Protocol for Managing and Processing Camera-Trap Data

Supplemental research to:
Influence of deer harvest regulations on antlerless harvest, abundance, and sex and age composition: implications for managing deer in the face of chronic wasting disease

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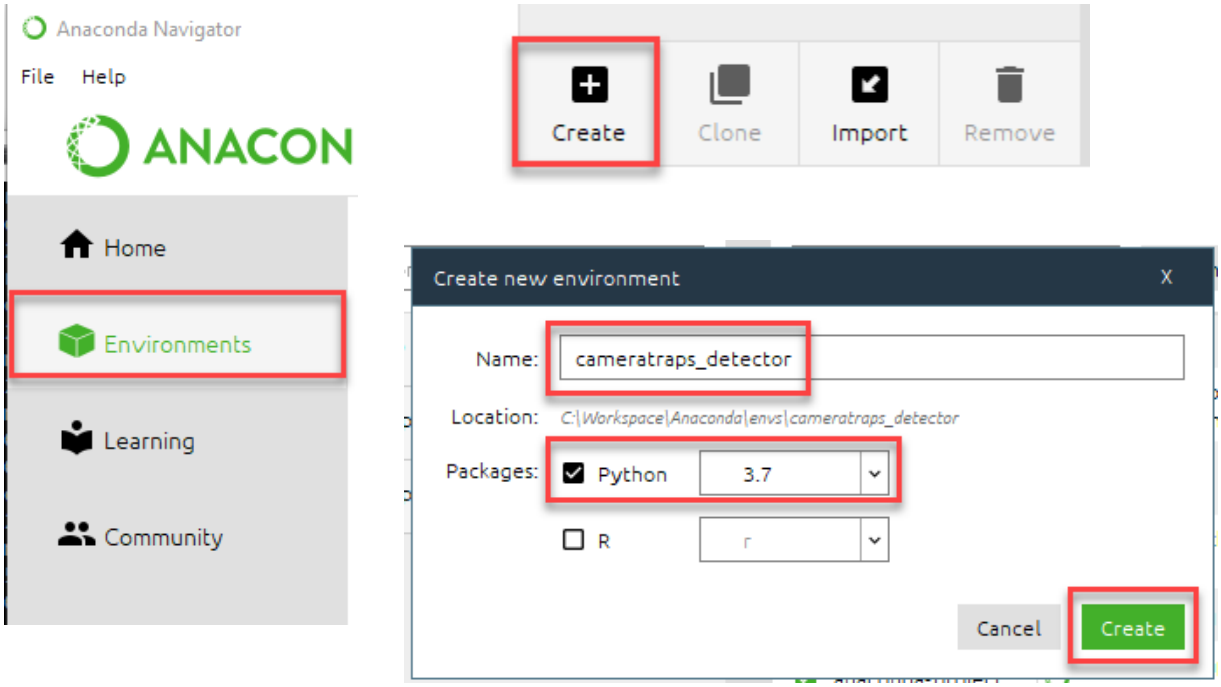
MegaDetector Installation and Setup

1. Go to https://docs.anaconda.com/anaconda/install/windows/ and follow instructions to install Anaconda. You can skip step 2 (verify data integrity) and step 12 (installing PyCharm). The rest of the instructions will assume you have installed to `C:\Workspace\Anaconda` but you can choose a different location, if necessary. It is recommended you choose a location where you know you have write authority and whose address does not contain any spaces (so don't choose `C:\Program Files` or something similar).

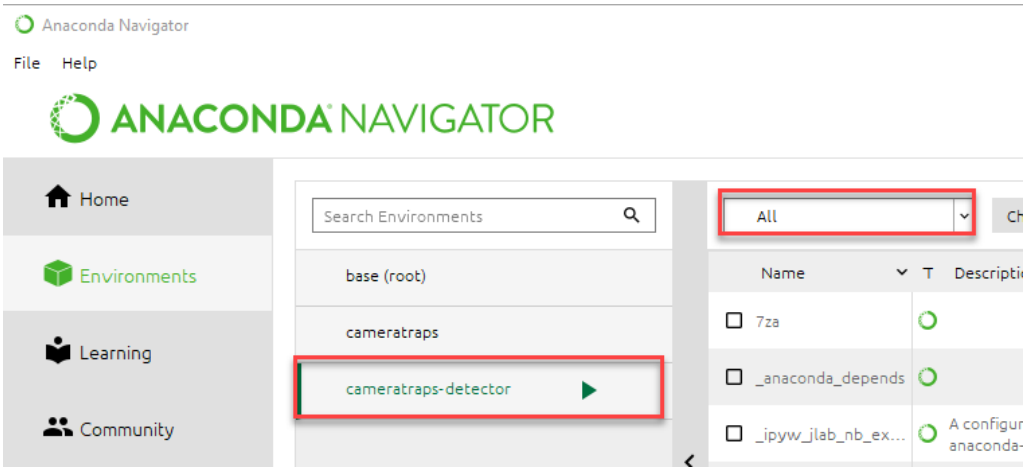
2. From your Start menu, Open Anaconda Navigator. Update to latest version, if prompted.

3. In Anaconda Navigator, go to Environments and then Create *cameratraps-detector*. Make sure to select the Python package and select 3.7 from the dropdown.

   You may not see an option for 3.7 initially because Anaconda needs time to think, or you need to "update index" first, this might prompt an update too. If 3.7 is not an option try typing it in, otherwise you may need to download a more current version and troubleshoot to downgrade to get the 3.7 version used here.

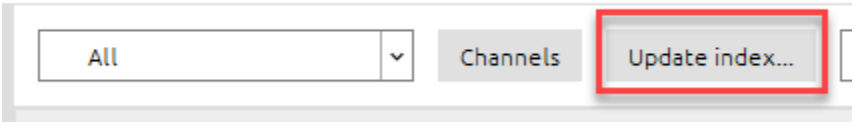


4. Go to Environments, select *cameratraps-detector,* change dropdown to All.



   a. Make sure all items listed in https://github.com/microsoft/CameraTraps/blob/master/environment-detector.yml as dependencies are selected except `tensorflow`. After selecting each necessary package, click Apply. Dependencies may also need to be installed.

      i. You may need to Update index to find all the packages.



      ii. While you are installing packages, if Anaconda seems to get stuck on the *fetching* step, cancel the process, close and restart Anaconda. Then you can start installing the rest of the packages.

      iii. MegaDetector may require additional downloads, specifications include:

```
name: cameratraps-detector,
channels:
- conda-forge
- pytorch
dependencies:
- python=3.8
- Pillow=9.1.0
- nb_conda_kernels
- ipykernel
- tqdm
- jsonpickle
- humanfriendly
- numpy
```

- matplotlib
- nb_conda_kernels
- ipykernel
- opencv
- requests
for running MegaDetector v4
- tensorflow>=2.0
for running MegaDetector v5
- pandas
- seaborn>=0.11.0
- PyYAML>=5.3.1
- pytorch::pytorch=1.10.1
- pytorch::torchvision=0.11.2
- conda-forge::cudatoolkit=11.3
- conda-forge::cudnn=8.1
the `nb_conda_kernels` and `ipykernel` packages are installed so that we can use Jupyter Notebooks with this environment as a kernel

5. Download MegaDetector from https://lilablobssc.blob.core.windows.net/models/camera_traps/megadetector/megadetector_v3.pb. The rest of the instructions assume you have installed to `C:\Workspace\MegaDetector` but you can choose a different location, if necessary. It is recommended that you choose a location where you know you have write authority and whose address does not contain any spaces (so don't choose `C:\Program Files` or something similar). Other than that, you should not need to do any special setup with this step.

6. Go to https://git-scm.com/download/win and follow the instructions to download and install Git. Install the version called *64-bit Git for Windows Setup*. The rest of the instructions assume you have installed to `C:\Workspace\Git` but you can choose a different location, if necessary. Again, no spaces in the address. Accept all defaults while installing (make sure to open and use all pre-selected options for setup).

    a. I renamed my file pathway and workspace to match what I thought would be easier to run on S. Gurney's laptop, "c:\Users\gurneyst\Git"

7. Go to Start menu and open Anaconda prompt.

    a. In the prompt enter: **`conda activate cameratraps-detector`**

    b. At the next prompt, enter: **`cd c:\workspace\git`**

i. Instead of `c:\workspace\git` you should enter the location where you installed Git. I had `c:\Users\gurneyst\Git`. You can move the MegaDetector files to your liking, just make sure that the code matches the pathway where the files are.

c. At the next prompt, enter: **`git clone https://github.com/microsoft/CameraTraps`**

d. At the next prompt, enter: **`git clone https://github.com/microsoft/ai4eutils/`**

e. At the next prompt, enter:
`set PYTHONPATH=c:\workspace\git\cameratraps;c:\workspace\git\ai4eutils`
   i. Instead of `c:\workspace\git` you should enter the location where you installed Git.

f. At the next prompt, enter: **`pip install tensorflow==1.13.1`**

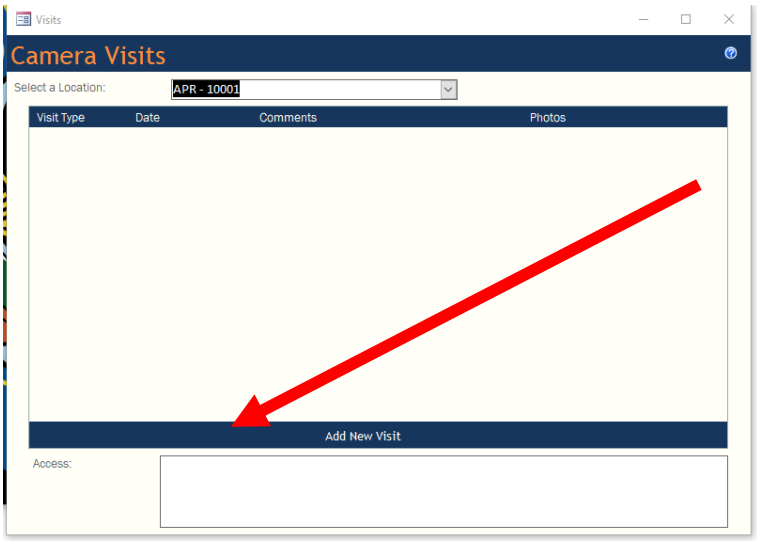
g. At the next prompt, enter: **`pip install humanfriendly Pillow pandas tqdm`**

8. Close all open windows.

9. If the software does not operate, it may require additional troubleshooting. New software updates might require this troubleshooting.

Data Management and Processing with CPW Photo Warehouse and MegaDetector

A. Create 2 separate CPW Photo Warehouse databases—one for the APR Zone and one for the NonAPR Zone. Dividing the databases this way will prevent the databases from getting too bogged down (and makes it easier when dividing database tasks among technicians). Using CPW Photo Warehouse, you (the data manager) will need to begin by entering all the camera sites using the "Add or Edit Locations" button in the switchboard (the main menu). Do not enter location information here (e.g., coordinates; this information is private to MSU). Once all camera sites for the appropriate study area are listed in the locations table, you can begin adding camera visits. Click on "Add or Edit Visits" in the switchboard then select a location from the dropdown in the visits form. Once you have selected a location click "Add New Visit".



B. For each camera you will need to first add the set date. Because we are only collecting data starting July 15 you should make the set date 07/15/YYYY for all cameras.

C. Pick up SD card from field technicians
   a. Use pocket organizer (i.e., SD wallet) to keep cards organized and to help keep track of when the cameras were checked. A mailbox-type system works well for delivering and returning SD cards (e.g., one mailbox for SD cards that need to be uploaded and one mailbox for SD cards ready to go back into the field).

D. For the first camera check (which should occur shortly after July 15), start by moving all photos from the SD cards to the correct 1-TB external hard drive (individual 1-TB hard drives should be assigned to individual townships). Next, separate photos into "pre-July 15" and "post-July 15" locations. So, create a folder called "Pre-Post-Jul15" in the Check

1 folder, include a subfolder for each site, like “11001” and then give it subfolders “pre-Jul15” and “post-Jul15” to store photos before renaming them (e.g., “APR_Easton\Check1\Pre-Post-Jul15\Post-Jul15”). We only want to import post July 15 photos into the Photo Warehouse database, and it will be easier to have them presorted. None of the folder or file names can have spaces in them. So, you will need to create:

a. Subfolder for pre-July 15 photos

b. Subfolder for first access post-July 15 photos (this is a subfolder needed before manual file renaming happens in CPW Photo Warehouse).

    i. Subfolder for each township

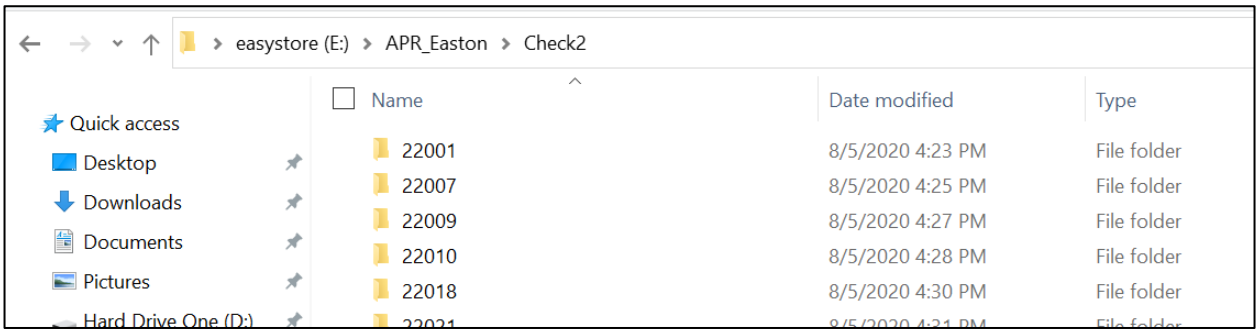
        1. Subfolder for each site

c. Subfolder for each Access (i.e., camera check)

    i. Subfolder for each township

        1. Subfolder for each site

For example, the file pathway for site 22001, Check2, in Easton Township (APR Zone) will be: “APR_Easton\Check2\22001”. Below is a screenshot for Easton Check2 showing individual folders for each camera site:



It is very important to have file pathways good from the start; and maintain organizational structure of hard drives throughout seasons).

Since the sampling period ends on September 15th, we will use a similar approach (like D-a and D-b) for separating Pre- and Post-Sep15 photos in the Check 5 folder. Do not forget to separate Pre- and Post-Sep15 photos after the last camera check or it will cause many problems.

E. Once you have a set date in the database you can add check dates and pull dates using the "Add or Edit Visits" option from Photo Warehouses switchboard (main menu) and clicking the "Add New Visit" button. When you choose "Check" in the Visit Type field, a subform will pop up allowing you to load photos. Do not forget to list the final camera check as "pull."

F. Enter the path for the folder containing the photos just for that camera site (for first access, you would choose the path from the "post-July 15 Access 1" subfolder (or at the end of the season "pre-Sep 15 Access 5"), then click the "copy image files". I know it seems redundant to re-copy the images when they are already stored on the hard drive, but this will allow us to rename all the images in a consistent way. Copy the images into the appropriate subfolder and click the "Rename image files" box. Use the Location ID as the "Prefix option" and Image Number + Date as the "Rename files using" option.

    a. After the first camera check (except for the final camera check), photos can be imported directly from the SD cards rather than saving them to the external hard drive first, then importing them. Continue uploading photos through the "Visits" subform in the database and copying and renaming the files in the same way as above.

    b. It is easy to mix up what SD cards have and have not been uploaded, so keep track of what you upload in a notebook (e.g., write Sherman Township Check 3 and list bullet points for each successful upload like, "Card 16/Site 11045, Card 18/Site 11018" and so on). Keeping notes like this allows you to double check that you have uploaded all 18 SD cards per township—and that is important to prevent missing data. You may need to refer to the first few images on the SD card (which show a whiteboard) to identify what the site ID is.

    c. <u>Make sure that Check 1 and set date are not the same.</u> Camera set = July 15th, Check 1 = any date other than July 15th. When check and set date are the same it creates duplicates of photos that are labeled incorrectly when adding into the database—and this cause serious database problems. Make sure technicians do not check the cameras on July 15th.

G. The 1-TB hard drives (containing township photos) should be backed up to a 5-TB hard drive weekly (the 5TB hard drive will be stored at the MDNR warehouse). It is good practice to regularly backup the 5-TB hard drive with a separate 5-TB hard drive that is housed at a location off site (e.g., MSU). The 1-TB hard drives must be backed up after each camera check before the SD cards go out in the field again (because photos will be deleted from SD cards in the field). External hard drives can get damaged or ruined during the MegaDetector process (it has happened), so it is critical to back everything up before each round of MegaDetector. For example, after Sherman Check 3 photos have been uploaded to the Sherman external hard drive from the Sherman SD cards, the

Sherman hard drive must be backed up before MegaDetector scans the Check 3 photos on Sherman's hard drive.

H. You will run MegaDetector to screen out the images that do not have any wildlife (i.e., blank images). You will need separate computers, best case scenario is to have one computer designated for each 1-TB hard drive (i.e., township). Repeat the steps below for each computer-hard drive pair. MegaDetector may run for several hours or days (most likely over a week), so the computers you use for MegaDetector should be dedicated to that sole process alone. It is important to change each computer's settings to prevent it from automatically shutting down, going into sleep mode, or doing automatic updates—all of which will disrupt MegaDetector from running continuously. When running MegaDetector, keep computers and drives well ventilated (e.g., create additional space between hardware and surfaces) because days of use and heat can damage hardware (use additional fans if possible).

    a. Connect 1-TB hard drive to the computer. Make sure the hard drive is listed as the "D" drive on your computer, if not it will cause many issues down the road. If the hard drive is listed on the computer as something else, like "E" drive, you will need to change the setting in your computers Disk Management (this issue is very common). You can fix the issue with the computer's "Create and format hard disk partitions" option in the Control Panel. Once you open the Disk Management page, right click the hard drive and select "Change drive letters and paths…" and change the letter to "D." If something else is currently listed as "D" you will need to change it so the hard drive can be labeled "D".

    b. Go to the Start menu, open Anaconda prompt. These instructions assume you have installed all software to locations recommended in the MegaDetector Installation and Setup instructions (above). You will need to modify the code below according to site, camera check, and zone. The easiest way to do this is by copying and pasting prompts into Anaconda (but remember you need to revise the code first). It can be helpful to save different versions of code below for each township—that way all you need to do is update camera check number. It also can be helpful to keep the original code below intact. The comment section is a good place to revise the code accordingly—comment on this document by clicking on the "Review" tab and add a "New comment."

        i. In the prompt, enter:

```
conda activate cameratraps-detector
```

        ii. At the next prompt, enter:

```
cd c:\workspace\git
```

a. Here is an example pathway for setting the workspace on S. Gurney's laptop:

```
cd c:\Users\gurneyst\Git
```

b. In the example above, all program downloads for MegaDetector were in the folder "Git"

iii. At the next prompt, enter:

```
set PYTHONPATH=c:\workspace\git\CameraTraps;
c:\workspace\git\ai4eutils
```

iv. At the next prompt, enter:

```
python
CameraTraps/detection/run_tf_detector_batch.
py
c:/workspace/megadetector/megadetector_v3.pb
d:/Access1 d:/Access1/Access1_APR.json --
recursive --output_relative_filenames --
checkpoint_frequency=50
```

a. In the command above, instead of `d:/Access1`, use the appropriate path for the access number you are trying to scan (i.e., run MegaDetector on).

b. In the command above, instead of `d:/Access1/Access1_APR.json`, use the appropriate path and file name to indicate both the township, access number, and whether the results are for APR or NON.

c. Here is example code from S. Gurney's laptop **(**MegaDetector will run this code to analyze each photo in the Easton Check2 folder)**:**

```
python
CameraTraps/detection/run_tf_detector_b
```

```
atch.py
c:/Users/gurneyst/Git/megadetector_V3.p
b d:/APR_Easton/Check2
d:/APR_Easton/Check2/Check2_APR_Easton.
json --recursive --
output_relative_filesnames --
checkpoint_frequency=50
```

v. If the scan is interrupted for whatever reason, use the following code to restart from the last checkpoint:

```
python
CameraTraps/detection/run_tf_detector_batch.
py c:/workspace/megadetector_v3.pb
d:/Access1 d:/Access1/Access1_APR.json --
recursive --output_relative_filenames --
checkpoint_frequency=50 --
resume_from_checkpoint=d:/Access1/checkpoint
_20200601145050.json
```

a. In the command above, instead of `checkpoint_20200601145050` you should enter the name of the checkpoint file created during the interrupted run (it will be a .json file automatically saved on the external hard drive; MegaDetector saves output at regular user-defined intervals [50]).

I. Backup MegaDetector data immediately after it finishes running. You can do this by backing up MegaDetector's .json and .csv output files to our cloud storage (SharePoint). Also, make sure to include MegaDetector out files when backing up data on the 5-TB hard drives. For example, MegaDetector just finished processing Douglass Check 4, now immediately backup the .json and .csv files to the SharePoint cloud storage—then when you go and backup Douglass Check 5 photos on the 5-TB hard drive at the warehouse, make sure to also backup Douglass Check 4 MegaDetector data at that time.

J. After MegaDetector has finished running, disconnect the hard drive from the designated MegaDetector computer—do not just unplug drive as it can cause issues—use the computer's function to safely eject drive (e.g., right click on the drive icon at bottom right of the desktop screen [next to the clock] and select eject). Next, connect the hard drive to a computer not designated for MegaDetector tasks. Make sure the hard drive is listed as the "D" drive on your computer, if not it will cause many issues down the road (refer to section H-a for directions on how to change the drive settings). Copy the file

called Mayhew_Test_Template.tbd (custom template for photo and MegaDetector data created by S. Mayhew) from wherever you have installed it and paste into the appropriate Access folder on the 1-TB external hard drive. Open Timelapse2.exe (Timelapse software) from C:\Mayhew on the computer (folder created by S. Mayhew designated to everything Timelapse).

a. Go to File -> Load template, images, and video files...

b. Select the template file from the Access folder and open.

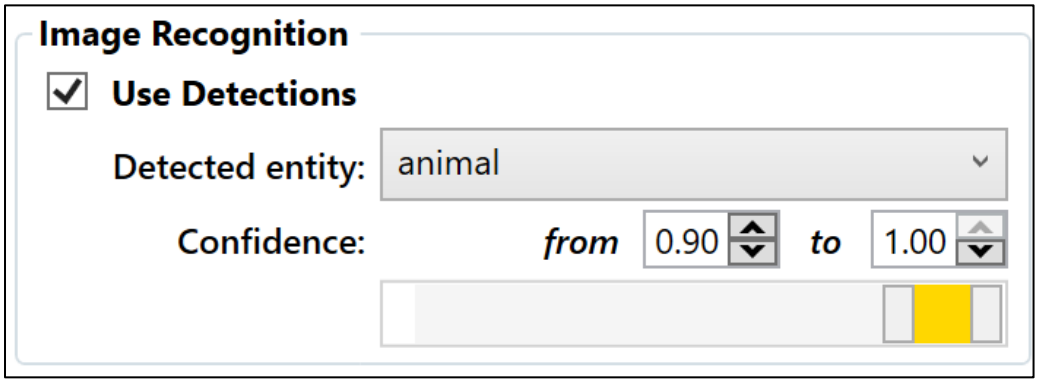
c. When the image set has opened, go to File -> Import image recognition data for this image set.

   This option above might be hidden at first. Look at the Timelapse user manual for instructions on how to make it unhidden. Also, if the file path was written wrong in the code, then it will not transfer recognition data—to troubleshoot this, you can save copy of the .json as a .txt and inspect it—to fix issues you can use the "replace" feature to fix the pathway code.

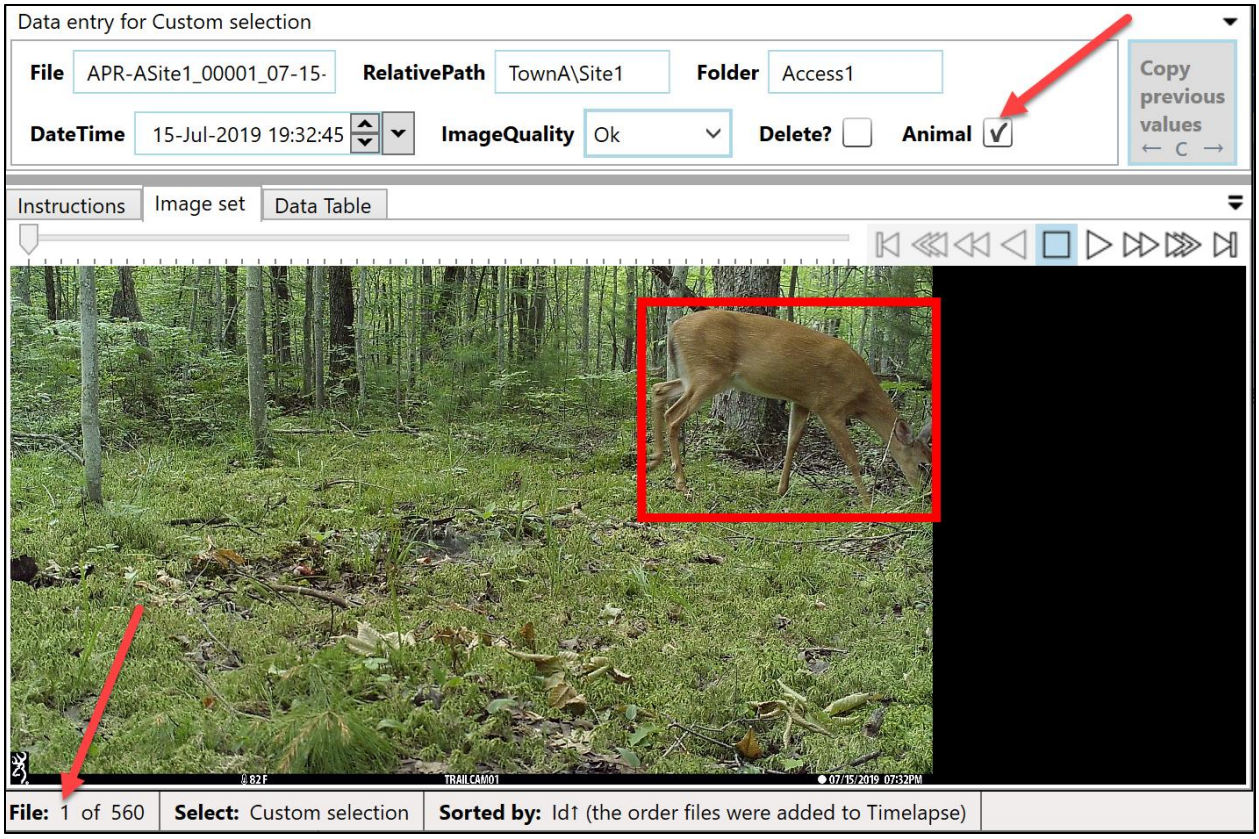
d. Select the .json file you created above and open it.

e. Go to Select -> Custom selection...

f. In the Image Recognition box, select the Use Detections check box. Make sure the Detected entity says "animal." Adjust the Confidence to 0.90 to 1.00. Click OK (see screenshot below).



g. Back on the image screen, make sure you are at the first image in the set and select the check box next to Animal (see screenshot below). Right-click on the check box next to Animal and select Copy forward to end. Click Yes in the message box that appears.



h. Go to Select -> All Files.

Do not skip this step above, it selects all files that are labeled with and without wildlife. You want to make sure that all files get exported.

i. Go to File -> Export data for this image set as a .csv file...

The data file will be exported and automatically saved to the Access (i.e., camera check) folder where the images are stored.

j. Close Timelapse.

k. Go to the Access folder where Timelapse sent the .csv file (it will still be named "Mayhew_Test_Template"). Rename the .csv file to indicate the appropriate study area, site ID, and camera check number (e.g., "APR_Bushnell_Check2").

    i. Open the CSV file in notepad or excel to make sure in the last column there are "false" and "true" labels, these are MegaDetector's assigned

labels for the photos (i.e., animal/no animal).

l. Copy the .csv and paste it at the root of the hard drive (D:\), and make sure to first delete any previous .csv file you had copied there. Rename the .csv Timelapse.csv. The name of the file must be exactly Timelapse.csv and stored exactly at the root of the hard drive (so the file address is D:\Timelapse.csv) or the next steps will not work.

    i. Make sure to rename that file at the root of the hard drive when you are done with it (e.g., Timelapse_Check3) because you will be putting the .csv file for each camera check here at the root drive and you do not want duplicates, or it will cause issues.

K. Make sure Photo Warehouse is closed. Open the database called MD_to_CPW.accdb (this is an intermediary database used to move MegaDetector data to Photo Warehouse). Follow the instructions that are displayed on the screen.

    a. When you follow the instructions, know that MegaDetector1 = "1" and MegaDetector2 = "2". These will be the observer IDs (ObsID) Photo Warehouse assigns to MegaDetector 1 and 2 (there are 2 MegaDetectors because MegaDetector uses a dual scan like a dual observer process).

    b. When you import timelapse, there will not be a pop up to indicate a successful import.

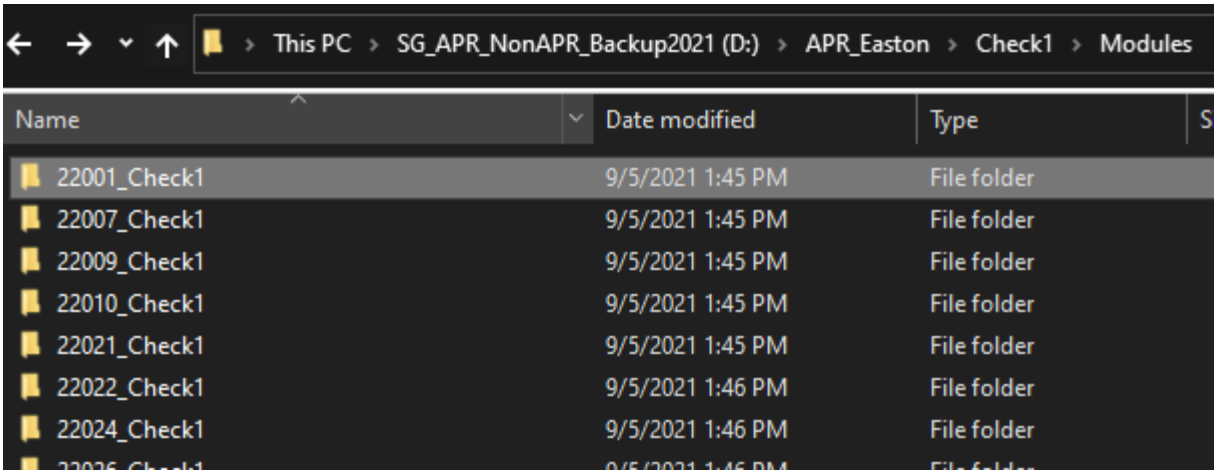
    c. You might need to manually input detection data when you upload data for the first time (it is programmed to remove any previous data but since there is none, the program may not work appropriately). If this is the case, follow this workflow: MD_to_CPW > External Data Source > New Data Source > From File > Text File > Select the Timelapse.csv from external drive's root and keep defaults > select delimited option > Specs (and keep default) > OK > Finish and close. Hit F11 to make sure that it was named Timelapse, if not right click and rename. This whole step can be tricky and may require some expert assistance.

L. Close the MD_to_CPW database.

M. To check to see if MegaDetector data successfully imported to Photo Warehouse, open Photo Warehouse, select the "View or Print a Report", and create a "Photo ID Summary" from the dropdown menu. Once the report is produced, check to see if MD1 and MD2 observers are listed as observers at the site(s) of interest for the date(s) of

interest.

N. Once you have successfully imported all photos and MegaDetector information you can create a photo module for photo ID. Go to “View Photos” from the main switchboard then use the filters on the right to determine which photos you would like to ID. You will first select “Photos that haven’t been ID’d” in the “Species” section of filters to remove all the photos that MegaDetector determined there were no animals in. When you have selected the appropriate filters, click the “Copy Photos” button. Make sure to click the “Include Runtime Database” option and copy the photos to the appropriate external hard drive (you will probably get a security warning, but just hit “Open” numerous times and it will eventually work). It is important to keep a good organizational structure when saving modules and mirror structure across seasons (e.g., APR_Easton/Check1/Modules/22001_Check1). It is easiest to create and save modules first—then you can drag and drop modules to technician flash drives later. Use spreadsheet journal to stay organized and keep track of what modules have been created (example at bottom of document). Below are screenshots of module file path for Easton Check1 modules and the content in the Easton Check1 Module for site 22001.



O. Distribute modules to technicians by copying entire module folders (e.g., 22001_Check1) to a flash drive (via drag and drop from external hard drives). Keep track of who has what modules in the designated spreadsheet journal (example at bottom of document) and keep it updated in real time (e.g., once you load 22001_Check1 on a flash drive for Technician A, immediately record it in the Excel document).

P. Once technicians have finished their assigned modules, have them give you (the data manager) the flash drive back with many completed modules (.accdr files). Import the technician's modules when they are finished—this will allow you to import data slowly and steadily—and it can prevent both flash drives and work from being lost in the mix.

Q. To import the IDs, choose the "Import Photo ID Module" option from Photo Warehouse's main switchboard, then search for the .accdr file you would like to import. Once imported, Photo Warehouse will tell you how many IDs it imported and how many are pending (i.e., not verified with a second observer) and how many were verified (i.e., they match an observation already in the database). Again, keep track of who has sent you what modules and when you have imported them in the spreadsheet journal (example at bottom of document)—and make sure to update it in real time to prevent mistakes (e.g., once you import 22001_Check1 from Technician A's flash drive, immediately record it in the Excel document).

R. Often the two photo observers will disagree on an ID. These instances get flagged in Photo Warehouse and someone will need to be the referee (the photo referee should be consistent and should be someone with years of photo-tagging experience). Do this by choosing the "Compare IDs" box from the main switchboard. Choose your name from the dropdown menu and any photos that need to be compared will pop up. If you have many flagged photos, you can filter by location to break them into easier-to-handle chunks.

    a. View the photo and decide which species, detail and individual count is correct and click the "X" next to IDs that are incorrect. Sometimes all IDs will be correct (i.e., one observer saw a doe and one saw a doe and fawn, the fawn will display in red as it was only marked by one observer), in this case you would click the "Verify All Species" button. If you make a mistake and click the "X" on the wrong line you can click the "Reset" button and all IDs will pop back up.

    b. You can use context clues to help you with refereeing by opening the original photo series and looking through surrounding photos. This can help when one observer notices a nose or piece of a leg in a photo that is easy to miss without the context of the deer popping into frame in the previous or next photo.

S. Once your spreadsheet journal (example at bottom of document) indicates all modules have been completed by 2 observers and uploaded, you will need to double check that everything is completed. It is likely that a few (or thousands) of photos will slip through the cracks and go untagged. To check, go to Photo Warehouse's main switchboard and select "View Photos". Next, use the species filter options to identify any photos that still need one or multiple observers. If photos still need to be reviewed, take note of the zone, township, date, and site. Next, you will need to share the entire module associated with the unreviewed photos, so the technician has all photos for reference. Repeat steps above to complete the process.

Below: Example of spreadsheet journal for tracking the creation and completion of modules by camera site (Point) and camera check number (Access), including the distribution (Sent) and upload of completed modules (Received) and record of technicians involved.

Zone	Township	Point	Access	Created	Sent 1	Sent 2	Received 1	Received 2	Complete	Notes
APR	Easton	22047	1	X	Jazmyn	Veronica	Jazmyn	Veronica	X	
APR	Easton	22047	2	X	Jazmyn	Rachel	Jazmyn	Rachel	X	
APR	Easton	22047	3	X	Jazmyn	Katie	Jazmyn	Katie	X	
APR	Easton	22047	4	X	Katie	Taylor	Katie	Taylor	X	
APR	Easton	22047	5	X	Amber					
APR	Easton	22047	ALL							