumulation of un-processed paper data forms can quickly become a barrier to efficient workflow and project completion. The UCBN hibernacula bat survey database is a Microsoft Access application. QA and QC checks in the database are designed to minimize data entry error and logical inconsistencies with collected data. The final step in the data entry process will be to scan paper data sheets so that both hard copy and digital copies of the data sheets can be archived at CRMO. Digital copies of the data sheets will be archived for the life of the project by the UCBN and CRMO and can be reviewed at any time if discrepancies are subsequently detected.

After the Field Season

After the survey is completed, the CRMO Project Lead or other designated park staff should organize and decontaminate all field gear equipment from participants. The park, with the assistance of the

UCBN, is responsible for ensuring that field data are entered into the project database. Data entry should take place between monitoring field trips to lessen the possibility for technical errors or QA/QC problems from fading memories. All equipment should be cleaned and returned to CRMO storage. Equipment will be checked for damage and the equipment check list (SOP #1) will be reviewed to ensure that nothing has been lost or in need of repair or replacement. Repairs and replacements should be made as soon as possible and the equipment list updated with this information.

Data Handling, Analysis, and Reporting

The UCBN hibernacula bat survey database is an application developed within Microsoft Access. It adheres to Natural Resource Database Template standards (NRDT v. 3.2). The database application consists of a front-end user interface linked to a back-end database file. The front-end provides forms for entering data, updating links to and viewing cave maps and bat photos stored within the same project directory, queries for facilitating QA/QC, and tools for exporting data. The back-end of the database holds the core data tables and also various lookup tables. The UCBN data management staff is responsible for development and maintenance of the database, including customization of data summarization and export routines. This database may undergo revisions which will be reflected in future protocol narrative and data management SOP revisions. However, the underlying data structure (tables, fields and relationships) will remain unchanged, as will that of the front-end database applications ("user interface" with forms, queries, etc.) accessed through a user-friendly graphic user interface "switchboard" (Figure 2).

The data management strategy employs a "working copy" of the database application to enter and store the current season's data and to perform error-checking and validation. A "master copy" of the database application stores all validated data and is used to support multi-year analyses and provide specific data report and export formats. Details of the database, including a description of core and peripheral tables, a logical model of table relationships, and a data dictionary, are presented in SOP #4.

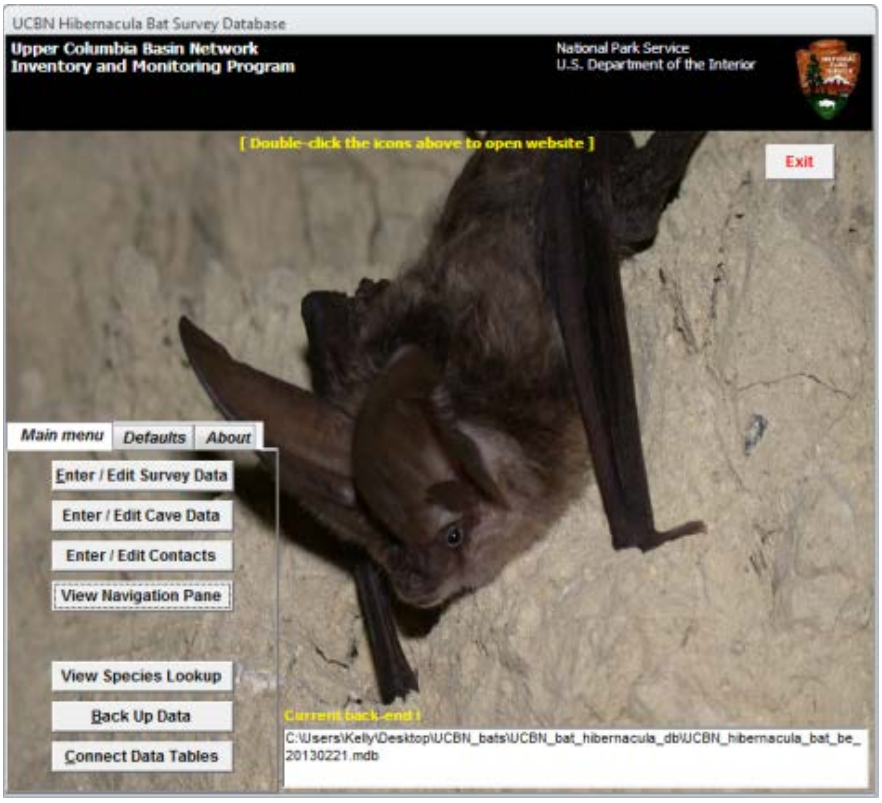

Figure 2. View of the UCBN hibernacula bat survey database user-interface "switchboard".

Data Entry

Accurate data recording is a central step in the overall QA/QC process, and care should be taken to review all cave survey data while the observers are still in the field. In addition, the database has built-in quality assurance components such as pick lists and validation rules to standardize spelling and test for missing data or illogical combinations. Transcription of data from paper field sheets to the working copy of the database should be accomplished as soon as possible after each survey. The basic components for data entry into the working UCBN hibernacula bat survey database are described in SOP #4.

Quality Review

The CRMO Project Lead will review data after entering and processing for quality, completeness, and logical consistency. Using QA/QC queries within the front-end database checks for data integrity, data outliers and missing values, and illogical values are performed. Data flagged as having integrity issues should be fixed and documented if possible. Data identified as erroneous but is irreconcilable, should be flagged and documented within the database, and accompanying annual data certification report.

Metadata Procedures

Data documentation is a critical step to ensure data sets have long term sustainability. This involves the development of metadata that is structured information about the content, quality, and condition of data. Additionally, metadata provide the means to catalog data sets within intranet and internet systems, making data available to a broad range of potential users. Metadata for bat monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. For long-term projects like this one, metadata creation is most time consuming the first time it is developed; after which most information remains static from year to year. Metadata records in subsequent years then only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in individual network Data Management Plans. In general, the CRMO Project Lead, UCBN Ecologist, and the Data Manager (or Data Technician) work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The UCBN Ecologist or Data Manager will update metadata content as changes to the protocol are made, and each year, during analysis, reporting, and project close-out processes. Edits within the document should be tracked so that any changes are readily apparent to those who will use it to update the XML metadata file. At the conclusion of the field season, the CRMO Project Lead will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager and UCBN Ecologist. The Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to national clearinghouses as described below.

Sensitive Information

Metadata development includes determining if the data contain sensitive information such as specific locations of rare, threatened, or endangered species. In some cases, it may be necessary to restrict access to data containing sensitive information, except where a written confidentiality agreement is in place. The CRMO Project Lead and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager and UCBN Ecologist.

Locations of the lava tube caves in CRMO are considered sensitive and are not available to the public. These locations are stored in the database; therefore care should be taken to remove the cave location coordinates from the database prior to any release to the public. Publically released hibernacula databases will have all cave location information removed.

Data Certification

Data certification is a benchmark in the project data management process that confirms 1) the data are complete for the period of record; 2) the data have undergone and passed quality assurance checks; and 3) the data are appropriately documented and suitable for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies, which may not have been detected during quality assurance reviews.

To ensure data of the highest possible quality are included in reports and other project deliverables, the data certification process is an annual requirement for all tabular and spatial data. The CRMO Project Lead, UCBN Ecologist, and Data Manager together are responsible for completing certification. The project database includes checkboxes within the data entry form for verification and certification. Once the box is checked, the person who verified or certified the data, as well as the date, will be automatically populated with the user name from the PC in use and saved within the project database. The certified data and updated metadata should be delivered to the CRMO Project Lead as well as the UCBN Data Manager at the end of the field season. Additional details of the certification and delivery processes are included in SOP #4.

Data Analysis and Reporting

Annual Survey Results

Annual survey results will be summarized after each winter's survey and reported in an annual resource brief, consisting of a very concise description of the project, current year results compared with past results, a statement of significance of findings as appropriate (e.g., if notable reduction in bat counts occurred), and distributed to park and Network audiences via the UCBN website. A template for annual resource briefs can be found here.

Multi-year Survey Results

In-depth reports of multi-year survey results will occur at 5-year intervals, or as CRMO management needs require. These reports will be published in the NPS Natural Resources Data Series (http://www.nature.nps.gov/publications/nrpm/). The reports produced by Stefanic and Rodhouse (2013, 2015) and Slocum et al. (2016) provide excellent templates (available here). Basic summary statistics will be presented in a table similar to the one used in these reports, which lists all caves

surveyed and the number of bats counted. Graphical representation of survey results will be presented as a map showing the approximate location of caves and the number of bats counted. Other basic reporting metrics will include the proportion of caves in which bats were found, as well as the total number of bat species encountered (species richness). For example, in 2013, the proportion of the 33 targeted caves with bats encountered during surveys was 0.15, or 15%. The total number of species confirmed was 2. The average number of bats per cluster was 3 (SD=3), ranging from 1 to 12. These simple summaries can be used in State of the Parks reporting and in resource briefs and other short communications. Multi-year trends from counts in Arco Tunnel will be presented in simple table and scatterplot formats.

Data Archival Procedures

Paper data sheets and digital copies of datasheets will be archived at CRMO, and the UCBN will also maintain an archive of digital copies of data sheets. Data sheets will be scanned and stored as .jpg image files for the life of the project. Upon certification, data and reports will be archived on the UCBN and CRMO servers, posted to the UCBN website, and posted to the national web-accessible secure database hosted by the NPS Washington Areas Support Office (WASO) or National I&M program and accessible through the NPS Integrated Resource Management Applications (IRMA) portal (https://irma.nps.gov).

Protocol Testing and Revision

Pilot data were collected at CRMO during the winters of 2012-2016 and reported by Stefanic and Rodhouse (2013, 2015) and Slocum et al. (2016). These pilot efforts were instrumental in helping the UCBN and CRMO develop and test this protocol. The methods described in SOP #3 have been tested at Lava Beds National Monument as well. Over time, revisions to both the protocol narrative and specific SOPs are expected. Careful documentation of any changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate summary analyses. The database for each component will contain a field that identifies which version of the protocol was used when the data were collected. The protocol narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide the methodological details. The protocol narrative will only be revised if major changes are made to the protocol. The SOPs, in contrast, are specific, step-by-step instructions for performing tasks, and are published separately (Rodhouse et al. 2017). They are expected to be revised more frequently. It will only rarely be necessary to revise the protocol narrative to reflect specific changes in an SOP. All versions of the protocol and SOPs will be archived in a CRMO bats project digital library on the UCBN and CRMO server. Current versions will be served off of the UCBN website and the national I&M protocol database, as well as the IRMA portal.

The steps for changing the protocol (either the narrative or an SOP) are given in SOP #6, “Revising the Protocol”. Each SOP contains a change log that should be filled out each time an SOP is revised to explain why the change was made and to assign a new version number to the revised SOP. The new version of the SOP or Protocol Narrative should be archived in the project library under the appropriate folder. A revision history log in SOP #6 will also document revisions over time.

Personnel Requirements and Training

Personnel Requirements and Roles and Responsibilities

The personnel requirements to implement this protocol are relatively modest. The CRMO Project Lead role will typically be filled by the existing wildlife biologist or similar permanent staff, and should be trained in Operational Leadership. Caving at CRMO requires a minimum of 2 people, so at least one additional technician will be needed during the winter survey period. This assistant does not need to be thoroughly trained and experienced in bat ecology or wildlife biology, although they must receive training in the protocol methods at the beginning of the survey period. Supporting roles from the UCBN I&M team will be filled by the UCBN Ecologist and the UCBN Data Manager. Table 1 provides a general outline for the roles and responsibilities of personnel involved in this monitoring protocol. A memorandum of understanding that clarifies roles and responsibilities between CRMO and UCBN is included as an appendix to this protocol in SOP # 1.

Table 1. Roles and responsibilities for implementing the bat hibernacula monitoring program in CRMO.

Role	Responsibilities	Name / Position
CRMO Project Leader	Project oversight and administration Track project objectives, budget, requirements, and progress toward meeting objectives Facilitate communications between UCBN and CRMO natural resources program staff Coordinate and ratify changes to protocol Acquire and maintain field equipment Direct training of field teams Maintain and archive project records Project operations and implementation Verify accurate data transcription into database Certify each season's data for quality and completeness Assist the UCBN Ecologist and Data Manager complete reports, metadata, and other products according to schedule	CRMO Wildlife Biologist
UCBN Liaison	Facilitate communications between the CRMO natural resources program staff and UCBN I&M team Maintain up-to-date protocol documentation; revise as necessary Perform data summaries and analyses Maintain and archive project records Complete reports, metadata, and other products according to schedule	UCBN Ecologist
Crew Lead	Plan and execute hibernacula surveys Oversee WNS decontamination procedures Oversee data collection and entry Responsible for safety of teams in the field	CRMO Wildlife Biologist, Seasonal employees, or interns
Technicians	Participate in training and agree to follow protocol methodology, including safety and decontamination procedures Collect, record, enter and verify data Decontaminate gear between cave visits	Seasonal employees, partners (e.g. Idaho Fish and Game) interns, or volunteers

Table 1. Roles and responsibilities for implementing the bat hibernacula monitoring program in CRMO (continued).

Role	Responsibilities	Name / Position
Data Manager	Consultant on data management activities Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule Maintain and update database application Provide database training as needed Consultant on GPS use Work with CRMO Project Lead and UCBN Ecologist to analyze spatial data and develop maps and metadata for spatial data products Primary steward of Access database and GIS data and products	UCBN Data Manager
Network Coordinator	UCBN liaison (Ecologist) and Data Manager oversight Administration and budget management for UCBN roles and responsibilities Consultant on all phases of protocol review and implementation Review of annual and 5-year reports	UCBN Program Manager
Park Resource Manager	Project leader oversight Administration and budget management for CRMO roles and responsibilities Consultant on all phases of protocol implementation Facilitate logistics planning and coordination Communicate management plans and associated information to CRMO Project Lead Review reports, data and other project deliverables	CRMO Chief of Integrated Resource Management

Qualifications, Training and Calibration

The CRMO Project Lead plays a key role in the implementation of this protocol. This person must be well-trained in wildlife biology or in a related natural resource field and must have knowledge and experience in conducting field biology. Operational Leadership training is highly recommended. Particular skills and experience with bat ecology is important although not essential, given that there will be no capture and handling of animals. Bat identification is the most specific technical requirement and prior identification experience will be a tremendous asset. However, identification keys and reference photographs are discussed in SOP #1 and will be sufficient to enable inexperienced Project Leaders to implement the protocol. Inviting regional bat experts from the Idaho Department of Fish and Game or other similar organizations to assist with training and surveys is recommended. Project Leads should have familiarity with using Microsoft Access Database. Training opportunities for CRMO staff are also periodically available through organizations such as Bat Conservation International (www.batcon.org). In the event that the CRMO Project Lead changes, it will be imperative that they contact their UCBN counterparts and consult with the CRMO Chief of Integrated Resource Management to ensure that all responsibilities are properly addressed. It is the intent of this protocol to require little to no training for a new Project Lead to understand and implement this protocol if they are sufficiently proficient already with budget and data management skills. Decontamination procedures do not require specific knowledge and experience, and US Fish

and Wildlife Service protocols are straightforward and easy to follow. Technicians do not need to become adept at bat identification because all bats will be inspected by the CRMO Project Lead and photographed, allowing expert identifications to be made after surveys.

Operational Requirements

Annual Workload and Field Schedule

Arco Tunnel will be surveyed during the first full calendar week of February each winter. The total amount of time required to survey Arco Tunnel is approximately 5 hours. Several weeks of preparation and analysis and reporting will be required from the CRMO Project Lead and UCBN Ecologist and Data Manager. Table 2 details the annual workload and schedule.

Table 2. Annual schedule of major tasks and events for the CRMO bat hibernacula monitoring protocol.

Month	Administration	Field	Data Management/Reporting
January		Prepare field and GPS equipment and training manuals. Train assistants and conduct cave surveys Recruit assistants Conduct auxiliary cave surveys as resources allow	Data entry and verification
February		Conduct Arco Tunnel survey Conduct auxiliary cave surveys as resources allow	Data entry and verification
March		Conduct auxiliary cave surveys as resources allow	Data entry and verification
April			Data certification complete; Metadata production, quality review
May			Data archival and posting; Annual report complete
June			Project close-out complete
July			
August	Budget preparation for new fiscal year		
September	Close-out of fiscal year Hiring of field staff		Annual resource brief prepared for UCBN Science Advisory Committee meeting
October	UcBN and CRMO annual reports and work plans drafted		Protocol revisions complete, if necessary
November			
December		Prepare field equipment and GIS; Review FWS Decontamination Protocol	

Facilities and Equipment Needs

A list of necessary and recommended field sampling equipment is given in Table 3. Winter weather can be challenging in CRMO. Personal protective equipment will include adequate warm clothing that can be cleaned after use as part of the WNS decontamination procedures. CRMO will provide dedicated canvas suits and other gear specific to WNS decontamination that is not expected to be provided by employees and assistants from outside the NPS. Park housing is not a requirement for this protocol, but may be offered to outside personnel traveling to assist with surveys. The CRMO Project Lead will coordinate equipment and housing logistics well in advance of the field season.

Table 3. Equipment list for monitoring bat hibernacula in CRMO.

Equipment Type	Equipment Description
Decontamination Equipment	Coverall suit
	Plastic trash bags
	Gallon zip-lock bags
	Rubber boots or boot covers
	Shower caps (optional)
	Disinfecting wipes or spray
	Hand warmers
Personal Protective Equipment	Warm winter clothing
	Caving helmet
	Dust mask
	Snowshoes and trekking poles
	Kneepads/Elbow pads
	Gloves
	Headlamp with spare batteries (50 or more lumens)
	Flashlight with spare batteries (50 or more lumens)
	At least one other source of light (50 or more lumens)
	At least 2 forms of communication (see SOP #6)
	“Yak tracks” or other slip-on traction device (optional dependent on conditions)
	First aid kit/Winter survival kit
	Compass
	Large capacity backpack
Survey Equipment	Laser thermometer
	Kestrel pocket weather meter
	Binoculars
	Laser pointers
	Spotlights (for caves with high ceilings)
	Mechanical pencils and clip board
	Bat identification reference
	Laminated arrows

Table 3. Equipment list for monitoring bat hibernacula in CRMO (continued).

Equipment Type	Equipment Description
Survey Equipment (continued)	GPS with spare batteries
	Digital camera
	Paper cave maps (write in rain)
	Blank paper (if mapping/remapping)
	Measuring tape/reel (if mapping/remapping)
	White boards/dry erase markers

Budget

Table 4 details the annual operating budget for this protocol. Budget expenses are identified separately for CRMO and UCBN, and a summary of the subset of funds required to only survey Arco Tunnel, a 2 week endeavor only for the CRMO Project Lead, are also provided.

Table 4. Annual budget for surveying Arco Tunnel and other caves in CRMO for bat use.

Line Item	CRMO Bat Hibernacula Monitoring Budget	Time allotted	% of time spent on DM*	Cost in dollars DM*	Cost in dollars UCBN	Cost in dollars CRMO	Cost in dollars for Arco Tunnel only
NPS Personnel	CRMO Project Lead (GS 11)	2 weeks field season prep and logistics; 4 weeks field surveys (intermittent); 2 weeks QA/QC, data archiving, analysis and reporting, close-out	50%	$6,690		$9,264	$2,316
	CRMO Natural Resources Chief (GS-13)	1 week pre-season preparation review and logistics/consultation; 1 week post-season review and report editing	75%	$2,383		$3,300	$3,300
	UCBN Program Manager (GS13)	1 week project & report review	100%	$1,650	$1,650		$1,650
	UCBN Data Manager (GS12)	1 week field season prep, QA/QC, data archiving and close-out	100%	$1,387	$1,387		$1,387
	UCBN Ecologist (GS12)	1 week field season prep and report review and editing	100%	$1,387	$1,387		$1,387
Seasonal Personnel	Biotechs (GS-5)	1 week training and preparation, 4 weeks surveying (intermittent), 1 week post-season data entry, QA/QC, close-out	40%	$2,019	[$5,048]***	$5,048	

Table 4 (continued). Annual budget for surveying Arco Tunnel and other caves in CRMO for bat use.

Line Item	CRMO Bat Hibernacula Monitoring Budget	Time allotted	% of time spent on DM*	Cost in dollars DM*	Cost in dollars UCBN	Cost in dollars CRMO	Cost in dollars for Arco Tunnel only
Operations/ Equipment	Housing (1-2 persons)					$500	
	Survey/Decontamina-tion Equipment					$500	$500
	Travel – CRMO vehicle					$500	$500
	Other (contingency)				$1,000	$1,000	$1,000
Total				$19,774	$5,424	$20,112	$12,040

* DM = data management

** More than 40% of the bat hibernacula monitoring protocol budget is dedicated to data management, analysis, and reporting activities.

*** In some years UCBN may also contribute additional support with a season biological technician.

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