Yellowstone Phenology Project
Volunteer Handbook

2020

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Phenology ***noun*** *phe·nol·o·gy | \ fi-ˈnä-lə-jē*

1: a branch of science dealing with the relations between climate and periodic biological phenomena (such as bird migration or plant flowering)

2: periodic biological phenomena that are correlated with climatic conditions

The study of nature's calendar

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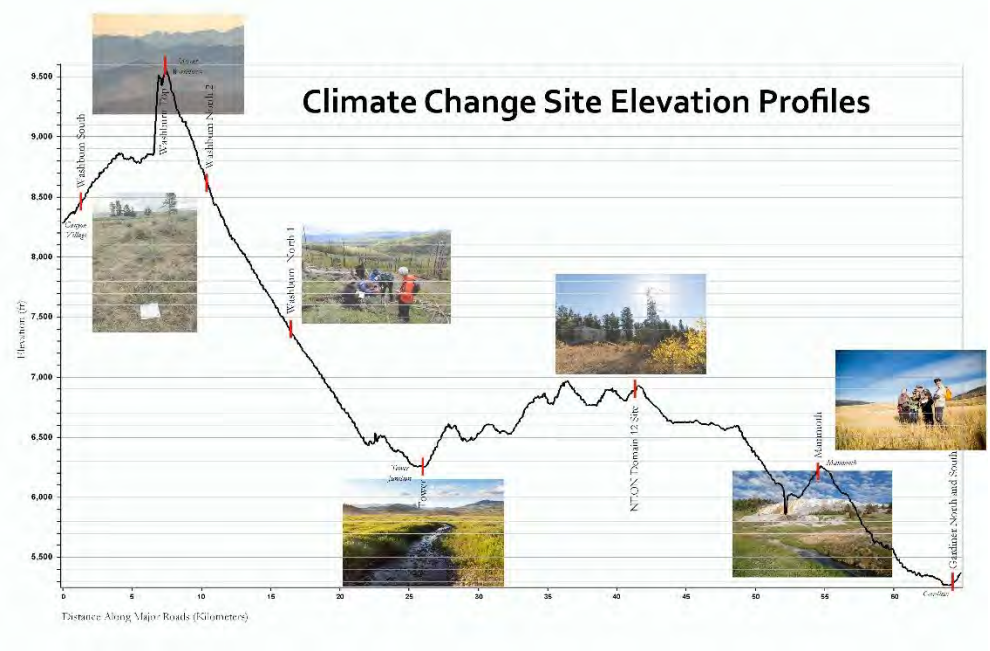
INTRODUCTION

The *Yellowstone Phenology Project* is a citizen science initiative designed to monitor environmental change over time across a 5,000' elevation gradient in Yellowstone National Park. The project contributes additional monitoring elements to baseline data gathered at seven sites from Gardiner Basin to the top of Mt. Washburn (Figure 1).



These sites were originally established in 2008 by the park's physical scientist, Dr. Ann Rodman, to monitor pollinator diversity and abundance. Since its inception, remote sensing equipment has been added to these climate change monitoring plots. The *Yellowstone Phenology Project* has established ten invertebrate pitfall traps and three plant transects at all seven climate change sites.

Located in the middle of this elevation gradient, the National Science Foundation's NEON (National Ecological Observatory Network) site completed construction in 2018. The NEON site in Yellowstone is one of 81 locations across the United States (Figure 2) that utilizes sophisticated methodologies to monitor 32 environmental conditions, including documenting carabid beetle diversity. The *Yellowstone Phenology Project* extends the NEON dataset to cover a wider elevation gradient by replicating the NEON carabid beetle field protocols.

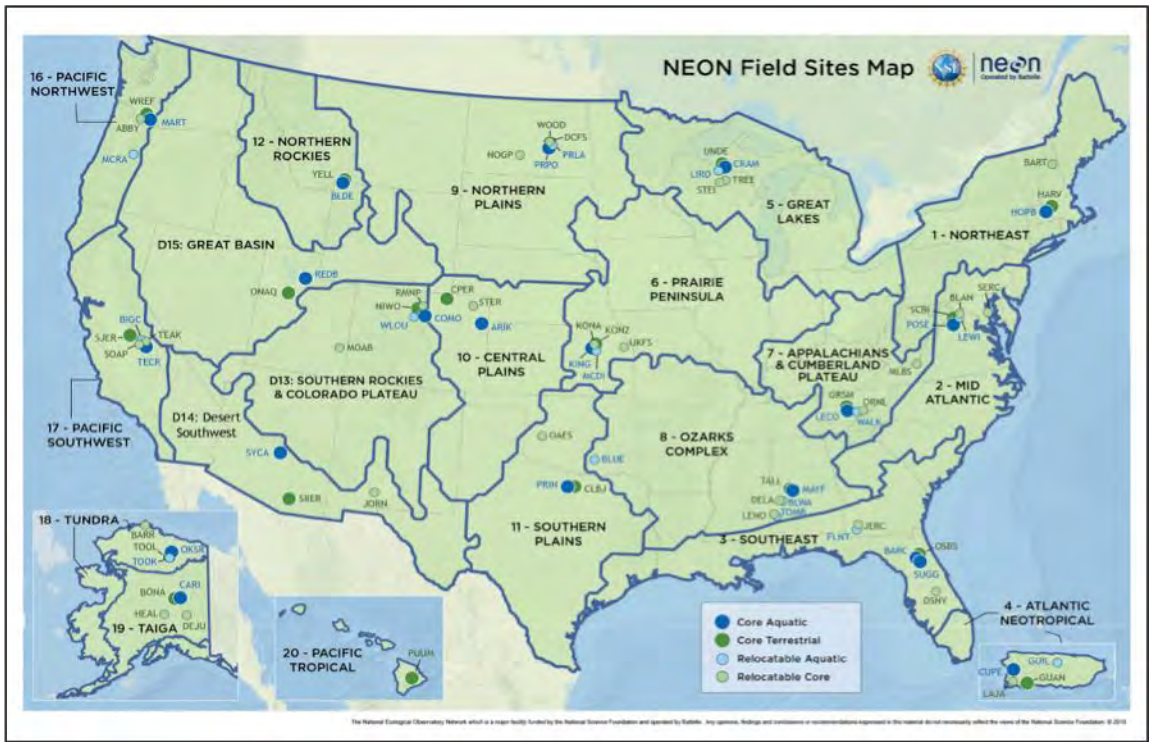


Figure 2. NSF's National Ecological Observatory Network

Figure 3. Pitfall trap.

Carabids, collected with pitfall traps (Figure 3), are a well-documented family of ground beetles that may serve as an indicator of environmental health and change. Carabid samples will supplement Yellowstone's beetle catalog housed at the Heritage and Research Center. Other invertebrate samples contained in the pitfall traps will be available to collaborating institutions for further research. Many new park species and range extensions are expected to result from this work. Data derived from *orthoptera* (grasshopper) diversity and abundance samples will also contribute to *Home on the Range* research objectives.

Plant phenology transects are located at each of the three points associated with the seven climate change sites. Citizen scientists identify plants falling along these transects and document phenophases including first flower, first fruit/seed, and brown out. The timing of these events is correlated with environmental changes.

Yellowstone National Park has developed strategic priorities with key focus areas that can be sequenced, funded and implemented. These priorities serve as a guide and citizen science volunteers help achieve them as follows:

1) **Focusing on the Core** – Improve strategic management and business acumen; improve organizational alignment and effectiveness. Citizen science volunteers with proper training contribute to cost effective workforce performance. Pilot projects in 2018 contributed in-kind support and cash donations equaling $51, 678. Over 2000 volunteers were engaged with a 100% safety success rate. When volunteers participate in field and lab work, operational workloads are managed more efficiently.
2) **Strengthening Ecosystem and Heritage Resources** – Advance and sustain the Yellowstone Ecosystem; promote and protect Yellowstone's cultural heritage. The Phenology project contributes directly to Yellowstone's climate monitoring effort. The volunteers document wildlife and vegetation resource conditions at a fine scale to inform landscape level management decisions. This effort was developed through collaboration with NEON, and has since fostered cooperative research with Montana State University, Colorado State University, the University of Nebraska and the USDA (office of Plant Protection and Quarantine). Data generated will provide critical information for focal species (ungulates and sage habitat) as well as inform larger trends that may be incorporated into climate adaptation response planning.
3) **Delivering a World Class Visitor Experience** – Understand and respond to increased visitor use; connect people to Yellowstone. Having a cadre of trained volunteers allows for more flexibility to supplement staffing needs. Volunteers make excellent program ambassadors to explain project objectives and recruit new volunteers. 40% of the 2019 Phenology project's 29 volunteers were recruited by 2018 participants. Local and regional residents have often moved here to enjoy the GYE and are highly motivated to "give something back" to the park. Hands-on stewardship programs offer powerful kinesthetic learning experiences and program participants enjoy "dive deep" learning about park resources like plant ecology, invasive species impacts, ungulate guild dynamics, raptor population trends, invertebrate taxonomy, museum curation, and database management. These deep connections foster a better understanding for resource management complexities and give a tangible sense "doing something real" to benefit the park by following rigorous scientific protocols to collect useable specimens and data. Participants become well-informed resource stewards and park advocates. Participants return to the park many times throughout the season, building a community of practice by making personal connections to YF, YCR staff, and each other.
4) **Building Coalitions and Partnerships** – Strengthen Yellowstone Forever and Philanthropic Capacity; Build Trust with Gateway Communities; Strengthen Conservation, Environmental, Economic, and Recreation Partnerships. YCR staff prioritizes program needs that may benefit from citizen science, and YF assists with recruiting, training, and working in the field with volunteers (Figure 4). YF added citizen science to its strategic priorities in 2018 and hired a full-time program manager. Citizen science collaboration has made significant contributions to strengthening partnerships

between YCR and YF. Gardiner, Livingston, Bozeman, Billings, and several Native American communities have contributed to Yellowstone Citizen Science.

Figure 4. 2019 Citizen science volunteers and Park staff.

Yellowstone Forever Phenology Project home page:

https://www.yellowstone.org/experience/citizen-science/phenology-project/

SCHEDULE OF WORK 2020

Pitfall traps will be checked, emptied, and reset and plant transects will be read every 14 days so that the samples from each bout are directly comparable. The sampling will occur consistently every 2 weeks for the entire field season, on the same day of the week, and at roughly the same time of day as follows:

April 10, day trip, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm (no housing)
April 24, shared cabin housing available in Gardiner, MT, check in 4-8pm,
April 25, shared cabin housing available in Gardiner, MT, check out by 9am, April 26

May 8, day trip, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm (no housing)
May 22, shared cabin housing available in Gardiner, MT, check in 4-8pm
May 23, shared cabin housing available in Gardiner, MT, check out by 9am, May 24

June 5, day trip, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm (no housing)
June 20, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm, shared cabin housing available in Gardiner, MT, check in 4-8pm, check out by 9am, June 21

July 3, day trip, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm (no housing)
July 18, shared cabin housing available in Gardiner, MT, check in 4-8pm, check out by 9am, July 19
July 31, day trip, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm (no housing)

August 14, shared cabin housing available in Gardiner, MT, check in 4-8pm
August 15, shared cabin housing available in Gardiner, MT, check out by 9am, August 16
August 28, day trip, meet @ YF Bookstore in Gardiner, MT @ 8:00am, finish by 4pm (no housing)

September 11, shared cabin housing available in Gardiner, MT, check in 4-8pm
September 12, shared cabin housing available in Gardiner, MT, check out by 9am, September 13
September 25, day trip, meet @ YF Bookstore in Gardiner, MT @ 9am, finish by 4pm (no housing)

October 9, shared cabin housing available in Gardiner, MT, check in 4-8pm
October 10, shared cabin housing available in Gardiner, MT, check out by 9am, October 11

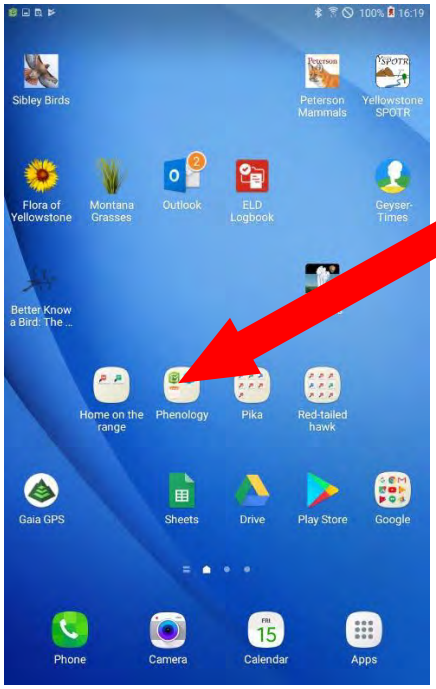
PROTOCOLS

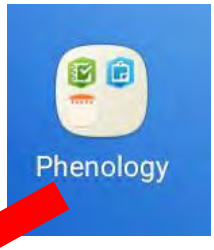
NAVIGATING TO THE SITE

Use Yellowstone Forever's Samsung tablets to navigate to the YNP Phenology Project sites, using the Collector app. To collect data, use the Survey123 app.

Using Collector to Locate Phenology Project Sample Sites

1. Power the tablet on by pushing the external button on the upper right edge of the tablet.
2. From the home screen locate and open the Phenology folder.

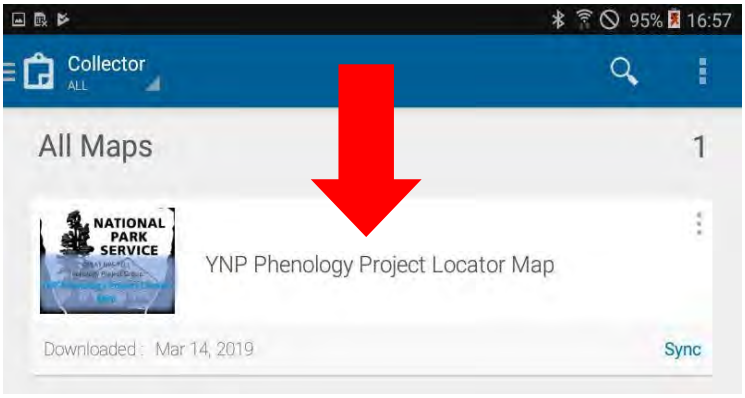




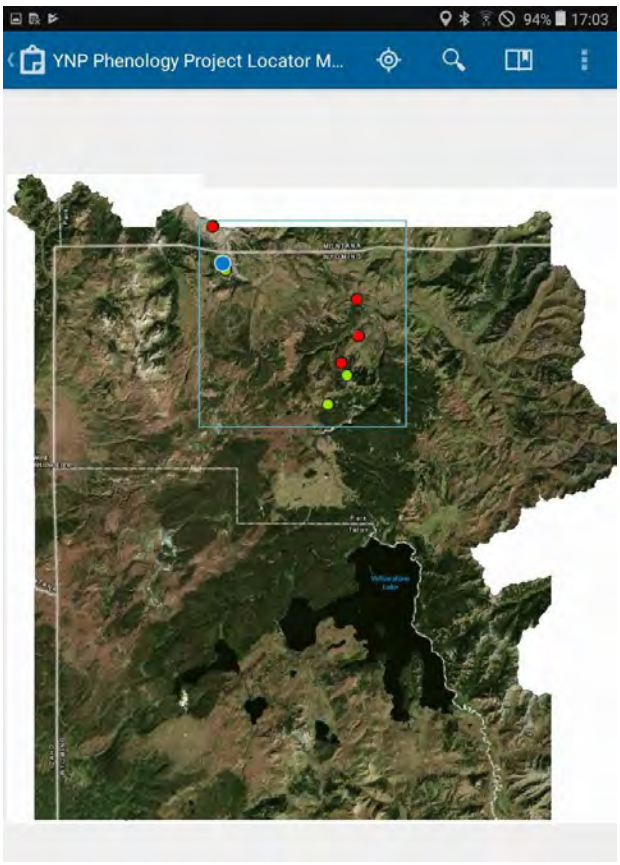
3. The next screen will show icons for three apps: Survey 123, Collector and Memos. Use the Collector app to navigate to sites; Use Survey 123 to collect site data.
Memo app is a place to take notes and save them on the tablet.

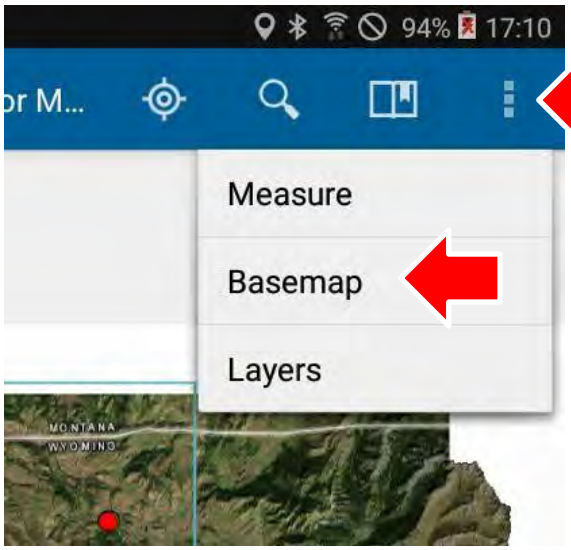
4. Tap the Collector app icon to open it.

5. The screen that appears shows the maps that are stored on this device. Tap on the YNP Phenology Project Locator Map.



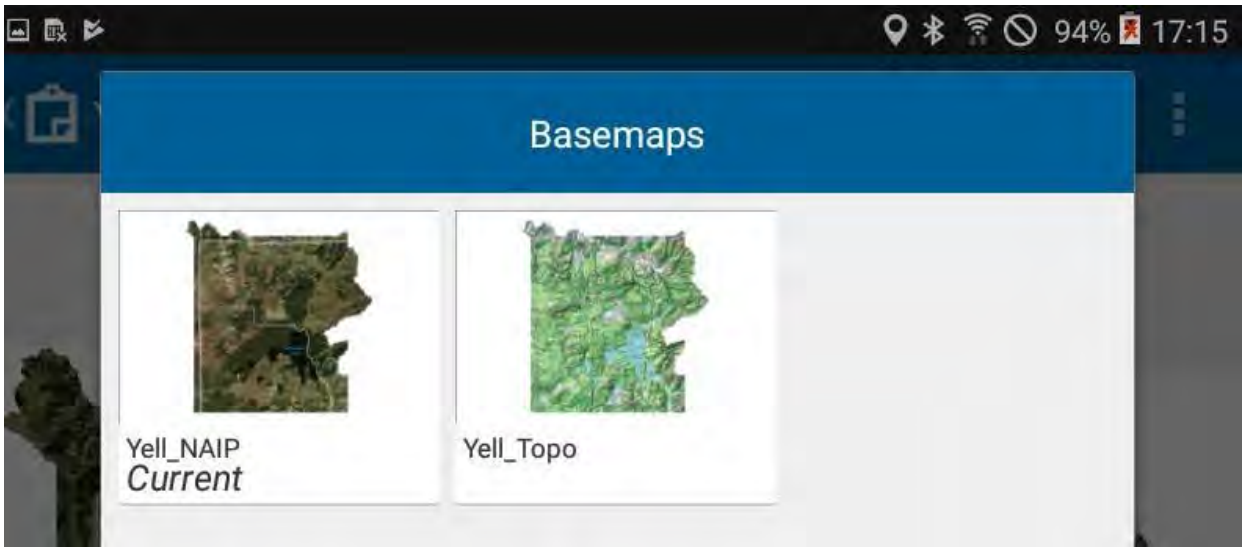
6. A map will open showing imagery of YNP with several colored dots. The blue dot represents your present location and will move with you even if your device is not connected to a signal. If the blue dot is grey go to an open canopy area to get a satellite location fix.



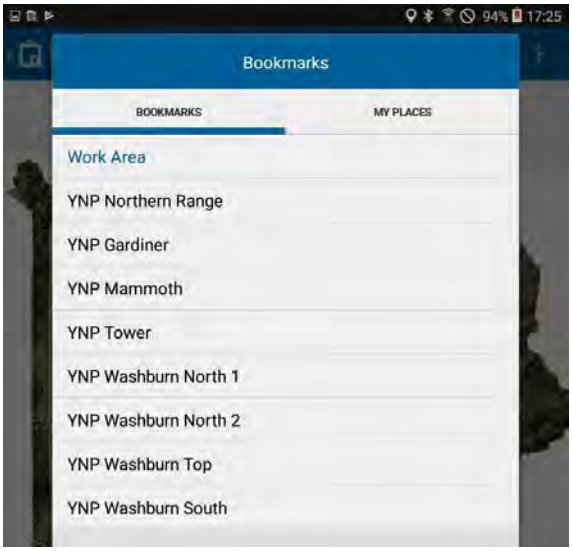


7. If you tap the three vertical squares in the upper right side of the screen a drop down will appear, tap Basemap.

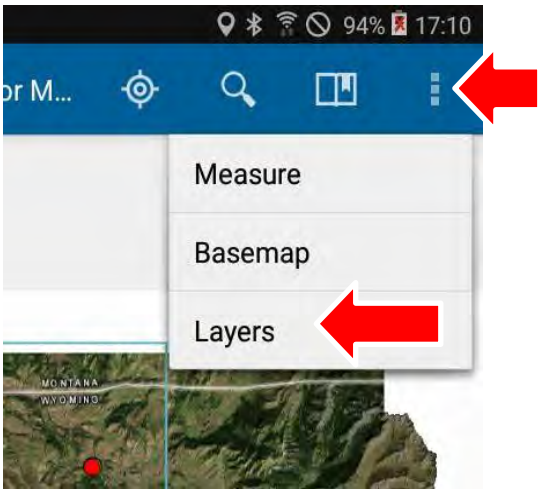
8. The screen that appears will show your basemap options. Yell_NAIP is satellite imagery and Yell_Topo is a topographic map. Toggle between these for the background you prefer at any time. For driving to the site use Yell_Topo to see roads and other land marks. For locating the sample sites use Yell_NAIP. Tap map to select.

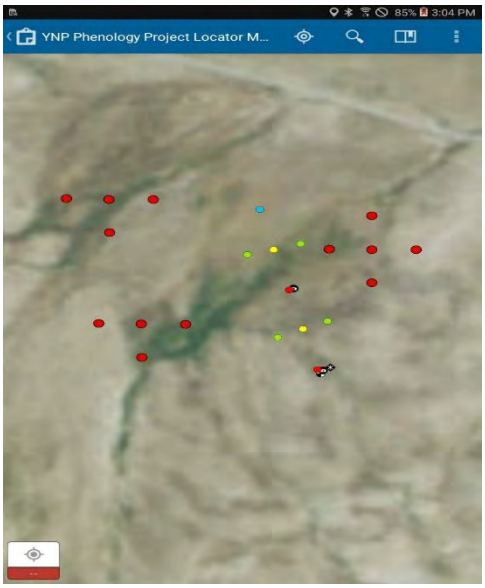


9. The icon below is the bookmarks icon. Tapping this will show a list of our sampling locations which will zoom your map to your area of interest.



10. Once zoomed in to your area of interest, you will see a cluster of dots. Tapping on the three vertical dots on the upper right will bring up the drop down menu you saw before. This time tap on Layers.





11. Touch either a red circle pitfall icon, or a yellow circle plant transect icon and follow your blue dot until you arrive. Once you are close, put the tablet down and look around for the white square pitfall - it is now time for you to conduct your sampling and switch to viewing the Survey 123 app. When you are ready to resume navigation to your next site return to Collector for help locating it.

12. If you do not record anything in the comments field and you only use this map for locating your sites, you are done. However, if you did record comments then you need to push those edits back to “the cloud” once you are able to reconnect the tablet to a wifi or LTE network via a mobile hot spot. See the Synching Collector section for more instructions.

PITFALL SERVICING

Phase One: Preparation

1. Checklist the "Kit" before leaving the classroom. Resupply as needed. Make sure Tablet is fully charged. Some supplies will need to be carried in back packs. They won't all fit in the tool tray (Figure 5).

2. Drive to the site area, park in a safe spot and walk to the collection site carrying the kit. You can use the "collector" app, select Basemaps, and then YELL_Topo_Current to navigate to the site both driving and hiking. Be aware of your surroundings, keeping a watchful eye on the bison, elk, deer, or other wildlife. Stay back 25 yards.

3. Using the Tablet, navigate to the collection site.

4. Approach the site from the side while avoiding areas marked with yellow/blue circles on the map (Figure 6). These are the "core" climate monitoring areas we need to avoid walking through. Sound recorders are active – be mindful.

5. The writing on the white cover plate (Figure 7) is on the side toward the center rebar. As you approach from the outside, the writing on the cover plate should be away from you. Approaching from the outside minimizes vegetation trampling.

Figure 7. Cover plate.

6. Set kneeler down on ground behind cover plate by approximately 1.5 feet (Figure 8). The Primary person kneels onto pad. The Secondary person stays behind the Primary and acts as an assistant.

Figure 5. Carrying supplies in the field.

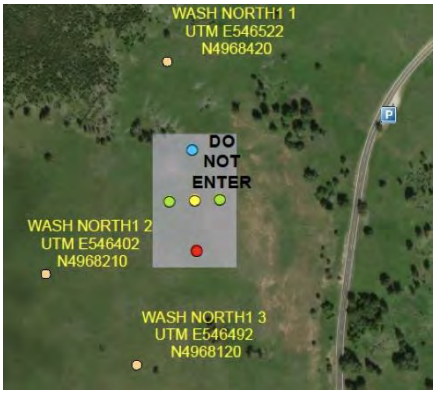


Figure 6. Approach the site from the side.

Figure 8. Kneeler and cover plate.

Phase Two: Collecting the Pitfall Sample

The priority of the following procedure is to secure the specimen packet into the gallon Ziploc. Once the insect packet is secure, you can then reset the pitfall trap and tidy up the area.

Figure 9. Cutting labels.

1. Prep wash bottle with filter fabric.

2. Pull out the labels sheet. Find and confirm a strip of labels matching the site location (i.e. MAMM) and pitfall code (i.e. 1S) match what is written on the plastic cover plate. Cut a strip of 3 labels (Figure 9) and hold aside by putting labels into a shirt pocket. Protect labels from flying away.

3. Pull out a whirl pack and spread it open. Blow into it to open it up completely.

4. Place two clean empty deli cups in front of you, one to the left and one to the right.

5. Put on a pair of skin protecting gloves. The clay in the dirt is very drying.

6. Remove 3 of the 4 stakes. Lift and carefully swing plate and wire grid, together as one unit, toward downhill side so plate does not bump into slope (Figure 10). Avoid knocking dirt into the pitfall cup.

Figure 10. Swing cover plate to the downhill side.

7. Carefully lift out collection cup filled with glycol, insects and labels. Leave the second deli cup with drainage holes in the ground. Clean out dirt and rocks from drain cup.

8. Set the specimen collection cup between the two clean deli cups.

9. Fish out the labels from the specimen cup (Figure 11). Rinse them with water over the right-side deli cup.

Figure 11. Remove labels.

10. Place the wet labels (text facing out) inside the whirl pack and set aside. Strain the insect specimen and glycol through the fabric into the deli cup on the left side. Set this cup with strained glycol aside to the left. This cup of strained glycol will be reused later when resetting the trap. Catch the rinse water into the deli cup on the right side. Inspect the cup for any straggler insects, rinse again, strain through fabric, catch liquid into the cup on the right side (Figure 12). Try to be conservative with rinse water because this strained water gets poured into the "Glycol Discard" bottle which needs to have enough room to service 10 sites.

Figure 12. Strain and rinse specimen, catching glycol and rinse water in deli cups.

11. Holding on from the bottom of the bottle, gently clasp the filter fabric while unscrewing the ring from wash bottle. Barely pull the wash bottle away from the ring. The bottle, fabric and rings should all be in close contact while you rinse the neck of the bottle of any straggler insects. Inspect bottle to ensure all specimens have washed into filter fabric.

12. Gently remove wash bottle and ring and set aside. You should now be holding only the filter fabric filled with insects.

13. Gather the four corners of the fabric together (Figure 13). Twist the four corners together. Do not squish the insects! This will leave open gaps in the fabric pouch and that is just fine.

14. Secure the fabric with a small binder clip (Figure 13).

15. Place the insect packet in a whirl pack. Blow into the whirl pack forcing the insect packet to the bottom.

Figure 13. Insect specimen in filter fabric, held by four corners and secured with binder clip.

16. Ensure the out-facing labels and the insect packet are both securely at the bottom of the whirl pack. Squirt ethanol into the pack so the insect packet and labels are covered using about 1.5"-2.0" of ethanol (Figure 14).

17. Place whirl pack against your thigh, press pack flat to push air out.

18. Grab metal twist ends and flip or whirl the pack to seal in contents (Figure 15). Twist the metal ties together.

19. Place the whirl pack with insect packet and labels into the large gallon Ziploc bag (Figure 16).

Figure 14. Add ethanol.

Figure 15. Ensure labels are visible, whirl the bag, and seal contents.

Figure 16. Ziploc bag with whirl packs.

Phase Three: Reset the Trap and Tidy Up

1. Pour the rinse water collected in the right-side deli cup into the Glycol Discard bottle. Reseal the bottle and set in carrying tray. Wipe out the deli cup and set in tray.

2. Place a strip of three site matching new (current date forward) labels into the strained glycol cup.

3. Make sure the labels are deep in the liquid, either plastered onto the side or on the bottom.

4. Top off the glycol if necessary so cup is about a third full. Fill to the bottom line etched onto cup.

5. Clean out the drainage cup.

6. Place the strained glycol cup back into the base cup and press into place (Figure 17). Inspect the outer edges of the glycol cup. The surrounding dirt needs to be pressed flush to the edge of the rim.

7. Carefully swing metal grid and plastic cover back into place. The metal grid is to help keep larger animals from falling into the cup.

Figure 17. Replace glycol cup with new labels into base cup.

8. The metal grid should lightly rest on the dirt while the plastic cover hovers above it. Reset pvc spacers if needed to keep trap lid above ground level.

9. Reinsert the stakes into original holes (if possible).

10. Leave about an inch of stake showing above the plastic cover. Tidy up your supplies making sure all bottle caps are secured and tools are returned to the kit.

11. Stand up and fold up kneeler, back out of the pitfall site, open Tablet and answer questions regarding the collection site, using the Survey 123 app. (Detailed instructions for Survey 123 app use in next section.)

Navigate to next site.

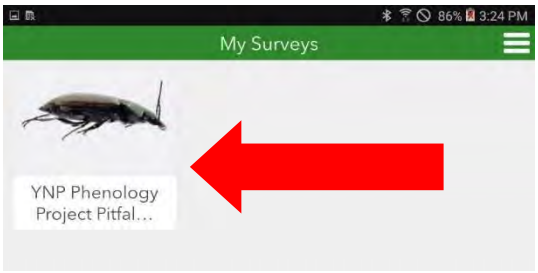
For additional details and to see the protocol demonstrated, a video tutorial of the pitfall servicing protocol is available at

https://youtu.be/XDsiTtf2qjY

USING SURVEY 123 TO RECORD PITFALL OBSERVATION DATA

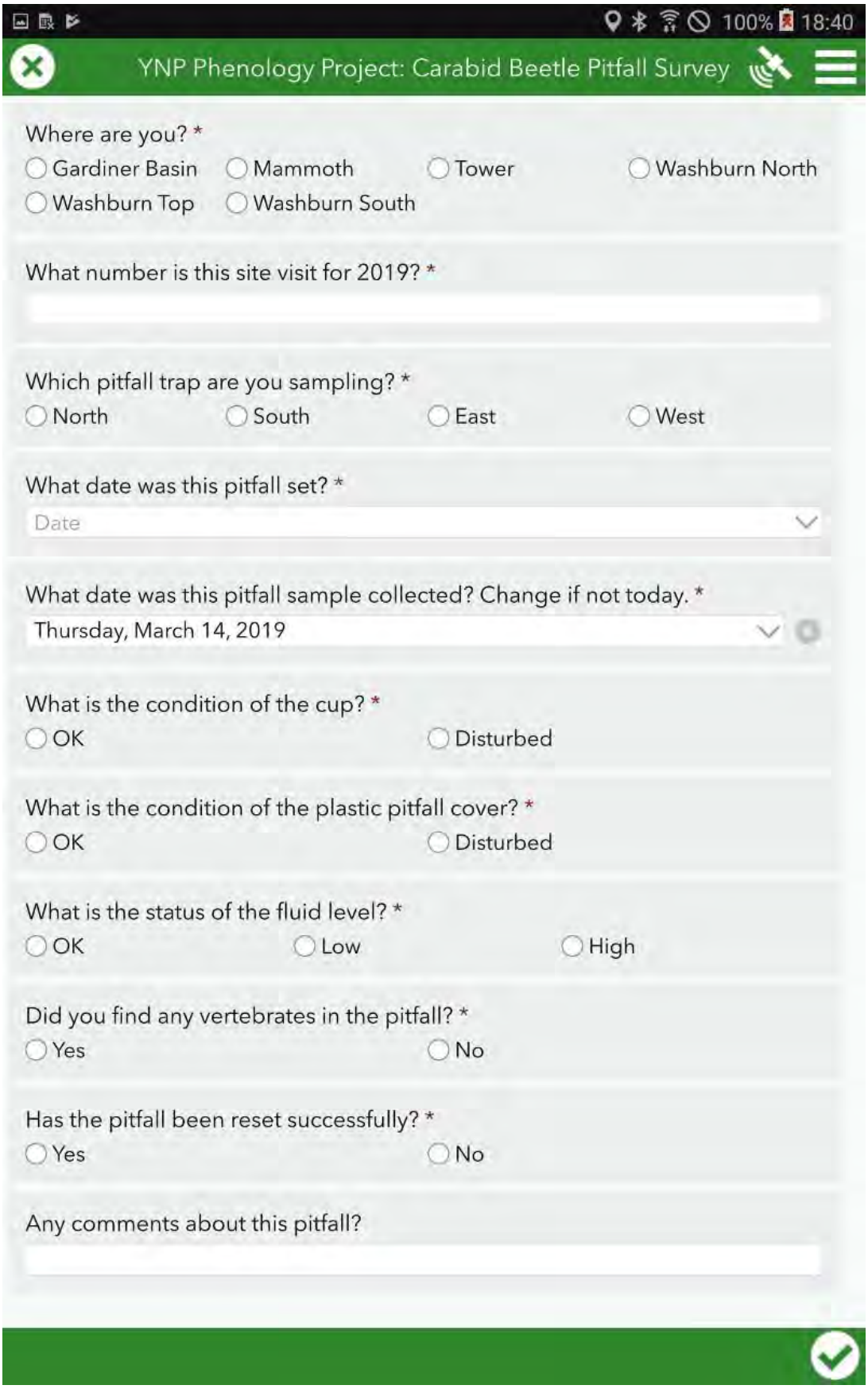
1. Press the home button on your tablet (the oval button in the bottom center of your device) to escape Collector. On the home screen locate the Phenology folder as you previously did, open it, but this time tap the Survey 123 icon.

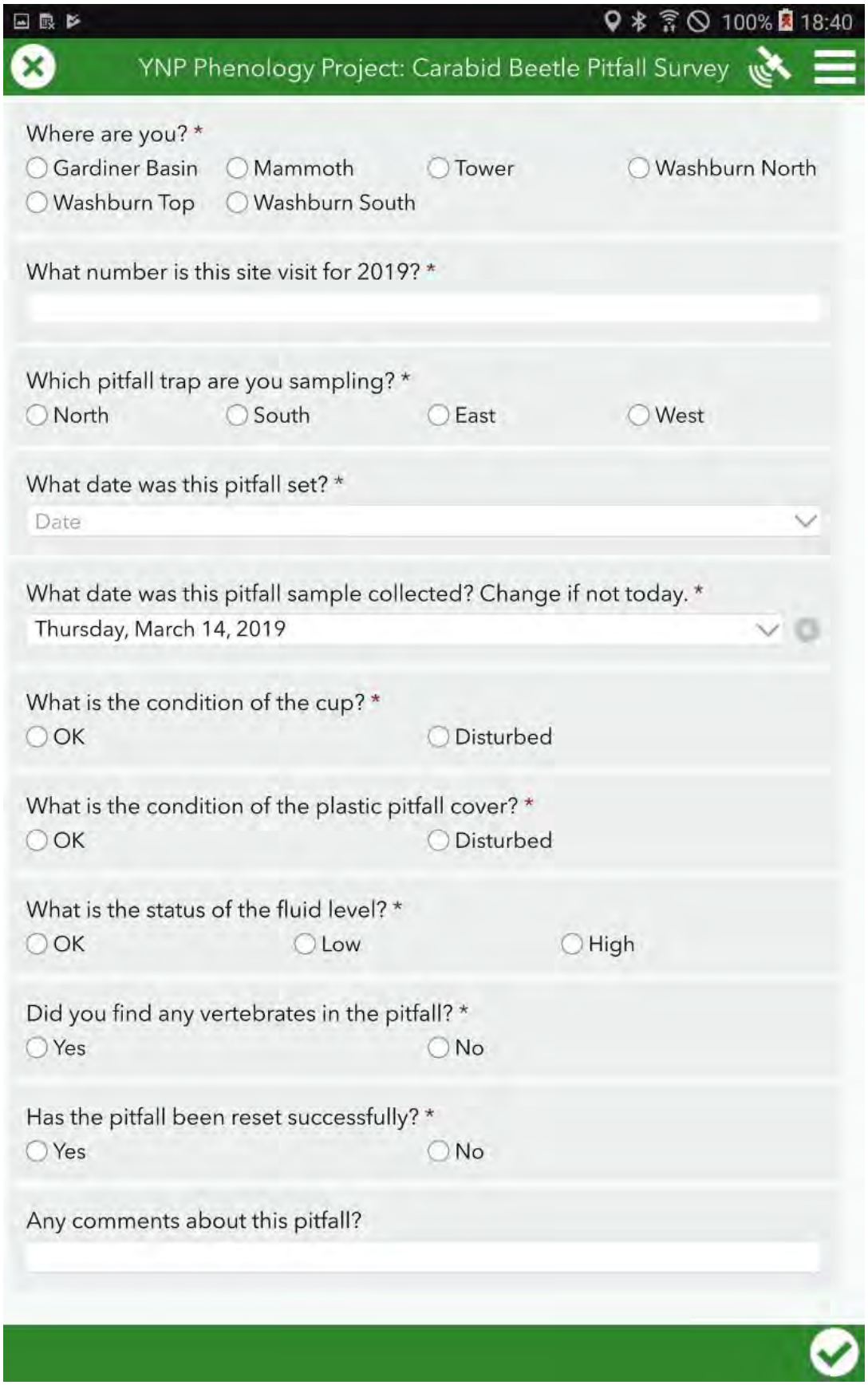
2. Allow the app to load; this will take a few seconds. Once loaded you will see a screen titled "My Surveys"; tap the YNP Phenology Project Survey icon.



3. Tap on the "Collect" icon at the left bottom of the new screen that is launched. This will load the survey.

4. Respond to the questions asked for each pitfall site that you visit by either tapping the radio buttons or typing the information requested. Responses to all questions are required except for the last question requesting comment; this is optional. When you have completed the survey tap the check mark in the lower right-hand corner. This will launch a screen that says that the survey is completed and has been saved in the outbox. Screenshots of the survey questions:


100% 18:40
YNP Phenology Project: Carabid Beetle Pitfall Survey
Where are you? *
Gardiner Basin
Mammoth
Tower
Washburn North
Washburn Top
Washburn South
What number is this site visit for 2019? *
Which pitfall trap are you sampling? *
North
South
East
West
What date was this pitfall set? *
Date
What date was this pitfall sample collected? Change if not today. *
Thursday, March 14, 2019
What is the condition of the cup? *
OK
Disturbed
What is the condition of the plastic pitfall cover? *
OK
Disturbed
What is the status of the fluid level? *
OK
Low
High
Did you find any vertebrates in the pitfall? *
Yes
No
Has the pitfall been reset successfully? *
Yes
No
Any comments about this pitfall?


100% 18:40
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Where are you? *
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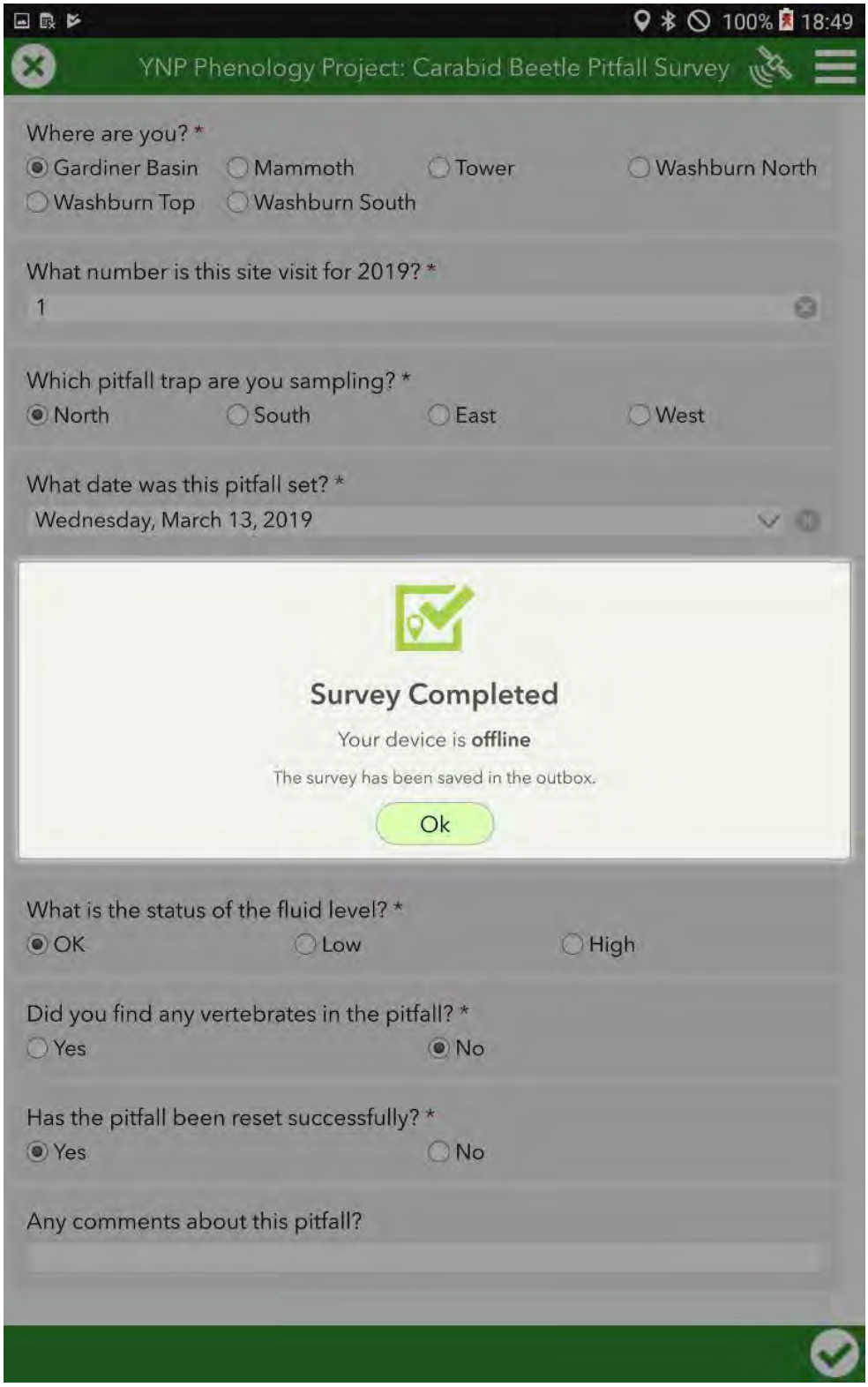
OK
Low
High
Did you find any vertebrates in the pitfall? *
Yes
No
Has the pitfall been reset successfully? *
Yes
No
Any comments about this pitfall?

5. Tap the OK button. If you need to return to the Collector App to locate your next sample site, press the home button and navigate back to Collector. Once you have located your next sample site repeat the above steps to fill out a new survey for your next pitfall sample.



READING PLANT PHENOLOGY TRANSECTS

Plant Observation Protocol

This protocol is repeated three times at each site. 1-2 person teams are used to read plant transects. If two people are available, one reads the transect, the other captures observation data on the tablet using Survey 123. See user guide. Otherwise one person must read transect and enter observations.

1. Locate the yellow rebar center stake, 1 Center, 2 Center, or 3 Center (Figure 18).

Figure 18. Yellow rebar stake.

2. Next locate the yellow and blue rebar transect end stake, 16 meters away (Figure 19). This stake will always point towards the core (do not enter) climate monitoring plot, in between cardinal directions, i.e. NE, SW, etc.

Figure 19. Blue rebar stake.

3. The plot reader slides the metal tab end of the measuring tape over the top of the yellow rebar center stake down to the ground, walks towards the yellow/ blue stake, keeping to the left of the tape as it unspools (Figure 20), and wraps the tape three times around the base of the yellow/blue stake. Try to make as straight a line as possible. Weave tape under shrubs down to the ground as needed.

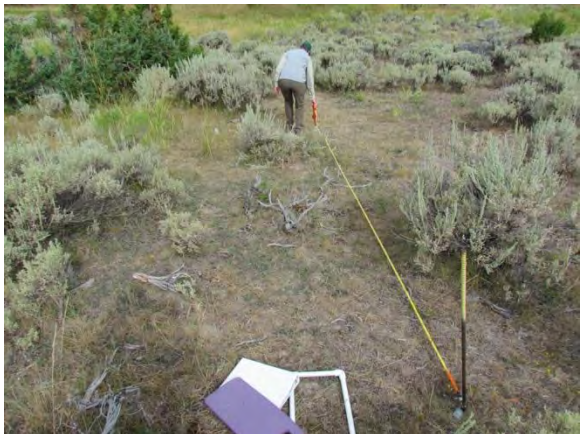


Figure 20. Plot reader walking towards blue stake, keeping tape straight and close to the ground.

4. Return to center stake, avoiding the “read on right” side of the tape.

5. Take out the Daubenmire, go to meter mark 5, center the frame on the 5m mark, perpendicular to the tape, (short axis of frame touching tape) (Figure 21).

Figure 21. Place frame along the tape.

6. Using kneelers, closely examine all plants with stems in frame. Ask data entry team member to read the dropdown species list, and use plant guide to ID plant species present and phenophase (i.e. sticky geranium, full flower) (Figure 22). Record data in Survey 123.

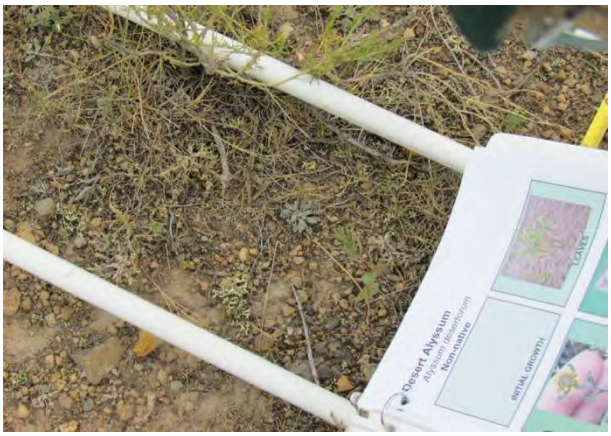


Figure 22. Use plant guide to identify species and phenophase.

7. Repeat 10 times at every meter mark (5m-14m).

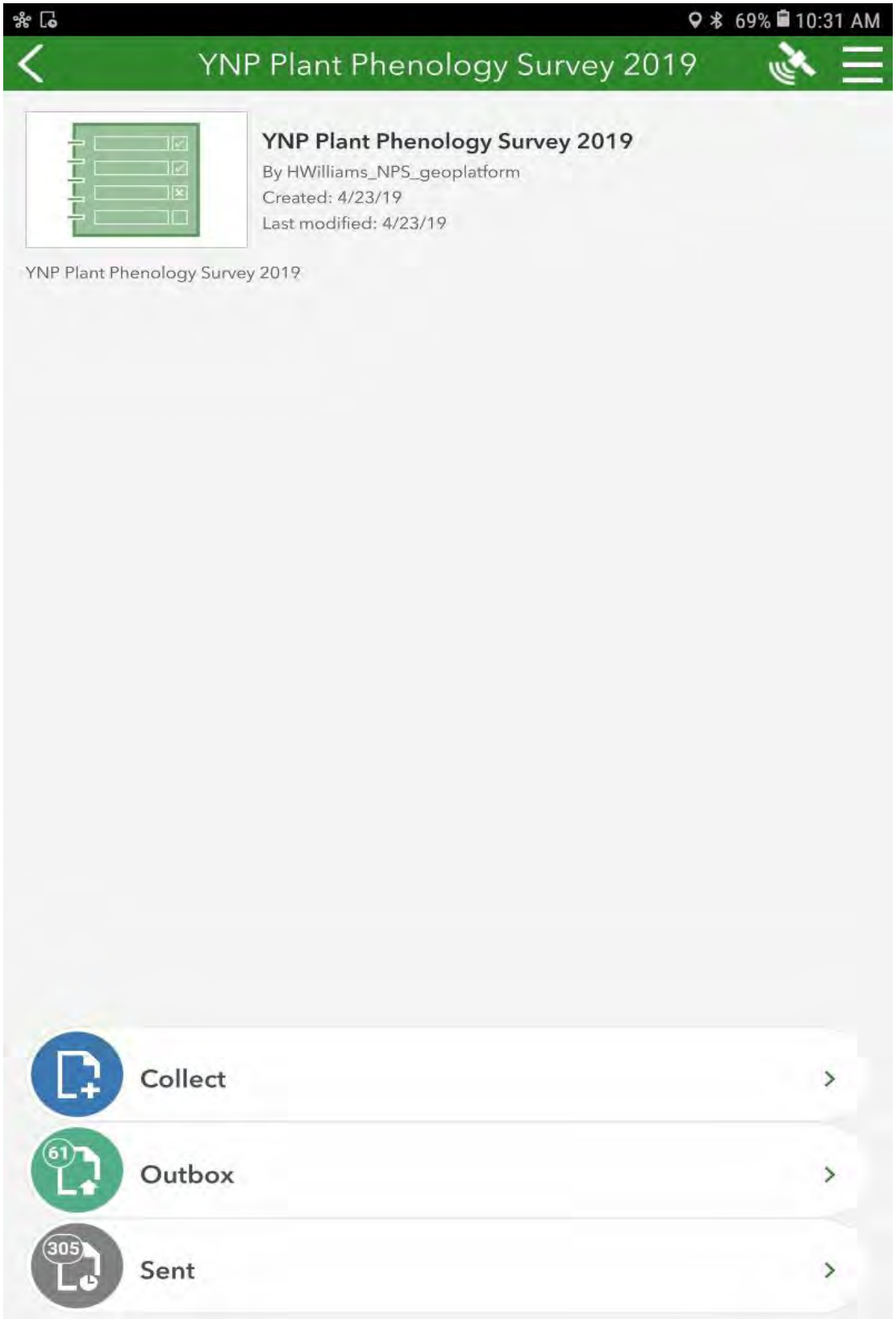
8. Unwrap tape, walk back, avoiding the “read on right” side of the tape, secure all gear.

9. Navigate to the next center stake.

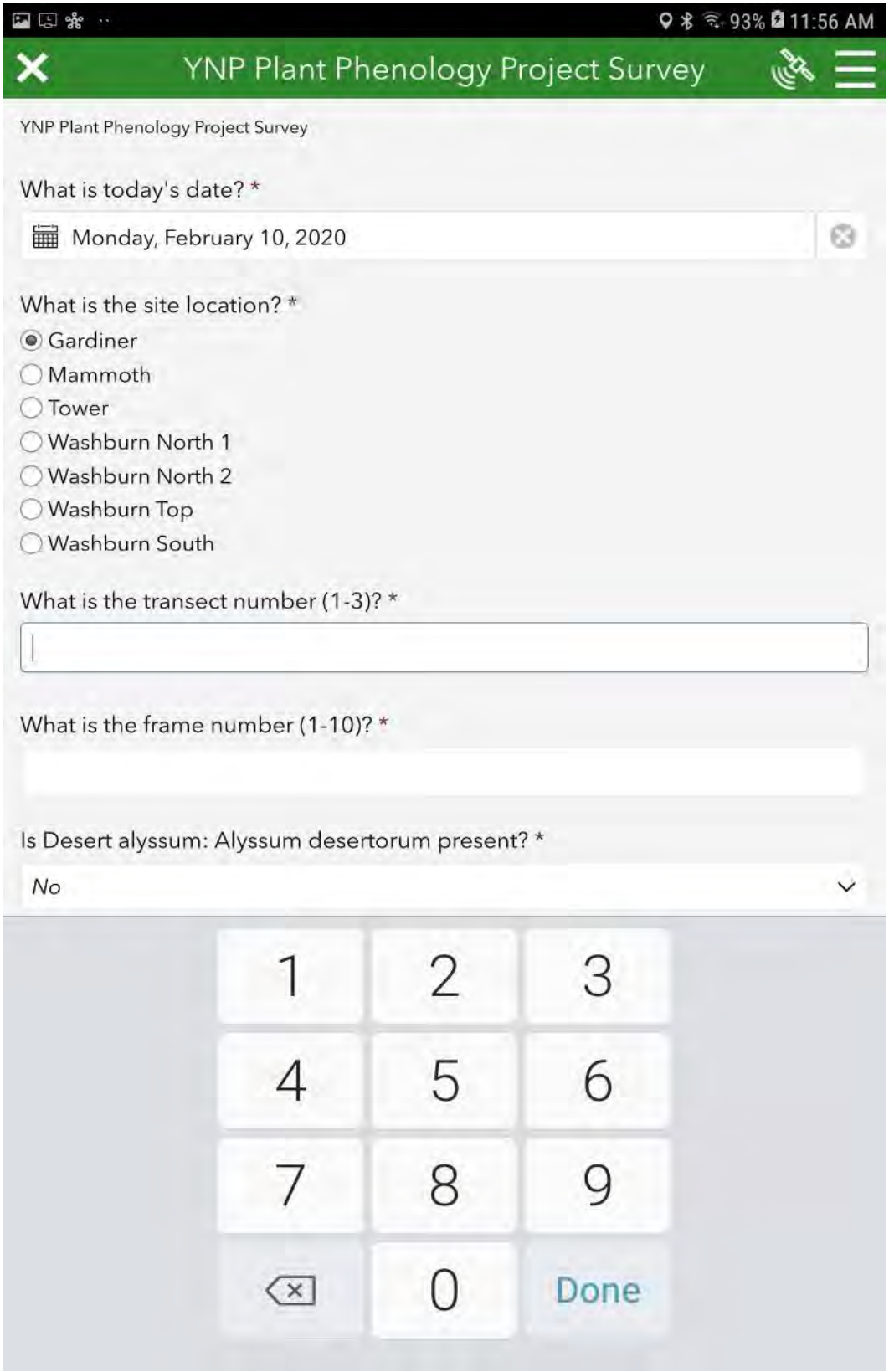
For additional details and to see the protocol demonstrated, a video tutorial of the plant survey protocol is available at:

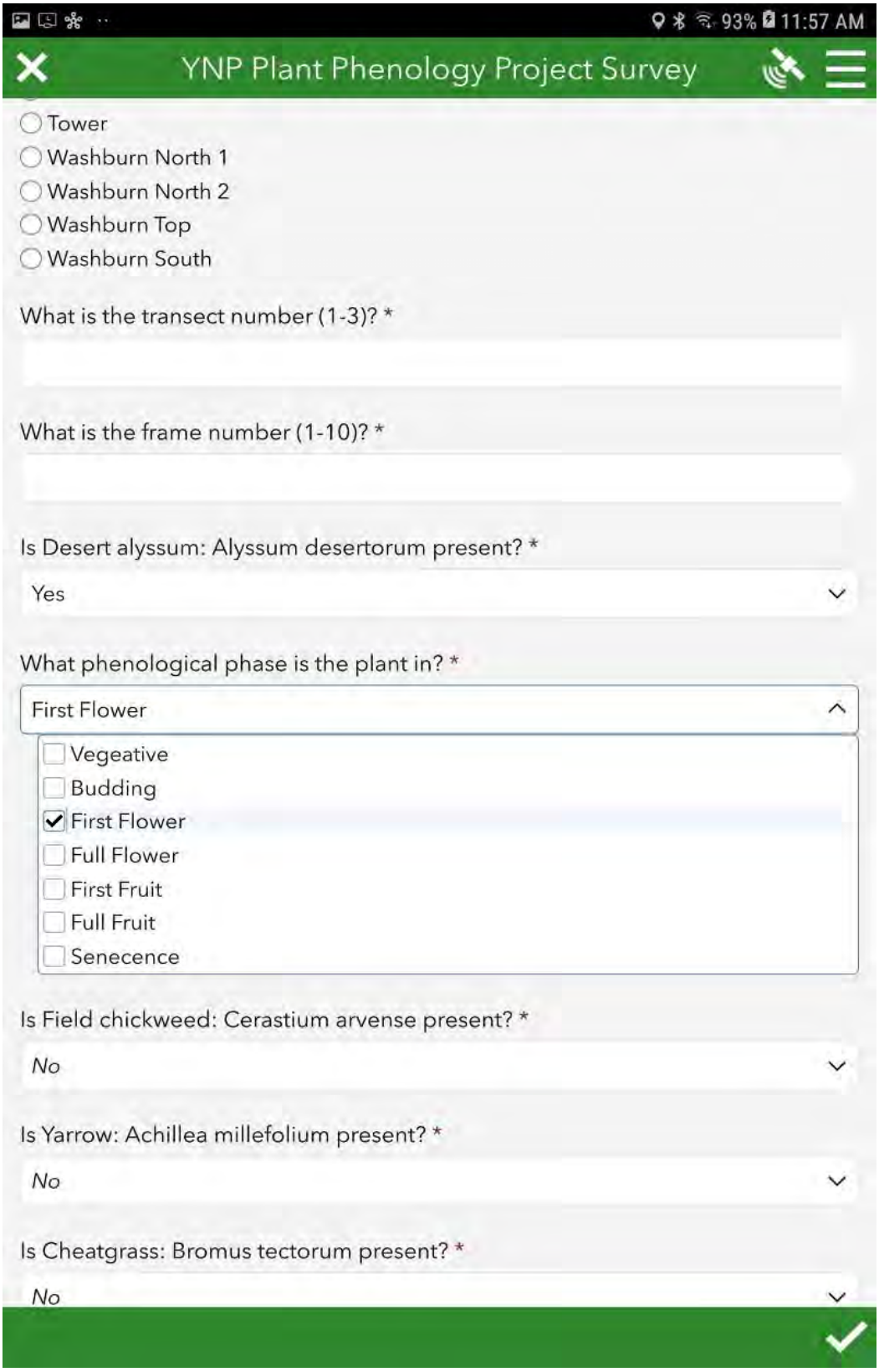
https://youtu.be/g6L21ZyUDts

Using Survey 123 to Record Plant Data




92% 12:00 PM
YNP Plant Phenology Project Survey
YNP Plant Phenology Project Survey
What is today's date? *
Monday, February 10, 2020
February
2020
Sun Mon Tue Wed Thu Fri Sat
26 27 28 29 30 31 1
2 3 4 5 6 7 8
9 10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28 29
1 2 3 4 5 6 7
What is the site location? *
Gardiner
Mammoth
Tower
Washburn North 1
Washburn North 2
Washburn Top
Washburn South
What is the transect number (1-3)? *
What is the frame number (1-10)? *
Where pollinators present? Please describe.


93% 11:56 AM
YNP Plant Phenology Project Survey
YNP Plant Phenology Project Survey
What is today's date? *
Monday, February 10, 2020
What is the site location? *
Gardiner
Mammoth
Tower
Washburn North 1
Washburn North 2
Washburn Top
Washburn South
What is the transect number (1-3)? *
What is the frame number (1-10)? *
Is Desert alyssum: Alyssum desertorum present? *
No
1 2 3
4 5 6
7 8 9
0
Done


93% 11:57 AM
YNP Plant Phenology Project Survey
Tower
Washburn North 1
Washburn North 2
Washburn Top
Washburn South
What is the transect number (1-3)? *
What is the frame number (1-10)? *
Is Desert alyssum: Alyssum desertorum present? *
Yes
What phenological phase is the plant in? *
First Flower
Vegeative
Budding
First Flower
Full Flower
First Fruit
Full Fruit
Senecence
Is Field chickweed: Cerastium arvense present? *
No
Is Yarrow: Achillea millefolium present? *
No
Is Cheatgrass: Bromus tectorum present? *
No

Arrowleaf Balsamroot, *Balsamorhiza sagittate*, Native

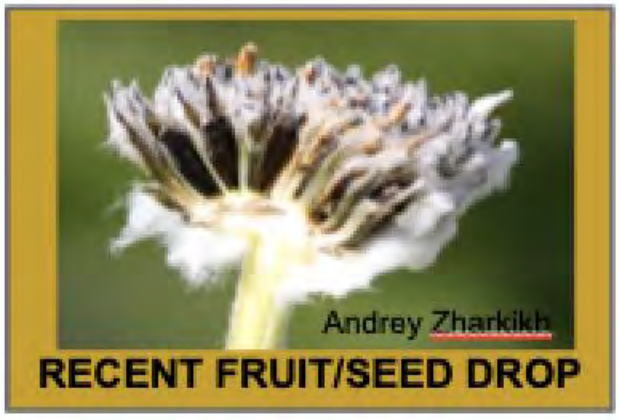
INITIAL GROWTH

LEAVES

FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

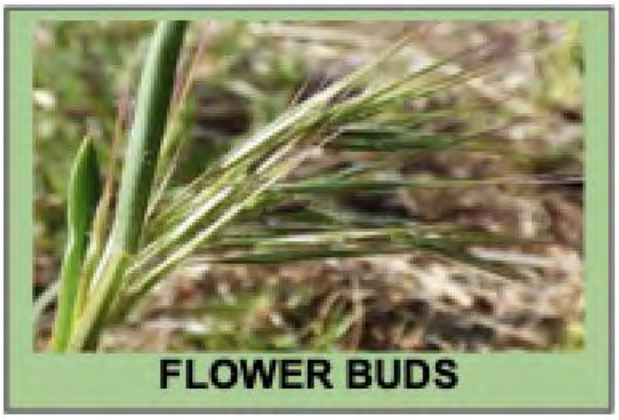


RECENT FRUIT/SEED DROP

Cheatgrass, *Bromus tectorum*, Invasive


INITIAL GROWTH


LEAVES


FLOWER BUDS


OPEN FLOWER


RIPE FRUIT


RECENT FRUIT/SEED DROP

Common Dandelion, *Taraxacum officinale*, Non-native, naturalized


INITIAL GROWTH


LEAVES

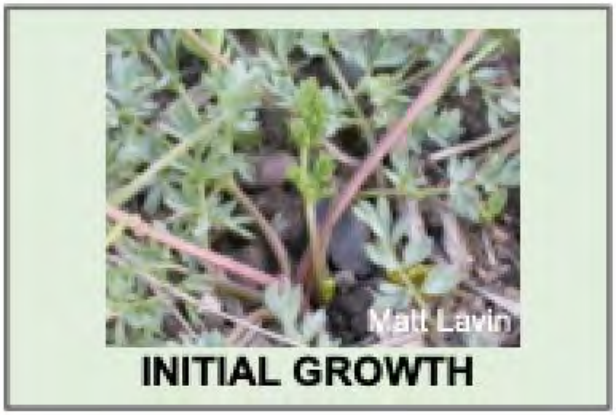

FLOWER BUDS


OPEN FLOWER


RIPE FRUIT


RECENT FRUIT/SEED DROP

Cous Biscuitroot, *Lomatium cous*, Native



Desert Alyssum, *Alyssum desertorum*, Non-native


INITIAL GROWTH

LEAVES


FLOWER BUDS


OPEN FLOWER


RIPE FRUIT

RECENT FRUIT/SEED DROP

Field Chickweed, *Cerastium arvense*, Native


INITIAL GROWTH


LEAVES


FLOWER BUDS


OPEN FLOWER


RIPE FRUIT

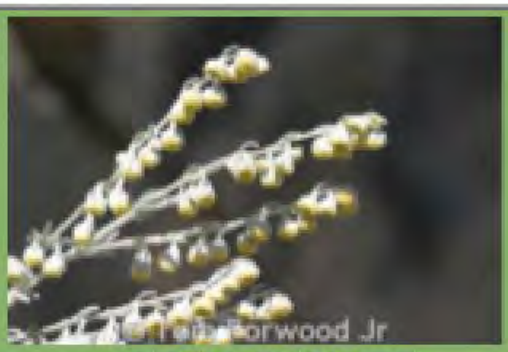

RECENT FRUIT/SEED DROP

Fringed Sage, *Artemesia frigida*, Native

INITIAL GROWTH

LEAVES

FLOWER BUDS

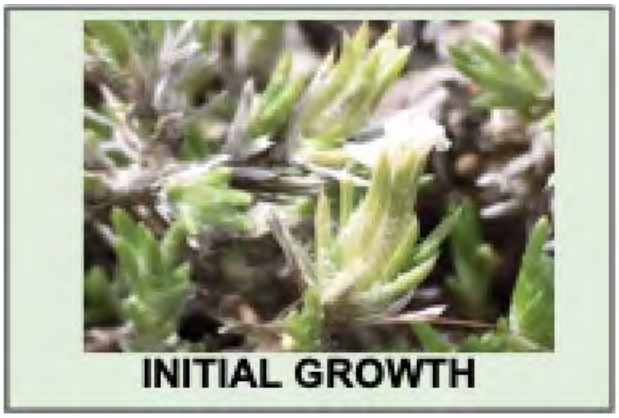


OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Hood's Phlox, *Phlox hoodii*, Native


INITIAL GROWTH


LEAVES


FLOWER BUDS


OPEN FLOWER


RIPE FRUIT

RECENT FRUIT/SEED DROP

Lupine spp., *Lupinus spp*., Native

INITIAL GROWTH

LEAVES

FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Musk Thistle, *Carduus nutans*, Invasive

INITIAL GROWTH

LEAVES

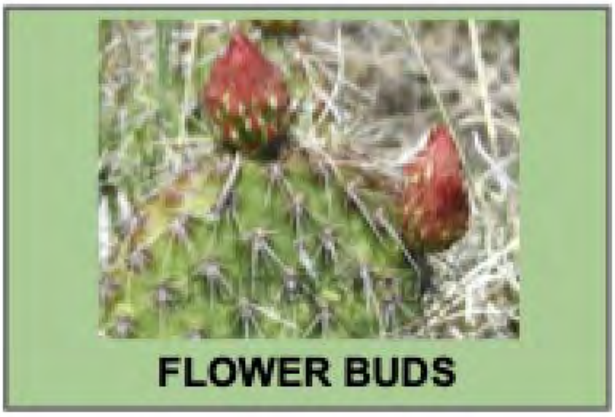
FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Plains Pricklypear, *Opuntia polycantha*, Native



Prairie Smoke, *Geum triflorum*, Native

INITIAL GROWTH

LEAVES

FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Pussytoes spp., *Antennaria spp*., Native

INITIAL GROWTH

LEAVES

FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Sagebrush Buttercup, *Ranunculus glaberrimus*, Native


INITIAL GROWTH


LEAVES


FLOWER BUDS


OPEN FLOWER

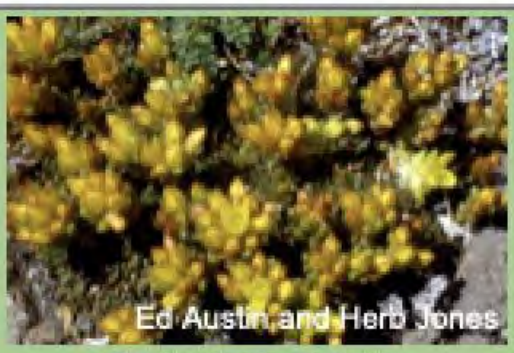

RIPE FRUIT


RECENT FRUIT/SEED DROP

Spearleaf Stonecrop, *Sedum lanceolatum*, Native

INITIAL GROWTH

LEAVES



FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Sticky Geranium, *Geranium viscosissimum*, Native

INITIAL GROWTH

LEAVES

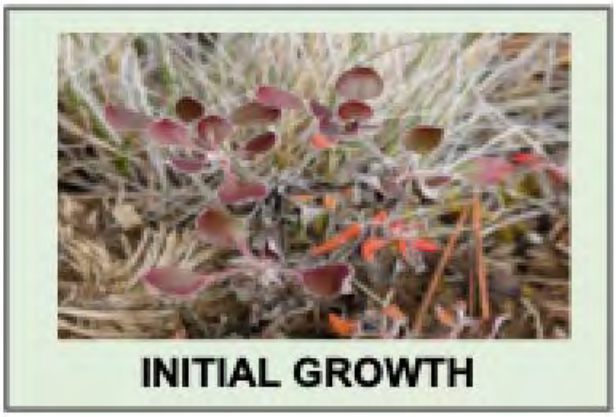
FLOWER BUDS

OPEN FLOWER

RIPE FRUIT

RECENT FRUIT/SEED DROP

Sulphur Buckwheat, *Eriogonum umbellatum*, Native



INITIAL GROWTH

LEAVES

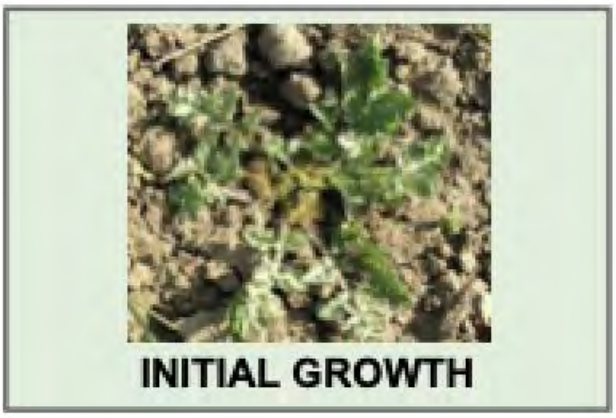
FLOWER BUDS

OPEN FLOWER

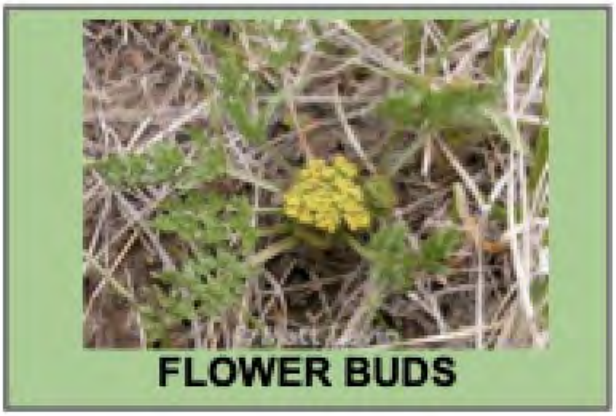
RIPE FRUIT

RECENT FRUIT/SEED DROP

Wild Parsley, *Musineon divaricatum*, Native


INITIAL GROWTH


LEAVES


FLOWER BUDS

OPEN FLOWER


RIPE FRUIT

RECENT FRUIT/SEED DROP

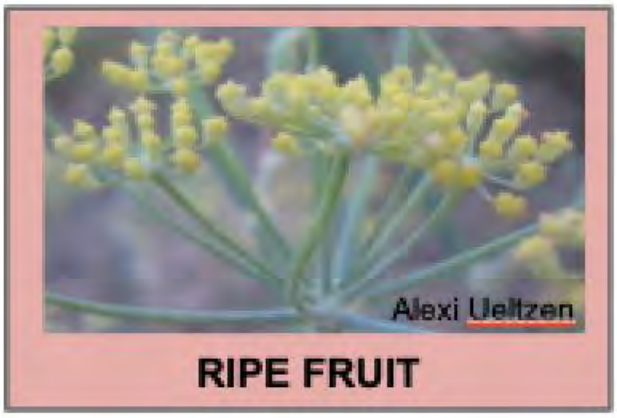
Yarrow, *Achillea millefolium*, Native


INITIAL GROWTH


LEAVES


FLOWER BUDS


OPEN FLOWER



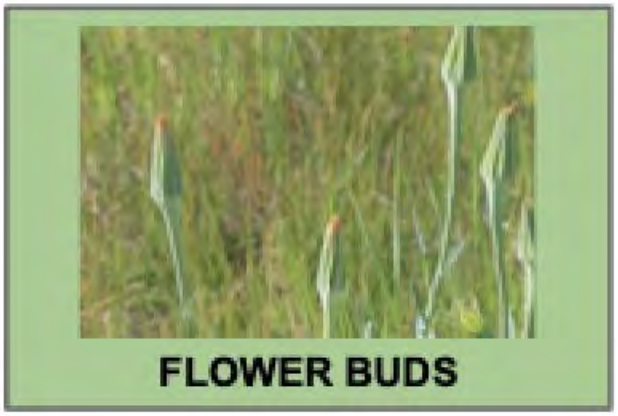
RIPE FRUIT


RECENT FRUIT/SEED DROP

Yellow Salsify, *Tragopogon dubius*, Native


INITIAL GROWTH


LEAVES


FLOWER BUDS


OPEN FLOWER


RIPE FRUIT

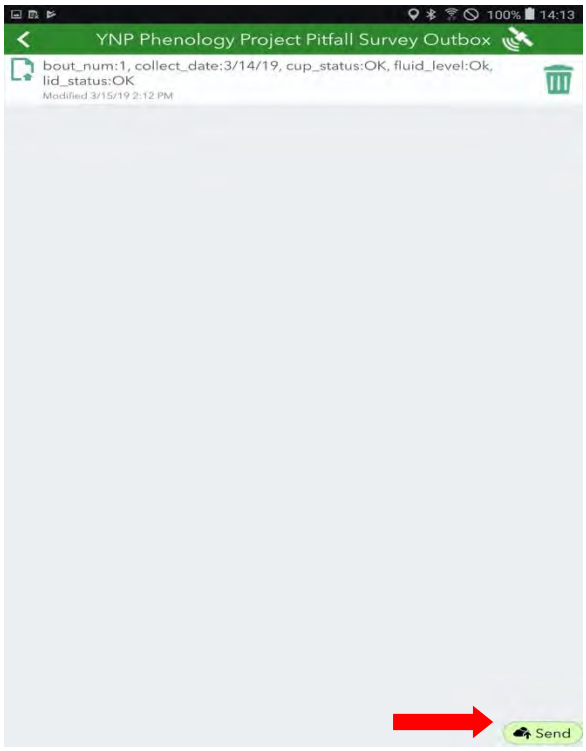

RECENT FRUIT/SEED DROP

SYNCHING SURVEY 123

1. Now that you have collected your data in the field, it is time to push that information to the cloud where we can connect to it within the YNP computer network. In order to perform a sync with the cloud you need to connect your tablet to a wifi network or to the LTE network via a mobile hot spot. The procedure for how to do this will depend on the network where you are connecting to. If you are connecting at the YCR office, please get the assistance of one of our staff to connect to a mobile hotspot, as we do not have public wifi at the NPS. If you are connecting at Yellowstone Forever, ask for assistance for a Yellowstone Forever staff member with connecting to their guest wifi network. You can also use your personal LTE connected device as a mobile hotspot. However, it is not recommended because it will use up a lot of your data. Once your tablet is connected to a network, open Survey 123 again.

2. Tap on the Outbox icon at the bottom left of the Survey 123 screen.

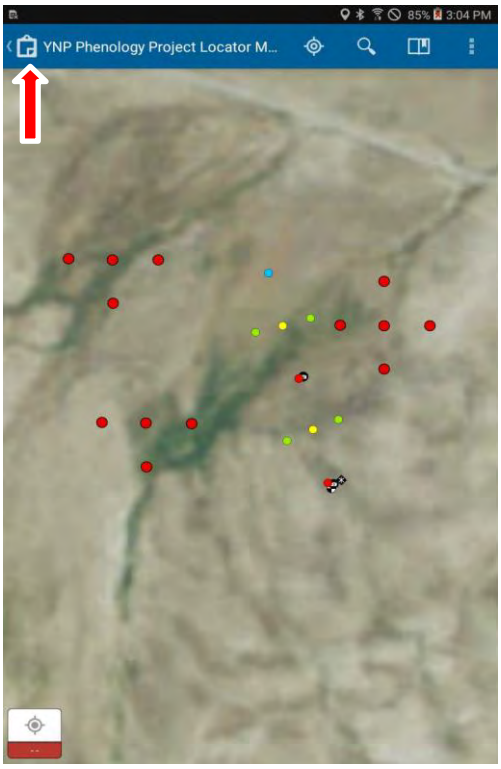
3. Tap the send button at the lower right of the new screen. If you are connected to the internet and you do not see the send button, your tablet may need to update its position. If you are inside, go to a window or take it outside so the onboard GPS can update. Once your position is established the send button will appear.



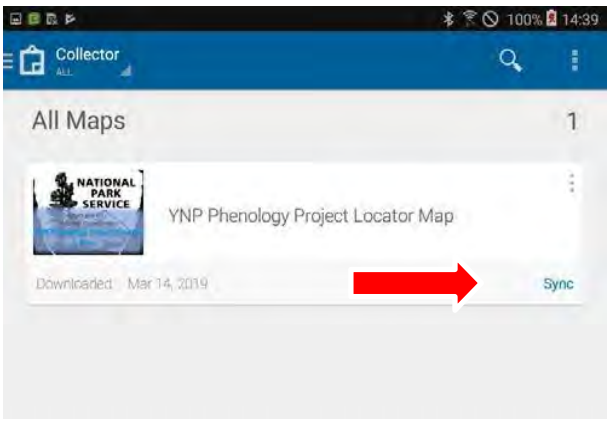
4. This will send your survey results to the cloud. You will know that your data has been sent because the Outbox will turn from blue to grey and will say “Sent”.

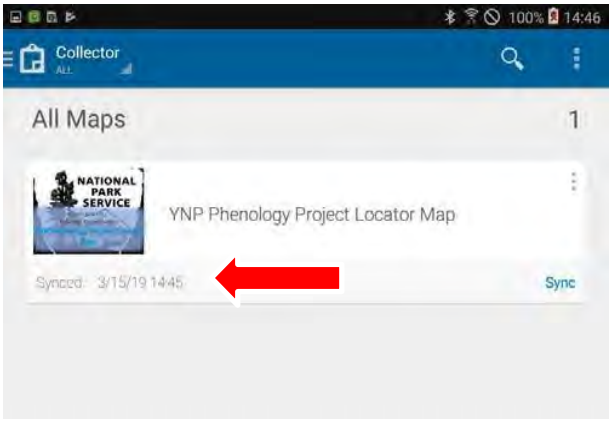
5. Congratulations you are finished, unless you made comments in the YNP Phenology Project Locator Map. You can now power off your tablet and plug it in to recharge.

6. If You made comments in the YNP Phenology Project Locator Map you will need to sync your map to the cloud. This process is very similar to the process of synching Survey123 only now you will do it in Collector. To perform a sync you need to connect your tablet to a wifi or LTE network, ask YNP or YF staff for help connecting your tablet to the internet. From the home screen of your tablet open the Collector App. If Collector opens to the map you need to tap the back arrow on the upper left corner to take you back to the All Maps page.



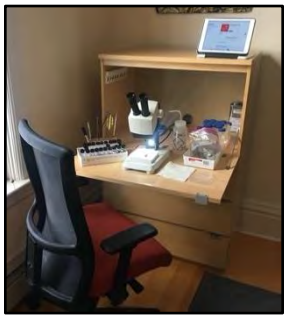
7. If your device is connected to the internet you will see the word Sync below and right of your map title. Tapping this button will send your changes to the cloud. A time bar will start scrolling on your map and when it is complete it reports the date and time of your sync.





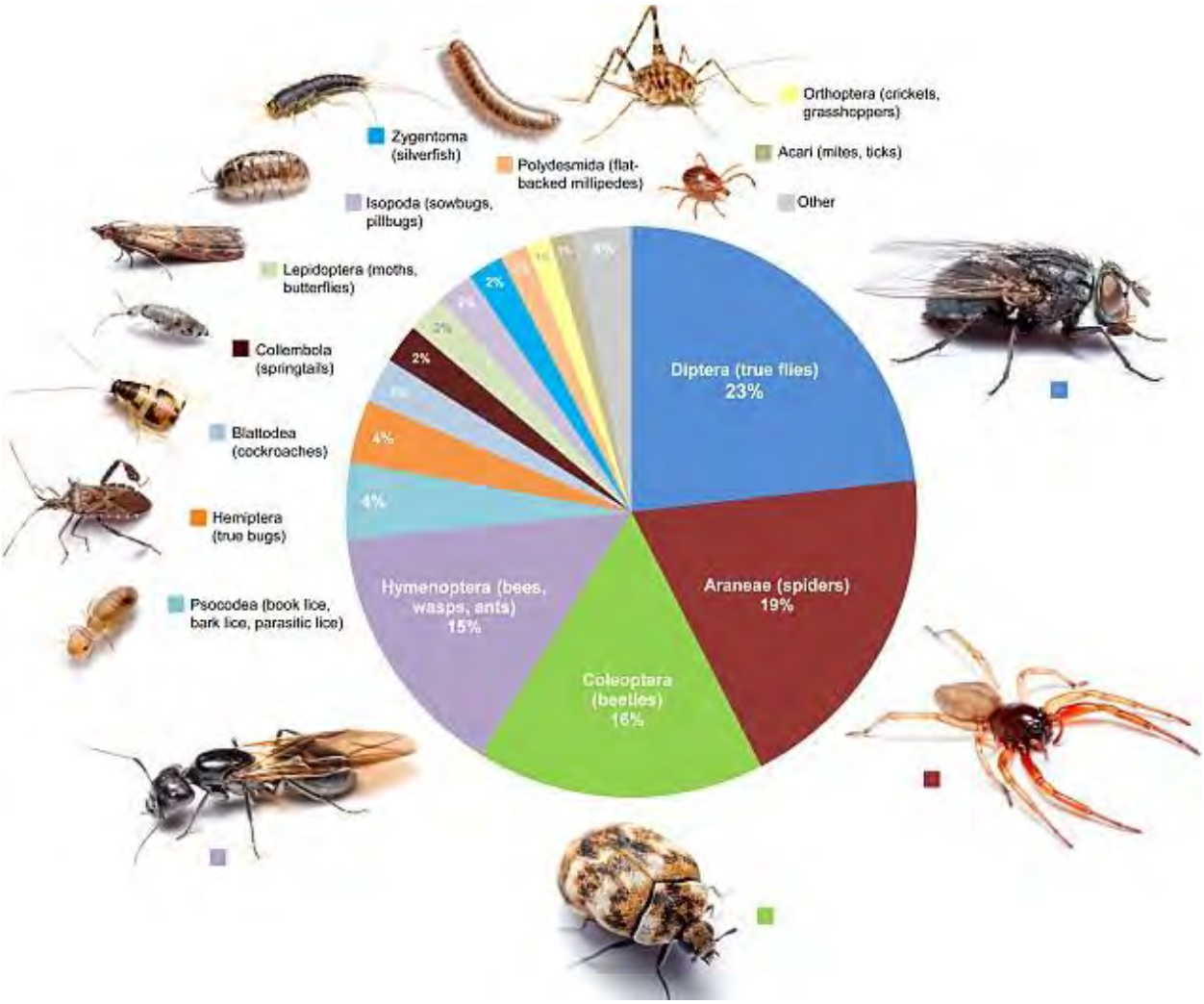
8. Congratulations you are now done and can safely power down you tablet and plug it in to recharge.

ORDER LEVEL INSECT IDENTIFICATION



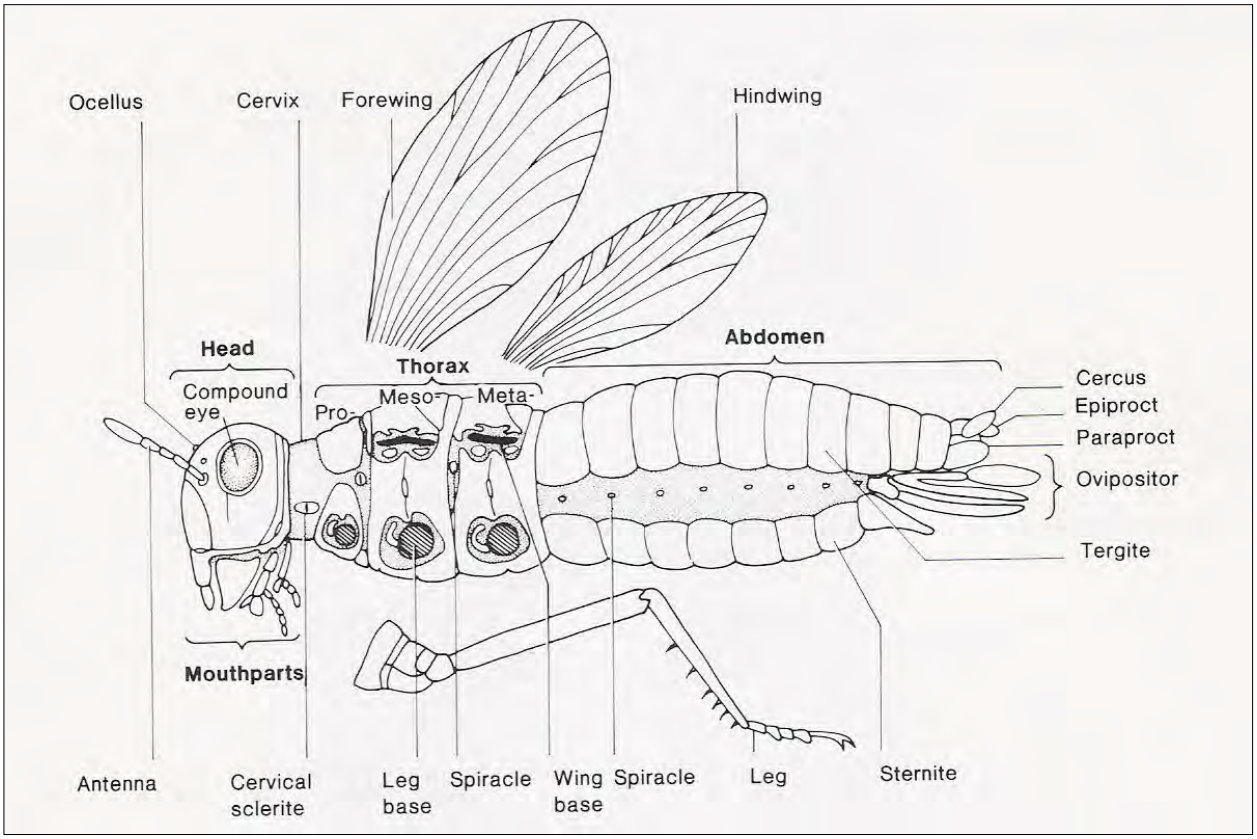
In general, sorting of bycatch should happen throughout the field season as samples are collected, so that the first stage of sample processing is completed prior to the end of the field season. Identification, pinning, and pooling of carabids occurs at the end of the season when the majority of species have been collected. Although these activities may occur several months after sample collection, all beetle processing must be completed within four months of the end of the field season.

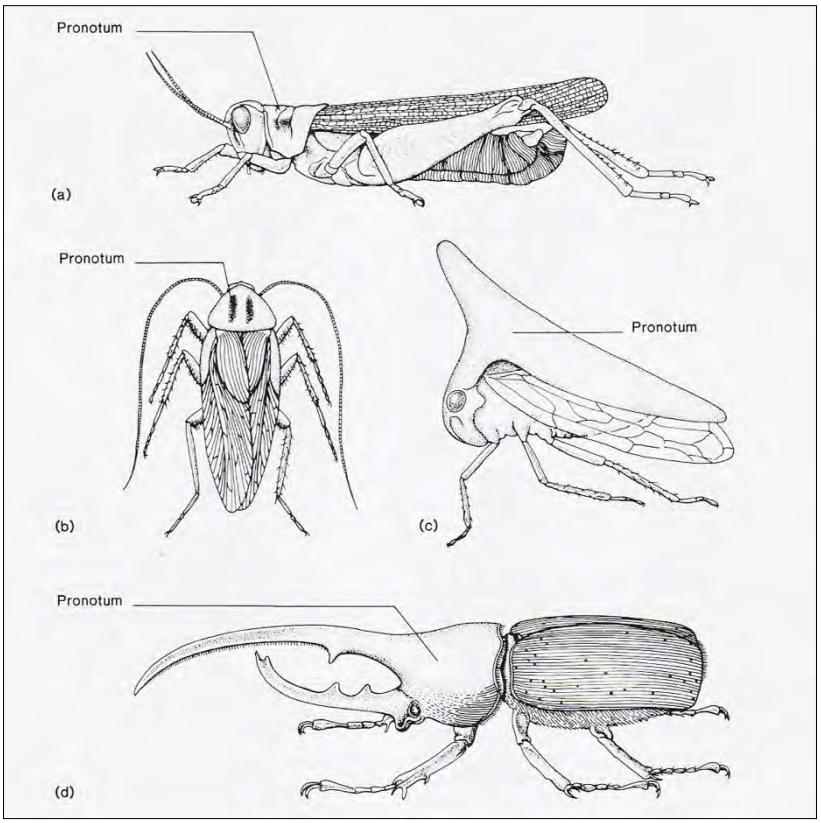
First, an introduction. Insects are the most dominant group of animals, and the Earth's most varied organism. 80% of all known animals are insects, and they comprise 57% of all life on Earth. There are more than one million described species (only 54K vertebrates).



View macrophotography images of Yellowstone insects here:
https://www.flickr.com/photos/yellowstonenps/albums/72157704843714434

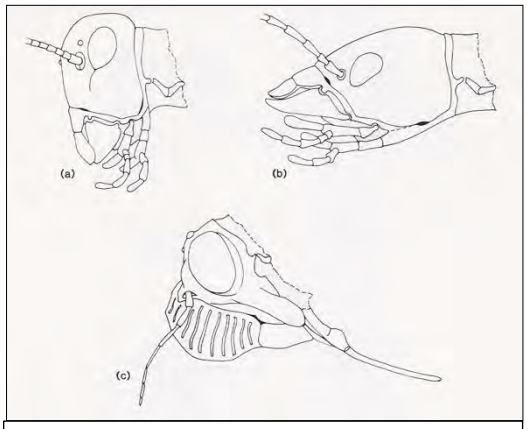
A bit of insect anatomy…



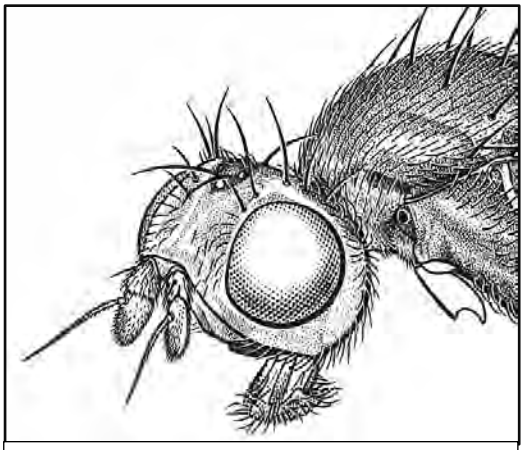


The **pronotum** is a prominent plate-like structure that covers all or part of the thorax of some insects.

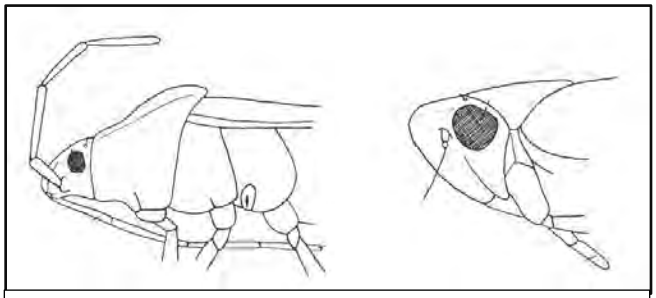
Head/Mouthparts



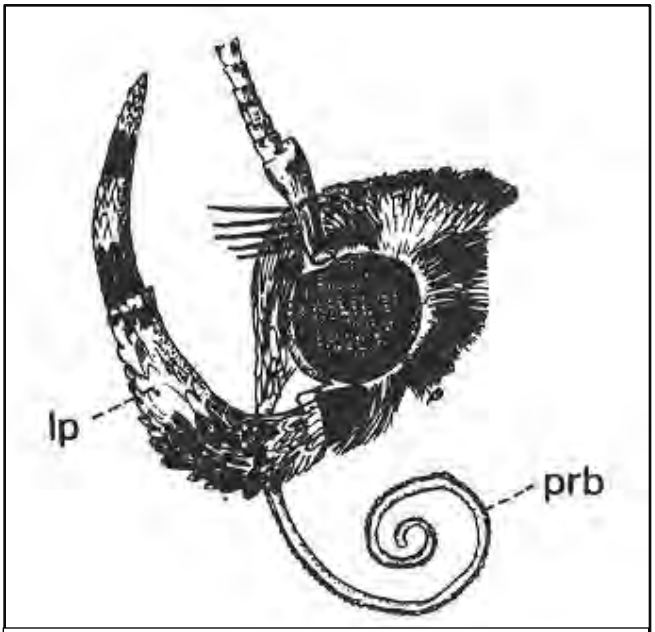
a. Herbivore – chewing
b. Carnivore – slicing
c. Herbivore - sucking



Sponging-sucking

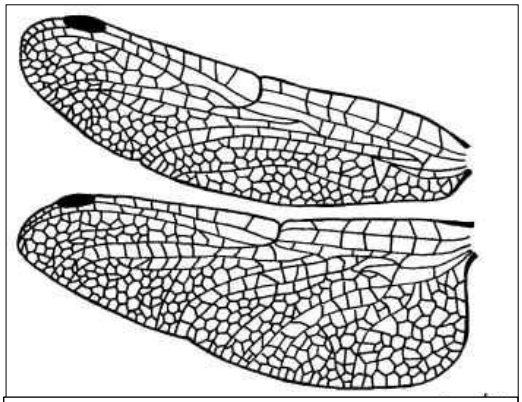


Piercing/sucking



Coiled

Wings and wing modifications

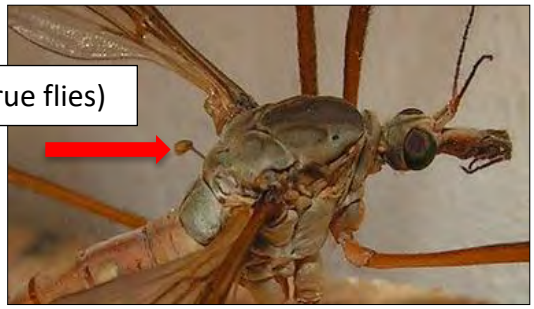


Generalized, membraneous (dragonfly)

Elytra (beetle)

Hemiptera (true bug)

Halteres (true flies)

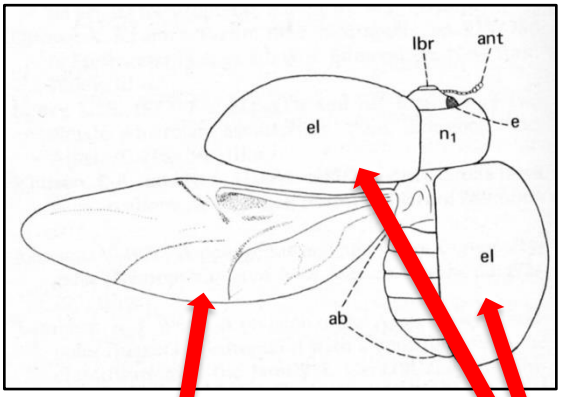


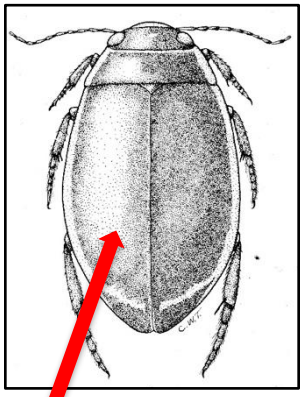
Coleoptera

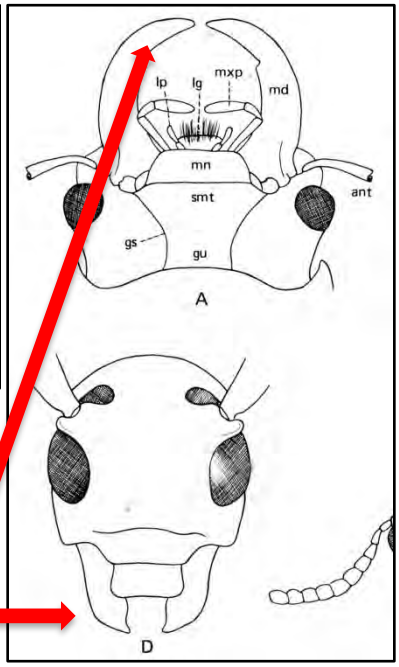
Tiger beetle. Label and place in a separate vial.

Podcast on the "Tigers of Yellowstone": https://go.nps.gov/tigersofyellowstone

Beetles vary in length from 0.25 mm to 150 mm and include the largest insects by biomass known. They are characterized by having chewing mouthparts, large compound eyes and usually possessing thickened forewings (elytra) which meet at the midline when folded. Their membraneous hind wings fold up under the elytra when not in use, permitting them to inhabit rugged environments without endangering their flight capability. Antennae are highly variable.







Membraneous hind wing

Elytra (fore wing)

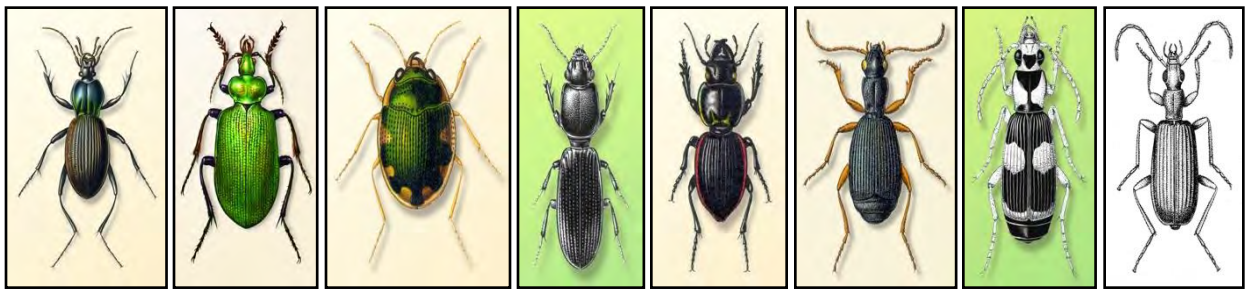
Chewing mouth parts

Coleoptera – Carabidae

In our work, Carabid beetles are separated from other Coleoptera because they are a target Family for the Phenology project. In 2018 alone, 3,620 Carabids were collected, including 55 different species (one, a new Wyoming state record, pending confirmation). Five species comprise 54% of the Carabids collected, with species abundance and composition varying throughout the field season.

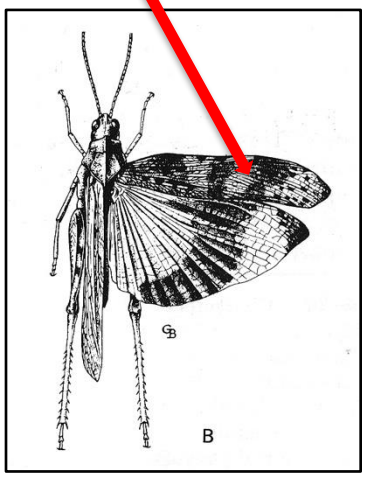
The most notable characteristics in Carabid identification are the notopleural suture and the offset trochanter. Also look for tactile setae over the eye and pronotum.

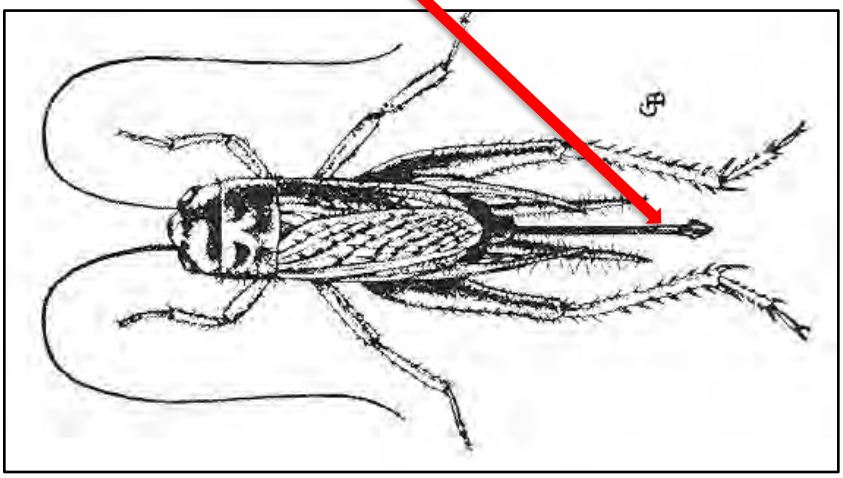
Carabid beetle diversity



Orthoptera (Grasshoppers, Crickets, and Katydids)

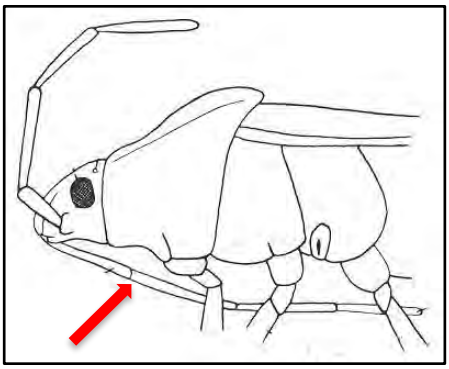
Orthoptera generally have modified hind legs for jumping and thickened fore wings called tegmina. Their name comes from the Greek “orthos” meaning straight, and “pteros” meaning wing. Some may have an ovipositor at the hind end.

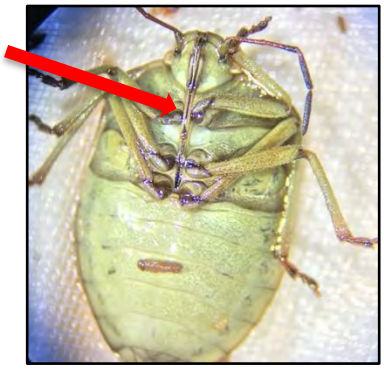


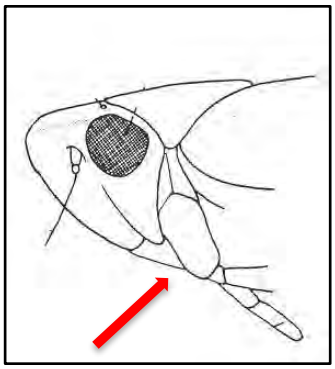


Hemiptera (Bugs, Hoppers, Aphids, Scales, Whiteflies, Cicadas)

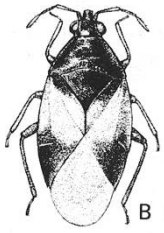
Hemiptera, the “half-wings”, have piercing, sucking mouthparts.





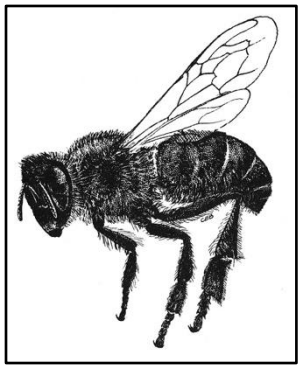


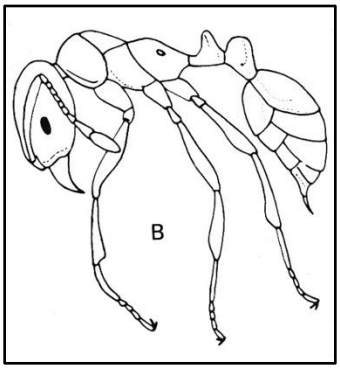
There is a huge diversity in this Order with respect to body form, wings, and antennae. They are predators, herbivores, and parasites; some may be vectors. Their fore wings cover the hind wings and often form an “x” when viewed from above.

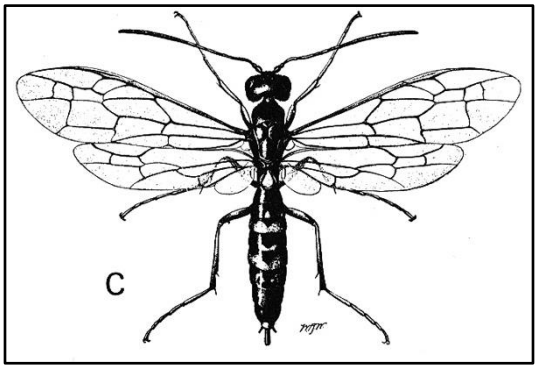


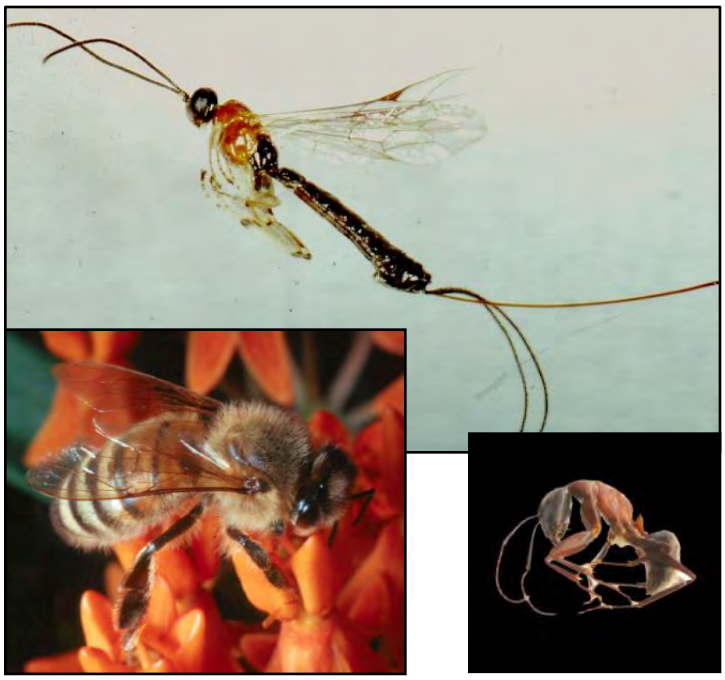
Hymenoptera (Bees, Wasps, Ants, Sawflies)

The Hymenoptera are so named because of the Greek “hymen” + “ptero” meaning “membrane wing”. Also, for “Hymen”, the Greek god of marriage, because the fore wings and hind wings are joined together with small hooks called hamuli. They have chewing mouthparts, four membranous wings, and their waist is often constricted.



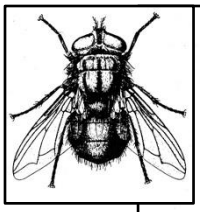


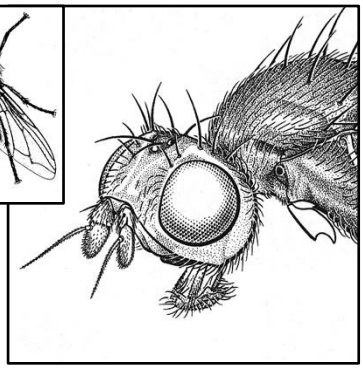


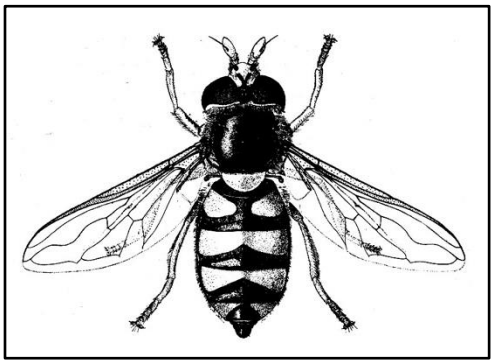


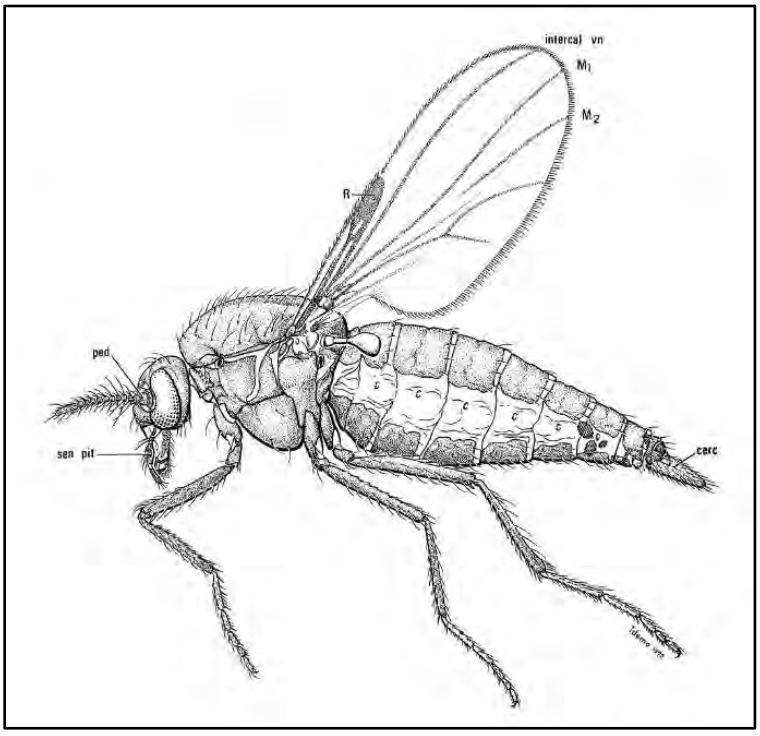
Diptera (Flies, Midges, Mosquitos)

Diptera, meaning “two wings”, have modified hind wings (halteres). They have a great diversity of natural history strategies and many are pests and vectors of disease. There are a variety of mouth types, from sponge-sucking to skin-piercing.



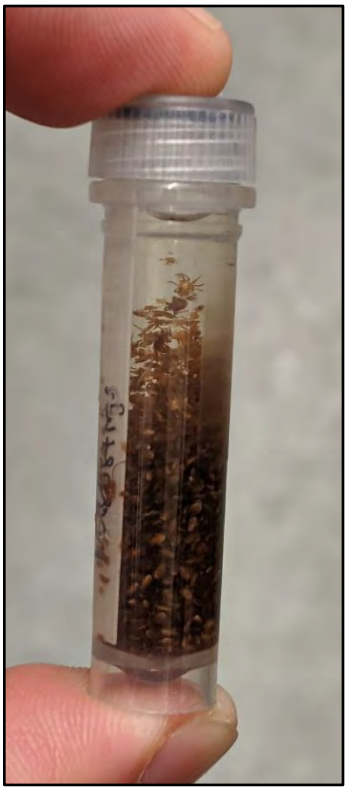


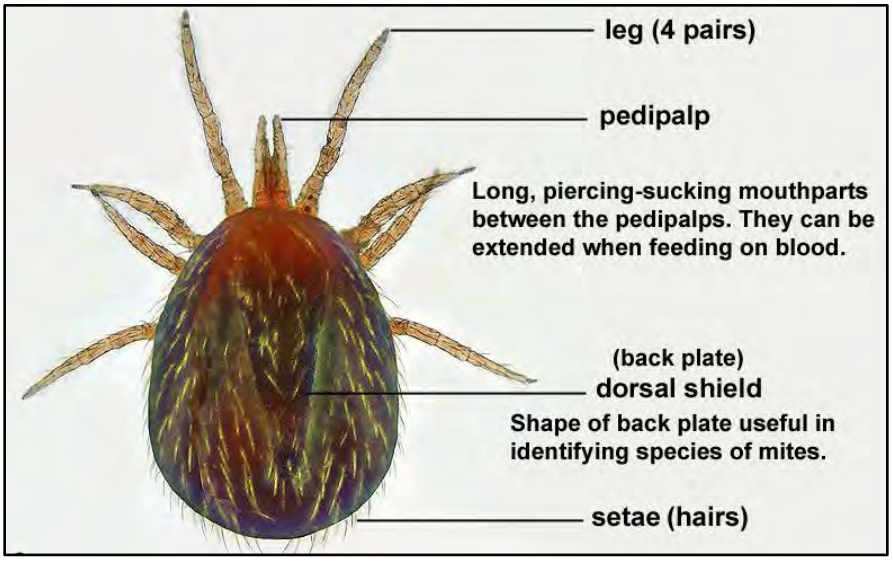


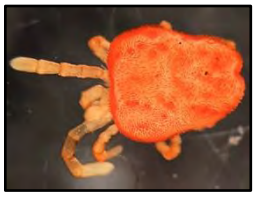


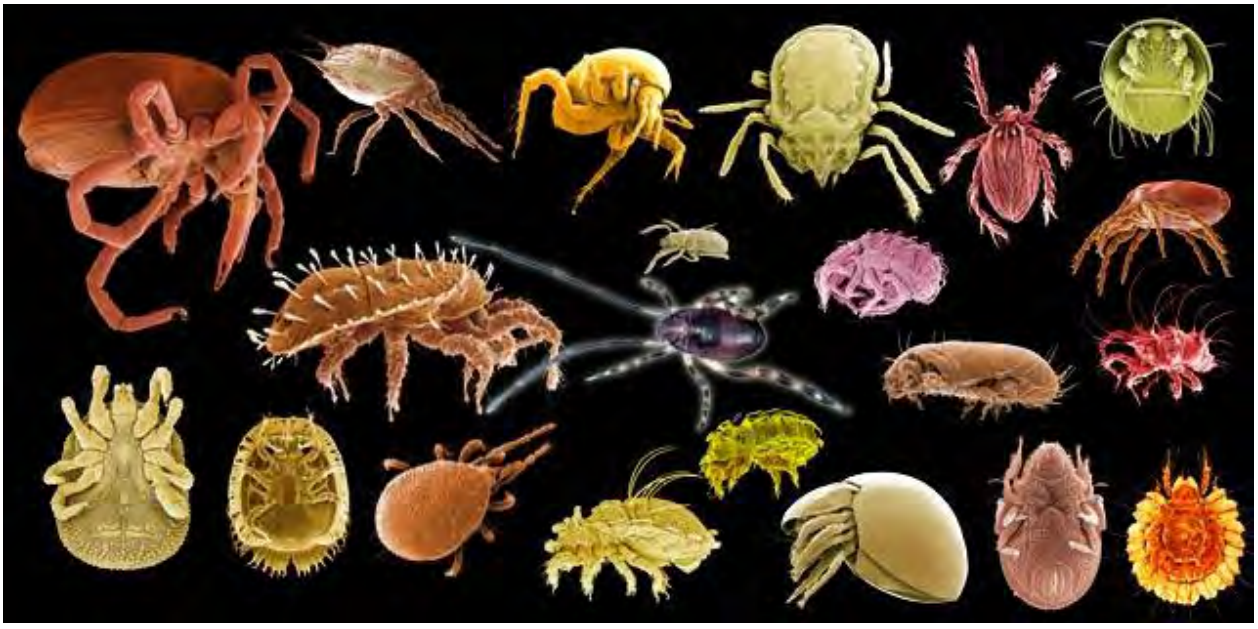
Acari (Mites)

Mites are related to spiders and scorpions, having eight legs. They have two body sections, the prosoma and opisthosoma, but often appear to have only one body section. They lack a separate head structure and leg length is highly variable.





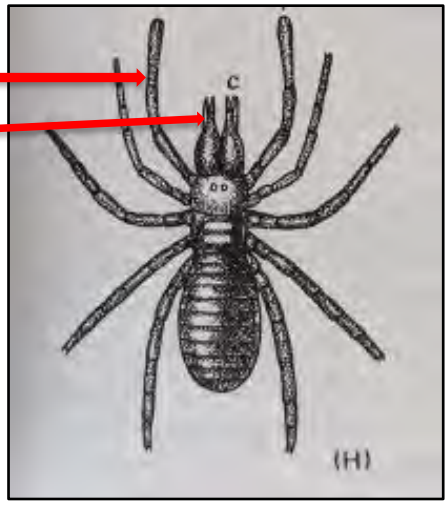




Spiders

Spiders are characterized by possessing pedipalpi

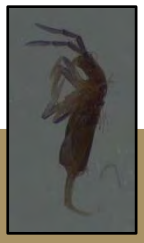
and chelicerae,



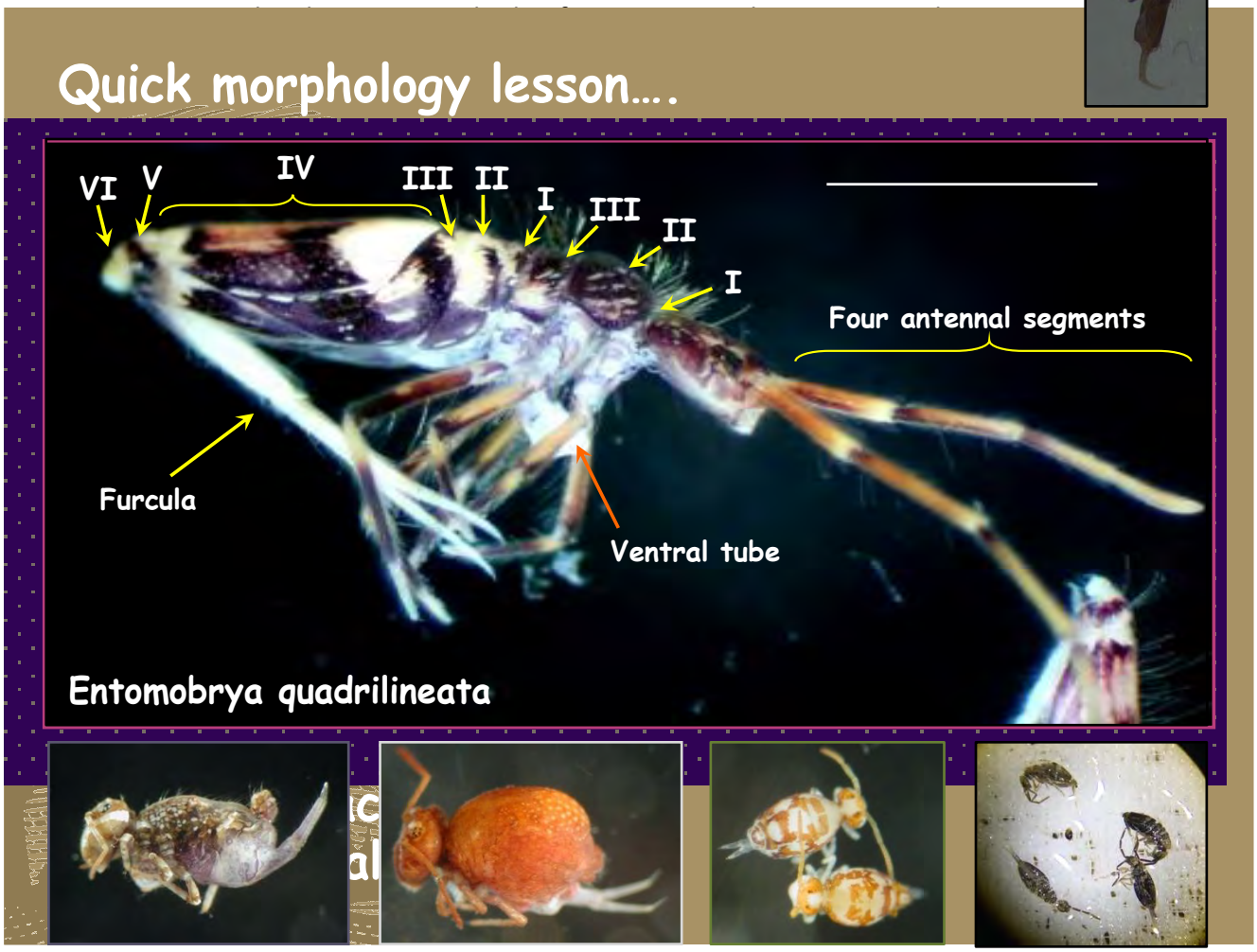
lacking antennae, and having four pairs of legs and a cephalothorax and abdomen.

Chelicerae are believed to be appendages of the third body segment, usually modified into predatory organs. Pedipalpi are sensory structures that form the base of a preoral cavity in which the chelicerae function.

Collembola (Springtails, Snow Fleas)

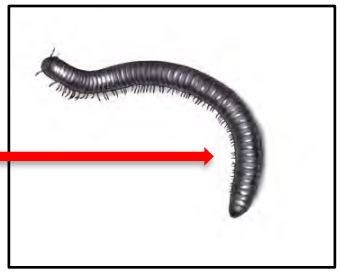


Collembola are the most abundant hexapods on Earth and the earliest fossils are over 400 million years old. They are mostly tiny litter and soil inhabitants. A few



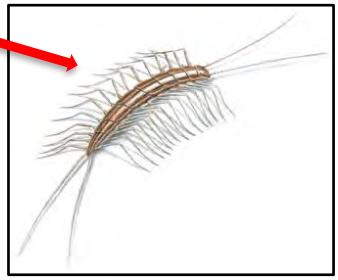
Neanurid sprigtails are poorly known in most areas of the U.S. Some even lack eyes.

Millipedes and Centipedes



Both millipedes and centipedes have segmented bodies with many legs. Millipedes are somewhat cylindrical and have two pairs of legs per segment,

while centipedes are flat and have one pair of legs per body segment.



Millipedes move slowly and burrow, while centipedes are known for their speed. Millipedes are primarily detritivores; centipedes are carnivorous and kill their prey by injecting them with venom. Centipedes sometimes bite humans, but it is rare that their venom will produce a severe reaction.




Non-Target groups (DISCARD)

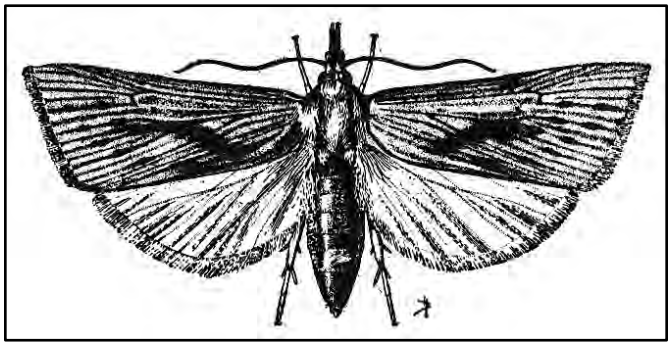
Pseudo scorpion

Earwigs

Thrips

Silverfish

Moths and Butterflies (scaled wings)



Unusual Observations

Make a separate vial and label for any unusual specimens.

Tiger beetles – label and save in separate vial

Parasitic eggs

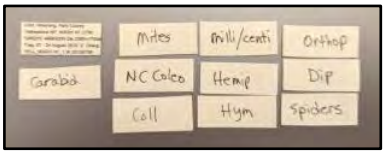
INSECT SORTING PROTOCOL

1. Remove labels from whirl pak, attach clean filter fabric to funnel, dump sample into funnel, rinse whirl pak and label into funnel.

2. Submerge funnel contents in bowl of water to float specimens above soil, gravel. Skim samples off surface and place into sorting tray or petri dish.

3. Remove filter fabric from funnel, rinse residual sample onto filter fabric, set aside on petri dish to dry.

4. Dry and cut labels, create one Carabid label for every whirl pak, write Carabid on back of label, place in a 4 dram vial. Repeat for every whirl pak. Use extra labels for other orders as you find them. Write with archival pen on back as: Mites, Carabid, NC Coleo, Coll, Dip, Milli/Centi, Hemip, Hym, Orthop, Spiders.



5. All specimens except Carabids from each collection event are pooled together into one vial. One collection event has 10 whirl paks, one from each pitfall trap. All ten whirl paks should have labels with the same collection date range, but will have unique pitfall codes. (1S, 2E, etc.) indicating where the Carabids came from. ***This means for each collection event you will have one vial per Order, and up to 10 vials for Carabids***. This is the most important part of our Carabid research.

6. Wet sample with ethanol, remove large specimens with forceps, sort into Order-level vials or tubes.

7. Use a brush to remove soft-bodied or small specimens such as springtails and mites.

8. Shift filter fabric under scope to look for residual specimens, repeat steps 4-5.

9. Flatten, dry, and return undamaged whirl paks and filter fabrics. Trim frayed fabric fibers, discard whirl paks with separating twist wires or leaks.

10. Pin the Carabids. Please refer to these training videos for pinning protocols:
Card (0-6') and point (6'-10') mounting: https://www.youtube.com/watch?v=ORP5WK5AVqs
How to Pin a Beetle: https://www.youtube.com/watch?v=kMYeWN7mN_w

11. Return pinned Carabids, vials, whirl paks, and filter fabrics to bug hub or Erik Oberg.

PHOTOGRAPHY

MACROPHOTOGRAPHY

This project helps illustrate biological diversity at Yellowstone's climate monitoring sites and correlate the presence of sentinel taxa - Carabid beetles, with their occurrence across a 5,000' elevation gradient. Documenting invertebrate shifts over time provide a sensitive indicator to better understand how Yellowstone's changing climates and influence park habitats and wildlife. The photos from this project allow for the accurate and timely identification of several insect taxa and demonstrate the beauty and complexity of Yellowstone's charismatic micro fauna.

Equipment

- Camera: Canon EOS 5D Mark IV
- Macro Lens: Canon MP-E 65mm (1-5x)
- Macro Flash: Canon Twin Lite MT-26EX-RT
- Stackshot Rail by Cognisys, Inc.
- Zerene Stacker (Software, Build 1.04)
- Canon ACK-E6 AC Adapter Kit
- Slik AF2100 Single Action Head
- Mounting platform
- Four NiMH Batteries (with four alternates in charger)
- Finnhomy Professional light box or foam cooler
- Black Felt

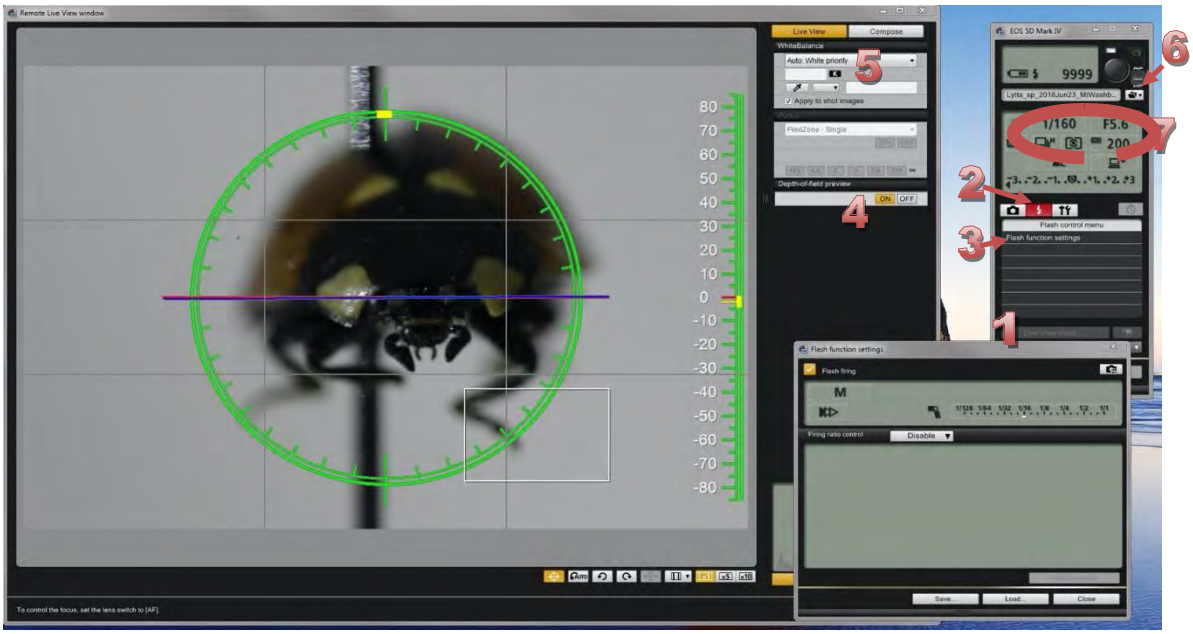
Our setup is pictured below. The doors on the front of the light box can be manipulated to allow more or less light to be reflected. To illuminate the box, flip the switch on the power chord. Adjust the brightness with the adjacent dimming knob. Be sure to turn the lights off with the switch when they are not necessary to prevent over-heating.

Because of the high level of detail recorded, ensure specimens have been cleaned before photographing. The side of the specimen you wish to photograph dictates which method and setup procedures to follow.

Front, side, and rear images are captured with a modeling clay base and the specimen mounted in the same manner they are stored, rotated as necessary, with the distant lightbox serving as backdrop. The mount rotates using the handles to the side and beneath the modeling clay base. Use these in conjunction with the Slik camera mount to determine the appropriate angle to photograph the specimen.

Top and bottom photos are critical for diagnostic identification, but can be significantly more time and energy intensive. First, place the pin end into the small ball of modeling clay fixed to the mount. Determine the angle you would like to photograph the subject. Attach either black felt or a white piece of paper as close to the mount as possible by cutting a slit to the center of the felt or paper and sliding the mounted pin through the slit so that it rests behind the specimen. No two setups are quite alike (and white paper needs to be changed periodically as oils from the clay saturate the paper). You can continue to rotate the mount as necessary.

Examples of these setups are shown below (Figure x). The photo on the left depicts the setup necessary for side or front (face) shots whereas the right photo shows how to photograph the specimen from the top. To photograph the bottom, the specimen will be mounted with the pin completely through the insect, so you would only need to flip the pin around and mount it to the clay from the other side.



CAMERA—COMPUTER INTERFACE

Connect all cables to appropriate locations, including the USB cable from the camera directly to the computer. The cords are all labeled, but if further clarification is needed, use the list below to match the letter to the corresponding cord.

A – These two cords connect the camera to a power source. The cords connect to each other and connect to the camera in the front on the right side.

B – This connects the Stackshot Rail to a power source.

C – This connects the Stackshot Rail to the camera. The port for this cord is on the front left side of the camera.

D – There are two cords labeled D. One is white and is attached to the motorized mechanism that allows the camera to move forward and backward. This connects to the other cord labeled D and then to the Stackshot Rail.

E – This is a USB connector that should go from the computer to the left side of the camera.

Once powered on, a prompt will appear automatically for Canon EOS Utility (assuming its downloaded and installed). If it does not, open the program from the desktop or start menu.

Select “Remote Shooting” to the following windows. The top right “EOS 5D Mark IV” will be the only window initially present.

To activate all necessary options follow the steps labeled in the image above.

1. Select “Live View shoot.” This will allow you to view the frame on your computer screen.
2. Select the flash icon
3. Double click “Flash Function Settings.” The window that appears will allow you to manipulate how long the flash is on. Make sure the flash is set to manual.

Tip: If while you are shooting pictures, you notice that a number of the frames are black, abort the process on the Stackshot Rail and replace the batteries in the flash. The battery

compartment is located on the right side of the flash on top of the camera. The flash requires four AA batteries and sometimes need to be replaced once a day depending on how many photos are being taken and how long the flash is on when firing.

4. Turn on depth of field preview to view the specimen in front of the lens.
5. Change white balance from “auto” to “Flash”
6. Change the destination folder by clicking on the small folder icon. This determines where the photos are stored. Under “DestinationFolder,” change the destination to:

Genus_Species_YEAR(MONTH)DAY_CollectionLocation_Collector
Ex: Coccinella_transversoguttata_2016JUN23_MtWashburn_Bowser

File structure and organization are covered next in this document.

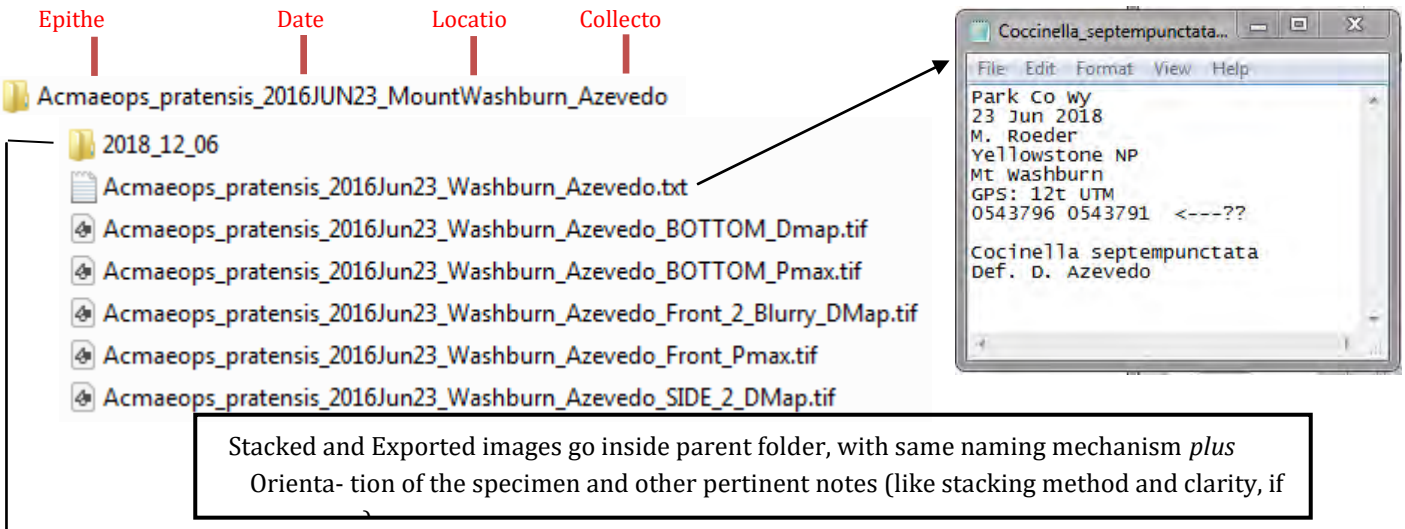
TIP: Clicking on the folder location name next to the folder icon immediately brings you to that folder and your photos.

7. This is where you will control your camera settings (aperture, ISO, and exposure). Details about these settings are included later in this document under the section titled “Camera Settings.”

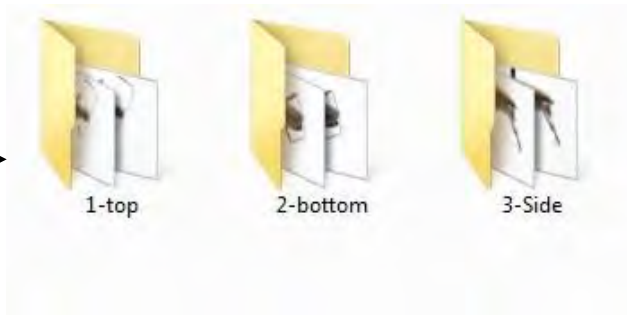
FILE STRUCTURE

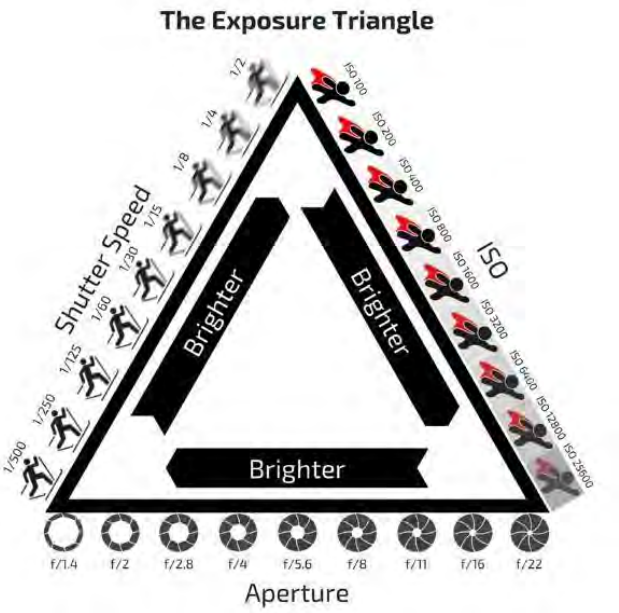
EOS Utility will automatically create the folder above if it does not exist. Created within is another folder populated with the cur- rent date– this is where your raw photographs will go. Within this folder, create new ones based on the angles you are photo- graphing (ex: “1-Front”, “2-Side”, “3-Bottom”, “4-Top” or “5-Top_2”, etc.). Drag completed series (carefully removing test shots) from the parent date folder into your labeled sub-folders. Within Windows Explorer, navigate to the parent folder for the specimen. Create a text file by right clicking anywhere -> New -> Text Document. Transcribe any tags associated with the specimen to this location.

Once photos are stacked with Zerene Stacker, they are exported to the parent specimen folder in the format shown below (Figure x).



Stacked and Exported images go inside parent folder, with same naming mechanism *plus* Orienta- tion of the specimen and other pertinent notes (like stacking method and clarity, if





CAMERA SETTINGS

Check all the camera joints to make sure they are tight.

Below are some starting points for aperture, ISO and exposure time. These are flexible and should be manipulated as necessary to achieve the proper lighting for each specimen.

Aperture: Primarily between f/5.6 and f/8
Increasing this number decreases light but increase focus area.
Keep aperture as high as possible to ensure highest level of focus.

ISO: 100, 125, 160, 200, 250
Sensitivity of the sensor to light. Higher numbers increase graininess

Exposure time: Common values are 1/100, 1/125, 1/160, 1/200
Speed of shutter actuation and resultant light allowed to expose.

Keep shutter speed above 1/50 to avoid camera shake, above 1/100 when possible.

Flash: Set to **Manual**

Double check your settings to make sure they are correct between photo shoots.

Flash Time: Between 1/8th and 1/16 sec.

Higher magnifications may require more light (1/4 sec)

Experiment with these settings by taking several test photos of the specimen and assessing if the image after each photo to see if it needs more or less light. Look for an exposure that gets rid of most glaring white patches reflecting off the insect. *(The photo may appear slightly darker than you think it should, but brightness can be adjusted post-processing in Adobe Photoshop.*) Manipulate these settings and continue taking test shots and making adjustments until you are satisfied with the lighting on the specimen. Once this is complete, you can set up the start and end points with the Stackshot Rail.

STACKSHOT RAIL CONTROLS

After the specimen is centered in front of the camera and a magnification has been set by rotating the lens barrel, all focusing should occur with the Stackshot and Rail combo. "Fwd" and "Back" refer to the manual movement of the camera along the rail axis. Use this function when establishing a focus and framing the specimen. All options on the Stackshot Control screen are navigated between with the "Select" button, followed by "Up" and "Down" to adjust selected parameters.

Magnification	Distance Camera is Moved (microns)
1X	600
1.5X	325
2X	230
2.5X	165
3X	135
3.5X	115
4X	90
4.5X	75
5X	65

1) Start by selecting the MODE and using Up/Down to navigate to: Auto-Dist (this is the only mode utilized in this guide)
2) "Select" down to Dist/Step. This option controls the distance (in microns) the camera will move between each image to create our stacked photos. Refer to the guide to the right, based upon the magnification level indicated on the top of the macro lens barrel.

**Larger Apertures will increase depth-of-field and decrease the movement needed between images— this will require experimentation.*

3) Now "Select" down to "Select Start Pos" and use the Forward/Back buttons to locate the point you would like the rail to begin photographing. Press Up to set this point, then use Forward/Back again to find the end of the photographed range.

**It is advisable to set the Start and End points just beyond the final point you would like in focus.*

Once both are set the option “Press Up/Down to Start” will appear. Once completed, “Select” down to Change Settings for a new setup run.

STACKING IN ZERENE

Once a series of photos have been taken, ensure they are placed in a correspondingly labeled folder (ex: “3-Side”). With this folder still open, start the Zerene Stacker software.
Drag the collection of photos to the left hand column.
Next, on the top menu bar click Stack -> Align and Stack All

Pmax– Good at finding and preserving detail and at handling overlapping structures like mats of hair and criss- crossing bristles. But PMax tends to increase noise and contrast, and it can alter colors somewhat. Images can appear dark or overblown.
Dmax- “depth map” method. It does a better job keeping the original smoothness and colors, but it's not as good at finding and preserving detail. Sometimes blurry artifacts occur.
Both– (preferred) running both will greatly increase processing time, but provide two potential outputs that can be conjunctionally Retouched to create one clear picture.

**When running Dmax select the highest % that makes the background black without black appearing on the insect, this will help reduces swirls around the edges of the insect.*

Once the photos have been stacked retouch the images with the Zerene Stacker software. (*This can only be done at after stacking the photos, you cannot retouch a photo later.)* Blurry bristles or transparent appendages (from overlap, typically) can be addressed using Retouching mode. First, Save your stacked image(s). Next, select the stacked image you want to retouch and go to Edit -> Retouch. Find the layer where the part of the bug you are editing is in focus and use the brush to retouch the stacked image.

**It can be helpful to start with the layers furthest away and move up through the nearest layers when retouching.*

Important functions to know: Left clicking and dragging over an area will copy from the selected layer to the stacked layer. The mouse scroll wheel changes the size of the editing brush. Spacebar + left click will pan the image. Spacebar + scroll wheel will zoom the image. S-key + scroll wheel will scroll between the different layers.

For an in depth presentation of these processes its best to watch an 8 minute video on Zerene’s website:
https://zerenesystems.com/cms/stacker/docs/videotutorials/retouching001/index (also on Thorax Hard Drive\Documents)

Once the processing and retouching are complete, highlight the desired final product under the “Output Images” box in the lower left. Navigate to File -> Save Output Image

Save the image in the specified format (example below) and choose JPEG at Quality 10.
(Ex: Coccinella_transversoguttata_2016JUN23_MtWashburn_Bowser_BOTTOM_PMax)

ALWAYS SAVE WORKING IMAGES AS COPIES. SELECT “SAVE AS” AND ADD THE APPROPRIATE VERSION NAME TO THE IMAGE NAME

If the license for Zerene Stacker expires, enter this license key into the space provided:

==== BEGIN LICENSE KEY ==== Copyright 2019 Zerene Systems LLC, all rights reserved. This key is unique -- do not redistribute. Licensed To: YCR Software Name: Zerene Stacker 1.0 Licensed Versions: through 1.99 License Type: Personal Edition Payment ID: ZER190320-8399-54103 Issue Date: Wed, 20 Mar 2019 14:37:55 -0700 License Signature:
c49603679ea7d7239e7d13042b49f8c528296b9793aec4
ae5b41031e862fc2237c63d04fc5235eb0718a71971564
195c85883982dcfdd85d27c255a237d0ced2b18416573e
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PHOTO EDITING

PHOTOSHOP

Adobe Photoshop is used for editing out pins and removal of debris. First, make a copy of your image by right clicking the "background" layer in your layers table and selecting "duplicate layer." Now you can begin retouching your photo. You will always want to make edits on the "background copy." There are myriad methods for removing and altering photographs. The tools listed below are primarily used for cleaning up the photo.

(All tool sizes can be adjusted using the bracket keys on your keyboard)

Begin by opening Adobe Photoshop from the Start menu. Bring a photo into the program by clicking and dragging it from its folder on the external hard drive.

It can be helpful to give the image some contrast. To do this, select "Image" on the toolbar and click "auto contrast." This can also been done manually by navigating to the "adjustments" tab located in the menu on the right side of the page.

Crop – Resize your image and place the specimen in the center of the frame. This will also allow you to rotate the image if the specimen is not level.

Spot Healing Brush Tool—Designed to automatically detect and replace selected areas with imagery from the sur- rounding area, and then blend. Very useful for small grains of dirt, and other debris.

Clone Stamp Tool—Similar to Spot Healing but allows the user to select the source material for fill. This tool also doesn't blend with surrounding imagery. Useful for removing the mounting pin with surrounding white/black.

Sharpen – Bring definition to edges that became fuzzy when using the clone stamp. This can also help sharpen images taken at a high magnification.

Dodge/Burn Tools—Use to increase or decrease exposure in selected areas. (Right click tool to toggle between)

Zoom – Use to zoom in and out of the image.

Basic editing of Diagnostic photos:

1) Crop the image
2) Select Image -> Curves (Ctrl+M) – drag the upper corner box along the top edge to lighten the image and the lower corner box along the bottom edge to darken the image (saturate it with more color—only requires a minimal adjustment if any)
3) Select Image -> Shadows/Highlights – Take shadows down to 0% initially, Adjust Highlights %, Adjust Shadows % if it helps clarify image
4) Select Image -> Levels (Ctrl+L) – Use the three arrows to adjust light levels within the image
5) Select Image -> Brightness/Contrast – Adjust levels for best image
6) Save Image in A:\Macro Insect Photos file with _final at end of file name
7) If background seems patchy use the Spot Healing Brush or Patch Tool (under the Spot Healing tab) to smooth out background. If satisfied with edits Save image again.

Masking – for Artistic Photos

You will use masks to create an even background for the image. Once you have cleaned the specimen with photoshop, you can begin masking out the subject. Start by selecting the "quick selection tool" (fourth from the top of your vertical toolbar on the left side of the page.) There are a number of options to select your subject, but I've found that clicking "select subject" from your toolbar at the top of your screen is the most effective. You can alter the automatic selection by clicking and dragging the selection to incorporate more of the subject or by pressing alt on your keyboard and clicking to remove objects from the mask. Once you've selected your subject, create a mask by selecting the vector mask in the layers toolbar. This is the white rectangle with a hollow, grey circle inside it. De-select your original background image by clicking on the eye located next to the layer. You will now be able to continue editing your mask. Use the paintbrush tool to continue painting over the background of the image, thus removing it. Try to remove as much of the background as possible, but it is okay if you cannot remove all of the background from areas closest to the specimen, as we will use another tool to do that next. Once you've removed as much of the background as you can, double click on the "background copy" mask and select the "refine edge brush" tool. This is the second one from the top of your left toolbar. This tool will allow you to paint closer to the specimen and paint over hairs without masking them out with the background. Be careful to only use the edge of this tool. You do not want to paint directly over the main body of the specimen or you may accidentally remove parts of the subject. If this does happen, you can remove it by pressing alt on your keyboard and painting back over it. It can take a moment for photoshop to catch up with your brush strokes, so take a moment to pause between clicks to evaluate what you've done. Once you've refined the edges around your specimen, click "OK"

on the bottom right corner of the screen. From here, you can fill in the background with a solid color. Select the tile for your original background copy (not the mask,) and navigate to the icon in your layers tools that shows a circle that is half white and half gray. Click this and select "solid color." The window that appears will allow you to select a color. You will likely only use white and black. Be sure that you've selected true white or true black by selecting a color from the absolute corner of the "color picker" square and click okay. Next, drag the new "color fill" layer so that it appears in your layers list beneath your background copy/masked layer. Your mask should now appear with a completely uniform background.

Next, you can alter the color vibrancy or contrast of your photo by working under the "adjustments" tab on the right side of your page beneath your layers. You don't want to alter the colors too much, because the image needs to remain true to what we would see in nature, but this can help to bring colors back that may have gotten dull with the flash from the camera. I have found the most useful adjustment to be the "vibrance" tool, which is pictured as an upside-down triangle. Any changes you make in the adjustments tab are added as layers, so you will need to edit them from within their respective layer. These changes can also easily be deleted, so feel free to play with them.

Lastly, press ctrl + alt + shift + E on your keyboard to flatten all of your layers and make a copy. Now we will sharpen the image. Note that this is not always necessary, but can really help to bring out details in your image. Navigate to the toolbar on the top of your page and select "filter." From this drop down menu, navigate to "other" and select "high pass." The radius should be set to a very low number of pixels – I would suggest staying below 2.5. Click OK and then navigate to the dropdown menu in your layers tab. Change the menu that reads "normal" to "overlay." Your image should now appear sharper.

Once you are satisfied with the image, save the finished product as a copy with the same naming format, followed by the word "edited" to show that the image is done being retouched. Again, always select "save as."

TEXT FILES

Each image must be associated with its corresponding metadata. Create a text file under the same name as the folder for the designated specimen and write in the following information in this format:

Long-horned beetle - Acmaeops pratensis
Photo by: NPS

Collected by: D. Azevedo
Park County, WY
June 23, 2016
Mount Washburn N1
Determined by: G. Bowser

This information can be found on the tag that corresponds to the specimen. Make sure the tag always stays with the insect.

Create a folder for each specimen in the following location: P:\Strategic Communications\Macro photos

Transfer the final photo product and the text file into the corresponding folder. This is where they need to be in order to be uploaded to the park Flickr page.

View macrophotography images of Yellowstone insects here:
https://www.flickr.com/photos/yellowstonenps/albums/72157704843714434

APPENDIX

CONGRESSIONAL LETTER

Congress of the United States
Washington, DC 20515

September 12, 2019

Dear Deputy Director Dan Smith,

On behalf of members of the House of Representatives Sustainable Energy and Environment Coalition (SEEC), we would like to express our gratitude to the National Park Service staff at Yellowstone National Park for their professionalism and for sharing their insight into the impact that climate change is having on our national parks. Our three days exploring the park and interacting with your staff further underscored our commitment to meeting the challenge of climate change both in our national parks and beyond. Witnessing climate change impacts firsthand, especially in the context of the unique challenges faced at America's oldest national park, only strengthened our resolve to take concrete action as we return to Congress.

This visit enabled us to engage with NPS staff and learn directly about the scope and severity of climate change impacts at Yellowstone. As one of America's most visited national parks, Yellowstone offered us a unique opportunity to better understand how climate change is affecting the landscape, ecosystems, and visitor experiences within the park. The skilled and professional National Park Service staff at Yellowstone were excellent guides. Their understanding of the science of climate change and its potential to impact the unique and delicate ecosystems in the park- from changing weather patterns to increased wildfires to shifting growing seasons for crucial native plants- was an inspiration. We all agree that this natural treasure is in strong and steady hands.

That said, climate change is a global problem with local consequences. It is on all of us to ensure that the iconic herds of bison, Old Faithful, the Grand Canyon of Yellowstone, and other treasures that belong to the American people, exist for future generations in a pristine state.

Our time at Yellowstone provided us with invaluable information about how climate change is affecting our national parks, and what can be done to mitigate the worst of its effects. Yellowstone and national parks across America are at the forefront of the fight against climate change, and it is critical that Congress continues to give NPS the tools and resources its needs to continue its conservation and research missions. Thank you again for your service to the American people and for your commitment to maintaining the majesty and health of our national parks.

Sincerely,

Mike Quigley
Member of Congress

Katherine Clark
Member of Congress

Ann McLane Kuster
Member of Congress

Denny Heck
Member of Congress

Deb Haaland
Member of Congress

Raúl Grijalva
Member of Congress

CC

Cameron Sholly
National Park Service

Grace Stephens
National Park Service
Jennifer Carpenter
National Park Service

Ann Rodman
National Park Service

Jody Lyle
National Park Service

Lauren Miller
National Park Service

Vanessa Lacayo
National Park Service

Todd Koel
National Park Service

Jeff Hungerford
National Park Service

Pat Bigelow
National Park Service

Doug Smith
National Park Service

Chris Geremia
National Park Service

Dan Stahler
National Park Service

Erik Oberg
National Park Service

Roy Renken
National Park Service

A DAY IN THE FIELD

Citizen Science Engagement: A Vital Part of Yellowstone Science

by Erik Oberg

Citizen science volunteers collect insect samples and record phenology data at a Washburn Mountain monitoring site.

Understanding long-term environmental change and documenting patterns in nature requires rigorous protocols, dedicated observers, and a long-term commitment. Increasingly citizen scientists or volunteers from outside the scientific community are contributing to monitoring programs that are difficult or impossible to carry out (Bonney et al. 2009). There are many examples of citizen-based monitoring programs, but one of the most successful and best recognized is the annual Breeding Bird Survey (BBS; Ziolkowski et al. 2010). Beginning in 1966, BBSs included approximately 600 survey routes east of the Mississippi River. Today citizen scientists complete nearly 3,000 survey routes annually throughout the U.S. and Canada. These efforts help track population trends for over 400 bird species, and the data have contributed to more than 450 scientific publications. Citizen science volunteers at Yellowstone have been conducting BBSs since 1987.

Many decades before the coining of the term "Citizen Science," Yellowstone National Park (YNP) benefitted from volunteer data collection with early park managers relying on visitor creel counts to estimate fish populations. Today, volunteer anglers continue to help characterize native and non-native fish distributions. Between 2002 and 2016, over 900 volunteers logged almost 23,000 hours and sampled 7,000 fish, contributing much to our current understanding of trout genetics. Before the days of tracking collars and digital photos, visitors also turned in thousands of wildlife observation cards, as nothing inspires citizen science volunteers like YNP's big mammals. Throughout the 1990s, park researchers engaged over 600 citizen science volunteers to study coyotes and foxes; other citizen monitoring projects enhanced Yellowstone's ability to collect water samples. These efforts helped shed light on meso-carnivore response to wolf reintroduction and provided useful baseline water quality data to examine watershed responses to changing mammal populations. Another ongoing citizen science campaign in YNP formed following the reintroduction of wolves in 1995. "Wolf Watcher" volunteers arrived to help record pack movements, dynamics, and wolf ecology. Wolf Watchers have helped park managers document a mange

Carabid beetle, *Poecilus scitulus*, with mite parasites collected near Gardiner, Montana as part of a citizen science Climate Change Monitoring Phenology Project. Only 0.75in. long, this tiny creature is a key indicator species. NPS PHOTO - A. ZAIDEMAN

outbreak, monitor genetic characteristics, and study seasonal variations in predation patterns. These watchers share their passion, knowledge, and spotting scopes with thousands of visitors every year. In 2016 alone, Wolf Watchers contributed over 13,000 hours, delivering public presentations and making visitor contacts in the field.

Despite its rich biodiversity, YNP was set aside for its geysers. It's no surprise that a citizen science program grew around these unique park treasures. Have you ever stood by a geyser and wondered, "When is this thing going to go off?" There is a decent chance a "Geyser Gazer" volunteer, clipboard in hand, was there to provide you an estimate with train-schedule precision. Founded in 1983, the Geyser Observation and Study Association's (GOSA) purpose is the collection and dissemination of information about geysers and other geothermal phenomena in YNP. They gather eruption data on many of the park's most popular thermal features and maintain an online database and timetable for eruptions. Some GOSA data is being incorporated into a park study examining geyser eruption cycles.

Among the most successful citizen scientist opportunities across the National Park Service (NPS) has been the BioBlitz: www.nps.gov/subjects/biodiversity/national-parks-bioblitz.htm. A BioBlitz is an organized event focused on identifying as many species as possible in a specified area, typically over a 24-hour period. BioBlitzes are a partnership between the NPS and National Geographic Society and have introduced many citizens to volunteer science opportunities in the parks. In 2009, approximately 125 scientists, park staff, and volunteers conducted Yellowstone's first BioBlitz and documented over 1,200 species, including the first park records of little seed ricegrass (*Piptatherum micranthum*), a blue lichen (*Aspicilia desertorum*), and a tiger beetle (*Cicidela haemorrhagica*).

As the NPS enters its next century of stewardship, YNP managers recognize novel and emerging threats to park resources—some iconic and some little-known. The park is teaming up with Yellowstone Forever (YF), the park's education and philanthropic partner, to offer hands-on learning opportunities. Trained and accompanied by park biologists, these YF citizen science volunteers will gather baseline data to better understand stressors unique to each species or ecological community. Each of the five projects below was prioritized by park staff and began recruiting new citizen science volunteers in 2018.

A steadily recovering bison population has caused concern as to whether or not there is "home on the range" for the most diverse and abundant ungulate and carnivore community in North America. The YF Home on the Range Project will collect data to evaluate bison, elk, bighorn, mule deer, and pronghorn dietary patterns and nutrition, habitat use, migration patterns, birth rates, survival rates, and population growth rates. Managers and decision makers need new information on how park resources are being affected to guide future management.

Volunteers Dani Hatfield (foreground) and Maureen Cairns service a pitfall trap to monitor Carabid beetles, an important indicator species. Almost 800 samples were collected in 2018 with citizen science support.

Phenology is the study of plant and animal life cycle changes over time. By recording these changes, park managers can better anticipate resource protection needs and plan management actions. Volunteers will collect Carabid beetles, a diverse and abundant invertebrate community that represents ecosystem health. ("Insects as a Vital Sign in the Greater Yellowstone Ecosystem," this issue). Volunteers from YF will also participate in a simple monitoring program documenting key phenological events such as green-up, flowering, seed set, and die-off for sentinel plant species. Collected data will be used to fill an important knowledge gap about important phenological events and how they may be changing over time.

Invasive weeds compete with native vegetation for space and resources, lower species diversity, and provide little forage value for wildlife ("Invasive Plants as Indicators of Ecosystem Health," this issue). Given what we know about the current grazing pressures in the park, understanding how much forage is available for wildlife assists in making science-based management decisions. Weeds are an enormous economic drain that negatively impact ecosystem health. Volunteers coordinating with YF will photograph and gather locations for seven high priority invasive plant species. Data will be used to better understand invasive plant ranges, estimate rates of spread, and prioritize invasive plant treatments and native plant restoration locations.

Red-tailed hawks are charismatic, common, and easily recognizable, making them ideal candidates for citizen science monitoring. A red-tailed hawk nest monitoring project in YNP is part of a continental-wide effort to provide baseline data on nesting success and will serve as an important indicator for future change. Yellowstone's northern range offers a unique opportunity to monitor this species in a relatively natural landscape, providing baseline data from which to measure future trends as visitation and climate patterns change. Citizen science volunteers working with YF instructors will monitor breeding behavior and territory use by observing known nest locations.

Pikas are small, non-hibernating members of the rabbit family that typically dwell at high elevation sites. They are vulnerable to a warming climate and tend to abandon lower elevation sites in favor of higher, cooler habitat. Volunteers will assist by conducting surveys at historic pika sites, listening for pika calls, and searching habitat for evidence of recent pika activity.

Plants and animals within YNP are being affected by local, regional, and global stressors. Citizen science efforts will help maintain the park's capacity to monitor important park resources and will contribute to a deeper understanding of their status and trends. These authentic, hands-on volunteer and learning experiences also serve to educate and inspire the next generation of park stewards. To find out how you can become a YNP citizen science volunteer, visit www.yellowstone.org/experience/citizen-science or contact Erik Oberg, erik_oberg@nps.gov.

Literature Cited

Bonney, R., C.B. Cooper, J. Dickinson, S. Kelling, T. Phillips, K.V. Rosenberg, and J. Shirk. 2009. Citizen science: a developing tool for expanding science knowledge and scientific literacy. BioScience 59:977-984.

Ziolkowski, D., K. Pardieck, and J.R. Sauer. 2010. On the road again for a bird survey that counts. Birding 42:32-41.

Participants learn field techniques in the first Yellowstone Forever Citizen Science Field Seminar. (PHOTO - ©L. OSBURN)

Erik Oberg is a Yellowstone Biologist with 25 years of National Park Service experience in resource education, water quality monitoring, and biological inventories, with a focus on invertebrates. He has worked in six parks, including Joshua Tree, Sequoia, and the George Washington Memorial Parkway, and has recruited hundreds of citizen science volunteers.

CITIZEN SCIENCE PARTICIPANTS IN ACTION

- NOVEMBER 28, 2018
- INSIDE YELLOWSTONE, YELLOWSTONE QUARTERLY

BY CHELSEA DEWEESE

The buzz of grasshoppers fills the sagebrush-scented air atop an open hillside in Yellowstone National Park's northern range when Dani Hatfield breaks her silence. "Wow. There's some cool stuff in here," she says, looking into a plastic container filled with insects suspended in cloudy liquid. "It keeps changing every time. That's my favorite part." The number of millipedes captured in this particular "pitfall"—a plastic container placed in the ground that bugs crawl into—is more than last month's capture, she continues. Hatfield, a 19-year-old from nearby Gardiner, Montana, studies filmmaking and entomology at Montana State University in Bozeman and has volunteered with the National Park Service (NPS) since high school. This project isn't necessarily tied to what she studies in school though, she says: "I just like bugs. So I volunteered." Nearby, Hatfield's teammate, Maureen Cairns, documents plants growing in plots adjacent to field equipment gathering temperatures, precipitation, wildlife sounds, and other data.

Hatfield, Cairns, and their other teammate, Gabrielle Blanchette, were three of nearly a dozen volunteers gathering data for Yellowstone National Park that afternoon as part of the joint Yellowstone Center for Resources and

Yellowstone Forever Citizen Science Initiative, a cooperative effort between Yellowstone Forever and Yellowstone National Park biologists. Citizen science allows volunteers to participate in scientific undertakings to further their appreciation of Yellowstone, and it also helps the park achieve more research than current funding and staffing may allow.

Since its inception more than 10 years ago, citizen science has been a resounding success, and Yellowstone Forever is now working to create more opportunities and fold them into existing programs. The Yellowstone Phenology Project, described above, is the study of plant and animal life-cycle changes over time. Other citizen science projects include red-tailed hawk nest monitoring, invasive weeds mapping, and northern range ungulate research. Erik Oberg, a biologist with NPS and the lead on the phenology project, described the volunteer help to his project as "invaluable." It's the perfect hands-on opportunity for volunteers and a chance to recruit, train, and retain volunteer staff, he says.

The volunteers run the gamut. Some, like Blanchette, who is an entomology graduate student at MSU Bozeman, use it for professional development. Some, like Cairns, see it as a way to get outside and away from the desk while continuing to learn about Yellowstone. Retired entomology professor Bob Stoltz lends his expertise identifying bugs captured in the pitfalls. And Jana Paus, of Bonn, Germany, finds it a way to make friends and stay occupied while she visits her boyfriend for the summer while he's working in Yellowstone. All find fun in the camaraderie of collecting and sorting data. "I always thought I'd like to do volunteering," says Paus, who recently earned her undergraduate degree in biology and is enrolling in a master's program.

The morning after collecting insects and plant data in the field, volunteers gather in a classroom at the Yellowstone Forever building in Gardiner, Montana, to carefully extract insects from the pitfall samples, examine them under a microscope, and sort them into vials filled with ethanol. These samples will be made available to permitted researchers, including graduate students, and will be stored in a repository at the Yellowstone Heritage and Research Center for future study. Some, like the carabid ground beetle, of primary interest in the insect portion of the phenology study, will be sent to outside experts for further classification. Beetle species trends can be a key indicator of climate

change, Oberg says. The study is being conducted in a way that data can be shared with the National Ecological Observatory Network, which is in the process of finalizing a field site in Yellowstone. Plant information will illustrate what plants are growing, flowering, and seeding at certain times of the year. In terms of what the data will be used for: "We are documenting what is happening in Yellowstone at this moment in time at different elevations," Oberg says. This can be incorporated into future studies.

Joshua Theurer, citizen science program manager at Yellowstone Forever, says visitors benefit greatly from participation in citizen science because it allows them to "peek behind the perceived veil of science" and have a more in-depth visitor experience. He says Yellowstone Forever is working to include more youth—from middle school to college-aged—in volunteer roles. "The hope is that these projects are not just a nice, isolated experience but will inspire continual engagement with projects in participants' local areas," he says. Yellowstone Forever is working on ways for students to remain involved remotely both before and after their visit.

For volunteers Brian and Sydney Wallace of Bozeman, the benefits of volunteering are more visceral. Sydney says focusing on something so small, like a collection of insects, allows her to think about the park in an entirely different context, instead of focusing only on big things like bears, and wolves, and mountains. Plus, "It was a lot of fun!" For Bryan, it was reassuring to know somebody's paying attention to Yellowstone's smaller details, and he was happy to contribute. "It's an investment of a day," he says. "Who doesn't have a day to invest?"

For information on participating in the phenology project, please email Erik Oberg directly at erik_oberg@nps.gov. Learn more about the Citizen Science Initiative **here**.

*This article was originally published in the Winter 2018 issue of **Yellowstone Quarterly**.*
Photos by YF/Maria Bisso and YF/Matt Ludin

https://www.yellowstone.org/citizen-science-participants/

NEON BLOG POST

Citizen Scientists Extend Beetle Research at Yellowstone

What can a ground beetle tell us about the environment? Quite a lot! This diverse and ubiquitous family of insects provides a window into environmental health and change.

Erik Oberg, a biologist at Yellowstone National Park, is leading an ambitious beetle-biodiversity initiative on the Northern Range of the park. The Yellowstone Phenology Project collects data on Carabid beetles and other environmental indicators at seven sites across a 4,000+' elevation gradient. Erik has recruited a cadre of citizen scientists to collect, classify and count beetles collected at the sites.

Counting the Carabids
Carabids, or ground beetles, are a diverse family of insects found in nearly every terrestrial ecosystem on earth, with 40,000 species identified worldwide and more than 4,000 in North America. Many species are carnivorous, sitting at the top of the invertebrate food chain. Studying Carabid diversity, abundance and range may provide insights into what is happening with the invertebrate species they prey on as well as the numerous bird and small mammal species that rely on them for food. Because insects have short life spans, they are also highly sensitive indicators of environmental change.

Carabids have the advantage of being fairly easy to capture and count (though with so many similar species, accurate species identification can be challenging). Erik and his team collect the beetles in pitfall traps using the same collection protocols developed for use at NEON's terrestrial field sites.

The Yellowstone Phenology Project (YPP) began the beetle inventory in 2018 and will continue through 2019 and 2020. The three-year study will provide baseline data on Carabid diversity and abundance across the elevation gradient in Yellowstone's Northern Range that will be invaluable for future researchers. "We're not drawing any conclusions with these data," Erik explains. "What we are doing is establishing a baseline that will allow future researchers to assess how beetle populations are changing over time. For example, are new species of beetles moving in at lower elevations? Are species now present mainly at higher elevations leaving the park?"

The seven sites are located along an elevation gradient that begins in Gardiner Basin (5,300') and ends at the peak of Mt. Washburn (9,600'), rising over 4,000 feet along the way. The sites were originally established by Yellowstone GIS Specialist Ann Rodman in 2010 as part of a pollinator study. At the time, NEON was nearing the end of its design phase. Ann chose these study locations with the vision that when NEON field sites completed construction, the study locations would bracket a planned NEON field site. The sites now function as climate change indicator sites for Yellowstone, with a broad range of sensors and data collection efforts aimed at monitoring key indicators of climate change such as temperature, soil moisture and snow depth. NEON's Yellowstone Northern Range (YELL field site) sits near the midpoint of these sites as part of NEON's D12: Northern

Rockies ecoclimatic domain.

Partnering with the NEON Program

Erik collaborated with Ann to build on her vision by adding Carabid data to the other data that are collected at the indicator sites. Because the team uses NEON's beetle collection protocols, data will be comparable between YELL and the YPP sites located up and down the elevation gradient. The project gives park managers and researchers an exciting opportunity to compare Carabid distribution and abundance paired with meteorological data at different elevations and see how beetle communities are changing across the gradient over time.

Erik reached out to the NEON science team during the planning phase of his project. He has a long connection with the NEON program and was part of a team instrumental to finalizing the NEON permit and application to conduct research inside Yellowstone National Park. Once YELL was established, he saw an opportunity to build on NEON's research by using their protocols across a broader cross section of the park. "We wanted to make sure that data we are collecting are accurate and comparable. The NEON protocols are scientifically valid and were easy to implement with our volunteers."

The NEON program provided training resources and guidance to the YPP team. In addition to using the same pitfall trap design, YPP used a stratified random spatial design to select the collection plots within each site. This method, also used by NEON, ensures that human bias does not influence plot selection and results in samples that are more representative of the habitats found within each site.

Interested in implementing NEON's data collection methods? Contact Us with your ideas!

Katie LeVan, a Research Scientist for the NEON program specializing in insect ecology and data, says, "This was a very collaborative process between NEON and the Yellowstone team. Erik reached out to us to see how his research questions and interests fit into what NEON was already doing in Yellowstone. We were able to support him with the sampling design so he can use the NEON protocols with very minimal modifications. His work represents a deep dive into Carabid populations in the park that goes beyond what we are able to do with a single site."

The Power of Citizen Science

As valuable as the Carabid data will be for the scientific community, the project would never have gotten off the ground without the hard work of Erik's team of citizen scientists. In 2018, "Carabid Crew" volunteers put in more than 1,340 hours of effort to collect beetles from the pitfall traps and sort, pin, label and catalog more than 3,900 specimens. Undergraduates and graduate students from seven different universities participated. Two volunteers in Louisiana dedicated hundreds of hours to mounting and cataloging specimens. In addition to collecting beetles, field volunteers also recorded plant phenology observations (the timing of events such as leafing, flowering and leaf drop).

Erik says, "It would be impossible to do this project without our volunteers. I don't have a

line item in my budget for Carabid collection. We are lucky to have a team that is very dedicated and excited to be bringing new knowledge to science through their efforts. It's impossible to have a bad attitude at work when working with our volunteers."

Engaging the general public in science is an important part of the missions for both Yellowstone and the NEON program. Erik says, "We need this research to inform management decisions, but we also want people to understand why we are doing it. Our citizen science programs get people engaged and foster increased scientific literacy and support for park stewardship."

Katie says, "It's exciting to see so many people now engaged with science through projects like Erik's or through apps like iNaturalist or eBird. Of course, when working with untrained non-scientists we always have to consider the accuracy and reliability of the data. But in many cases, the data being generated by citizen scientists has proven to be highly reliable. Participants are adding incredibly valuable data that the scientific community would not be able to collect otherwise, especially when it comes to things like species distribution."

The Carabid Crew is now engaged in data collection for the 2019 field surveys. The 2019 team has grown to 37 volunteers ranging from ages 8 (the son of another park ranger) to 77 (a retired laboratory assistant).

Over the winter, teams will count and catalog the species collected. A contract entomologist will check their work and identify Carabids to species. Volunteers are also starting to take a look at the bycatch (non-Carabid invertebrates caught in the pitfall traps). One student at Montana State University, Bozeman is cataloging ant species collected at the sites. This year, volunteers began capturing high-definition images of Carabids using a macrophotography studio set up by the Canon Foundation. The stunning images are publicly available on Flickr.

Katie says, "This is exactly the kind of collaboration I would like to see more of as the NEON program matures. We have a lot of resources available for researchers that they can leverage for their own projects and interests. Our infrastructure, samples, data and protocols are available to support a broad range of research initiatives."

The Yellowstone Phenology Project will continue at least through 2020.

https://www.neonscience.org/observatory/observatory-blog/citizen-scientists-extend-beetle- research-yellowstone

PARAMOUNT STUDIOS DOCUMENTARY AND ARTICLE

Paramount Studios short documentary and article
link 1 https://www.youtube.com/watch?v=F9ovWx3sul8
link 2 https://popculture.com/tv-shows/2019/08/13/yellowstone-ian-bohen-paramount-network-save-yellowstone-national-park/

Yellowstone Citizen Science Initiative

2018 PROJECTS

YELLOWSTONE PHENOLOGY PROJECT

YELLOWSTONE PHENOLOGY PROJECT

152
Number of Participations

1341
Effort (Hours)

$27,949
In-Kind

Introduction

The ***Yellowstone Phenology Project*** is a citizen science initiative designed to monitor environmental change over time across a 5,000' elevation gradient in Yellowstone National Park. The project contributes additional monitoring elements to baseline data gathered at seven sites from Gardiner Basin to the top of Mt. Washburn. These sites were originally established in 2008 by the park's physical scientist Dr. Ann Rodman to monitor pollinator diversity and abundance. Since its inception, remote sensing equipment has been added to these climate change monitoring plots. The *Yellowstone Phenology Project* has established ten invertebrate pitfall traps and three plant transects at all seven climate change sites.

Located in the middle of this elevation gradient, the National Science Foundation's NEON (National Ecological Observatory Network) site completed construction in 2018. The NEON site is one of 81 locations across the United States that utilizes sophisticated methodologies to monitor 32 environmental conditions, including documenting carabid beetle diversity. The *Yellowstone Phenology Project* extends the NEON dataset to cover a wider elevation gradient by replicating the NEON carabid beetle field protocols.

Carabids, collected with pitfall traps, are a well-documented family of ground beetles that may serve as an indicator of environmental health and change. Carabid samples will supplement Yellowstone's beetle catalog housed at the Heritage and Research Center. Other invertebrate samples contained in the pitfall traps will be available to collaborating institutions for further research. Many new park species and range extensions are expected to result from this work. Data derived from *orthoptera* (grasshopper) diversity and abundance samples will also contribute to *Home on the Range* research objectives.

Plant phenology transects are located at each of the three points associated with the seven climate change sites. Citizen scientists identify plants falling along these transects and document phenophases including first flower, first fruit/seed, and brown out. The timing of these events are correlated with environmental changes.

YELLOWSTONE PHENOLOGY PROJECT

Methods:

The *Yellowstone Phenology Project* involves servicing ten pitfall traps at each of the seven climate change sites on a two-week cycle. Center points, located around the perimeter of climate change sites, are located utilizing handheld GPS units. From each center point, pitfall traps are located 40 m away along cardinal directions. Each pitfall trap consists of two plastic cups nested together and placed in an excavated hole approximately six inches deep. The bottom cup contains holes in the bottom to drain any moisture. The second cup serves as the holding container for invertebrate samples, in which 2 inches of propylene glycol (preservative) is placed. The cups are covered with a 1" wire mesh to exclude vertebrate by-catch. A square plastic cover is placed over the entire trap to protect the trap from larger animals and precipitation.

Small teams of citizen scientists navigate to each of the 70 pitfall traps. At each of the traps, the cover is removed. Samples are filtered through fine cloth along with respective labels. The cloth filters and labels are deposited in whirl-paks, and samples are preserved with ethyl alcohol. Whirl-paks are labeled with the date, site name, and pitfall number. Each trap is reset by placing the drain cup first and the second cup is nested with the drain cup and refilled with approximately 2 inches of propylene glycol. The metal screen and plastic cover are placed over trap and held in place with spikes. Any disturbance to the traps or vertebrate by-catch are documented on digital data sheets.

Pitfall samples are then sorted in the lab utilizing dissecting stereo microscopes to the taxonomic level of order. Once a sample has been sorted to the order level, the order Coleoptera (beetles) is further sorted to isolate members of the Carabid family. Carabids are then pinned and mounted utilizing the Smithsonian Institute's protocols. These carabids are sent to specialists for species-level identification. All other taxa are stored for future research opportunities.

Plant phenology transects are established from each of the three center points associated with all seven climate change sites. Once a center point is located, a tape measure is pulled at a predefined direction off the center stake. A Daubenmire frame is placed on the right side of the tape (while facing away from the center point) at the 5m mark. Target plant species are identified with associated phenophase; data is recorded in digital form on tablets. Repeat readings are made at meter marks along the transect for a total of ten frames per center point.

Engagement:

Implementing the *Yellowstone Phenology Project* required unique considerations due to relatively complicated methods and regular data collection intervals. To accommodate these requirements, citizen science volunteers were recruited from surrounding communities who would be able to commit to monthly collection events. This group of volunteers, known as the Carabid Crew, was then trained on collection protocols and methods. Volunteers returned during field days to collect data at least once a month for two days of work in exchange for lodging at the Yellowstone Overlook Field Campus. Additional "Day Trip" volunteers committed to one day per month and were integrated into both field and lab work as needed. Four PhD entomologists, four entomology ~~graduate~~ students, and ten entomology undergraduates were engaged through this project in 2018.

Several university groups, including the Colorado State University Rocky Mountain Sustainability and Science Network (RMSSN) and the University of Nebraska-Lincoln, were also trained to assist in field days as a part of a larger educational experience. However, these opportunistic groups were limited due to the time commitment required for training and processing.

During winter months when field sites are shut down for data collection, seven lab kits and microscopes were assigned to volunteers who continue working from home. Workshops were held to train citizen science volunteers on sample processing techniques. This component has extended the effective season of this project and resulted in more samples being processed than otherwise could have beenachieved.

Yellowstone Forever and Yellowstone National Park collaborated to promote awareness of the Phenology Project through many avenues. Several YF and NPS social media posts recruited volunteers and described project progress. Yellowstone NP built an Arthropod Flickr page to illustrate insect diversity. MSU Bozeman *Wanderlust* sponsored a presentation given by Erik Oberg, featuring the project with 145 people in attendance. The *Yellowstone Phenology Project* was featured in the Yellowstone Quarterly winter magazine and in the 2018 issue of Yellowstone Science. Victoria Ibarra, an NPS Mosaic in Parks intern presented a poster in Washington DC highlighting her participation. Phenology Project participant Sarah Whipple and Project Co-Leader Joshua Theurer both gave presentations respectively at the 14th Biennial Science Conference of the Greater Yellowstone Ecosystem, and a regional citizen science workshop in Rocky Mountain National Park. The most recent *Telemetry* podcast also describes the importance of the *Yellowstone Phenology Project*, which will be released in early 2019.

Results:

During the 2018 pilot season, the *Yellowstone Phenology Project* engaged 152 participation events, resulting in 1341 hours of effort. This included 28 college students from two different universities.

The project attracted two volunteers from Louisiana who donated 186 hours of sorting and pinning in a mobile lab set up in Yellowstone Forever condos. These volunteers pinned a collection of 2,280 beetles. It is remarkable to consider that this pilot program contributed 75% of the total 2018 citizen science volunteer hours by only 7% of the participations events. This demonstrates a strong desire for and willingness to commit to in-depth, hands-on stewardship experiences. It also attracted a diverse range of students, subject matter experts, local residents and retirees.

The 2018 season also generated valuable plant phenology data forming baseline information and cataloging of represented species found at monitoring sites. Plant phenology methods will be refined to make this aspect of the project simpler.

Conclusion:

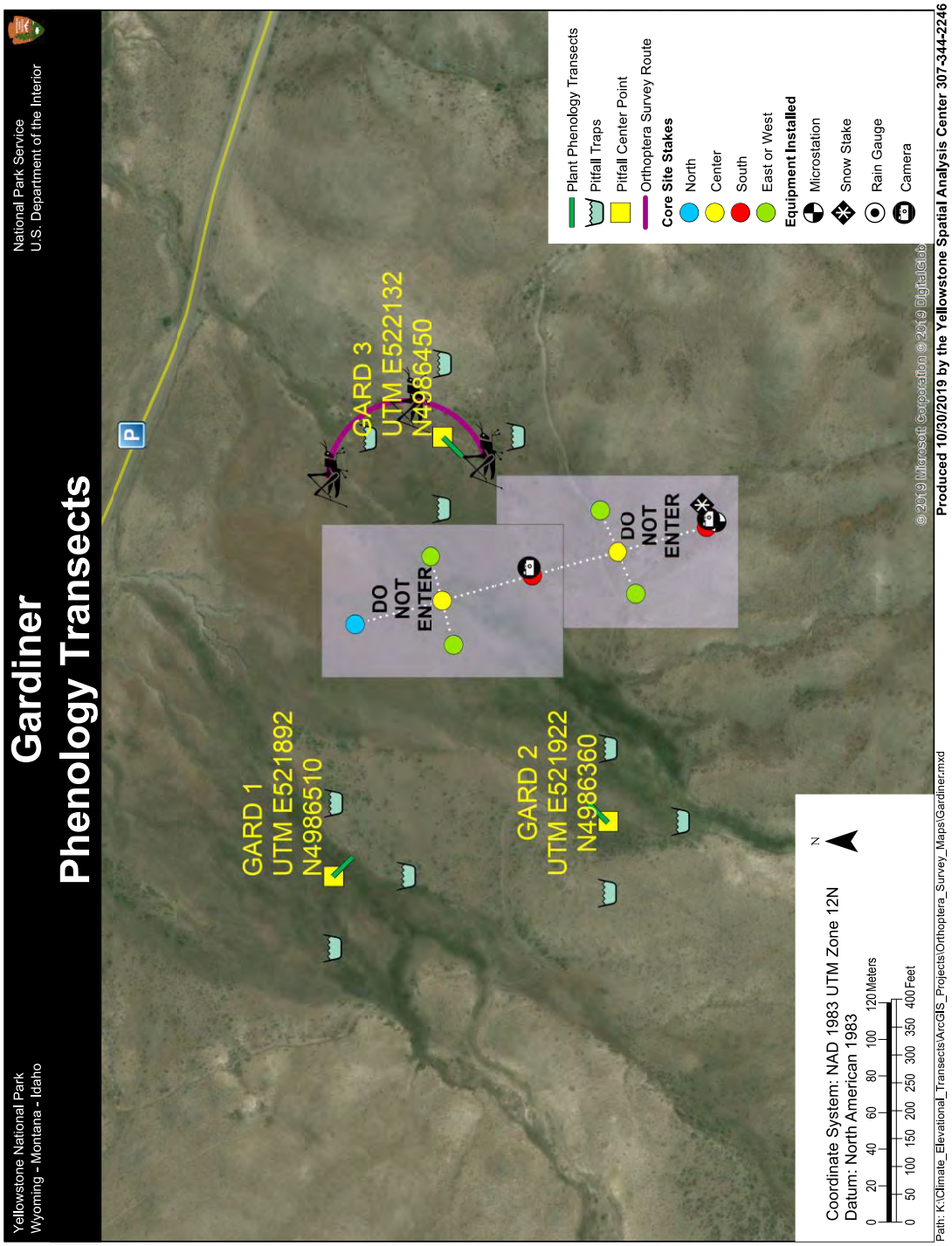
The *Yellowstone Phenology Project* will continue to collect pitfall samples and monitor plant phenology in 2019. Due to the project's complexity, volunteer recruitment and training will continue to be a controlled system. Calls for 2019 volunteers will be made through Yellowstone Forever's website, and other available platforms in January 2019.

The *Yellowstone Phenology Project's* high success is attributed to dedicated project leaders. Erik Oberg, National Park Service, is instrumental in all aspects of the success of this project. Erik will continue to champion this project with the support of Yellowstone Forever.

Winter sorting and mounting efforts will continue through this winter. The first training workshop was held on the campus of Montana State University in October. Seven volunteers have committed to sorting samples from home over the 2019 winter months. Two volunteers were recruited with a two-month commitment and will sort samples while staying in YF housing.

The *Yellowstone Phenology Project* is a model for citizen science collaboration efforts emphasizing private/government partnerships.

SITE MAPS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Wyoming - Montana - Idaho
Gardiner
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National Park Service
U.S. Department of the Interior
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GARD 2
UTM E521922
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GARD 3
UTM E522132
N4986450
DO NOT ENTER
DO NOT ENTER
P
Plant Phenology Transects
Pitfall Traps
Pitfall Center Point
Orthoptera Survey Route
Core Site Stakes
North
Center
South
East or West
Equipment Installed
Microstation
Snow Stake
Rain Gauge
Camera
© 2019 Microsoft Corporation © 2019 DigitalGlobe
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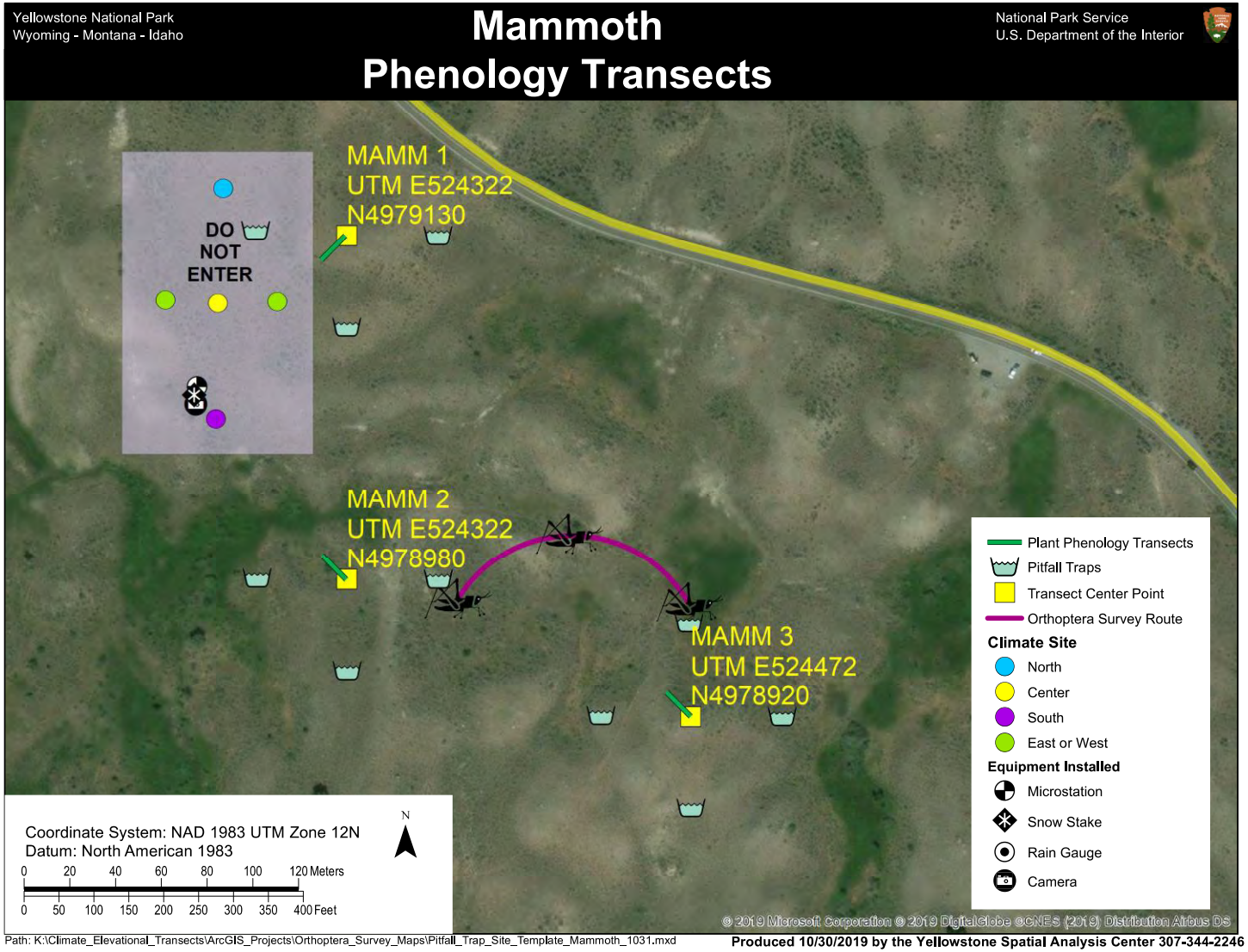

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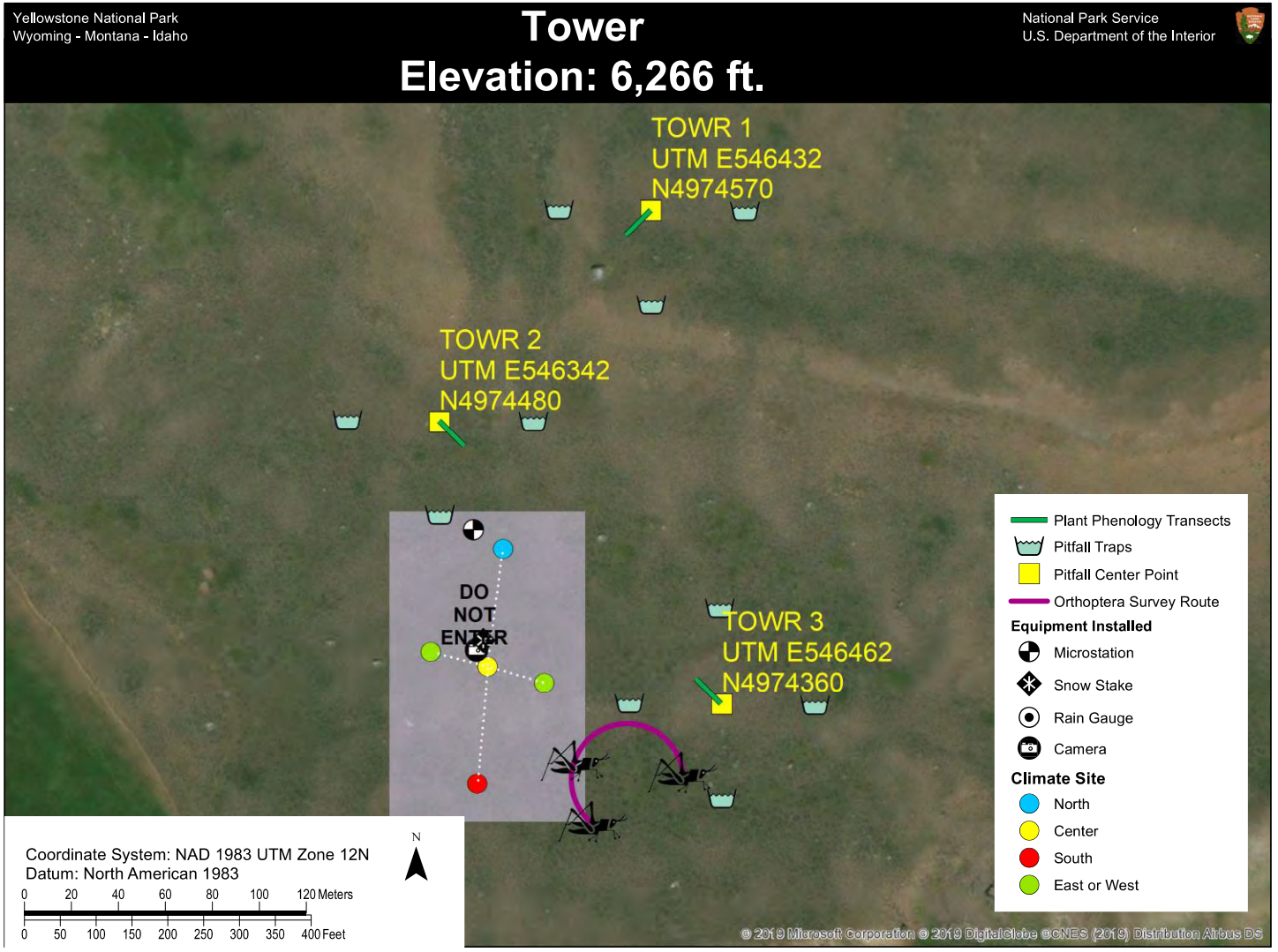

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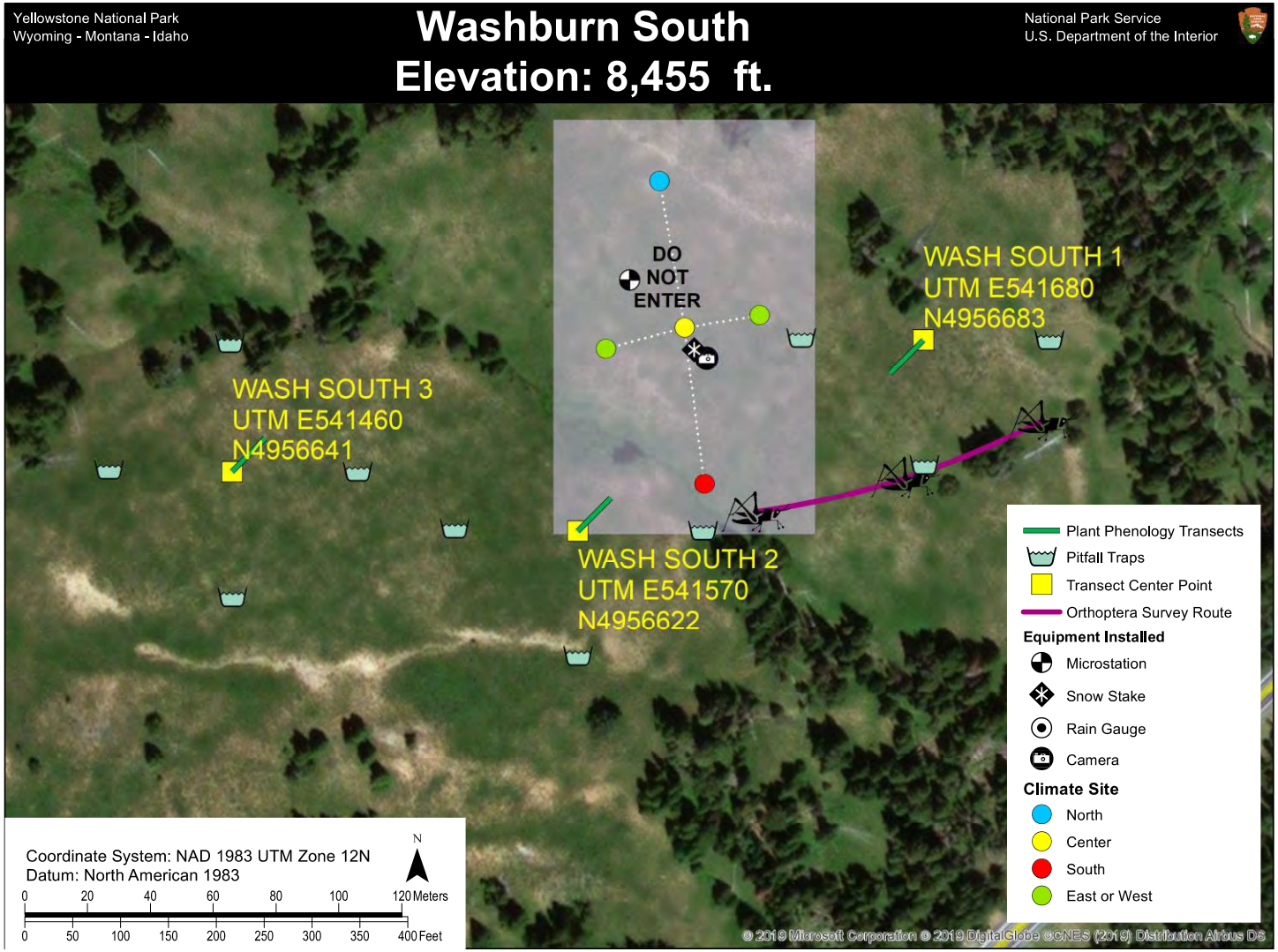

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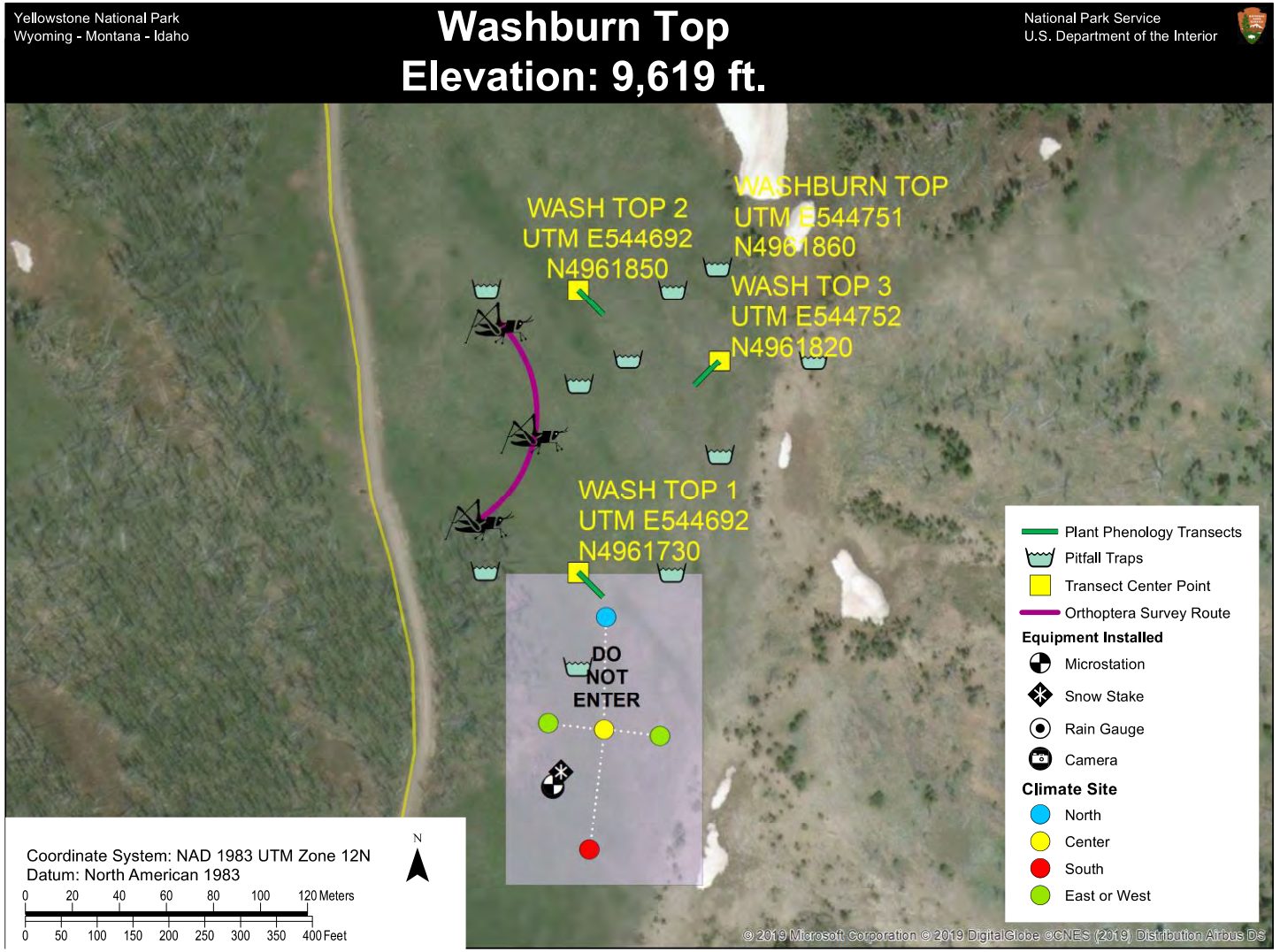

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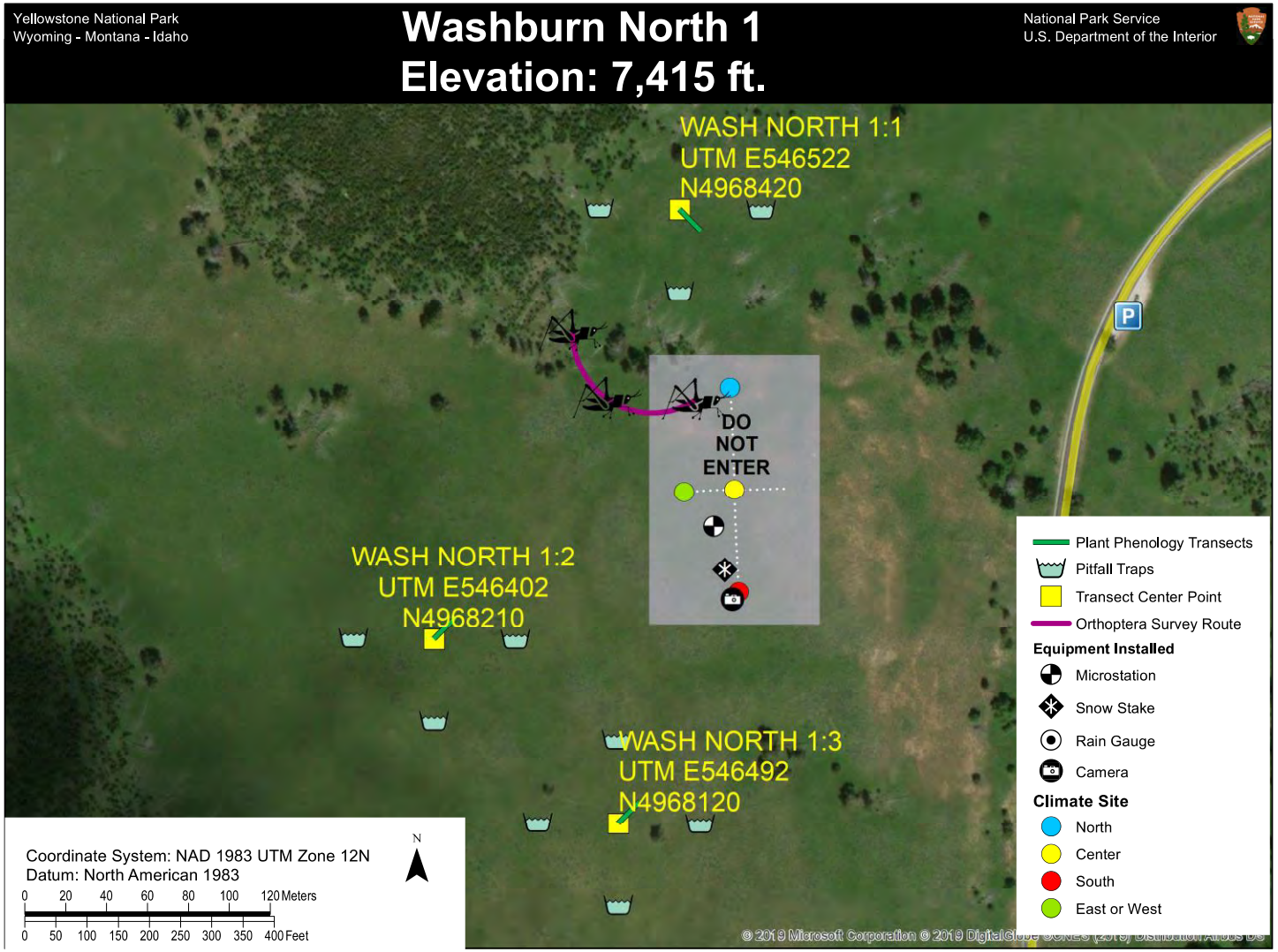

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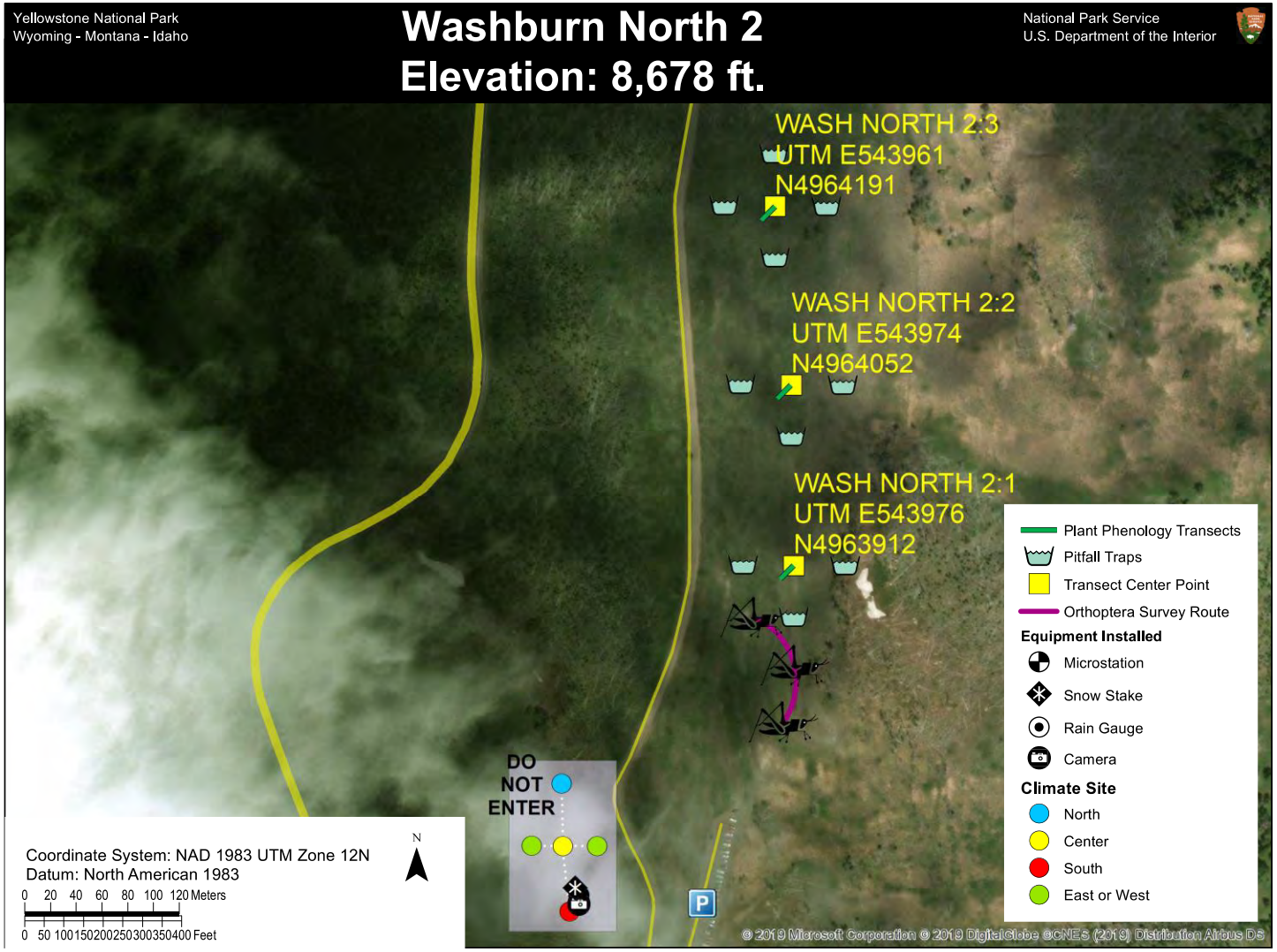

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Produced 10/30/2019 by the Yellowstone Spatial Analysis Center 307-344-2246

PERSONAL CHECKLIST FOR PHENOLOGY FIELD DAY

1. Volunteer Shirt
2. Layered clothing (for changes in temp)
3. Extra socks
4. Jackets: waterproof, lightweight and warmer
5. Waterproof pants
6. Gloves, hat for sun and/or cold
7. Water (hydropacks are easiest)
8. Small backpack for waterproof clothing, lunch, snacks and personal first aid…i.e. medications, Benedryl spray, children's dose tabs, bug spray, sunscreen)
9. Small front carrying fanny pack to hold bear spray and small notebook and pencil for anything in the field needed to be noted. Also good idea to have energy bar or nuts easily accessible.
10. Phone and car charger
11. Hiking poles if you use them
12. Sturdy hiking boots
13. Lunch, snacks
14. Money for incidentals if needed.

FIELD KIT CHECKLIST

Dry Side

- ☐ Binder (1)
- ☐ Measuring tape (1)
- ☐ Compass (1)
- ☐ GPS unit (1)
- ☐ Whirl Packs (30)
- ☐ Filter fabric (30)
- ☐ Gloves (4 pairs)
- ☐ Large Ziploc bags (3)
- ☐ Binder clips (30)
- ☐ First-aid kit
- ☐ Zip ties (6)
- ☐ Replacement spacers (6)
- ☐ AA Batteries (4)
- ☐ Extra Pitfall cups (2)
- ☐ Scissors (1)
- ☐ Permanent markers (2)
- ☐ Pitfall Labels

Wet Side

- ☐ Ethanol squirt bottle (1)
- ☐ Refill Glycol bottle (1)
- ☐ Hammer (1)
- ☐ Trowel (1)
- ☐ Strainer (1)
- ☐ Wipe cloth (1)
- ☐ Knee pad (1)
- ☐ Stakes (2)
- ☐ Pitfall cups (2) Note: There should be 4 total cups, 2 on wet side and 2 on dry side

Additional Supplies

- ☐ Discard bottle (1)
- ☐ Daub frame (1)
- ☐ Ethanol refill can (1)
- ☐ Extra Glycol bottle (1)
- ☐ Pin flags (3)

Please be sure to check all equipment is packed prior to heading out to your site and once again upon returning from the field.