

Cumberland Piedmont Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure CC04

Digital Image Scoring in ArcMap —Version 1.3

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Summary

This standard operating procedure (SOP) describes procedures to follow after completion of a sampling event/bout of cave cricket monitoring in Mammoth Cave National Park (MACA). This SOP gives step-by-step instructions that designated personnel follow for: (1) processing field data sheets, (2) downloading, sorting and labeling of cluster image files, (3) performing image scoring to collect data on cave cricket clusters, (4) processing cave and surface meteorological data files, and (5) post-scoring image archiving.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
7/2019	Helf	Revised section on processing field data sheets: scanning, naming convention, and storage. Revised section on disposition of digital images to reflect agreed upon conventions during database development. Added step-by-step sections on use of Bulk Rename Utility app, updated file naming conventions, added one-page flow chart of process, updated image processing section to reflect agreed upon conventions during database development. Updated section on merging shapefiles and converting them to .csv file for import into cave cricket database to reflect agreed upon conventions during database development.		1.1
11/2019	Helf	Updated section on processing cave meteorological data files: renaming and storage to reflect agreed upon standardization between cave bat and cricket protocols. Updated image processing section to reflect agreed upon conventions during database development.		1.2
12/2019	Helf	Updated section on processing cave meteorological data files: renaming and storage to reflect agreed upon standardization between cave bat and cricket protocols.		1.3
3/2020	Helf	Added prose to reflect experience in field with QA on field data sheets. Added prose to reflect planned practical image scoring training improvements/SOP.		1.3

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Overview

This standard operating procedure (SOP) describes procedures to follow after completion of a sampling event/bout of cave cricket monitoring in Mammoth Cave National Park (MACA). This SOP gives step-by-step instructions that designated personnel follow for: (1) processing field data sheets, (2) downloading, sorting and labeling of cluster image files, (3) performing image scoring to collect data on cave cricket clusters, processing cave and surface meteorological data files, and (5) post-scoring image archiving.

Prior to performing cluster image scoring for a cave cricket sampling event/bout all personnel involved will review this SOP, Appendix D, the Guide to Cave Cricket Morphology, of *A Protocol for Monitoring Cave Crickets (*Hadenoeus subterraneus*) at Mammoth Cave National Park* (Helf 2015), undergo practical image scoring training, and be tested on a pre-selected set of cave cricket cluster images. Image scorers should also participate in at least one cave sampling event as part of their training to perform the tasks described herein. Personnel who may serve as image scorers include Cumberland Piedmont Network (CUPN) staff, student interns, and volunteers. Image scoring tasks will be performed under the supervision of the project leader, who is responsible for ensuring that all image scoring and data entry is performed in a timely manner after completion of a sampling bout.

General Sampling Approach

Monitoring of cave cricket entrance populations involves photography of roosting clusters of cave crickets intersecting randomly located transects called “strips.” Scoring of the digital images and the image data entry element, as described in this SOP, will be performed in the CUPN office after completion of all field sampling elements described in SOP CC03a *Strip Adaptive Cluster Sampling—Version 1.1* (CUPN 2020) and SOP 3b: *Cave Meteorological Sampling—Version 1.0* (Helf 2015). Resultant data from scored images will be used to determine estimates of cave cricket entrance populations, their structure, and correlations with cave and surface meteorology.

Logistics

The project leader is responsible for post-field sampling communication and coordination with MACA staff, as well as logistics. At the end of a sampling bout (i.e., group of sampling events—visits to sampled cave entrances) the sampling crew must return keys, vehicle hang tags and borrowed equipment to the MACA Science and Resources Management office. Brief follow-up trip reports are to be completed and submitted to the park’s designated resources management contact within two weeks after each sampling bout.

Transit from Field to Office

- Upon exiting the cave contact the designated surface contact person via cell phone or radio.
- If necessary, use the GPS unit to navigate to the vehicle. Prerecorded GPS tracks are very useful for navigating to and from remote cave entrances.

- Secure any road gates used to access cave entrances.
- Prior to entering the vehicle, follow the latest national guidance (available at the [Whitenose Syndrome Response Team website](#) and stored on the CUPN server) regarding the proper storage of all gear used in the cave or that entered the cave entrance area to reduce the possibility of transmitting *Pseudogymnoascus destructans* fungal spores.

Arrival at Office

1. Sign in field crew at MACA's Science and Resources Management office message board.
2. Remove gear and refuse from field vehicles.
3. Carefully clean and decontaminate gear following the latest national WNS decontamination guidance (see link above or obtain from the CUPN server). Field forms, notebooks, and maps filled out in pencil or permanent ink and printed on Rite-in-the-rain™ paper that were exposed to a cave will be disinfected following current national decontamination protocols.
4. Check for damage to equipment and caving gear, perform required repairs or replacement, and return equipment and gear to the appropriate office or person for proper storage.
5. For NPS staff or volunteers injured in a non-emergency incident during the field trip, Worker's Compensation paperwork must be completed within 48 hours of incident.
6. The field crew leader or crew member should discuss any issues that arose with the monitoring procedures with the project leader.

Processing Field Data Sheets

Upon returning from the field to CUPN headquarters at Mammoth Cave National Park, the data chain of custody is closely controlled so data are not lost during processing. Transferring field data sheets and images to archival CDs can all be accomplished at a later date (see “Archives” in SOP 6 *Data Management—Version 1.0* [Helf 2015]); preferably after both monitoring bouts are finished. These tasks are all performed by the project leader or designated project personnel.

After disinfected field data sheets or maps have thoroughly dried (SOP 5 *Post-Field Sampling: Decontamination of Gear—Version 1.0* [Helf 2015]) they are returned to the project leader where they are retained in a physical file folder labeled with the unique cave entrance location ID, and the month and year of the sampling bout (“<Location_ID> <sampling bout>”). When the project leader confirms all field data sheets are present, manual entry of data recorded on the “Strips” and “Clusters” field data sheets is performed. As part of the data entry and image scoring QA/QC process field data sheets may be annotated to correct errors made in the field. After this process is completed the field data sheets are scanned and saved to folders with unique cave entrance and sampling bout identifiers on the CUPN network server in the following folder structure:

Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Data\Working_Data\Scanned_Field_Forms\<sampling bout>.

Example: Z:\Vital_Signs\...\Working_Data\Scanned_Field_Forms\Summer2019

There are three different field data forms onto which data are recorded during cave cricket monitoring sampling events: “Strips” and “Clusters” field data sheets, and “HOBO RH/Temp Data logger—Site Setup and Maintenance Field Observer Form”; there are at least two of the latter forms per entrance. Baseline Maps may be annotated during field sampling and are scanned or updated as needed. Follow the instructions below for the file naming convention of the two data forms being scanned:

Cave Cricket Monitoring Field Data Sheet

“Strips” and “Clusters” field data sheets from the same event are scanned as a single file. These files are saved utilizing a naming convention similar to that of cluster image files: <Entrance name>_<Event_ID>.pdf. “<Event_ID>” is an identifier which defines the place of a sampling event at a cave entrance in the sequence of all cave entrances sampled during a specific sampling bout.

Example: “Austin_CC_48.pdf”

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

Files of scanned HOBO data forms will be saved utilizing a naming convention similar to that of image files <Entrance name>_<Event_ID>_<HOBO location name>.pdf where the HOBO location name is the unique name assigned to the permanent location where the data logger was initially installed.

Example: “Austin_CC_48_H1.pdf”

Scanning Field Data Forms and Maps Directly to Email Account

All CUPN staff are assigned email buttons under the “Address” tab on CUPN’s Konica-Minolta Printer. Here are the steps that **must** be taken to scan an item and send it directly to both the CUPN data intern’s **and** the project leader’s email addresses. These steps must be followed whether using the scanning feeder or the scanning bed.

- Place the field data form on the scanning bed or in the feeder.
- Press the “Scan” button.
- Select the email buttons of the project leader and the data intern email accounts (more than one may be selected at once) under the “Address” tab.
- Select “Full Color” under the “Color” setting; no other color options will work.
- Under “Scan Settings” select “Compact pdf.”
- The “Resolution” setting is automatically set at 300 dpi and cannot be changed.
- Press “File Name” and use the keypad to rename the file according to this protocol’s naming convention (see above):

- Example: “Austin_CC_48.pdf”
- Press the “Start” button to scan and send the pdf to the desired email address.
- The pdf(s) are received as an attachment to an email from “CUPN_Konnica” (it’s spelled that way in the email). Note: File size should be less than 250 KB. Also, it is important to review the scans to make sure all pages scanned correctly and are legible.
- Download the file and save it in the appropriate folder on the network server.
- Files are saved/copied in a park specific folder on the CUPN network file server at:

Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Data\Working_Data\Scanned_Field_Forms\
<sampling bout>.
- The original hard copy field data sheets are returned to the project leader for storage and eventual archiving.

Processing Digital Images

A single sampling bout will yield many digital images of cave cricket clusters. Each image is stored as a “jpg” image file in the camera’s memory card. At the conclusion of the day’s sampling events the images are stored, for later sorting and labeling, in the sampling event’s “Raw” folder on the CUPN server (Figure 1). After the completion of the sampling bout the project leader (or designated personnel) sorts through the cave cricket cluster images, discarding unsuitable images (e.g., indistinguishable images, images of nothing, etc.), and renames them. The designated image scorer reviews the remaining images, chooses one suitable image within each sequence for scoring, enhances the image (if necessary) and stores them in the “Mod” folder (Figure 1). When all suitable images from the event are renamed the images are scored using ArcMap. The resulting shapefiles are merged into a single shapefile on a new .mxd file and saved in the “Merged” folder. The data from the modified images are later imported into the cave cricket monitoring database as described in *SOP 6 Data Management—Version 1.0* (Helf 2015). The folders and the images contained therein are later copied onto archival CDs. Downloading, sorting, labeling, and storing of images onto archival CDs is performed by a designated project team member.

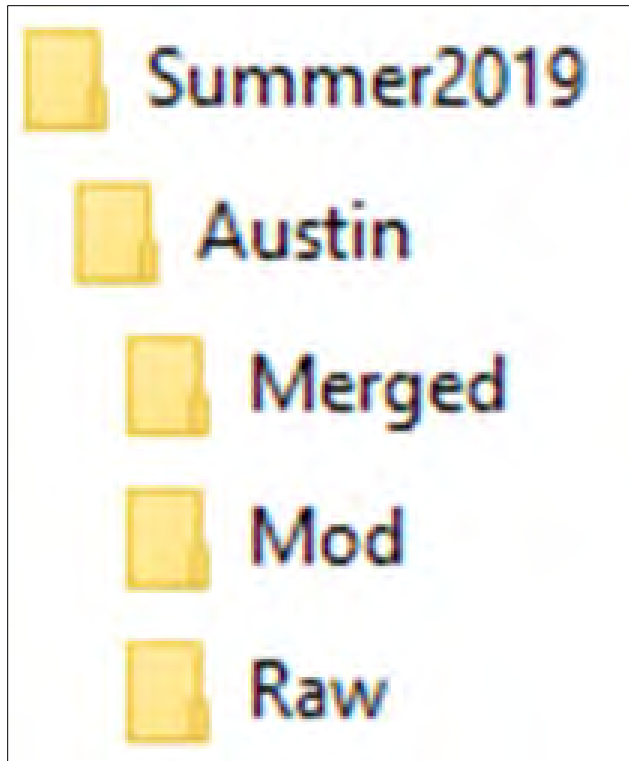


Figure 1. Images of cave cricket clusters from monitoring events are stored in monitoring bout folders. Each sampling bout (e.g., Summer2019) folder contains four folders: one folder for each entrance containing a “Raw” folder into which all unprocessed cave cricket images are uploaded from the camera’s memory card, a “Mod” folder in which renamed and modified images ready for scoring are stored, and a “Merged” folder containing the .mxd file where all shapefiles from an event (e.g., CC_48) have been merged into one shapefile.

Prior to Downloading Images from the Memory Card

1. The designated computer needs an available secure digital (SD) card slot or a USB port and adapter with an SD card slot. Uploading of image files from the camera’s memory card is performed by inserting the memory card into the computer’s SD card slot.
2. The computer on which image scoring will be performed must be connected to the MACA local area network (LAN) to provide for image transfer to the CUPN server via the LAN.

Upload the Image Files from the Camera to the Appropriate Image Folder on the CUPN Drive

Image transfer can take a substantial amount of time and it is best performed as soon as the project leader arrives at the office. The SD card from the digital camera is removed and plugged into the SD card slot on the project leader’s computer. The “Computer” window is opened and the “SD Disk” icon double clicked to access the cave cricket cluster images. In a separate window, the “Raw” folder with the appropriate cave entrance name into which the images will be dragged and dropped (Figure 1) is accessed via the following folder structure:

Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Images\<Location_ID>\<sampling bout>\Raw. A

window with the title “Copying...” opens automatically; indicating the image files are being transferred from the SD card to the folder. A bar graph and time remaining clock indicates the progress of the image transfer. Once all the images are transferred the “Copying...” window will automatically close. When the process is finished the number of images in the cave entrance folder window is compared to that of the “SD Disk” folder to ensure the integrity of the transfer. In addition, several of the transferred photos in the cave entrance folder window are randomly examined to ensure the images were not corrupted during transfer. The images are stored as “.jpg” files with annotation for date, time, and exposure parameters automatically provided by the camera. Once all raw images have been transferred the images on the SD card are to be deleted. **Even if the memory card has a large amount of space it is best to delete the images each day to avoid later confusion and/or having to pause during field work to delete old images in order to free space on the memory card.**

Performing Image Scoring

Renaming image files using Bulk Rename Utility (BRU) application Prior to Image Scoring

Sorting and renaming of cave cricket cluster images is performed by the project leader (or personnel designated by the project leader) using the open source application BRU:

Step-by-Step Instructions

1. Open the BRU application.
2. In the upper left hand window, select the folder containing the files you wish to rename. Files will appear in the box to the right (Figure 2).

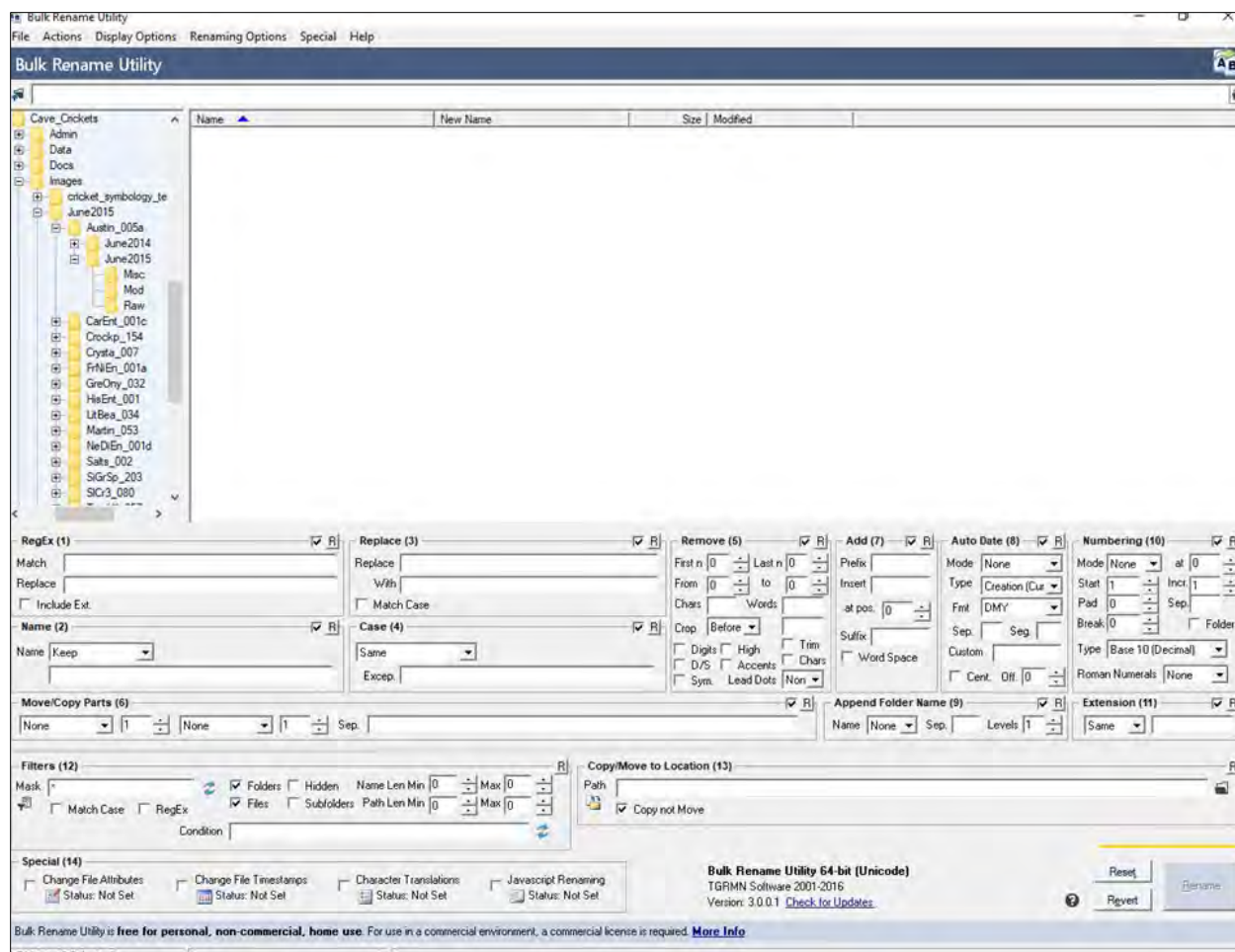


Figure 2. Opening screen of the BRU. Note the “Rename” button is disabled.

1. There are four simple rules to follow in this application:
 - a. Only complete the boxes you need: “Remove (5),” “Add (7),” and “Numbering (10).” For example, don’t assume you have to put something in the Regular Expressions box, or the New Location box.
 - b. You have to select files to rename from the file list before the “Rename” button is enabled (Figure 3, bottom right).
 - c. The “New Name” column will always be shown in the list, so you can experiment until you get the desired result before actually committing the changes (Figure 3).

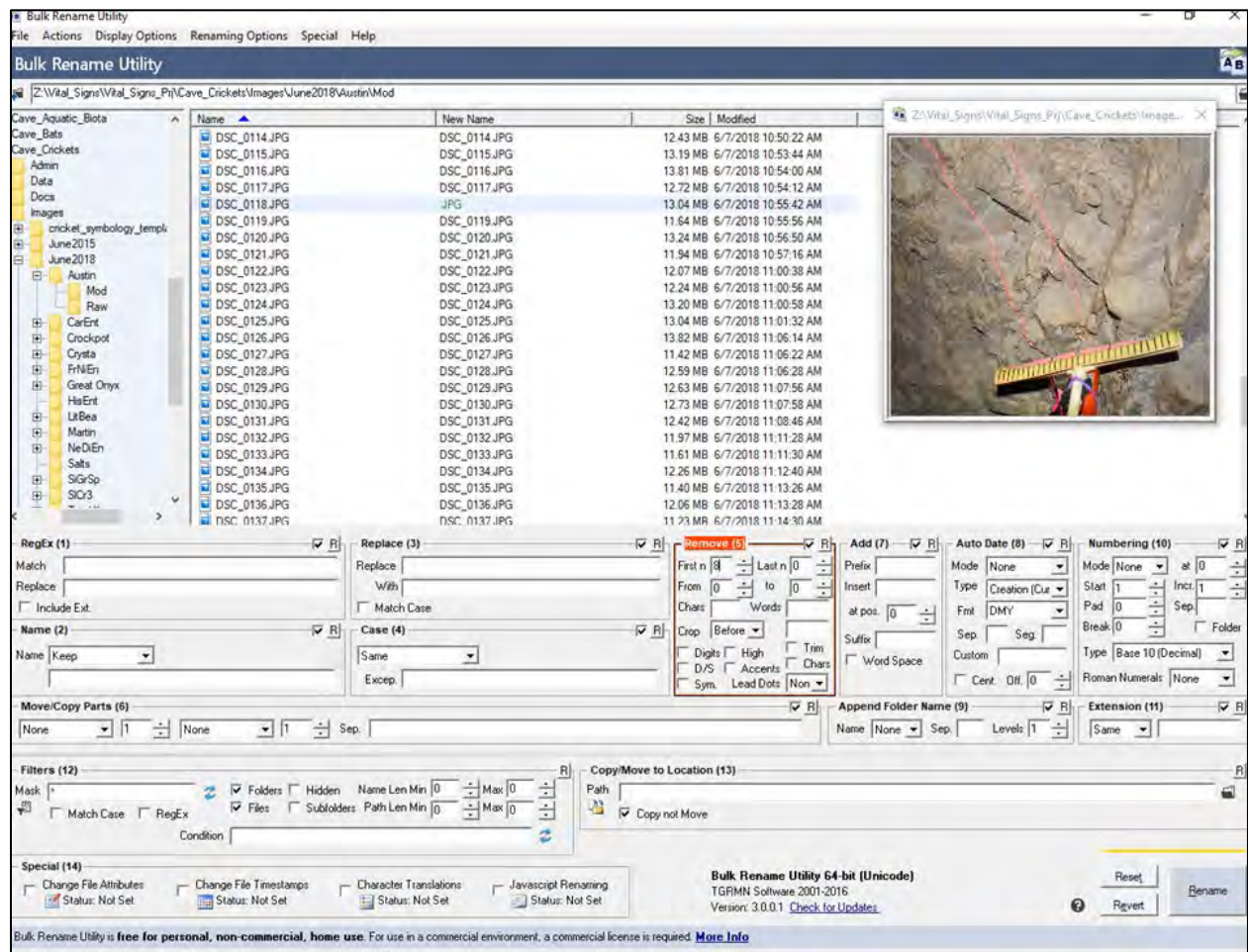


Figure 3. Screenshot of the BrU window showing the removal of 8 characters, in the “New Name” column, from the file name selected in blue. Note the “Rename” button is now enabled.

2. Almost all the boxes on the screen only affect the file name, not the extension. The only box which affects the extension is box 11.
3. Select the file(s) to be renamed. If renaming multiple files (see “Renaming images” below), use CTRL or SHIFT to select multiple files. Image files can be scrolled through using the arrow keys. **Note:** in the upper menu bar under “Display Options” and “List,” you may click “Display Picture Viewer” (or type “Ctrl + W”), which will show the image that is currently selected in the file list. This option can only display one image at a time. Alternately, you can double-click on a photo in the file list to open a full-screen image in Windows photo viewer (Figure 3).
4. Remove the old file name using the Remove (5) function. Remove the first (n) digits; n = however many digits the original name contained (for example, DSC_0118.JPG contains 8 digits before the extension, so you will remove 8 digits from the file name). Notice that in the upper window the “New Name” of the file is now blank except for the extension (Figure 3).

Renaming images

1. Add the event ID using the Add (7) function. For event <CC_35>, you will type “CC_35_” into the “Prefix” box (Figure 4).

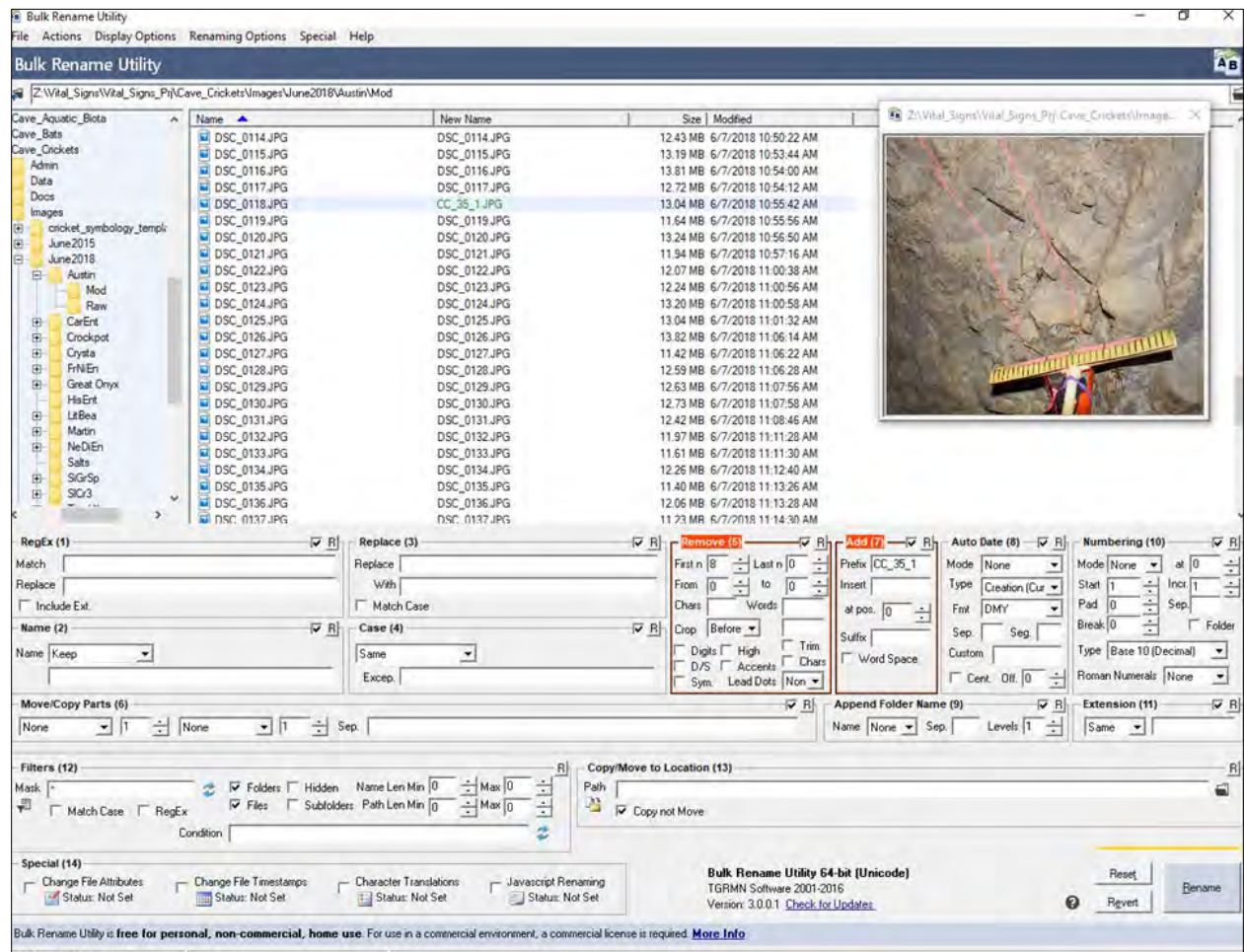


Figure 4. Using the “Add (7)” function to insert the event ID (CC_35_1) into the new file name.

- a. For clusters with only **one** image:

- i. Add the event ID and the cluster number using the “Add (7)” function. For event <CC_35> cluster number <1>, you would type “CC_35_1” into the Prefix” box (Figure 4).
- ii. Check the “New name” column in the upper window to make sure the new file names are correct.
- iii. When you are satisfied with the new name given to the file, click “Rename.” A pop-up window will appear asking if you are sure you want to rename the files (Figure 5). Click “OK.” If you misnamed a file, it is always possible to undo the mistake. Click “Undo Rename” in the “Actions” drop down menu or “Ctrl + Z.”

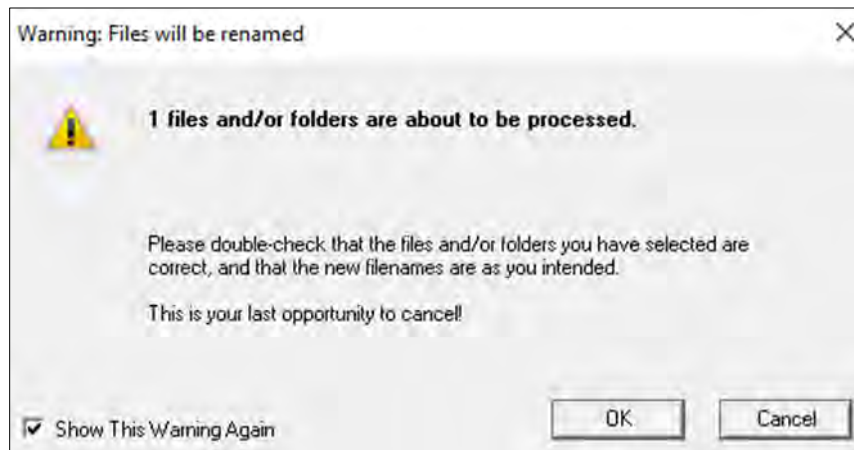


Figure 5. Warning message appears when you click “Rename.”

- iv. New file names will now appear in the “Name” column in the upper window, and in the folder that contains the files. Notice that the functions you used in this query remain selected, so if you select a new file from the list it automatically applies the rules you used previously which facilitates renaming of the following cluster and you only need to change the cluster number.
- b. For clusters with **multiple** images:
- i. Use the arrow key to scroll through images to see if the next cluster uses multiple images associated with the cluster.
 - ii. Add the event ID and the cluster number using the “Add (7)” function. For event <CC_35> cluster number <8>, you would type “CC_35_8” into the “Prefix” box.
 - iii. Use the Numbering (10) function to label each photo with a different letter (for example, if cluster 35 has 4 photos, they should be labeled CC_35_8a, CC_35_8b, CC_35_8c, and CC_35_8d). Choose mode “suffix”, start “1,” and Type “a-z” (or click from bottom of the drop-down list; Figure 6).
 - iv. **Important:** Be sure to examine the image of the whiteboard at the end of the sequence to determine if the cluster intersected more than one strip (Figure SOP3a-7). If this is the case add suffix “_Intersect” in the Add (7) function. For example, CC_35_8_Intersecta, CC_35_8_Intersectb, CC_35_8_Intersectc.
 - v. Large clusters that do not intersect more than one strip may require multiple, overlapping images to capture. If there are multiple overlapping images of a cluster and the whiteboard does not indicate a cluster intersects more than one strip the images are renamed as in step 1.b.iii above. These cluster images are stitched together by the PI using special software.

- vi. Check the “New name” column in the upper window to make sure the new file names are correct.
- vii. When you are satisfied with the new names given to files, click “Rename.” A warning window will pop up asking if you are sure you want to rename the files (Figure 6). Click “OK.” If you misnamed a file, it is always possible to undo the mistake. Click “Undo Rename” in the “Actions” drop down menu or “Ctrl + Z.”

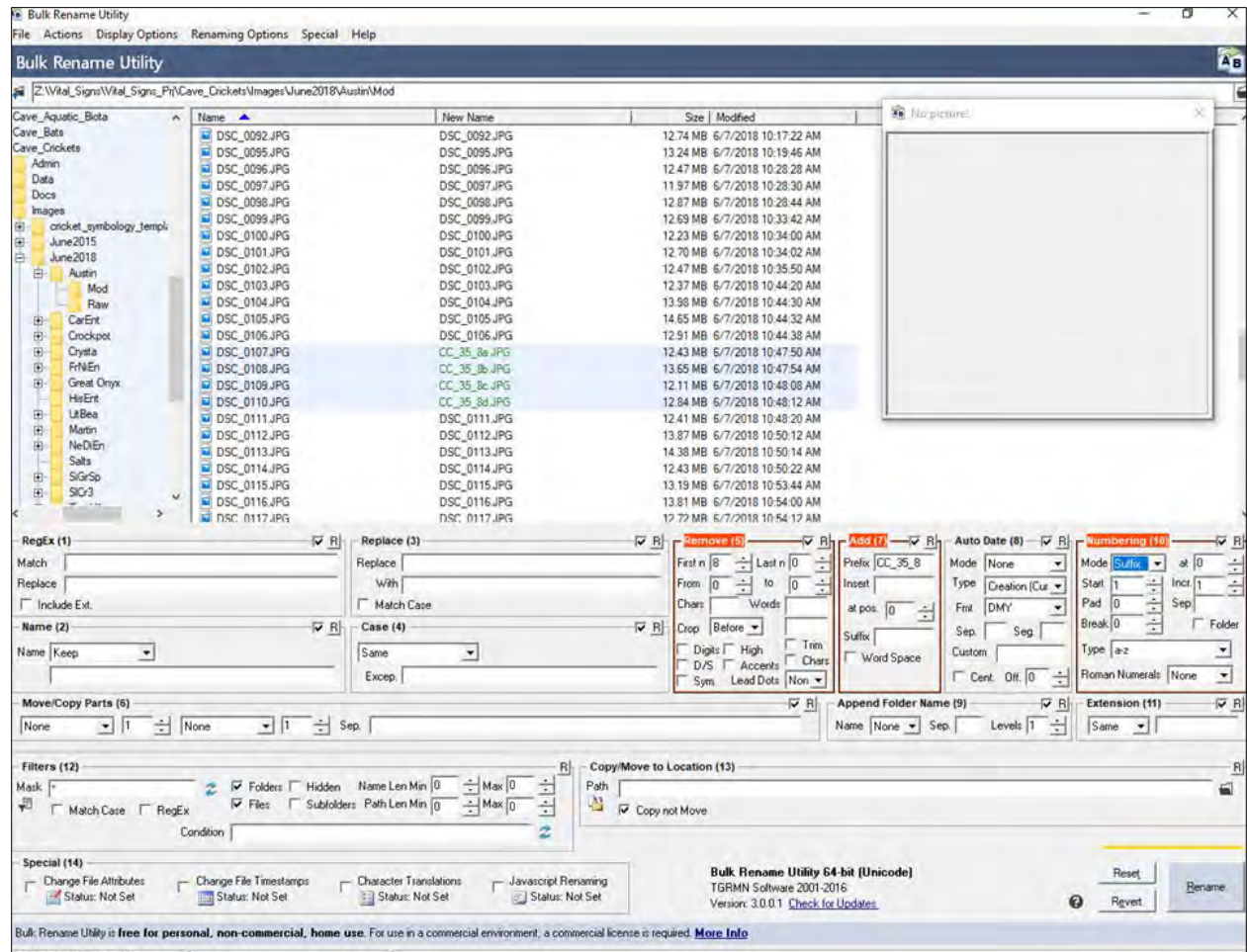


Figure 6. Using the numbering function with mode “suffix” to add the cluster number to the end of the new file name (starting with cluster number 8 in this case).

- viii. New file names will now appear in the “Name” column in the upper window, and in the folder that contains the files. Notice that the functions you used in this query remain selected, so if you select a new file from the list it automatically applies the rules you used previously. You can tweak your entries in the function boxes as needed to prepare the correct names/numbers for the next set of files.
- c. Figure 7 is a convenient flow chart synopsis of the renaming process for images and shapefiles.

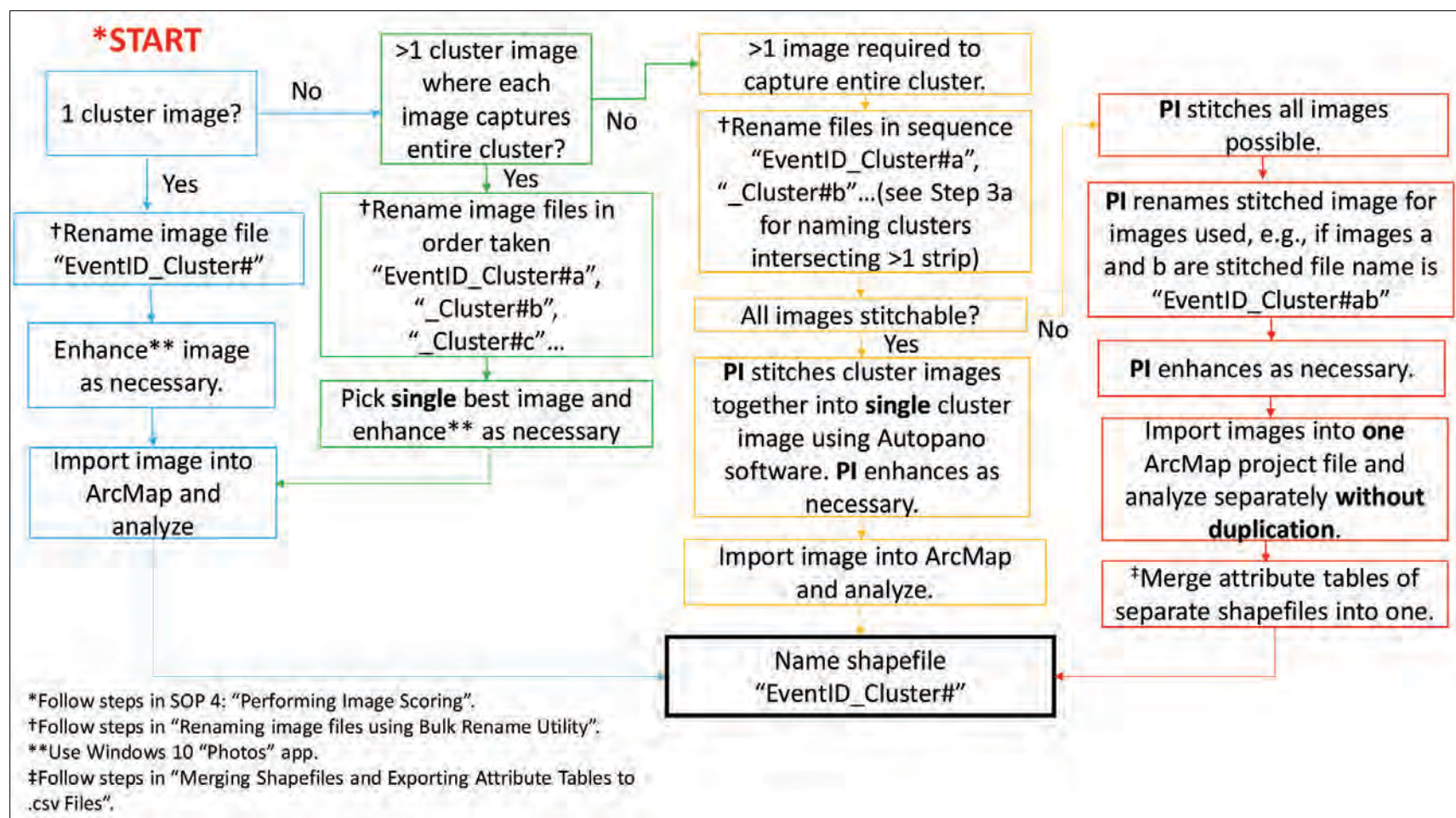


Figure 7. Flow chart depicting the renaming process for images and shapefiles. Note PI performs image enhancement for stitched images.

- d. **Images of other cave organisms, formations, personnel, etc. are renamed with appropriate content information (e.g., CC_35_Stalactite).** The PI reviews these photos to ascertain their value, processes appropriately, and stores them in an appropriate folder on the park photo drive.

Image Enhancement Prior to Image Scoring

1. The computer being used for image scoring must have an image editor application (e.g., Windows Photos) that permits the adjustment of contrast and brightness of an image to help distinguish among cave cricket life stages. While most image enhancement can be performed by the project leader, or personnel designated by the project leader, cluster image sequences with multiple overlapping images require special software. Stitching these images together, and subsequent enhancement of the final, stitched image, is only performed by the project leader (Figure 7).
2. As necessary, image enhancement can be performed using the “Edit & Create” pull-down menu in the Windows “Photos” Viewer, including image enhancement.
 - a. Click “Edit” in the pull-down menu.
 - b. Click “Adjustments.”
 - c. Adjust “Light,” “Color,” and “Clarity” with slide bars as necessary.
 - i. Light is best used to brighten dark images and increase the visibility of the laser strips.
 - ii. Color is used to increase the visibility of the laser strips.
 - iii. Clarity is best used to increase the sharpness of blurred animals but can reduce image brightness.
 - d. Click “Save” and be sure the enhanced image is saved to the proper “Mod” folder.
3. ArcMap can also perform any basic functions of image enhancement needed (e.g., alter contrast, brightness, image inversion).

Image scoring can be effectively performed by any trained project and program personnel. Image scoring is an easily learned skill that is developed by practicing using sample images under the guidance of the project leader. Primary skills needed include: recognition of the cricket genera (i.e., *Hadenoeus* and *Ceuthophilus*) recognition of secondary sexual characteristics of adults, and recognition of individual *Hadenoeus* life stages. Reference standards and materials, such as images showing morphological differences between genera, secondary sexual characteristics of subadult/adult *Hadenoeus*, and features that help distinguish among life stages, are provided in Appendix D *Guide to Cave Cricket Morphology* in the CUPN Cave Cricket monitoring protocol (Helf et al. 2015). Prior to performing cluster image scoring for a cave cricket sampling event/bout all personnel involved will review this SOP, Appendix D, undergo practical image scoring training, and be tested on a pre-selected set of cave cricket cluster images.

The computer being used for image scoring must also have ArcMap so that all cave cricket demographic data may be automatically obtained. ArcMap 10.1 was used to create the shapefile images and layers at the time this section of the SOP was written.

In general, all tasks involved in image scoring for a single monitoring event are performed by a single individual. If experienced personnel are available image scoring can begin as soon as image files from a monitored cave are available and need not wait until the sampling bout is finished. The following steps provide a chronological sequence of the major components of the general image scoring process: examine and choose the best image(s), open images in ArcMap, score images for cave cricket cluster and strip data, and save marked images for export into the database and archiving. Manual entry of event metadata, “strip”, and “cluster” data from field sheets into the cave cricket database is covered in SOP 6 *Data Analysis—Version 1.0* (Helf 2015).

Step-by-Step Instructions

1. **Image scoring is best accomplished with copies of the specific event’s “strip” and “cluster” field data sheets available for reference.**
2. **Cluster image sequences are best viewed as “Extra Large Icons” in their respective “Raw” folders.** Viewing the sequence this way makes it easier to compare among multiple cluster images and choose the image wherein all or most cave crickets are clearly distinguishable.
3. **There will be at least one image, more likely several, for a given cluster but, ideally, only one image is scored.** The scorer selects the image that provides the best data (i.e., a clear view of all individuals in a cluster). Clusters intersecting more than one strip, possibly requiring tiled/stitched images, may have multiple images associated with the cluster’s .mxd file (see step 17).
4. **The scorer copies the image(s) they determined to be best for scoring to the “Mod” folder (Figure SOP4-1) at:**
Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Images\<Location_ID>\<sampling bout>\Mod.

These will be the images subsequently scored in ArcMap. Steps 1–4 are repeated until all images from a cave’s sampling event are renamed and the best image(s) for each cluster captured during that cave entrance’s sampling event are transferred to the “Mod” folder.

5. **The scorer opens ArcMap, selects “File”, “New”, and “Blank Map”, clicks on the “Add Data” button and the “Connect to Folder” button.** The scorer connects to the “...\<Location_ID>\<sampling bout>\Mod” folder (see Step 4): this is the folder from which modified image files are selected, processed into shapefiles, and the folder in which they are subsequently saved.
6. **The first image from the cave sampling event being scored is selected.**
 - a. The scorer clicks on the “Add Data” button, clicks on the appropriate cave sampling bout “Mod” folder containing the jpeg files, selects the desired cluster image from among the others to be scored, and clicks the “Add” button once.

- b. A window opens requesting to create pyramids for the image file and the scorer checks the “Use my choice and do not show this dialog in the future” box and clicks “Yes.”
- c. If a window referring to an “Unknown Spatial Reference” opens the scorer clicks the “Don’t warn me again ever” box and “OK.”
- d. The cluster’s jpeg file is now visible, displayed in ArcMap’s Table of Contents (TOC) pane on the left. The ArcMap or “.mxd” project file is given the appropriate file name, based on the image’s file name “Event_ID_Cluster Number” (e.g., “CC_40_10”), and is saved in the appropriate cave sampling bout “Mod” folder (Figure 1 and 8). This “.mxd” project file is where all data associated with individual images of cave cricket clusters recorded at a cave entrance’s sampling event, along with the shapefiles and template layers subsequently created from them, will be stored.

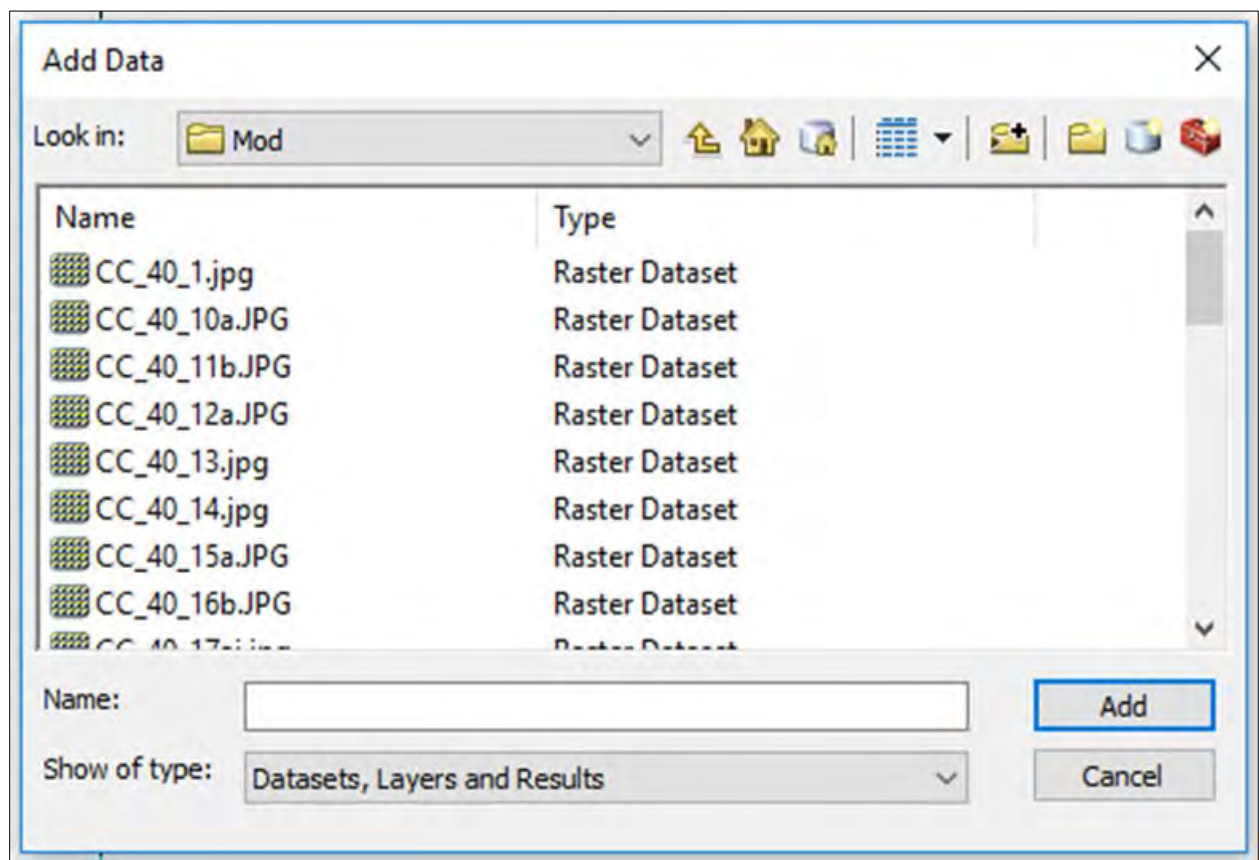


Figure 8. Connecting to the “Mod” folder from which jpeg files (i.e., Raster Dataset) will be selected for processing in ArcMap. The “Mod” folder is also where the “.mxd” project files containing the processed jpegs, and the subsequent shapefiles and layers associated with them, will be saved.

7. The scorer clicks on the “Add Data” button and adds the pre-made “Cricket_Symbology_Template_2018.lyr” file to the “.mxd” project file.

- a. The file is located in the “cricket_symbology_template” folder at:
Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Images\cricket_symbology_template.

- b. Once the layer is added to the “.mxd” project file it will appear in the TOC and the appropriate symbology will appear in the data view.

8. A new shapefile must be created by right clicking on the newly added “cricket_symbology_template.lyr”, going to “Data”, and “Export Data”.

- a. The scorer clicks the folder icon on the lower right of the “Export Data” pop-up window, navigates to the appropriate “Mod” folder for the cave sampling bout where the shapefile needs to be saved, names the shapefile to match the cluster number not the image number, e.g., CC_40_10, clicks “Save,” and clicks “OK.”
- b. The scorer clicks “Yes” when a pop-up window appears asking the question “Do you want to add the exported data to the map as a layer?”
- c. Once added, the newly added layer appears at the top of the TOC above the layer template (Figure 9).

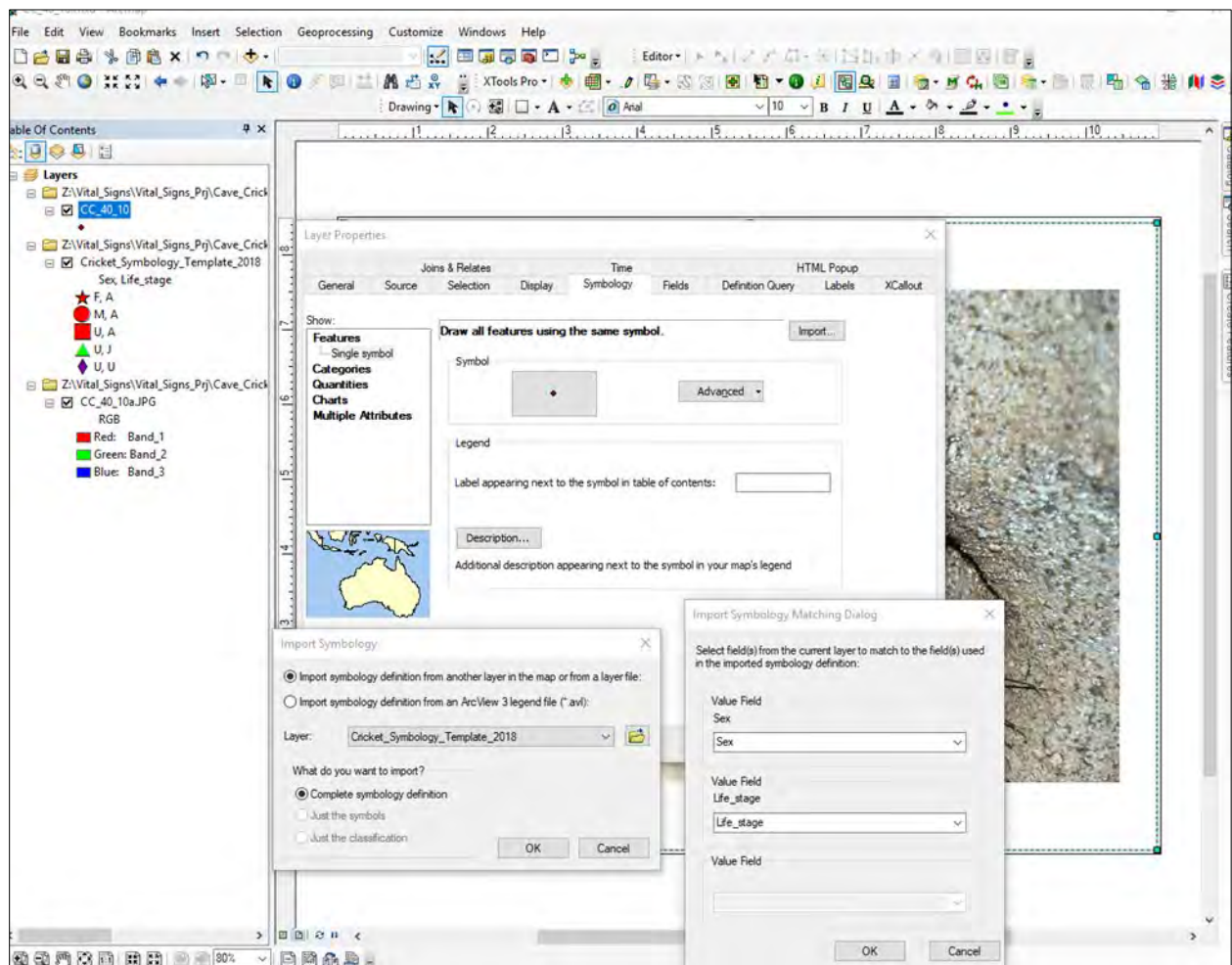


Figure 9. Importing the template's symbology to the newly created shapefile. At this point, all the elements necessary for image scoring have been added to the .mxd file's TOC on the left. Note the difference between the name of the .jpg file (i.e., CC_40_10a) and the shapefile which will contain the cluster data (i.e., CC_40_10).

9. The scorer imports the template's symbology to the shapefile just created.

- a. The scorer right clicks on the newly added layer, and left clicks on "Properties."
- b. The "Layer Properties" dialog box appears. The scorer clicks on the "Symbology" tab, clicks on the "Import" button at the top right of the "Symbology" tab, and clicks "Import."
- c. The "Import Symbology" pop-up window appears. The "Import symbology definition from another layer in the map or from a layer file" button and the "Complete symbology definition" button are both highlighted. The "Layer" pull down menu shows "cricket_symbology_template." The scorer clicks "OK."
- d. When the "Import Symbology Matching Dialogue" box appears the two "Value Fields" should be listed as "Sex" and "Life_Stage." The scorer clicks "OK."
- e. The scorer observes the "Layer Properties" now resemble the "cricket_symbology_template" from which they were created and clicks "OK."

10. The scorer begins editing the newly created layer.

- a. The scorer clicks on the "Editor" toolbar, selects "Start Editing" from the drop-down menu, selects the name of the current shapefile being edited in the "Start Editing" pop-up window, and clicks "OK" (Figure 10).

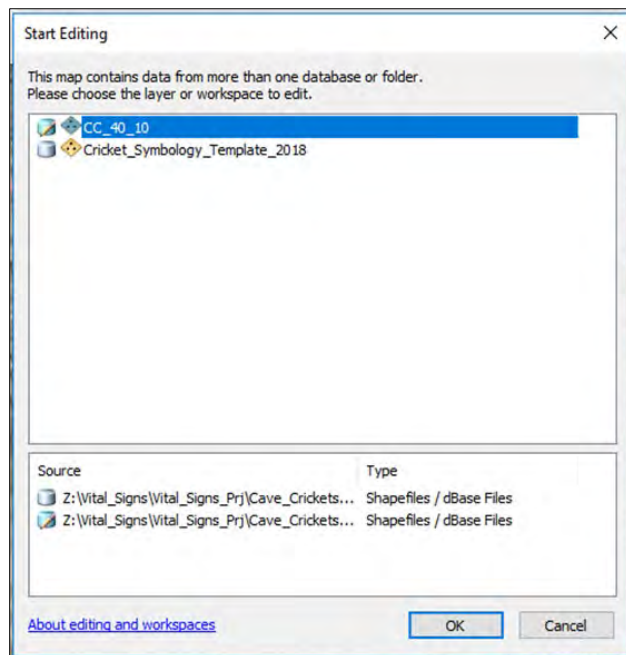


Figure 10. The "Start Editing" pop-up window where the current shapefile is selected.

11. The scorer begins adding data to the attribute table by clicking on the "Create Features" tab in the "Editor" toolbar on the right hand margin of the screen (Figure 11).

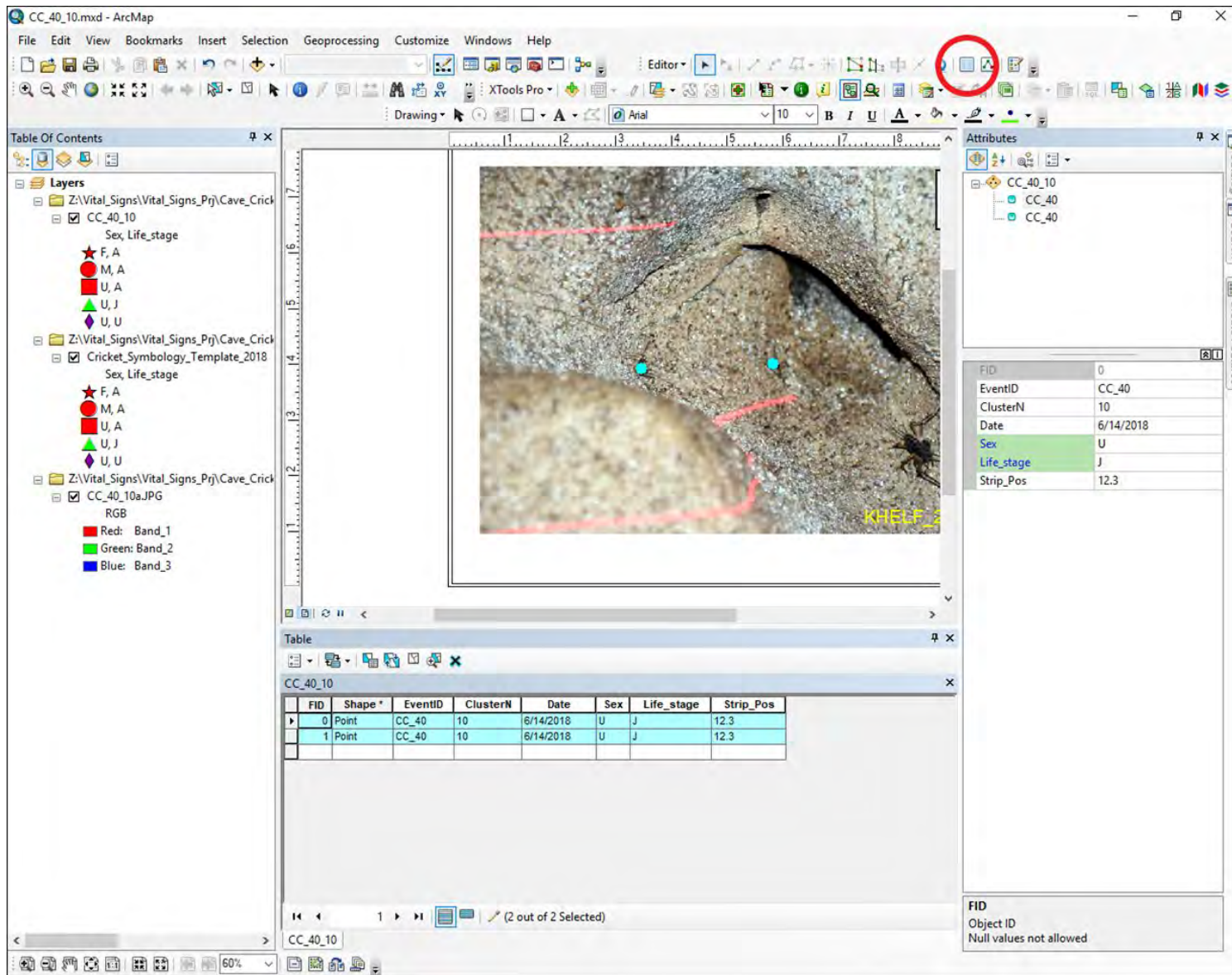


Figure 11. Image scoring on a newly created layer. When using the symbology in the “Create Features” tab to stamp individual crickets the “Sex” and “Life Stage” columns are automatically populated in the attribute table (bottom); “EventID”, “ClusterN”, “Date”, and “Strip_Pos” are added manually, in batches of selected individuals, by clicking the “Attributes” button in the editor toolbar (circled in red).

- a. A pop-up window appears with the symbology template for cave cricket life stage and sex.
- b. To add the window to the right-hand margin of the screen the scorer clicks on the pushpin icon in the window's top right-hand toolbar.
- c. Once the image is open the scorer uses the toolbar "zoom" and "invert" features to look at cave crickets as needed. The "invert" feature, accessed by clicking "Invert" in the "Symbology" tab in the image's "Properties," temporarily changes the color of the image, which may help reveal smaller and less "contrasting" individuals or sexual characteristics, such as the presence of an ovipositor (Figure 12).
- d. Though image enhancement is performed during the renaming process the scorer alters the image using any automatic enhance features, as necessary. This may be useful for better image scoring. The scorer may adjust contrast and brightness of the image.
- e. One suggestion for efficiently scoring images is to systematically "stamp" all individuals in one life stage and sex combination with their symbology combination. The scorer clicks the symbol in the "Create Features" pop-up window to select the appropriate life stage and sex combination for which the image will be stamped; this is done systematically from left to right. The symbology adopted for this protocol uses red for adults and green for juveniles. Sexes are distinguished by the following shapes: stars for female cave crickets, circles for males, and squares for adult cave crickets of indeterminate sex. For example, the scorer, intending to start with adult female cave crickets, clicks on the red star in the "Create Features" pop-up window, zooms in on a section of the image, scrolls through in either vertical or horizontal "slices" of the image while looking for adult female cave crickets, and clicks each to "stamp" them with a red star. The mouse wheel is used to zoom in and out to examine individuals for secondary sexual characteristics. The image is scored for the next life stage and sex combination by mousing over the "Create Features" pop-up window with the symbology template and clicking on the appropriate symbol (e.g., red circle for adult males). Distinguishing among sexes and life stage (and between genera) is a learned skill and is taught by experienced scorers and referencing the "Guide to Cave Cricket Morphology" in Appendix D in the Cave Cricket monitoring protocol (Helf 2015). Alternatively, the scorer may stamp all individuals of both sexes and life stages in the slice of the image they are searching.



Figure 12. The ‘Invert’ feature in photoprocessing software is useful for confirming sex when a cave cricket’s secondary sexual characteristics are in doubt (left). Note the ovipositor on this female is clearly visible when the image is inverted (right).

12. After all crickets in the image are stamped the scorer reviews the entire image once more to ensure all individuals were found and stamped. As necessary, missed individuals are stamped with the correct symbology.

13. The scorer fills in the remaining fields in the attribute table in the following order: “EventID,” “ClusterN,” “Date,” and “Strip_Pos” (Figure 11).

- a. These fields should be populated in batches by clicking the “Attributes” button in the Editor toolbar, clicking the single arrowhead in the Editor toolbar, and selecting all stamped individuals. The fields “EventID,” “ClusterN,” and “Date” may be populated in batches for all crickets in the cluster.
- b. The “Strip_Pos” fields are populated in separate batches:
 - i. Individuals inside the strip’s laser lines are assigned the strip’s position number (e.g., 12.3) in the “Pos. (m)” column on the “Strips” field data sheet associated with their cluster number (Figures 10a–c in *SOP CC03a Strip Adaptive Cluster Sampling-Version 1.1* [CUPN 2020] and Figure 11).
 - ii. Individuals outside the strip’s laser lines are assigned the number “-1.”

14. When finished, the scorer saves the edits by clicking “Stop Editing.” A window appears asking if the scorer wants to save edits and, if satisfied, the scorer clicks “Yes.”

15. The scorer determines the total number of stamped cave crickets in the shapefile image.

- a. The scorer accesses the “Layer Properties” by right clicking on the shapefile in the TOC and selecting “Properties.” The “Symbology” tab needs to be selected to access the appropriate field (Figure 13).

- b. The scorer clicks the “Count” column header to access a total of all sexes and life stages in the shapefile image. The total number of cave crickets stamped on the shapefile image appears at the end of each “Symbol” row for sex and life stage (Figure 13). Each individual layer’s symbols, such as adult female cave crickets, are tallied automatically. The total “Count” is cross-checked with the filled-in “Total Crickets” cell on the “Clusters” field data sheet associated with the appropriate cluster number. If they are different the count from the scored image takes precedence. **Note:** These data illustrate the excellent quality control inherent in this process versus the potential for human error in a manual count of cave crickets in situ.
- c. The scorer clicks the “Save” icon on the top menu bar after analyzing each shapefile image in the “.mxd” project file.

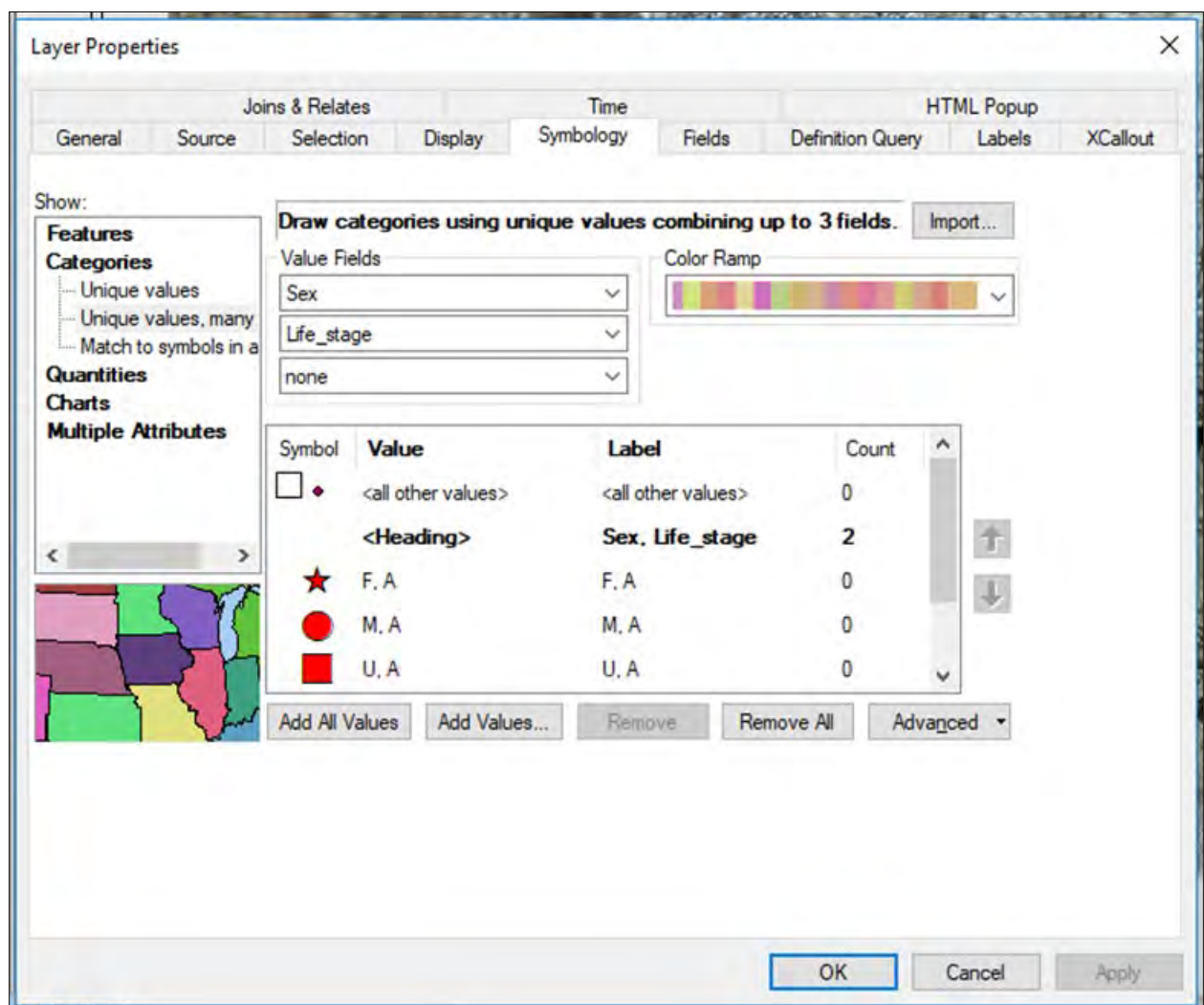


Figure 13. Layer Properties window with totals and symbology for each category of cave cricket stamped on the shapefile image.

16. The scorer creates a .pdf to save the scored shapefile image in an archivable form requiring less storage space.

- a. The scorer clicks on the “Layout View” tab on the bottom left hand side of the screen, turns on the “Layout View” toolbar by right clicking anywhere in the top toolbar, selects “Layout” in the drop-down list, and the “Layout View” toolbar appears on the top or bottom of the screen. The “Layer” toolbar is dragged to a preferred location using the mouse.
- b. As necessary, the scorer changes the orientation of the image by clicking the “Change Layout” button in the “Layout View” toolbar, clicking the “North American (ANSI) Page Sizes” tab, and choosing either “Letter (ANSI A) Landscape.mxd” or “Letter (ANSI A) Portrait.mxd.”
- c. To automatically populate the legend for the image file the scorer clicks on the “Insert” drop-down menu, and clicks “Legend.”
 - i. When the “Legend” wizard pop-up window appears, N items (i.e., the number of items the scorer has open) will populate the “Legend Items” on the right-hand side of the window. The scorer highlights (e.g., Ctrl + click) all items in the “Legend Items” box on the right with which they are currently not working (Figure 14), moves them to the “Map Layers” box on the left by clicking the single, left-pointing arrow, and then clicks “Next.” Note: If the scorer keeps the current image with which they are working at the top of the TOC it will appear at the top of the list in the “Legend Items” box. Then the scorer selects all items below it and moves them to the “Map Layers” box.

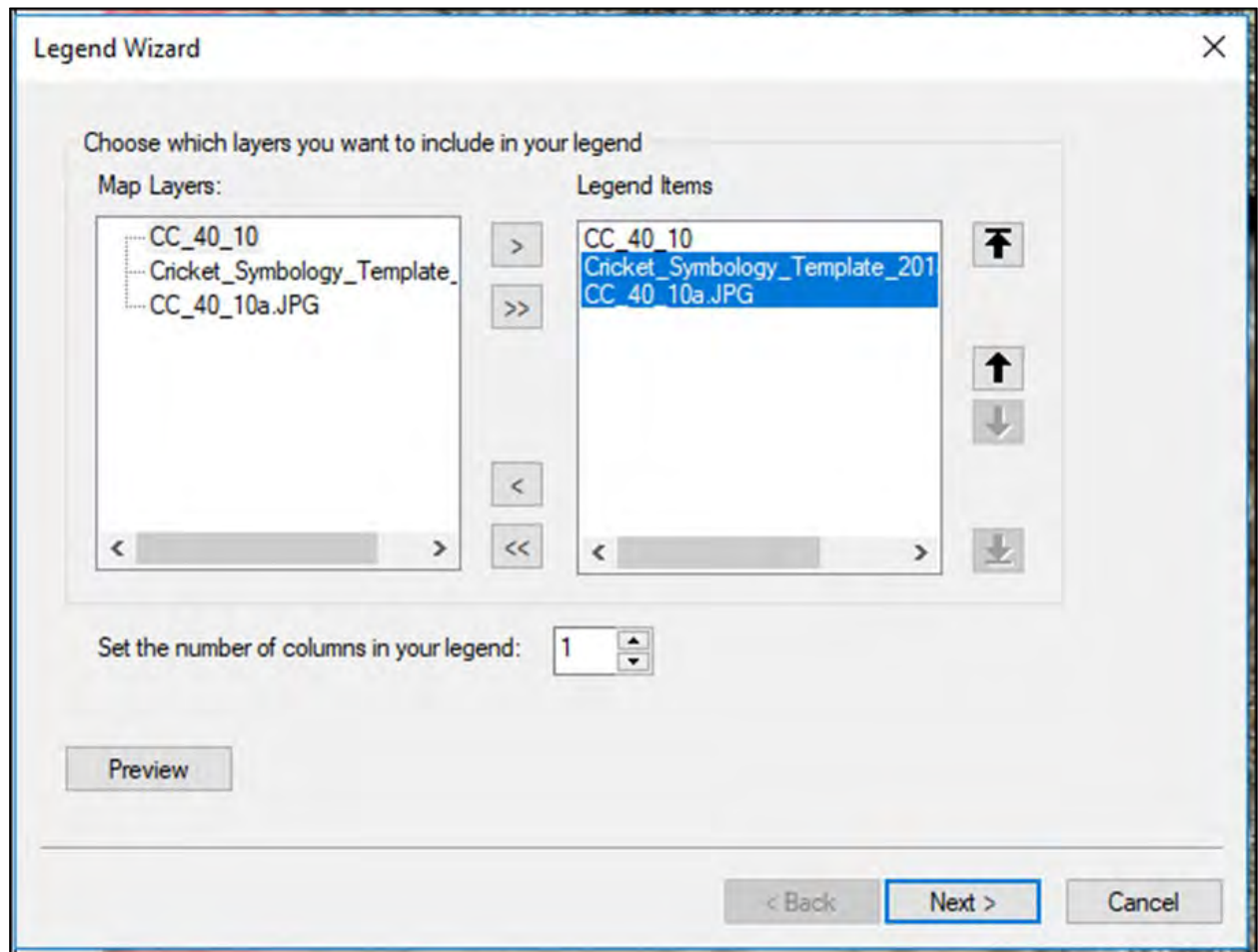


Figure 14. The Legend Wizard is used to create a Legend for the archived .pdf file of the scored image.

- ii. The scorer deletes the word “Legend” from the “Legend Title” box, ensures the font size is of a visible size (i.e., at least 26 points) and clicks “Next.”
- iii. The following settings are chosen for the “Legend Frame”:
 1. “Border” = 2.0
 2. “Background” = White
 3. Ignore “Drop Shadow”
 4. “Gap” = 10
 5. Ignore “Rounding”
 6. The scorer clicks “Next,” continues clicking through the remaining boxes, reaches the “Finish” button, and clicks “Finish.” The legend appears in front of the image file.

- iv. The scorer adds the automatically tallied life stage and sex combinations (from Step 15) to the legend:
 1. The scorer double clicks inside the newly created legend to bring up the “Legend Properties” pop-up box (Figure 15).

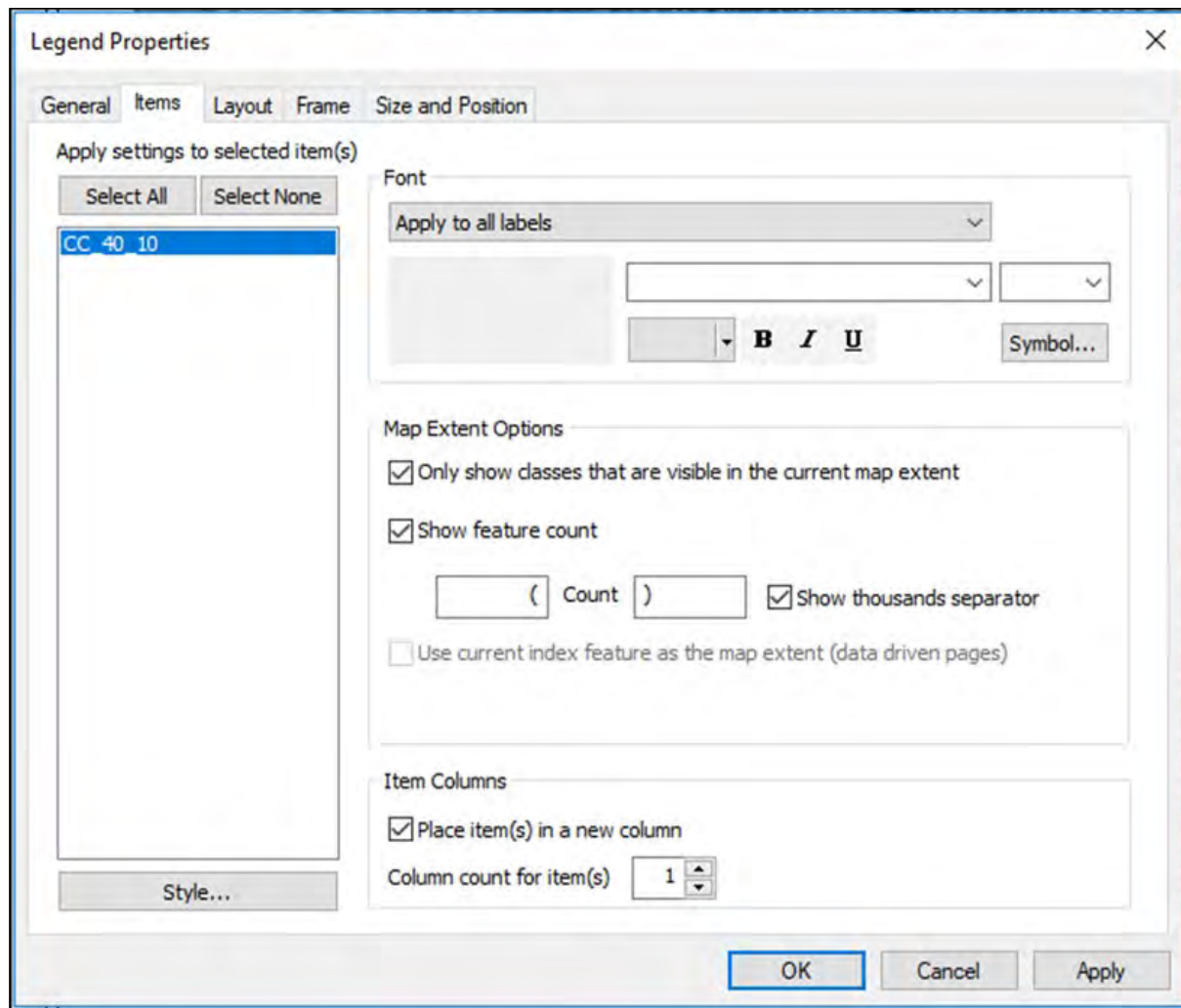


Figure 15. Refining the newly created “Legend” using the “Legend Properties” pop-up box.

2. The scorer clicks on the “Items” tab, checks the “Only show classes that are visible in the current map extent”, “Show feature count”, “Place item(s) in a new column” (Figure 15), and clicks “OK.”
- d. The scorer inserts a text box populated with their first initial and last name, and the date on which the image was scored (i.e., First Initial Last name_YYYYMMDD). The text box is created by clicking the “Insert” pull down menu and “Text”. Text is entered by double clicking the text box, the “Text” tab, and typing into the “Text” window; text may be edited (e.g., text size and color) by clicking the “Change Symbol” button. This step identifies the scorer and date associated with the scoring of the cluster’s image (Figure 16).

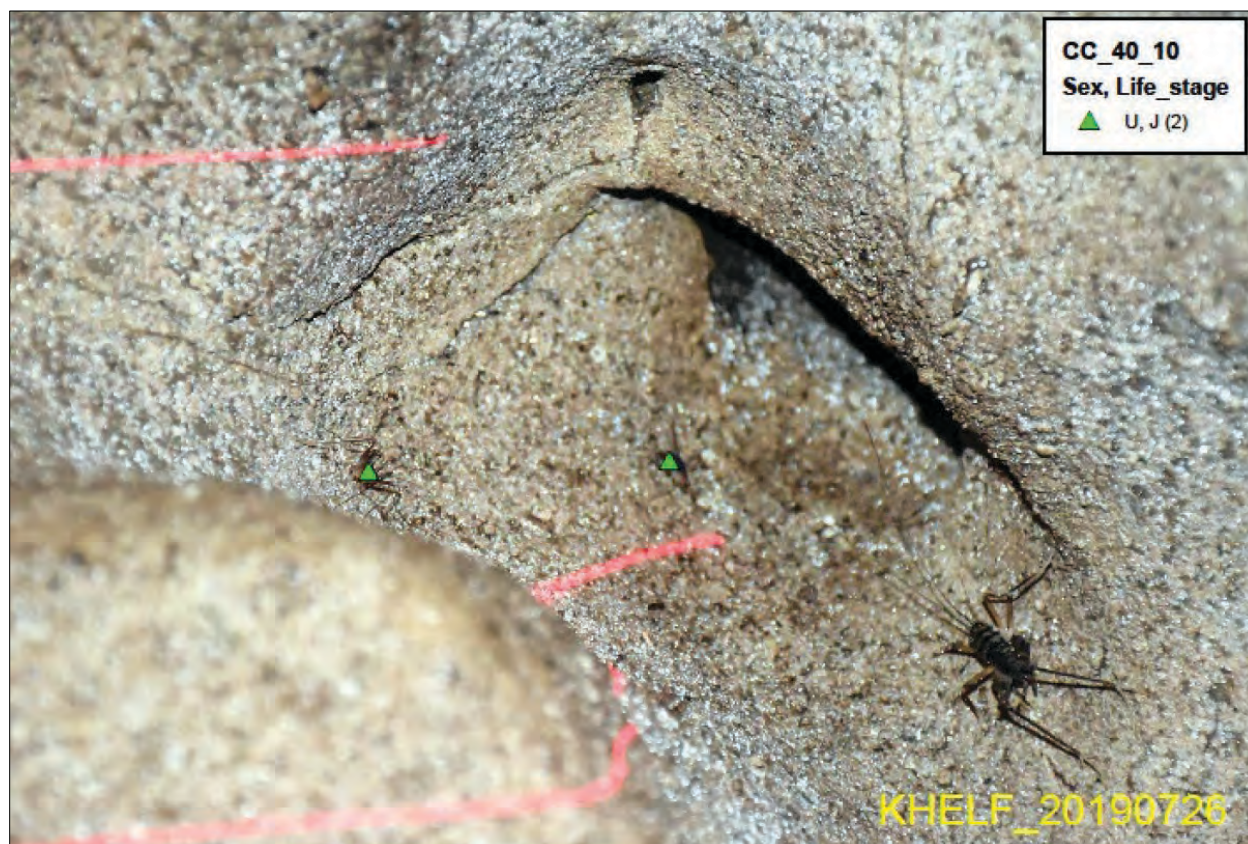


Figure 16. Example of a shapefile image file with an automatically populated legend and scorer's signature saved in a .pdf format which requires less storage space. Note non-target species *Ceuthophilus stygius* individual (lower right) captured in the image but not stamped.

- e. Finally, to export the image file to ".pdf," a more compact file format, the scorer clicks "File," clicks "Export Map," clicks the "Save as type" pull down menu and selects "PDF." Next, the scorer assigns the same name to this ".pdf" file as the cluster shapefile from which it was created (e.g., "CC_40_10"), sets the resolution to 200dpi, and saves the file in the appropriate "Mod" folder (Figure 1).

17. On occasion a cluster will intersect more than one strip along the baseline. The goal of the photographer is to capture, if possible, the entire cluster, including all laser strips, with a series of overlapping images (see SOP CC03a, "Step-by Step-Instructions," Step 8di [CUPN 2020]). The Project Lead stitches together these images with an image stitching desktop application. Stitched images are scored as normal via steps 5–16.

- a. Occasionally, these overlapping images of the supercluster will not stitch into one continuous image but only form several nonoverlapping sections. Thus, these project files may contain more than one scored image (Figure 7).
- b. The stitched image sections are named for the images from which they were stitched. For example, cluster 15 from CC_40 was a series of 17 tiled images but could only be stitched into 3 separate sections; the images were named CC_40_15ad, CC_40_15ej, and CC_40_15kq. These images are scored as normal via steps 5–16.

- c. In the same .mxd file these three separate shapefiles are merged into one shapefile, per steps 2–3 in “Merging Shapefiles and Exporting Attribute Tables to .csv Files” (see below), and saved with the same file name as the .mxd file (e.g., CC_40_15).

18. The scorer repeats steps 5–16 until all images from the cave entrance’s sampling event are scored and saves their work after processing each image.

Merging Shapefiles and Exporting Attribute Tables to .csv Files

These instructions are for exporting all shapefiles from an event into a separate .mxd file, merging all shapefiles from the event into a new shapefile, and exporting the attribute table from the merged shapefile into a .csv file for later export into the cave crickets database. ArcGIS Desktop 10.6.1 is used in this example, but subsequent versions also work.

To ensure your files are saved in the correct folder you may need to create a connection to the bout (e.g., Summer2019) folder with the “Connect to Folder” button. In the Name field, add the “Bout” folder (Figure 17) containing the event in which you’re working; from there connect to the event folder.

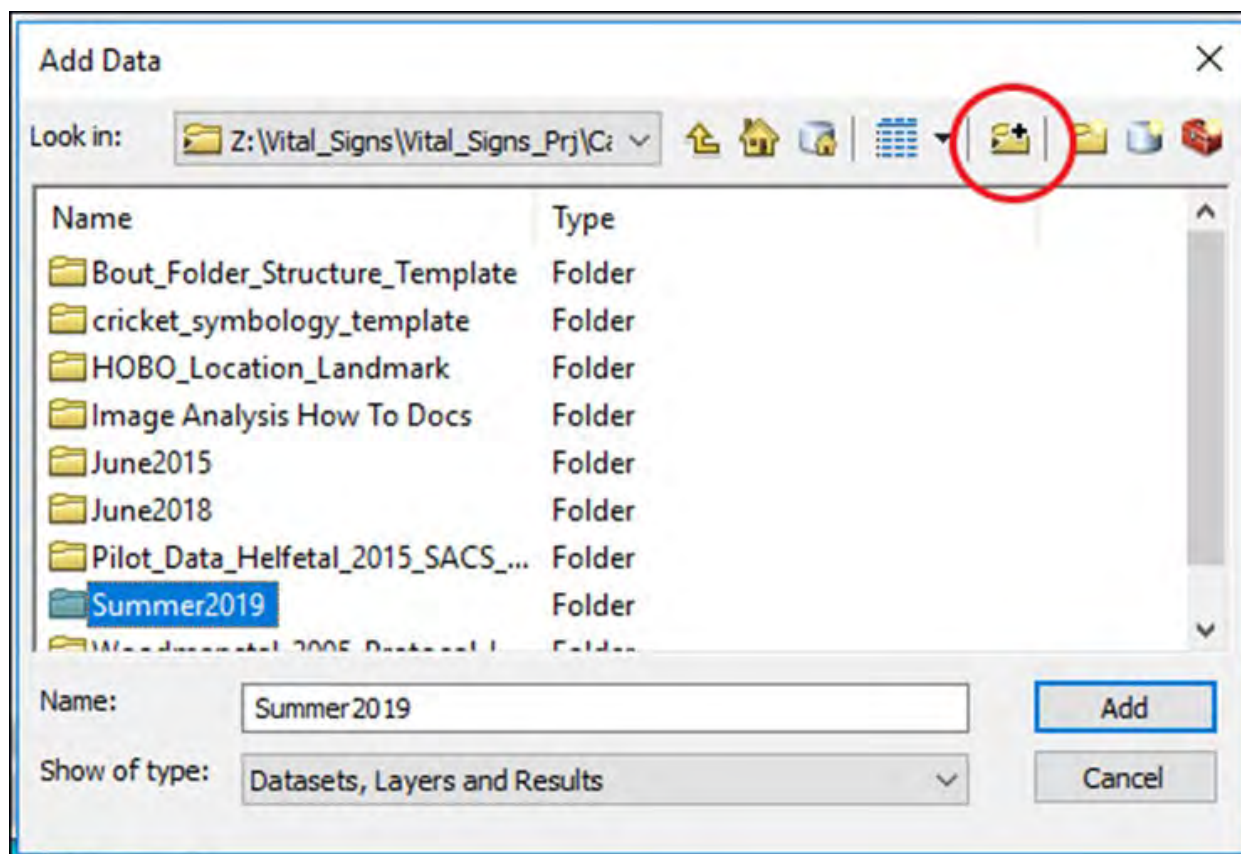


Figure 17. Click the “Connect to Folder” button to link to the folder containing the shapefiles to ensure the shapefiles are saved in the correct location.

Step-by-Step Instructions

1. Import all shapefiles from a specific event into a separate .mxd file.

- a. Open a blank .mxd file
- b. Click Start > ArcGIS > ArcMap
- c. Click New > Blank when prompted

2. Import the Shapefiles.

- a. Click on the “Add Data” button in the ribbon 
- b. Browse to the Bout folder (e.g., Summer2019) containing the event folder with the shapefiles you want to merge.
- c. From the Bout folder browse to the EventID folder, the Mod folder, and click on the heading “Type” to group all the shapefiles together (note they are out of numerical sequence) and select them all by left clicking on the first in the list, holding down shift, and clicking the last in the list. Click “Add” (Figure 18).

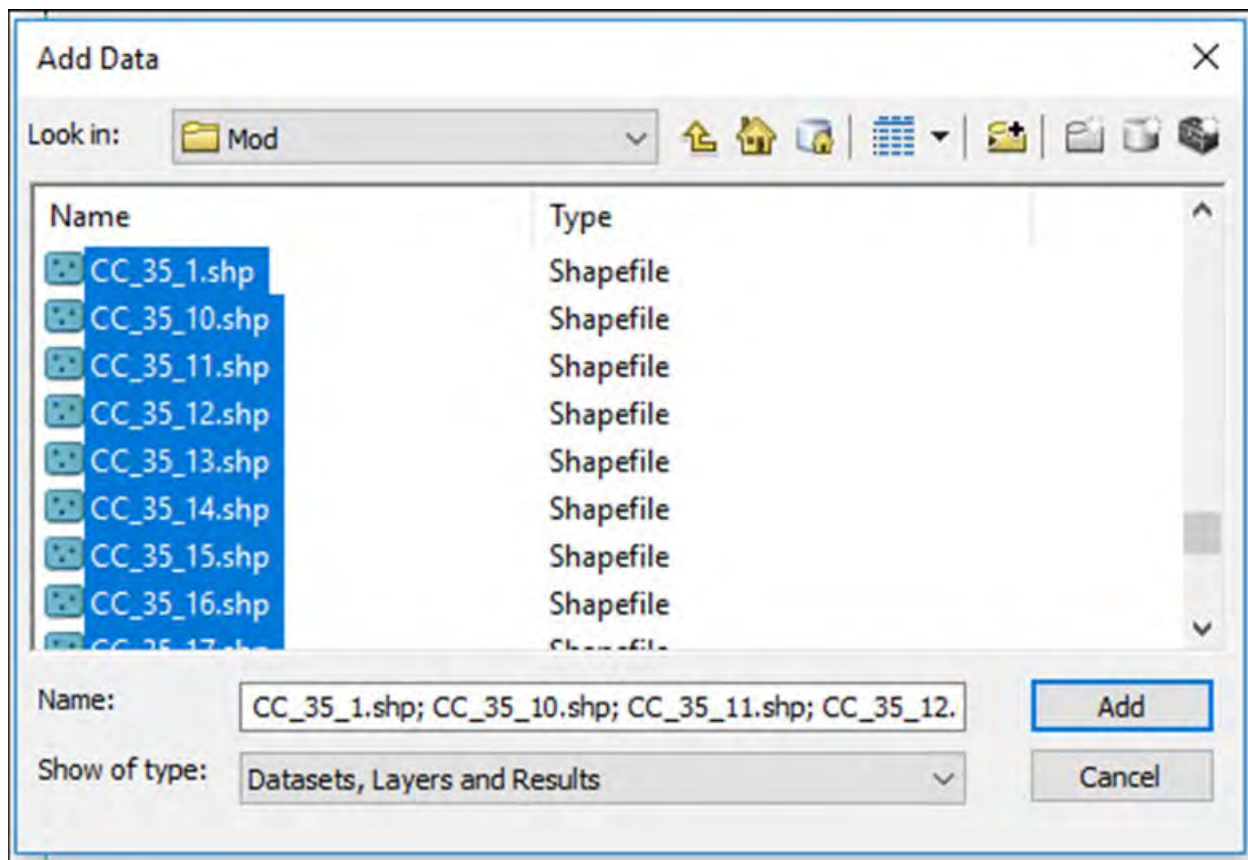


Figure 18. Sort the files in the “Mod” folder by type and select all shapefiles. Note they are out of numerical sequence.

- d. Click “Save As” to save the .mxd file, navigate to the event-specific “Merged” folder, and name the file using the Event_ID with the suffix “Merged” (e.g., CC_35_Merged) to distinguish it from the .mxd files for individual clusters.

3. Merge the separate event shapefiles into a single shapefile.

- a. Select all separate shapefiles in the TOC of the newly created Merged .mxd file (Figure 19) by left clicking on the first in the list, holding down shift, and clicking the last in the list.
- b. Select Geoprocessing > Merge in the toolbar. Then drag the selected shapefiles into the second box below ‘Input Datasets’ on the ‘Merge’ pop-up window (Figure 19).

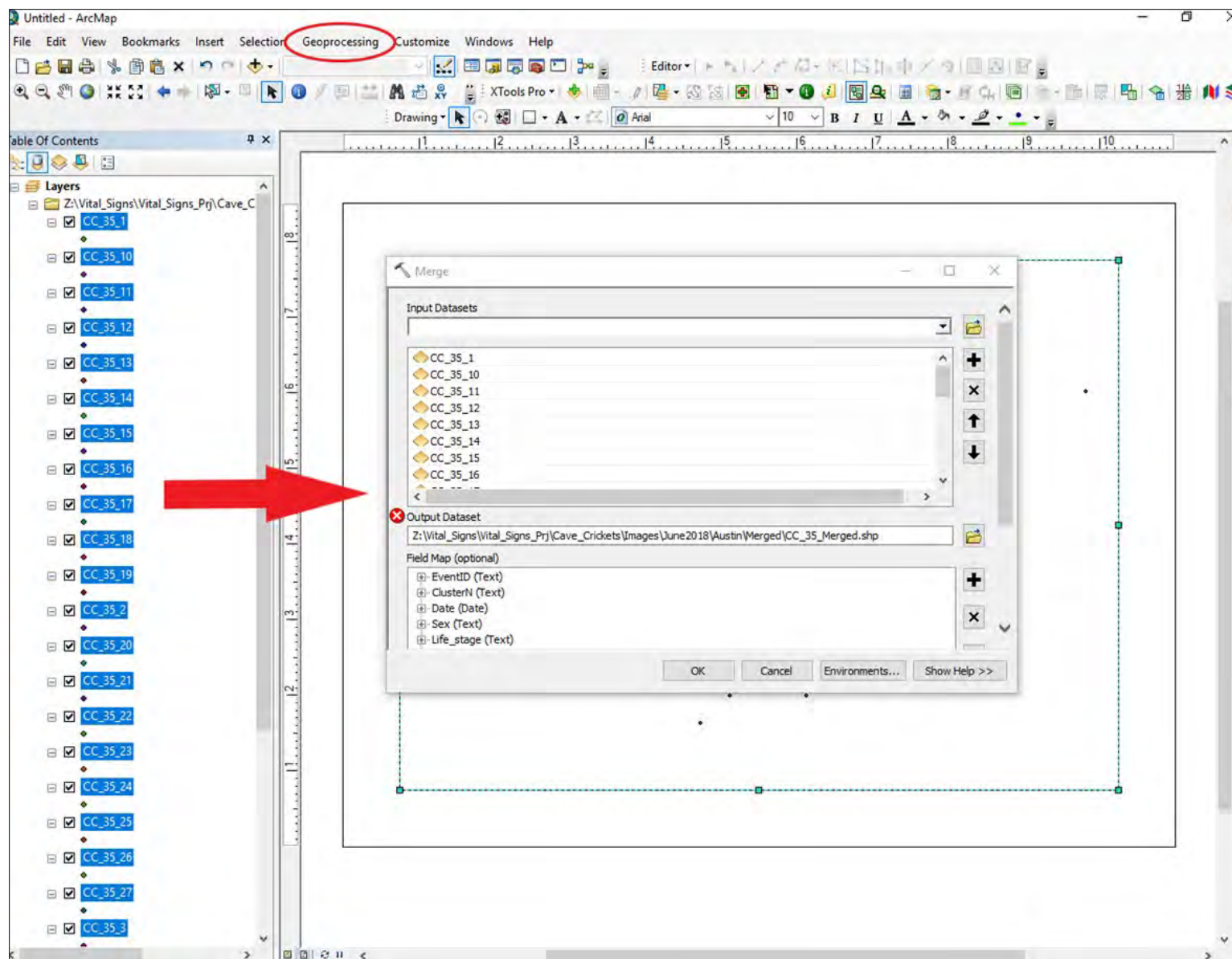


Figure 19. Merged .mxd file containing all shapefiles from one event (i.e., CC_35). Using “Merge” in the “Geoprocessing” drop down menu the event’s separate cluster shapefiles are merged into single event shapefile (i.e., CC_35_Merged).

- c. In the “Output Dataset” box, change the file path by browsing to your working directory and change the default file name to include the event (Figure 19). Click “OK.” Note: A small, side-scrolling message appears in the lower right hand corner of the screen reading “Merge...Merge...Merge”, the process takes a few seconds, a small pop-up box reading “Merged” appears at the lower right corner, and the new file appears in the Table of Contents.

4. Convert the attribute table in the merged shapefile to a .csv file for later export to the cave cricket database.

- a. Ensure the XTools extension is active by looking for a check mark next to the extension in two locations:
 - i. Right click on a blank space on the tool bar and scroll down to XTools.
 - ii. In the “Customize” drop down menu left click on “Extensions...”.
 - iii. XTools must be activated at both locations for it to work.
- b. In the .mxd file click on the merged shapefile in the table of contents so that it is highlighted. Click the dropdown menu on Xtools, select Import/Export Tools>Table to File (Figure 20). A pop-up window named “Export Table to File” appears (Figure 21).

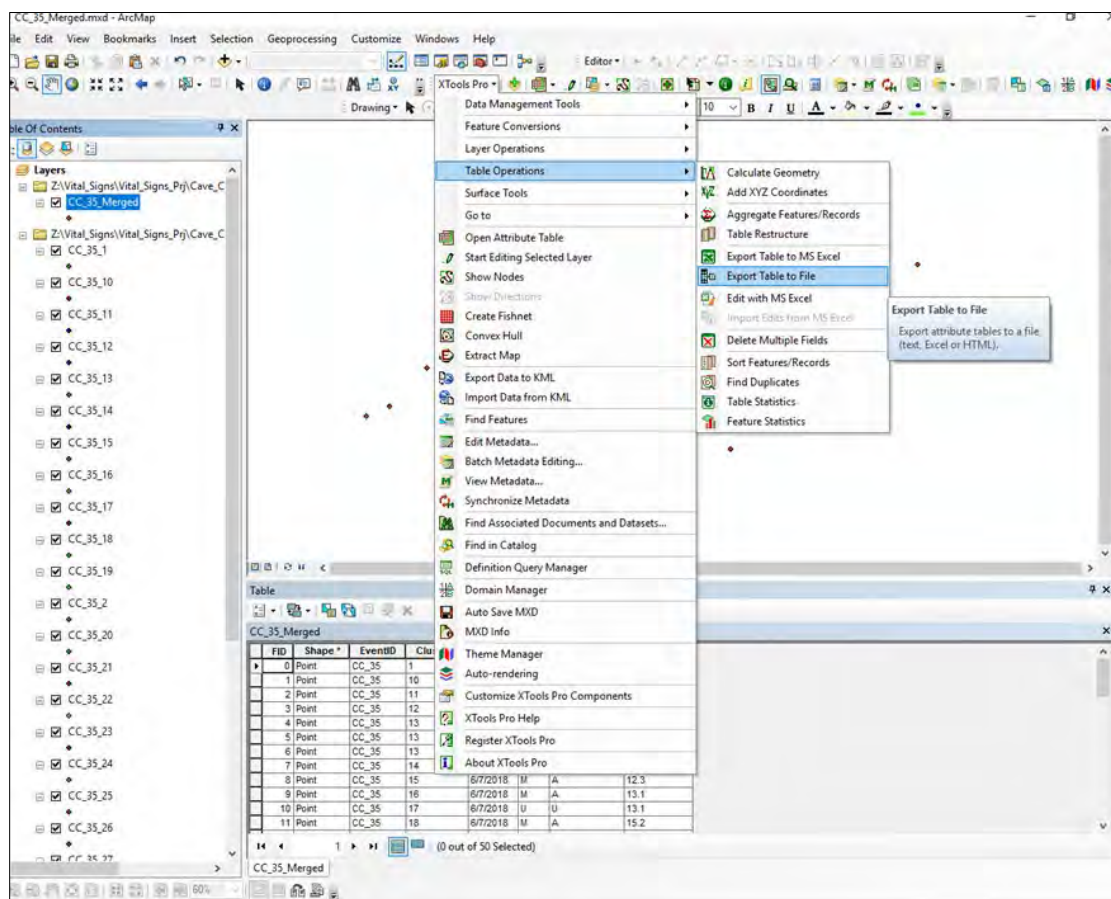


Figure 20. Convert the attribute table in the merged shapefile to a .csv file using the XTools extension.

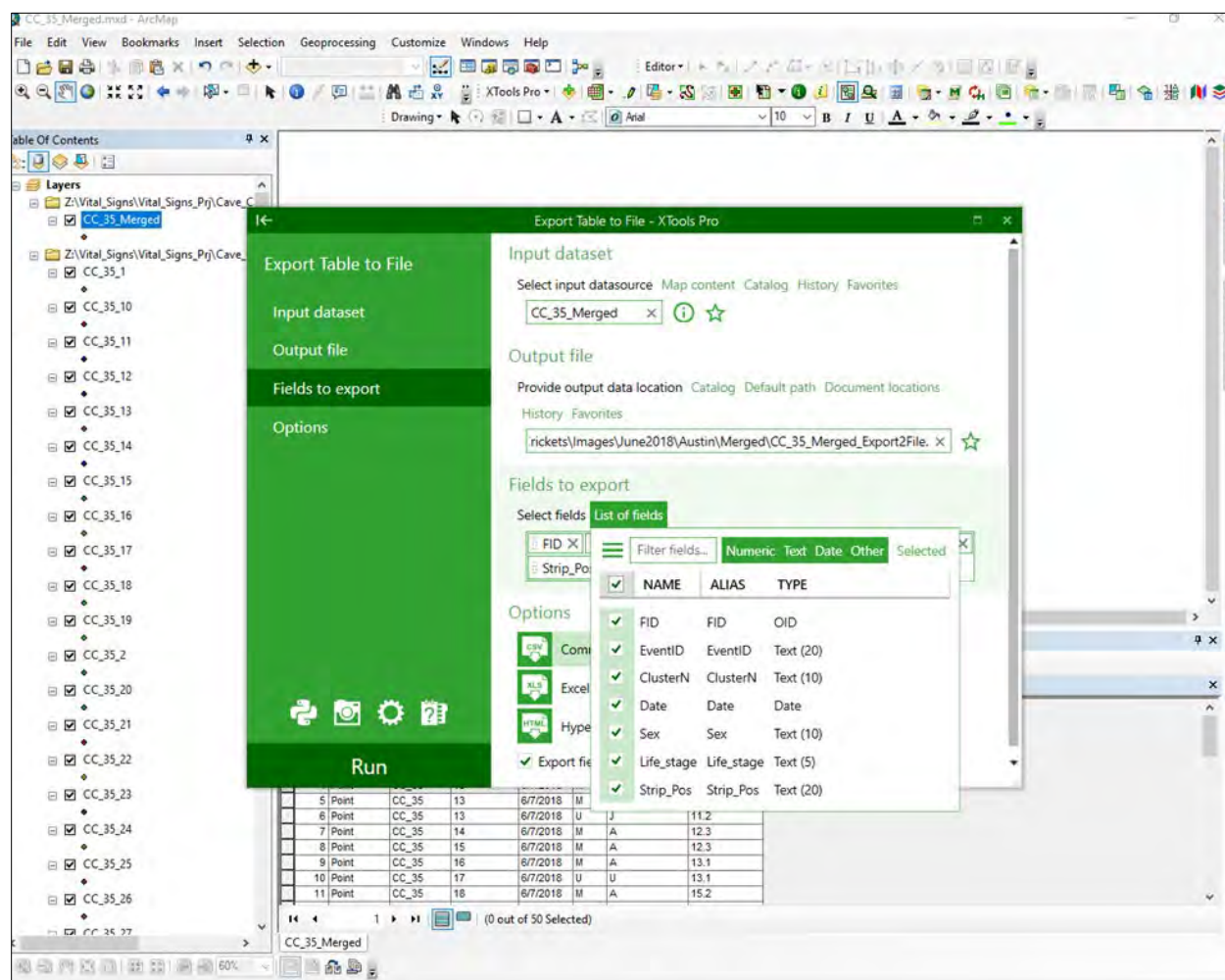


Figure 21. “Export Table to File” pop-up window.

- The file with which you’re currently working should already be selected in the “Input dataset” field but, as necessary, select the merged layer/shapefile you want to export (Figure 21).
- As necessary, under the “Output file” field select the location where you want it saved by clicking “Catalog” (e.g., “Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Images\June2018\Austin\Merged\CC_35_Merged.shp”)
- The default file name has the suffix “_Export2File”. Remove this suffix so the file name matches the shapefile name (e.g., CC_35_Merged).
- In the “Output file” box “.txt” is the default file type so you must change it to “.csv”.
- In the “Fields to export” field click “List of Fields” and check the box to the left of “Name” to select all the fields (Figure 21).
- In the “Options” field select “Comma separated values (CSV or TXT).”

- g. Check the “Export field aliases as column headers” box.
- h. Select “RUN.”
- i. The “Merged” folder in which you’re working should now contain a .csv file that matches the name of the merged shapefile (e.g., “CC_35_Merged”; Figure 21). This is the file that will eventually be exported to the specific event (e.g., CC_35) in the cave cricket database.

Processing Cave Meteorological Data Files

Cave temperature and relative humidity data files downloaded from automated HOBO data loggers are processed in the following way. The physical scientist, project leader, or designated field crew member or data intern downloads all automated data files from the data shuttles, downloaded during sampling events, and renames the files using the standard naming convention. The data files will be checked for completeness. The user manual for HOBO data loggers, containing instructions for their use, are maintained on the network’s server located here:

“Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Docs\Field_Forms\Checklists”

Upload HOBO data files in MACA’s “HOBO_Offload” directory folder on the network’s server located here:

Z:\Vital_Signs\Vital_Signs_Prj\Cave_Air_Quality\Data\Working_Data\MACA

Field crews will have maintained a record associated with each handling of a HOBO data logger at a cave on the field data form including the data logger serial number, the date and time the data logger was either installed or serviced or replaced, the unique data logger location name, whether the data transfer in the field was successful, etc. Therefore, **do not continue with processing of HOBO data files, beyond copying them to the network server as described above, unless you have the HOBO RH/Temp Data Logger field data form(s) at hand.**

All HOBO data files in Z:\....HOBO_Offload are copied and pasted in the MACA level folder in the “working data” directory before renaming. For example, HOBO data files from Frozen Niagara Entrance in the Working_Data folder are copied and pasted into:

Z:\Vital_Signs\Vital_Signs_Prj\Cave_Air_Quality\Data\Working_Data\MACA

Data files are renamed as “<Location_ID>_<HOBO location name>_<serial number>_<date>.hobo” where the HOBO location name is the unique name assigned to the cave entrance where a data logger was initially installed, the serial number is the number printed on the side of the data logger, and the date is the date recorded on the field data form when the data logger was downloaded inside- or removed from- the cave in YYYYMMDD format. These file names, unique to the cave cricket monitoring protocol, will distinguish them from other meteorological data files from other protocols (e.g., cave bat monitoring).

Example: “FrNiEn_001a_H1_675503_20170928.hobo.”

Processing Surface Meteorological Data Files

Validated data files on surface temperature, relative humidity, and precipitation from MACA’s SCAN station are obtained when the physical scientist, project leader or designated field crew member downloads temperature, RH, and precipitation data files, collected at MACA’s SCAN station, from the NPS Gaseous Pollutant and Meteorological data access website (Figure 22), renames the files using the standard naming convention, and saves them in the designated folder.

U.S. Department of the Interior
NATIONAL PARK SERVICE

Access to Gaseous Pollutant and Meteorological Data

HOME

MONITORING INFORMATION

- CURRENT MONITORING MAP
- HISTORICAL MONITORING MAP
- MONITORING SUMMARY TABLE
- MONITORING HISTORY
- MONITORING SITE REPORTS
- MONITORING INVENTORY REPORTS
- OTHER NETWORKS

DATA

- VALIDATED DATA EXPORT
- RAW DATA EXPORT
- DATA PRODUCTS
- REPORTS
- CONTACT US

DATA EXPORT - VALIDATED DATA

Data files in Comma Delimited Format (CSV) are available here. **Three file formats are available:**

1. Date/Times in rows and Sites/Parameters in columns.
2. Sites/Local Date Time/UTC in rows and Parameters in columns.
3. Sites/Local Date Time/Parameters in rows and hours in columns (hourly data only)

Please note that you must allow Pop-ups to successfully use this feature. If your query results in more than 65,536 rows the download file will be compressed. Queries resulting in more than 300,000 rows are not allowed. For large data requests, please [contact us](#).

Select Dates

Select start and end dates then click the continue button. The earliest date is January 1980.

Output Format: Date/times in rows and sites/parameters in columns

Start Date: 01/01/2020 End Date: 01/31/2020

Continue

Figure 22. Mammoth Cave National Park meteorological data access site.

Step-by-Step Instructions

1. Validated surface meteorological data are accessed at the [Data Export-Validated Data website](#). These data are to be accessed no earlier than December of the sampling year.
2. The first tab asks for Output Format, Start Date, and End Date (Figure 22). Output Format is the default “Date/times in rows and sites/parameters in columns.” Dates are selected from calendar drop-downs where the desired year, month, and days are selected that correspond to the 36-hour period prior to the date of the sampling events associated with the specific sampling bout. Thus, the number of time periods downloaded for each parameter in a given sampling bout depends on the number of days taken to complete the sampling bout. Once the time period is selected click the “Continue” button.
3. The second tab “Select Sites” appears to the right of the “Select Dates” tab. Select “(MACA-HM) Mammoth Cave National Park Houchin Meadow.” Click the “Continue” button.

4. The third tab “Select Parameters” appears to the right of the “Select Sites” tab.
 - a. Select “hourly” from the “Parameter Interval” drop-down list.
 - b. Hold down the “Ctrl” key and select “Ambient Temperature (aspirated),” “Precipitation,” and “Relative Humidity.” Click the “Export” button.
5. A warning will appear just below the box with the three tabs regarding the number of rows in the query. Click “Run query.”
6. Click “Download CSV File.”
7. Parameters are arranged in the file so that their order is always temperature, RH, and precipitation.

A pop up window will appear and the data are copied to the folder associated with the month of the sampling bout:

Z:\Vital_Signs\Vital_Signs_Prj\Cave_Crickets\Data\Working_Data\Surface_Met_Data\<Sampling Bout>.

The merged data file is renamed as “<Event ID>_SCAN2079_<date>.csv” where “Event ID” is the unique identifier for the particular cave entrance to which the data apply (e.g., “CC_48); “SCAN2079” is the unique site number assigned to MACA’s SCAN station location, and “date” is the date of the specific sampling event on which the cave entrance was sampled as recorded on the field data sheet. The date format used is YYYYMMDD.

Example: “CC_41_SCAN2079_20190520.csv.”

8. These data are deleted only after being imported into R data analysis files since they are archived at the National Water and Climate Center and are readily accessible from the MACA’s SCAN station website.

Saving Data to an archival CD for Long-Term Storage

All data produced by sampling bouts and their subsequent processing and analysis will be collected by the project leader who ensures they are archived for permanent storage. All scanned field data sheets, HOBO RH/Temp Data logger— Site Setup and Maintenance Field Observer Forms, labeled cluster image files, and ArcMap files are saved onto archival DVD memory media for archiving in the CUPN offices. Once all materials from a sampling bout have been labeled, scored, and saved on the CUPN server they are transferred to archival DVDs using an available CD “burner” utility. The general steps below are used to save files onto the DVD memory.

Step-by-Step Instructions

1. The computer on which data are transferred to archival DVDs must be connected to the MACA LAN to provide for data transfer from the CUPN server to the archival DVD.
2. The project leader opens the CD “burner” utility on the host PC and follows the commands to start creation of a “data” or “image” CD. The “create” process requires the project leader to select the file(s) and/or folder(s) to be saved onto the archival DVD. The CD “burner” permits browsing through the various CUPN directories on the server to select specific files to be copied to the archival DVD.
3. The project leader follows the commands for copying the file(s) and/or folder(s) onto an archival DVD. The transfer process should take several seconds to a few minutes, depending on the number of file(s) and/or folder(s) to be transferred.
4. The CD/DVD “burner” will indicate when photo transfer is complete and should query the project leader as to their next command (e.g., label archival DVD, add notes). The project leader clicks “Close” and saves the archival DVD using the appropriate commands. The archival DVD memory has been created and should be retrieved from the computer and stored in a DVD jewel box.
5. The project leader checks the final DVDs to ensure the files copied correctly.

The project leader continues saving image files to DVD memory by following steps 1–4 above, until all files for the sampling bout have been recorded. The labeled DVDs are delivered to the CUPN curatorial specialist who will ensure they are properly stored for archiving.

Literature Cited

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- Helf, K. L., T. Philippi, B. J. Moore, and L. Scoggins. 2015. A protocol for monitoring cave crickets (*Hadenoeus subterraneus*) at Mammoth Cave National Park—Version 1.0. Natural Resource Report NPS/CUPN/NRR—2015/934. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2220998> (Last accessed July 2020).