

Cumberland Piedmont Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure CC03a

Strip Adaptive Cluster Sampling—Version 1.1

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Summary

This standard operating procedure (SOP) gives an overview of strip adaptive cluster sampling (SACS) and step-by-step instructions for the field crew leader and field crew member(s) to follow to perform SACS at Mammoth Cave National Park (MACA) including: (1) laying out the baseline on which strips are located, (2) laying out the strip within which the field crew surveys for cave cricket clusters, (3) photographing cave cricket clusters in a strip, and (4) filling in the field data sheet.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
3/2020	Helf	Added prose incorporating suggestions in 2019 operational review, regarding implementation of pre-field briefing, integration of cave cricket database, redesign of field data sheets, baseline reproducibility, clarification duties of field assistants, clarification of cluster extent measurement, use of oversample strips, changes in QA/QC procedure, improved methods of capturing large clusters with tiled images, use of rangefinders in the field, and increased accuracy of cluster counts in field.	2019 Operation review	1.1

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Overview

This standard operating procedure (SOP) gives an overview of strip adaptive cluster sampling (SACS) and step-by-step instructions for the field crew leader and field crew member(s) to follow to perform SACS at Mammoth Cave National Park (MACA). These instructions include (1) laying out the baseline on which strips are located, (2) laying out the strip within which the field crew surveys for cave cricket clusters, (3) photographing cave cricket clusters in a strip, and (4) filling in the field data sheet.

Prior to conducting a cave cricket sampling event, all personnel involved must review SOP #2 *Pre-Field Sampling* (Helf et al. 2015), this SOP, and follow all safety guidelines (Figure SOP2-5). A pre-field briefing will be held for the field crew that will include assignment of specific tasks executed in the exact same order for all sampling bouts and, based on the scheduled cave entrances, any special instructions or equipment issues.

Strip Adaptive Cluster Sampling

While cave crickets are the most abundant large subsurface organism found in Mammoth Cave NP, sampling their populations in a statistically valid manner can be challenging. Indeed, while the bulk of cave cricket entrance populations roost in clusters (generally within 100 meters [328 feet {ft}] of cave entrances) they are rare relative to the surface area of cave ceilings and walls on which they roost. Further, their propensity to roost in clusters reduces the probability any one cluster would be detected by randomly located sampling units. As a result, the majority of randomly sampled units would likely contain no individuals and result in large variances of estimates of population size. The use of strip adaptive cluster sampling (SACS) takes advantage of cave crickets' tendency to roost in clusters to obtain more precise estimates of entrance population size and so increase the effectiveness of our sampling efforts (Thompson 2002). The main assumption of SACS is that the probability that sampling units adjacent to clusters of roosting cave crickets are occupied is higher than that of sampling units not adjacent to clusters, so sampling effort is increased in the vicinity of roosting clusters (Figure 1). For example, if a given strip intersects a cluster of cave crickets with greater than or equal to one cave crickets inside its 10 centimeter (3.9 inches [in]) boundary, then all cave crickets within 10 centimeters of the initially encountered individual(s), whether inside or outside the initial strip, are included in the cluster. This process of adaptively sampling the cluster continues until no more individuals are found within 10 centimeters of one another (Figure 1).

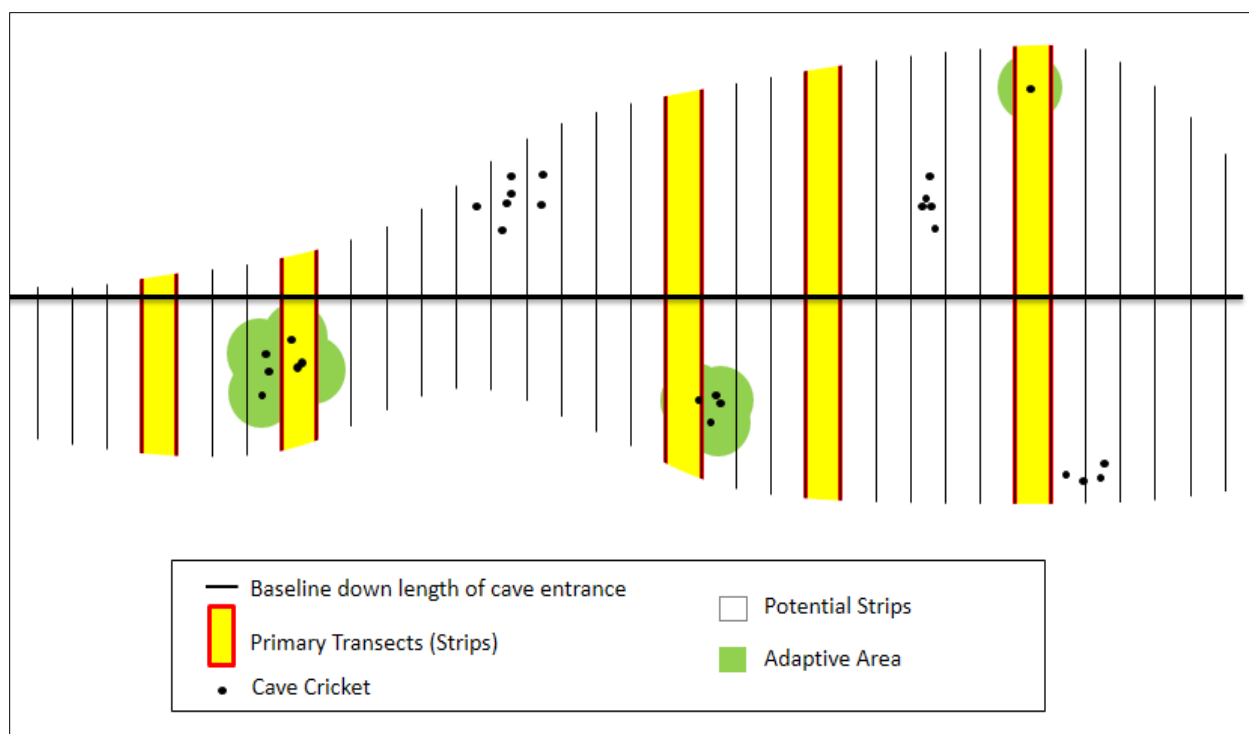


Figure 1. Diagram of the strip adaptive cluster sampling method used to monitor cave crickets entrance populations at Mammoth Cave National Park. Randomly selected strips are searched for crickets with search area expanded around detected crickets.

Step-by-Step Instructions

Note: While these steps are roughly sequential some occur simultaneously and so their order in these instructions is arbitrary (e.g., steps 6–9).

1. **Prior to each sampling event** the field crew leader uses the CUPN Cave Cricket Application (i.e., database) to randomize, via generalized random tessellation stratified (GRTS) draw, the order in which sampled cave entrances are visited. The field crew leader also generates the Pre-populated Field Data Sheet, also using the database, which contains the results of the 1-dimensional GRTS draw of spatially balanced strips, their positions on the baseline, and an additional oversample. The oversample is included in case there is a valid reason a few strips must be discarded and to maintain spatial balance (Table 1). The Pre-populated Field Data Sheet also contains space to record ancillary data on roosting clusters (e.g., their extent and location) and cave meteorological data at the cluster (Figure 2). Further, before leaving the office on a sampling bout, the field crew leader will review the Field Information Sheet, stored in the database, which provides an outline of the pertinent information describing conditions at each sampled cave, and equipment checklists for cave entrances (with which they are also responsible for supplying to field assistants) to reduce any confusion in the field. The field crew leader also ensures ample blank copies of field data sheets (with at least

two additional pages per cave), generated by the database, are stored in the covered clipboard.

Reviewed by **KH**

Cave Cricket Monitoring Protocol - Cumberland Piedmont Network

EventID: CC_47		Entrance: Crystal Cave		Bout: Summer2019	
Date	6/18/2018	StartTime	0920	StopTime	1218
Crew	Kurt Helf, Chaz Wells, Johnathan Jernigan				
Event Notes					

Strip Sample Codes:

1. Unused - Safety	3. Unused - Risk to Infrastructure	5. Sampled - Strip Sampled
2. Unused - Unsampleable/Inaccessible	4. Unused - Risk to Resources	

Strip #	Pos. (m)	sample Code	Clusters (separated by "-")	Strip Notes
25	0.1	5	1-2	
13	1.4	5	3	
22	2.3	5	0	
9	3.0	5	4-5	
19	4.2	5	6-7	
5	4.7	5	8	
28	5.7	5	9	Intersects w/ 6.2 (Cluster 9)
1	6.2	5	9	Intersects w/ 5.7 (Cluster 9)

Reviewed by **KH**

Cave Cricket Monitoring Protocol - Cumberland Piedmont Network

EventID: CC_47		Entrance: Crystal Cave		Bout: Summer2019	
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Clstr #	Extent: cm Min Max	Distnce (meters)	Side (L/R)	Est # crickets	Loc (C/W)	Temp deg	RH %	Air (m/s)	Edge (L/R)	Cluster Notes
1	6 8	1.85	L	1	C	16.6	76.3	0.0	L	
2	0 2	3.36	L	2	C	16.6	74.2	0.0	U	no target
3	6 7	4.29	L	1	C	14.9	80.8	0.0	L	
4	1 12	4.56	L	5	C	13.7	86.4	0.0	L	
5	3 4	3.70	L	1	C	13.8	87.3	0.0	L	
6	1 5	3.72	L	1	C	13.3	89.7	0.0	R	
7	7 8	1.44	L	1	C	13.1	90.4	0.0	L	
8	2 9	4.08	R	2	W	12.6	91.9	0.0	L	
9	6 26	3.55	L	5	C	12.6	92.8	0.0	L	
10	4 9	4.34	L	1	W	12.2	94.2	0.0	U	no target

Figure 2. Truncated Strip level data table (top) and Cluster level data table (bottom) from the “Strips” and “Clusters” field data sheets, respectively. Prior to the sampling bout both these field data sheets are generated in the CUPN Cave Cricket Application (i.e., database), via R code, with Strip IDs from the GRTS draw, the Strip’s sequential position on the baseline, an additional oversample, Entrance name, Bout, Event ID, and park code. Which strips or oversample strips are used and sequentially numbered clusters intersected by a strip are recorded in the field on the Strips field data sheet (top). The “Clusters” field data sheet (bottom) is where all ancillary data associated with cave cricket clusters (e.g., each cluster’s extent and cave meteorological data) are recorded in the field.

2. **Prior to each sampling event** the project leader, who acts as the field crew leader, ensures camera readiness. This is the protocol's main source of data, so preparation is crucial for obtaining adequate pictures.
 - a. The field crew leader is to be cognizant of the potential for mud, dust, trauma, and contamination of both the camera and the case by the fungus that causes white-nose syndrome (WNS) in bats. A hard case that is easily cleaned and decontaminated is used to house the camera (e.g., Pelican™ case). The field crew leader wears latex or nitrile gloves when handling the camera and replaces gloves, as needed, to help keep it clean.
 - b. When changing lenses minimize exposure to dust and dirt. If possible, the field crew leader uses one camera with a zoom lens for high ceiling areas and another camera with a smaller or fixed lens for low ceiling areas.
 - c. The field crew leader is to be exceedingly familiar with the camera gear before starting surveys. The field crew leader may create an abbreviated manual or "cheat sheet" including the essential functions of the camera and the flash (e.g., changing mode, shutter speed, ISO, aperture, image format, reviewing images); the list is kept with the camera to ensure continuity of settings among sampling events and event groups (Hicks et al. 2009). The following are recommended settings:
 - i. Image format: ".jpg" format.
 - ii. ISO setting: ISO-800.
 - iii. Mode: TAv-Automatic shutter and aperture priority where shutter speed and aperture will give proper exposure based on the brightness of the subject (Pentax K10D).
 - iv. Metering: Use center-point metering when possible, center-weighted when not.
 - v. Focus: Set to auto focus.
3. Once at the survey cave entrance the field crew member fills in the pertinent cave and sampling event metadata (i.e., Cave Name, Crew, Date, and Start Time) at the top of the field data sheet. The field crew member is the designated data recorder for sampling events. The data recorder performs verbal verification checks for data quality as data are received from the field crew leader and ensures that data are legibly entered into correct fields on the field data sheet. The field crew member retains the field data sheets in the covered clipboard at all times while in the cave so that their loss or damage (and potential loss of data) can be avoided. Data collected during the survey are entered onto a common field data sheet printed on Rite-in-the-Rain™ paper (Figure 2). The data fields are roughly arranged in the sequence in which the data are acquired in the field, analyzed at the office, and entered into the

database: (1) Cave level and sampling event data, (2) Strip level data, and (3) Cluster level data.

- a. Repeated monitoring visits increase the possibility of damage to fragile cave resources and so best management practices should be observed to prevent damage; these include:
 - i. Maintain a relatively small field crew size to minimize the impact on cave resources caused by repeated visits.
 - ii. Travel should generally proceed in a single-file line to confine impact to a narrow path. In general, but particularly through fragile cave sections, traveling slowly and deliberately is necessary to minimize the chances of impact such as breaking cave formations.
 - iii. As necessary, only the field crew leader should move outside the immediate vicinity of the baseline.
4. Both members of the field crew use a baseline map (Figure 3), generated during the cave entrance mapping survey for each monitored cave, to lay out the baseline using a fiberglass survey tape. The field crew references the baseline map for images of its starting point(s) or landmarks, bearing(s), and length to precisely relocate the baseline(s) in order to ensure continuity among cave cricket monitoring surveys. If the starting point is not tied to obvious landmarks, instructions indicate their distance (facing into the cave) from the left and right walls and the ceiling (up) and floor (down). A cave's baseline may have multiple segments if the cave passage meanders (Figure 3). However, multiple baselines must still be laid out continuously (i.e., with a single survey tape) so that all useable strip positions generated in the GRTS draw can be easily located.
5. The field crew member consults the Pre-populated Field Data Sheet (Figure 2) of entrance-specific strip positions from the GRTS draw (see step 1) and brings the tripod to the appropriate sequential strip position on the baseline. Facing into the cave the field crew member turns on the lasers to project the 10-centimeter (3.9-in) wide strip, ensures the tripod is leveled, and pans the assembly to the left and then down and moves the tripod as necessary to assure that the strip's minimum edge (i.e., closer to the cave entrance) is projected onto its correct position on the baseline and it is perpendicular to the baseline while the tripod is level. The field crew member then pans the assembly up so that the strip is projected onto wall of the cave passage. Generally, the field assistant is responsible for moving and positioning the tripod and laser platform on the baseline.
6. If the strip is not rejected (but see sub-step d below) the field crew member records a "5" in the "sample code" column in the "Strips" table on the "Strips" page. (Figure 2). Facing into the cave, the field crew leader visually scans the strip, at floor level from the left side to the right side of the baseline, for clusters of cave crickets that intersect with the strip. The scan begins at floor level, continues up the wall, onto the cave ceiling, and down to the opposite

floor level. Note: in wide cave passages this rule may be relaxed to prevent excess trampling associated with moving the tripod back and forth. The field crew leader coordinates the search with the field crew member, who pans the laser assembly to move the strip as needed. Panning the laser assembly keeps the strip perpendicular to the plane of the baseline and reduces problems with changing its width. A strip may intersect more than one cave cricket cluster (Figure 4).

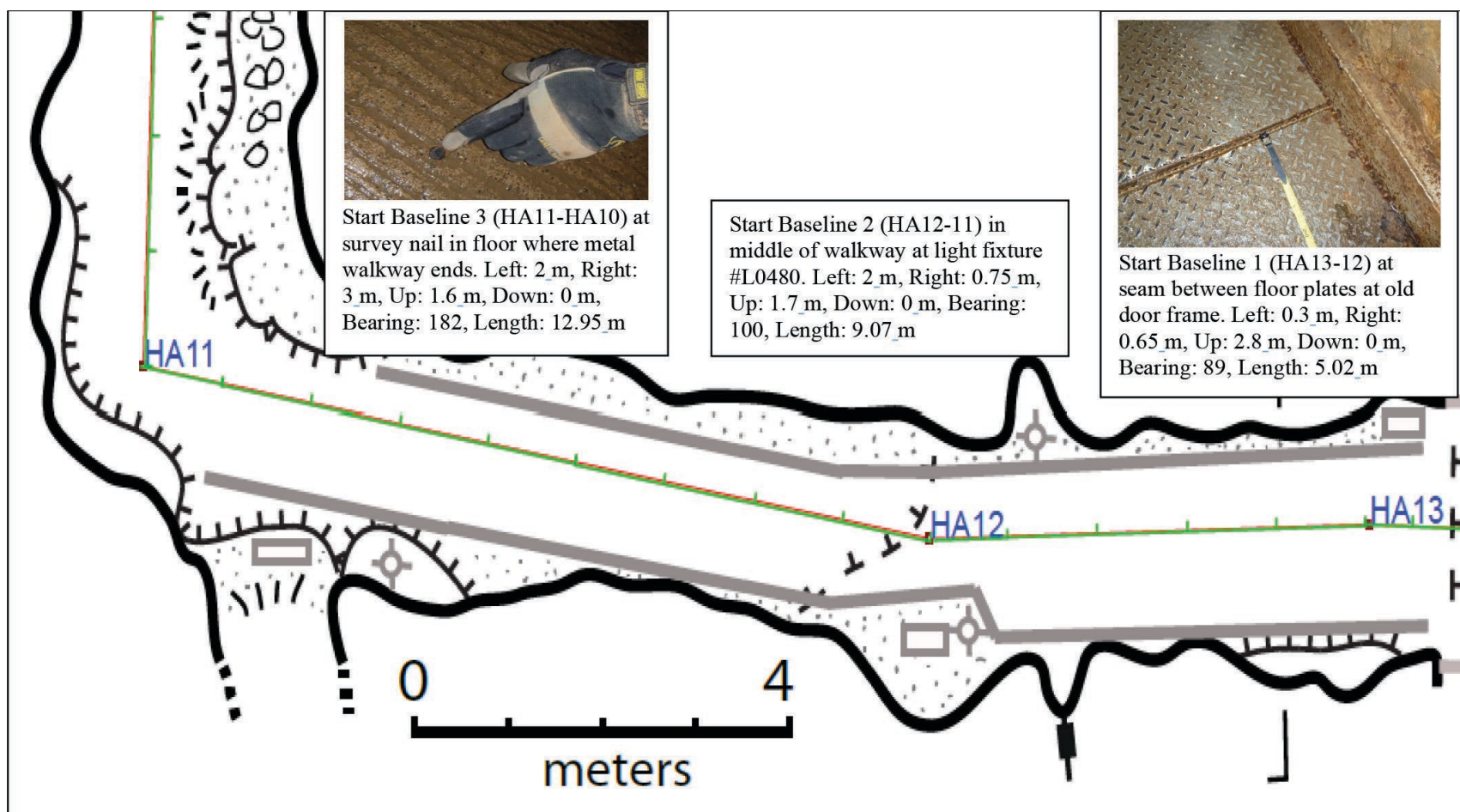


Figure 3. Section of the baseline map for Frozen Niagara Entrance. Baseline maps for each survey cave contain inset photographs or instructions to accomplish their accurate relocation among sampling events. Note: this example shows separate, but continuous, baseline segments may be necessary in caves with meandering passages.

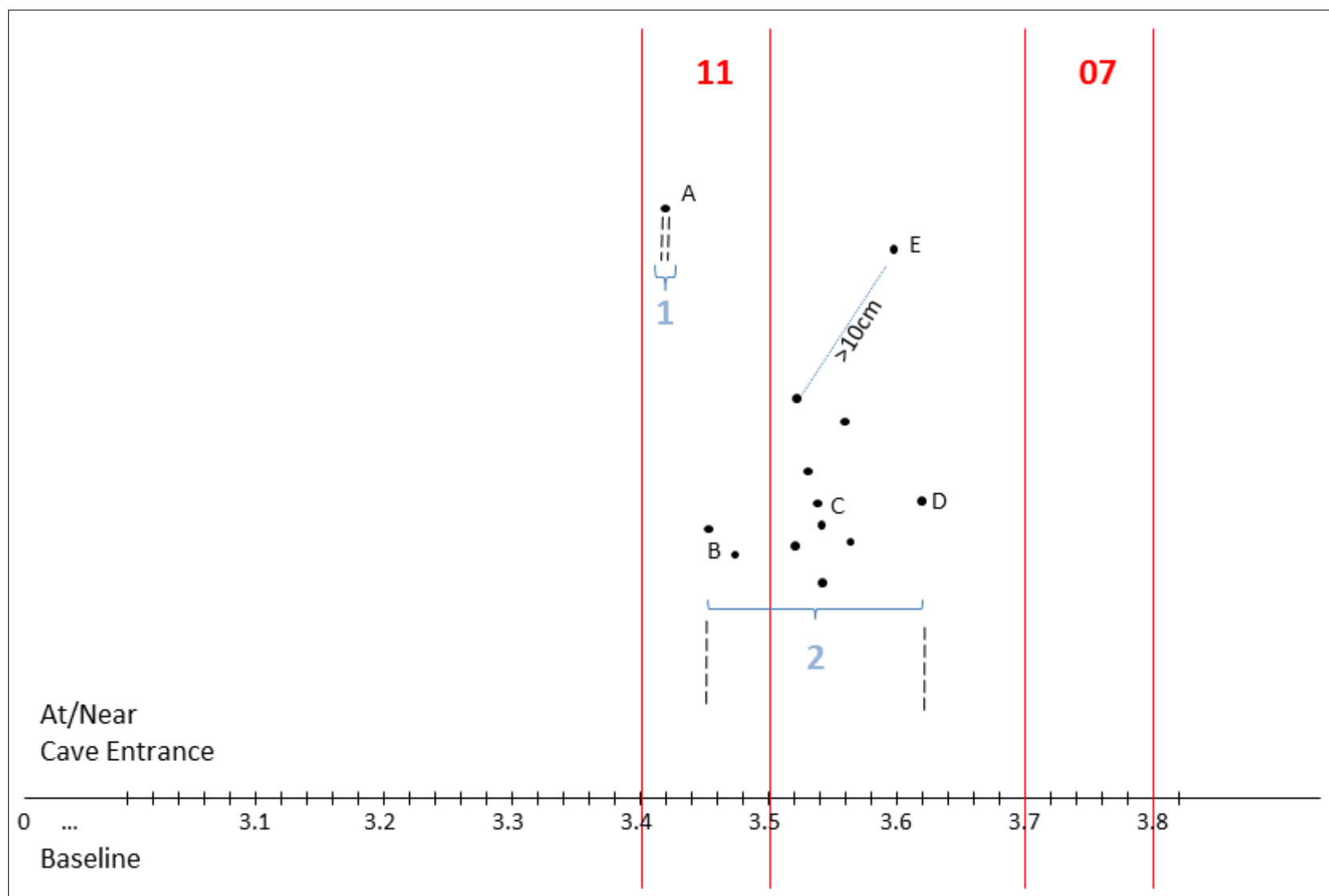


Figure 4. Example of cluster extent with respect to the surveyed strip in Strip Adaptive Cluster Sampling used to monitor cave crickets at Mammoth Cave National Park. Note: strip No. 07 extends from 3.7 to 3.8 meters (12.1 to 12.5 ft; red lines), and one row of data with 0 cave crickets is recorded in the Strips Table on page 1 of the field data sheet (Figure 2).

- a. If the field crew leader does not find any cave cricket(s) in the strip, the field crew member records “0” in the “Clusters” cell in the appropriate cell of the “Clusters” column on the “Strips” field data sheet (Figure 2, top).
- b. The first cave cricket found with at least 50% of its body within the strip is used by the field crew leader to determine whether other cave crickets within less than or equal to 10 centimeters (3.9 in), if any, are included in the cluster (Figures 4 and 5). The less than or equal to 10 centimeters proximity necessary for another crickets’ inclusion in the cluster is determined using the handheld laser strip generator. The handheld laser strip generator projects a 10-centimeter wide strip,

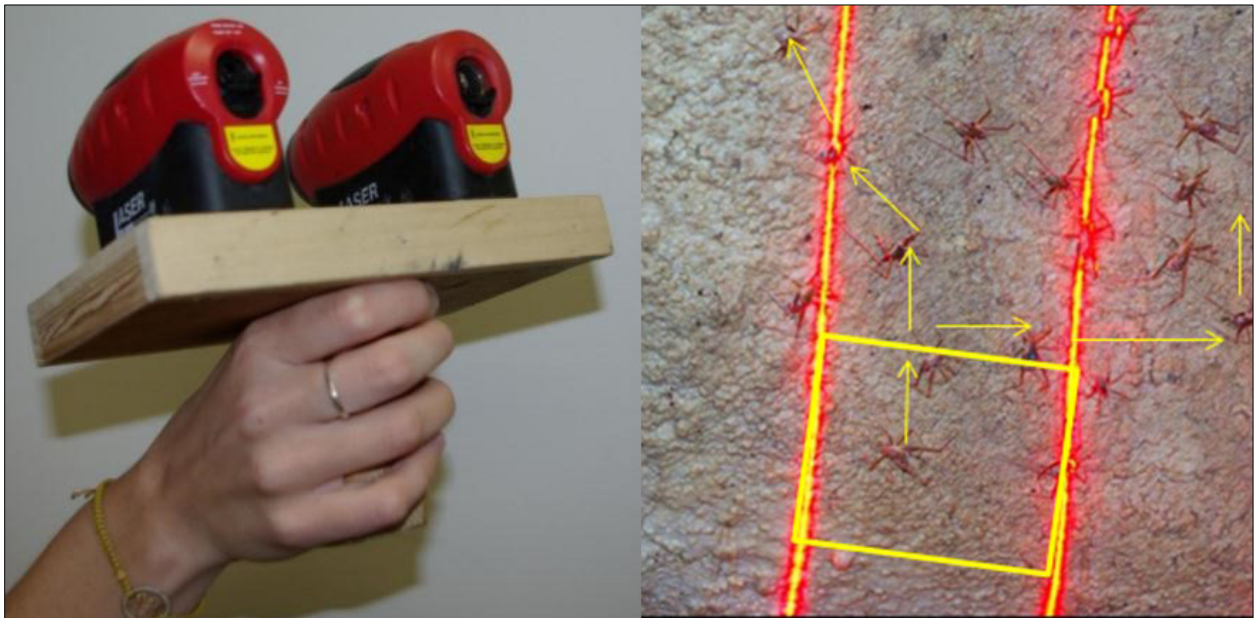


Figure 5. Handheld laser strip generator (left). It is primarily used as calipers to iteratively expand a cave cricket cluster intercepted by the laser strip (right) projected by the tripod laser assembly. The first cave cricket found with greater than or equal to 50% of its body within the lines of the strip (centered in yellow box) is used to begin expanding the cluster using the generator as calipers. Beginning with this first individual, the handheld is used to determine whether the cave crickets adjacent to it, if any, are within 10 centimeters (3.9 in). If so, the cluster is expanded iteratively by 10 centimeters (yellow arrows) until no more cave crickets are found within 10 centimeters of another.

used as calipers, for determining the distance between cave crickets and, ultimately, cluster extent. Starting at the strip’s minimum edge along the baseline (i.e., closest to the cave entrance) the field crew leader expands the cluster iteratively, using the handheld laser strip generator, to include cave crickets within 10 centimeters of any cave cricket already included on this side of the strip, until there are no more cave crickets within 10 centimeters of any other (Figures 4 and 5). The field crew leader estimates, in centimeters, how far the minimum edge of the cluster extends outside or inside the strip projected on the cave surface by the tripod mounted lasers. Their estimate can be a negative or positive number depending on whether the cluster

extends outside (i.e., down the baseline) or inside (i.e., up the baseline) the minimum position of the strip, respectively. The field crew leader calls out this number to the field assistant who records it in the “min” cell in the “Extent” column in the “Clusters” (Figure 2) field data sheet. The process is repeated for the strip’s maximum edge along the baseline (i.e., farthest from the cave entrance). It is useful to think of this process as adding and subtracting on a number line because that’s exactly what it is. For example, in Figure 4 the minimum position of Strip No. 11 on the baseline is at 340 centimeters (133.9 in) and its maximum position extends 10 centimeters (3.9 in) to 350 centimeters (137.8 in). Cluster No. 1 is the single cricket at “A” and its minimum and maximum cluster extents are recorded as “+2”, because the cricket is 2 centimeters (0.8 in) past the strip’s minimum extent, and “-7”, because the single cricket precedes the strip’s maximum position by 7 centimeters (2.8 in), respectively (dashed and blue lines). Cluster No. 2 starts with the two crickets at “B” and so is recorded as “+5” because it is 5 centimeters (2 in) past the strip’s minimum position. Nine crickets past the strip’s maximum position are adaptively added: eight crickets at “C” are added as they are less than or equal to 10 centimeters of those at “B” and one cricket at “D” is added as it is less than or equal to 10 centimeters of those at “C”. Cluster No. 2’s maximum extent is recorded as “+12” because it is 12 centimeters (4.7 in) past the strip’s maximum position (dashed and blue lines).

- c. In caves with convoluted ceilings the laser lines projected from the baseline may be blocked from the cluster image. The team leader will use the spare tripod and laser platform to match the laser lines with those projected from baseline so they are visible in cluster images.
- d. If the field crew leader rejects the strip the field crew member records one of five rejection codes in the “Sample Code” column (Table 1).

Table 1. Valid reasons for rejecting strip positions during a sampling event and their associated numbered code to be recorded on the field data sheet.

Rejection Code	Rejection Reason
1	Unused-Safety
2	Unused-Unsampleable/Inaccessible
3	Unused-Risk to infrastructure
4	Unused- Risk to resource
5	Sampled-Strip Sampled

- i. Reasons for discarding a strip position include situations where photography may be too difficult to attempt or data obtained are unreliable. For example, the strip may contain cave cricket clusters located too high on ceilings (i.e., code 2). In addition, the field crew leader must always consider the potential

for damage to sensitive cave features, such as speleothems or artifacts, and take all care possible if they are nearby. Therefore, do not compromise the crew's safety or cave features. The field crew leader should remember the mnemonic "If in doubt, throw it out."

- ii. After searching all the strips from the initial GRTS draw, any rejected strips are replaced by selecting, sequentially by Strip ID, a replacement from the oversample list (Figure 2). The assistant also records a "5" in the oversample "Sample Code" cell in the "Strips" table on the appropriate page in addition to the requisite cells the field crew member must fill in (e.g., "Cluster numbers"). If the oversample is rejected follow the same procedure as in step 6c and select the next Strip ID in the oversample sequence. At this point in the sampling event the field crew is at the end of the baseline (i.e., the highest/last strip position from the initial GRTS draw). As necessary, oversample strips needed to replace rejected strips from the initial draw are sampled. On the field data sheet oversample strips are out of sequence with respect to baseline locations (Figure 2). To avoid excessive trampling and disturbance to the cave habitat they are searched sequentially with respect to their, and the field crew's, location on the baseline (i.e., from high to low strip position) as the field crew moves back toward the cave entrance.
7. While the field crew leader shoots image(s) of a specific cave cricket cluster intersected by the strip the field crew member records cluster metadata on a small dry erase board (Figure 6). Cluster metadata include the sampling EventID, the sampling event date, the Strip Position, and Cluster Number of the preceding images. The field crew leader records a digital image of the filled-in dry erase board; this image immediately follows the sequence of cave cricket cluster images to which the metadata on the dry erase board applies (Figure 6). Not only does the image mark the end of the specific cave cricket cluster's image sequence but, critically, connects the data in the image sequence to the metadata on the "Clusters" field data sheet. All of these data are essential for image scoring, database entry and subsequent analysis.

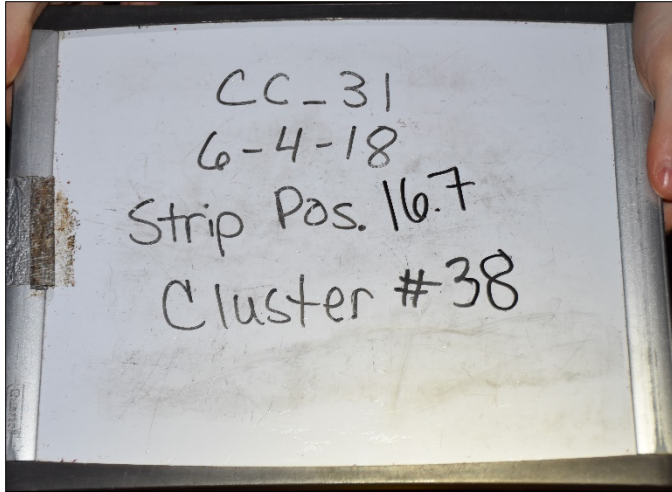


Figure 6. Image of dry erase board with cluster metadata identifying the sequence of cluster images preceding it. These data include (from top to bottom) sampling EventID, sampling date, Strip Position, and Cluster Number. **Note:** the only metadata on the dry erase board changed during an event is the strip position and cluster number.

8. The field crew leader captures images of cave cricket clusters as expeditiously as possible, limits their movement, and avoids shining light directly on the target cluster.
 - a. The field crew leader rotates the camera body and adjusts the zoom. Thus, the larger dimension of the image just includes the largest dimension of the cluster, so the frame is filled with cave crickets to the extent possible. When the image cannot be filled (e.g., distant clusters) flash power is increased or augmented to obtain a properly exposed image of the cluster. Note: the laser line delineating the minimum edge (i.e., the side closest to the entrance) of clusters to the left of the baseline is on the left side of the image whereas for clusters to the right of the baseline it is on the right side of the image.
 - b. The field crew leader always attempts to shoot on a line perpendicular to the plane of the cluster; though sometimes this is not possible due to passage height or sensitive resources. Shooting perpendicular to the plane of the cave cricket cluster avoids depth-of-field issues and minimizes the number of hidden cave crickets. The smallest aperture possible, generally f-8, is used to maximize depth of field to compensate for uneven surfaces of clusters.
 - c. If a cluster is not arrayed in a single plane the field crew leader shoots multiple images, if possible, with each perpendicular to the ceiling or wall of interest and clearly overlapping adjacent shots.
 - d. For large clusters a single image providing both accurate data and coverage of the entire cluster is the best-case scenario. However, if necessary, the field crew leader records multiple, overlapping tiled shots at a longer focal length so that individual

cave crickets can still be counted. The tiled shots should overlap unique ceiling characteristics to show places where images overlap. Every attempt should be made to shoot tiled images from the same spot, by slowly rotating the camera in place, to keep perspective in each image the same. The tiled images are “stitched” together back at the office using image processing software.

- i. When “superclusters” (i.e., clusters that may intersect greater than or equal to 2 strips) are encountered the field crew leader alerts the field assistant to check the next strip position on the field data sheet to determine if it is close enough to intersect with the cluster; typically, this can reliably be estimated by eye. The field assistant may set up the spare tripod and laser assembly at the next strip position, per step 5, to confirm the intersection. If the cluster intersects greater than or equal to 2 strips the photographer will attempt to shoot the image sequence from between the two strip positions and so capture the supercluster in one sequence. If the photographer has to move further up the baseline they again attempt to shoot the second image sequence from one spot by slowly rotating the camera in place.
- ii. For storyboarding superclusters the initial whiteboard must indicate the intersected strip position (Figure 7, left). This alerts the image scorer to look for, optimally, greater than or equal to 2 laser strips in the tiled image or a separate image sequence, with its own whiteboard image (Figure 7, right), of the cave crickets in the subsequent intersected strip position (see CUPN SOP CC04 *Digital Image Scoring in ArcMap—Version 1.3*).

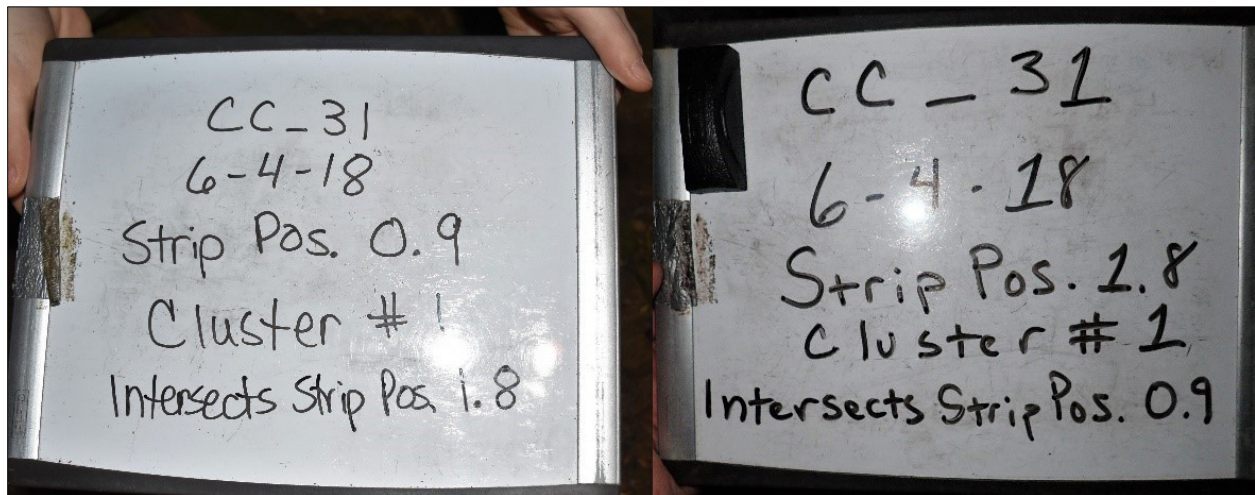


Figure 7. A cluster that intersects more than one strip will have two or more whiteboards associated with its image sequence. The first whiteboard in the image sequence contains an additional fifth line indicating the subsequent strip position with which the cluster intersects (left). The next whiteboard indicates that its image sequence is associated with the previous image sequence (right). Note while cluster numbers are the same the strip positions and the intersection notations are different.

1. For remaining supercluster whiteboards, as necessary, the field crew member changes the Strip Position on the whiteboard to the intersected strip and the intersection information to the previous Strip Position. Since the image sequence(s) capture one continuous cluster, however, the cluster number stays the same (Figure 7).
 2. As necessary, the field crew leader records an image of the whiteboard with the new information for the image sequence of the subsequent intersected strip position.
- e. In the event the cluster intersects greater than or equal to 3 strips, after the photographer captures the image sequence(s) of the first two strips the field assistant “leapfrogs” the first laser platform to the third strip position. The field crew repeats all steps in 8d.
- i. If the field crew leader wishes to capture images of an unusual feature or cave organisms other than cave crickets s/he may:
 - ii. The field crew leader maximizes the depth of field (f-20 or f-22).
 - iii. The field crew leader ensures the ISO setting is 100.
9. The field crew leader uses a reflective object (e.g., aluminum clipboard, or field data sheet) to soften shadows. The reflector is set as close as possible to the feature or organism without including it in the image, nearly on the opposite side of the feature or organism from the flash, and angled so the reflected light will fill in the shadow areas created by the flash. The distance of the cluster’s centroid from the baseline is determined using an electronic rangefinder. The Leica Disto™ E7400x is a self-contained rangefinder whereas the Sonin Combo Pro™ has a transmitter and receiver (Figure 8). For the Sonin Combo Pro™ both units are turned on prior to step “a” below. The switch on the right side of the transmitter is moved to the bottom position which shows a diagram of both the transmitter and receiver. While the following steps are followed regardless of which rangefinder is used the Leica Disto is to be used as the primary range-finding unit.



Figure 8. Rangefinders used to determine cluster distance from the baseline. The Leica Disto™ E7400x (left image) is a self-contained rangefinder. The Sonin Combo Pro™ (right image) rangefinder includes a transmitter (left) and a receiver (right).

- a. Cluster distance is measured holding the unit perpendicular to the baseline and parallel with the edge of the laser strip. The field crew member holds the rangefinder (i.e., either the Leica Disto™ E7400x or the Sonin Combo Pro™ transmitter) level at, but just above, the back edge of the laser platform so that the back of the transmitter lines up with the baseline. Note: if the centroid of the cluster is far outside the strip's boundary the field crew member measures from the location on the baseline where the cluster's centroid is in a line perpendicular from the baseline.
 - i. If using the Leica Disto™ E7400x the field crew leader holds a flat object, on which the laser point can focus, below the cluster's centroid and the same height as the transmitter. If using the Sonin Combo Pro™ receiver the field crew leader holds the receiver below the cluster's centroid at the same height as the transmitter.
 - ii. In the Leica Disto™ E7400x the point from where the rangefinder measures (i.e., from the back of the unit) is set prior to use. For the Sonin Combo Pro™ one of two buttons may be pressed. To determine the cluster's distance from the back of the unit the field crew member presses the large button with the triangle on it; the button is circular and red on the Leica Disto™ E7400x and on the Sonin Combo Pro™ transmitter use the triangle button with the line segment beneath it (Figure 8). The measurement is repeated three times to ensure accuracy; if the results are different the field crew member records the average of all three measurements. The field crew member records the

distance to the nearest centimeter in the “Distance (meters)” cell in the appropriate “Clstr #” row on the “Clusters” field data sheet (Figure 2).

10. The field crew member, facing into the cave, notes on which side of the baseline the cluster is located, i.e., left or right side, and records it in the “Side (L/R)” cell in the appropriate “Clstr #” row on the “Clusters” field data sheet (Figure 2). Note: if the cluster straddles the baseline the side on which the majority of the cluster is roosting is chosen.
11. The field crew leader calls out the total number of cave crickets in the cluster; for small clusters this number should be highly accurate. While accuracy is very likely reduced with increasing cluster size (e.g., greater than or equal to 30 crickets) estimates still serve as a good indicator of cluster size captured in cluster images. For very large clusters both field crew members will estimate the total and the average of the two estimates is recorded. The field crew member records the number of crickets in the cluster in the “Est # crickets” cell in the appropriate “Clstr #” row on the “Clusters” field data sheet (Figure 2).
12. The field crew member records whether the cluster is roosting on the ceiling or wall in the “Loc (C/W)” cell in the appropriate “Clstr #” row on the “Clusters” field data sheet (Figure 2). Note: if the cluster includes the wall and the ceiling the location on which the majority of the cluster is roosting is chosen.

The field crew leader holds the thermohygrometer (e.g., Kestrel® 3000 Weather Meter) at the densest portion (if applicable) of the cave cricket cluster; otherwise, it is held in the centroid of the roosting cluster. The crew leader calls out the values obtained for temperature (°C), relative humidity (% RH), and air flow (m/s) to the field crew member who records them in the “Temp deg,” “RH %,” and “Air (m/s)” cells in the appropriate “Clstr #” row on the “Clusters” field data sheet. If the cluster is too high to safely reach the thermohygrometer may be attached to a telescoping painting pole or PVC pipe with electrical tape. The tape should be wrapped around the bottom of the unit so as not to obscure the unit’s sensors or display. Note: to properly measure air flow at the cluster the thermohygrometer, or the target assembly to which it is attached, must be rotated so the impeller is perpendicular to the direction of airflow.

13. Given cluster proximity to the field crew leader, and no possibility of formation damage exists, the edge of the target ruler is lined up with either the left or right edge of the laser strip and is included in the cluster image (Figure 9). The field crew member records either “L” or “R” in the “Edge (L/R)” cell in the appropriate “Clstr #” row on the appropriate page of the “Clusters” table (Figure 2); “U” is recorded if no target was used.



Figure 9. Cluster image including ruler target assembly. Note thermohygrometer is attached with electrical tape to the PVC pipe.

- a. Once all relevant data are recorded the field crew leader searches for another cluster in the current strip. If the strip intercepts another cave cricket cluster steps 6b. to 13 in “Step-by-Step Instructions” and all data on the “Strips” and “Clusters” field data sheets are recorded (Figure 2). If the strip does not intercept another cave cricket cluster, the field crew performs steps 5 to 14 in “Step-by-Step Instructions” until the last Strip Position from the initial GRTS draw have been sampled. At this point in the sampling event the field crew is at the end of the baseline (i.e., the highest or last strip position from the initial GRTS draw). As necessary, oversample strips needed to replace rejected strips from the initial draw are sampled. On the field data sheet oversample strips are out of sequence with respect to baseline locations (Figure 10). To avoid excessive trampling and disturbance to the cave habitat they are searched **sequentially** with respect to their, and the field crew’s, location on the baseline (i.e., from high to low strip position) as the field crew moves back toward the cave entrance.
 - b. If the field crew runs out of space to write in cluster data on the event specific cluster field data sheets, two extra data sheets are created by the database during the bout generation process (see CUPN SOP#6: Data Management; Helf et al. 2015). These extra cluster field data sheets are contained in the clipboard. they have blanks for “Entrance Name,” “Bout,” “Event_ID” and “Page __ of __” so they can be used at any event. If unused, the blank sheets can be saved for the next sampling event or bout.
14. Prior to pulling up the baseline the field crew leader reviews all field data sheet pages for completeness and legibility, resolves any ambiguities with the data recorder, and initials them.

15. When the work is complete, the field crew exits the cave quickly, and moves cautiously (in a safe manner).
16. The field crew leader secures all cave gates and locks as required.
17. The field crew leader informs the surface watch of the field crew exiting cave ASAP (e.g., via cell phone or radio).
18. The field crew follows all applicable gear decontamination procedures as described in the White-nose Syndrome section of SOP #2: *Pre-Field Sampling* (Helf et al. 2015).

Reviewed by

Cave Cricket Monitoring Protocol - Cumberland Piedmont Network

EventID: CC_48 Entrance: Austin Entrance Bout: Summer2019

Date StartTime StopTime

Crew

Event Notes

Strip Sample Codes:

1. Unused - Safety 3. Unused - Risk to Infrastructure 5. Sampled - Strip Sampled
 2. Unused - Unsampleable/Inaccessible 4. Unused - Risk to Resources

Strip #	Pos. (m)	sample Code	Clusters (seperated by " - ")	Strip Notes
27	0.1			
11	1.0			
15	1.9			
17	2.9			
3	3.5			
20	4.6			
7	5.0			
12	6.4			
24	6.8			
16	8.2			
18	9.6			
4	10.0			
30	11.0			
21	11.6			
8	12.1			
10	13.6			
23	14.1			
26	15.4			
14	16.0			
2	16.7			
29	17.4			
6	17.8			
9	20.3			
22	21.0			
25	21.4			

Page of

Data Entry Updated

Figure 10a. Blank copy of pre-populated field data sheet for cave cricket monitoring protocol.

Cave Cricket Monitoring Protocol - Cumberland Piedmont Network

EventID: CC_48

Entrance: Austin Entrance

Bout: Summer2019

[illegible]Page of

Data Entry Updated

Figure 10b. Blank copy of pre-populated field data sheet for cave cricket monitoring protocol.

Cave Cricket Monitoring Protocol - Cumberland Piedmont Network

[illegible]Page of

Data Entry Updated

Figure 10c. Blank copy of pre-populated field data sheet for cave cricket monitoring protocol.

Data Dictionary for Field Data Sheets

A detailed list of sequential descriptions for the field data sheets (Figures 10a–c) is provided in Tables 2 and 3 below.

Table 2. Strips Field Data Sheet field descriptions for cave cricket monitoring protocol.

Strips Field Data Sheets	Field Description
Reviewed by	Initials of person reviewing the field data sheet for completeness; typically the team leader.
Event ID (pre-populated)	Unique event identifier—event defined as a single visit to a single cave entrance, of form “CC” & unique randomized sequence number generated by cave crickets database.
Entrance (pre-populated)	MACA’s unique cave entrance name being sampled. Example: “Austin Entrance”.
Bout (pre-populated)	Set of cave sampling events, analogous to event group (e.g., Summer2019). Typically, bouts will only occur during Summer and Winter.
Date	Starting date for the event in mm/dd/yyyy format. Example “06/18/2018”.
StartTime	Starting time for the event (i.e., arrival at the cave entrance); recorded in 24-hour clock in hhmm format. Example: “1040”.
StopTime	Ending time for the event (i.e., exit from the cave entrance); recorded in 24-hour clock in hhmm format. Example: “1237”.
Crew	Names of all field crew members participating in a given sampling event; first initial and spelled out last name. The crew leader’s name is circled. Example: “(K)Helf J.Jernigan”.
Event Notes	Any phenomena pertinent to the sampling bout, the data, or the cave’s resources. Example: “Adult woodrat seen”.
Strip # (pre-populated)	Strip sequential order generated during the GRTS draw. Listed out of sequence on the pre-populated data sheet (Figure SOP3a-2). Because more than one cluster may be intersected by a strip this row may contain multiple cluster numbers.
Pos. (m) (pre-populated)	Position (m) is the one-dimensional, discrete position on the baseline to the nearest tenth of a meter where strip is initiated. Strip positions are listed sequentially on the field data sheet and each is given one row. The minimum edge of the strip is projected perpendicular to its position on the baseline and its (parallel) maximum edge is projected 10cm farther down the baseline. Strip positions intersecting more than one cluster will have several Cluster #s associated with their row on the field data sheet. Example of Position: “3.4” (See Figure SOP3a-2).
Sample Code	Numbered code refers to whether strip is rejected or used during the sampling event. Record only one number per strip. 1 = Unused-Safety, 2 = Unused-Unsampleable/Inaccessible, 3 = Unused-Risk to Infrastructure, 4 = Unused-Risk to Resources, 5 Sampled-Strip Sampled.

Strips Field Data Sheets	Field Description
Clusters	Sequential number assigned to each cave cricket cluster detected within a cave entrance during a sampling event. Multiple clusters detected in the same strip are separated by a “-”. Typically, cluster numbers are assigned unique sequential numbers without regard to Strip ID or Strip Position. However, there are a few exceptions: a “0” is recorded in the cluster # column whenever a strip does not intersect any cave cricket clusters. Also, large cave cricket clusters are occasionally intersected by >1 Strip Positions. In this case, the first Strip ID to intersect such a cluster is assigned that cluster’s sequential number in its “Clusters” cell. Subsequent Strip IDs with which the cluster intersects are also assigned that “Clusters” number (Figure SOP3a-2). No other data are recorded in these rows on the “Clusters” table except a Note indicating the initial Strip Position with which it intersected. Example: “Intersects w/ 6.2 (Cluster 9)”.
Strip Notes	Any information pertinent to a specific Strip Position associated with that row.
OverSamples	Strips used sequentially when a strip from the original GRTS draw is rejected.
Page _of_	Number of pages in the field data sheets associated with a specific sampling event. Example “Page 1 of 2”.
Reviewed by	Initials of person reviewing the field data sheet for completeness; typically the team leader.
Event ID (pre-populated)	Unique event identifier—event defined as a single visit to a single cave entrance, of form “CC & unique randomized sequence number generated by cave crickets database.

Table 3. Cluster Field Data Sheet field descriptions for cave cricket monitoring protocol.

Cluster Field Data Sheet	Field Description
Event ID	Unique event identifier—event defined as a single visit to a single cave entrance, of form “CC” & unique randomized sequence number.
Entrance	MACA’s unique cave entrance name being sampled. Example: “Austin Entrance”.
Bout	Set of cave sampling events, analogous to event group (e.g., Summer2019). If a bout spans two months the month the bout started is used.
Clstr #	The sequential number assigned to each cave cricket cluster detected within a cave entrance during a sampling event; taken from the Strips Field Data Sheet.
Extent: cm (Min/Max)	An estimate, in centimeters, of the distance a cave cricket cluster extends from the minimum and maximum laser lines of the strip. Clusters can extend outside or inside either edge of a strip, in which case the field crew leader estimates a positive or negative distance, respectively, and adds it to the strip position. For example, in Figure SOP3a-4 the position of Strip ID 11 on the baseline is at 340 cm and extends to 350 cm. The proximal margin of the second cave cricket cluster with which it intersects, starting at “B”, is five cm inside the strip’s minimum edge. Thus, the strip’s proximal extent is recorded, in the “Min” column, as “5”. Further, the cluster’s maximum margin is 12 cm outside the strip’s maximum edge, so the cluster’s maximum extent is recorded, in the “Max” column, as “12” (See Figure SOP3a-2).
Distnce (meters)	Distance in meters from baseline to a point directly below the cluster centroid measured parallel with the strip and perpendicular to the baseline. Recorded to the nearest centimeter. Example: “1.92”.
Side (L/R)	The side of the baseline, facing into the cave, on which the cave cricket cluster is located. If the cluster straddles the baseline the side on which the majority of the cluster is roosting is chosen. Recorded as “L” for left or “R” for right.
Est # crickets	Total number of crickets within the cluster (either the exact number or, in the case of large clusters, estimated). Used as a reference for image analysis.
Loc (C/W)	Location of the roosting cave cricket cluster recorded as “C” for ceiling or “W” for wall. If the cluster includes the wall and the ceiling the location on which the majority of the cluster is roosting is chosen.
Temp deg	Temperature (°C) at the densest portion (if applicable) of the cave cricket cluster; otherwise, taken at the cluster’s centroid (see SOP #3b: Cave Meteorological Sampling). Recorded to the nearest tenth of a degree. Example: “15.5”.
RH%	Relative humidity at the densest portion (if applicable) of the cave cricket cluster; otherwise, taken at the cluster’s centroid (see SOP #3b: Cave Meteorological Sampling). Recorded to the nearest tenth of a percent. Example: “94.7”.
Air (m/s)	Air flow in meters per second at the densest portion (if applicable) of the cave cricket cluster; otherwise, taken at the cluster’s centroid (see SOP #3b: Cave Meteorological Sampling). Recorded to the nearest thousandth. Example: “0.043”.
Edge (L/R)	If laser lines are not visible in the image this is the edge of the target ruler on which the laser transect was focused.

Cluster Field Data Sheet	Field Description
Cluster Notes	Any information pertinent to the specific Cluster Number associated with that row.
Reviewed by	Initials of field crew leader who reviewed field data sheet for completeness <u>prior</u> to pulling up the baseline tape.
Page _of_	Number of pages in the field data sheets associated with a specific sampling event. Example "Page 1 of 2".
Data Entry	Date on which data from field data sheet were entered into the cave cricket monitoring protocol database.
Updated	Date document was last updated.

Literature Cited

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