

PhenoCam Installation Instructions

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Welcome

Thank you for your participation in the PhenoCam network! We try to make participating in the network as simple as possible. This guide is designed to help you get going with configuring and deploying your camera. Feel free to contact us at PhenoCam@nau.edu if you have questions.

Camera Configuration - Quick Start Guide

The following instructions have been developed based on more than ten years of camera deployment experience. The instructions are specific to StarDot-brand cameras, which is the standard camera used by "Type I" (top tier) PhenoCam Network sites. While cameras from other manufacturers can be used to monitor vegetation phenology, we have limited experience with these brands. Thus, we are only able to provide assistance with configuration, deployment, and troubleshooting of StarDot cameras.

We have tried to make getting your StarDot set up straightforward. Some knowledge of networking and Linux is helpful, but not required. **Configuration does involve several steps and attention to detail is important, as typing or syntax errors can have unintended (and sometimes serious) consequences.** The Quick Start Guide is a brief overview of the process. You will find additional information in the Detailed Guide on the next page.

Fill out the site survey

The first step is to fill out the PhenoCam site survey:

<https://phenocam.nau.edu/webcam/sitesurvey/>

Your site name needs to be in all *lowercase* alphanumeric characters. We recommend that the site name bear some relationship to the location where the camera will be installed—e.g., "flagstaffazpine" is recommended for a pine forest in Flagstaff, Arizona; "myphenocamsite" is not. Please email us (phenocam@nau.edu) if you have questions about choosing a site name.

After the survey is completed, we will set up your site on our server—this involves creating a directory to receive images from your camera and an associated "site page" where those images will be displayed. Once this is complete, you will receive an email from us (phenocam@nau.edu) with further instructions. **NOTE:** This email will be sent to the email addresses provided as the "site contacts" in the site survey form, and NOT to the email associated with the google account used to fill out the form. Please be sure to check your spam folder so you don't miss the email.

*If you are installing more than one camera, please fill out the site survey once for each camera, as every camera requires its own directory.

Run the PhenoCam Installation Tool (PIT)

Once you have received the email saying your site has been set up on our server, the next step is to configure your camera. We have developed a set of scripts—the PhenoCam Installation Tool, or PIT—to configure your camera according to the standard PhenoCam

Network configuration. The PIT can be downloaded from the following link, where you will also find full documentation:

https://bluegreen-labs.github.io/phenocam_installation_tool/

Note that to run the PIT scripts, you will need a computer (laptop or desktop) on the same local network as the camera. The local network must be connected to the internet, as the PIT will instruct the camera to pull files from our server (<http://phenocam.nau.edu/>). **You should not connect the camera directly to your computer with a network cable, as this will not give your camera the necessary network connectivity.**

You will know the PIT has run successfully if you see the following message:

```
Saving configuration files...
Configuration files saved.

#-----
#
# Done !!! - close the terminal if it remains open !
#
#-----
```

Verify the camera configuration

Once configured, the camera should start uploading images to the PhenoCam server. Initially, site pages are 'hidden', and the only way to view the images is through the "latest" link shown below. The latest image will always be displayed at:

```
https://phenocam.nau.edu/data/latest/<sitename>.jpg
```

where <sitename> is the name of your site. It may take up to 15 minutes for your images to appear, as the upload directories are only scanned 4 times per hour. Also, the "latest" image is only updated if the image is not overly dark. So for testing, make sure the lens cap is off and the camera view is well lit. If the latest image is not updating, see the detailed instructions below or contact us.

Note: Camera uploads will NOT occur exactly on the half hour (:00 & :30). Uploads are intentionally offset so that all the cameras are not sending images to the server at the same time.

Once the camera is set up in the field, please send us an email (phenocam@nau.edu), and we will make the site page active. At that time, we will also remove from the archive any images taken during the setup period, e.g., pictures from your laboratory, office or garage. Your camera's site page will be accessible at:

```
https://phenocam.nau.edu/webcam/sites/<sitename>/
```

Change the camera's default password

If the camera is on an open network connection that allows it to be accessed from outside a local area network, then it is **CRITICAL** that you change the camera's password from the default (user: admin, password: admin) to something that is more secure. Failure to change the password will likely result in the camera getting hacked, which may render it inoperable.

To change the password, follow the directions below for logging in to the camera's configuration pages, and then navigate to the Security tab. If you will be configuring the camera on an open network, you will probably want to change the default password immediately.

Camera Configuration - Detailed Guide

Overview

You can find an overview of the PhenoCam Network—what we are doing, and why—at:

<https://phenocam.nau.edu/webcam/about/>

The configuration guide below is specific to StarDot cameras. We have deployed these StarDot cameras in a wide variety of environments—from Alaska to Arizona to Florida, and from Hawaii to California to Maine—and have found them to be very robust and reliable.

StarDot cameras feature an embedded version of Linux and are capable of complex custom configurations. Our standard configuration will set up the camera to upload images to the PhenoCam server on a regular schedule throughout the day.

We highly recommend configuring the camera in a lab with stable power and network connections before deployment. Once the camera is configured, testing with the network equipment (e.g., cell modem) which will be installed in the field (while still in the lab) is also recommended. If your institution requires devices to be registered before they can be connected to the network, or a firewall which blocks certain types of internet traffic (e.g., telnet and/or FTP), it may be easier to configure the camera on your home network.

The manuals for StarDot cameras are available here:

<http://www.stardot.com/manuals>

The manual is quite detailed and has lots of additional information beyond what we describe here.

***We strongly discourage using any non-standard set-ups (cameras other than StarDot, not using the PIT to configure your camera). We don't have the resources to provide extensive troubleshooting for each site and will not be able to assist with these cases.**

Supplying power and network connections to the camera

Your camera requires DC power, and there are five ways to do this:

- (1) You can plug an AC-to-12V-DC adapter into the barrel jack on the back of your camera. This is convenient in the lab, but is generally not ideal in the field (unless you have an AC plug very near to where the camera will be mounted).
- (2) You can run DC power (from a DC battery bank or other DC power supply) directly to a barrel jack plugged into the back of your camera.
- (3) You can do either of the above, but use StarDot's combination power/network cable between your AC-to-DC adapter or 12V DC power supply. This is generally a good choice but it is not the best because it is not possible to protect the power wires against lightning damage.

- (4) If you have AC power available, you can use a power-over-ethernet (POE) injector, which will run 48 V DC to the camera on two (otherwise unused) strands of wire in a standard twisted-pair network cable. This is the best method because it requires only a single cable running to the camera, and the power wires can be protected against lightning damage.
- (5) If you have a POE-enabled network switch, you can use power-over-ethernet without having to rely on a separate POE injector.

Below, unless otherwise specified, "network cable" refers to a standard, Cat-5, Cat-6 or Cat6e twisted-pair Ethernet cable with male RJ45 connectors on each end. You will often need several different network cables, including a long cable that runs from a network port to the camera housing and usually one or two very short cables between camera and network surge protector or POE injector and network port.

The figure to the right shows a typical lab setup for camera configuration, with StarDot's combination power/network cable (white) supplying 12 V DC power to the camera via the black barrel jack connector (male; 12 V power is being supplied to the female connector on the other end of the combination cable by the black and red wires that are also visible). A surge protector (cream colored APC ProtectNet) is placed on the camera end of the long network cable, and a short network cable is then used between the surge protector and the camera. In the field, the green wire from the APC must be connected to a suitable ground.

We often use a small network hub (blue Netgear box in the photo) connected to the local network so that we can be sure we have the camera and another computer connected to the same network. The camera has a power indicator light on the front and it should light up (orange initially on power-up, then green). The Ethernet connector on the back of the camera also has a light which indicates whether the Ethernet port link has been established. The camera by default is configured to get its network (IP) address from a DHCP (Dynamic Host Configuration Protocol) server so the network hub should be connected to a network with a DHCP server. (These days, almost all networks use DHCP. If in doubt, talk to your local network administrator.)

Power-over-Ethernet (POE)

If your site has AC line power, then you should use an 802.3af-standard POE (power-over-ethernet) injector (illustrated in the photo on the right). Run one end of your network cable to the surge protector (which then is connected via a short cable to the camera), and the other end of the network cable to the "data & power out" socket on the POE injector. Then connect one end of a short network cable to the "data in" socket on the POE injector, and the other to your network hub. Then plug the POE injector into an electrical outlet. The camera's indicator lights should be illuminated, as described above.

Some network switches also have POE-enabled sockets, which would also provide an easy solution. There's good information about POE switches on this web page:

<https://intellinetsolutions.com/pages/what-is-a-poe-switch-guide>



Figure 2 – POE injector.

Combination Network/Power Cable

If your site uses DC power (e.g., solar or other system with a battery bank), then (unless the distance between your camera and power is very short) you are best to use the special combination network/power cable described above, which is usually 50' long. This eliminates the need for a separate power line running to the camera. The end with the male power jack goes to the camera (plug the power jack into the socket on the back of the camera, and plug the ethernet connector into to the surge protector, and then a short cable from the surge protector to the camera). You will then need to run a short length of two-strand wire from your DC power supply (e.g., battery bank) to a male barrel jack which then plugs into the female barrel jack on the combination network/power cable.

Before connecting power, however, make sure that the camera's network cables are plugged in so that the camera can obtain a network connection when it is powered up.

As mentioned above, when you use the combination network/power cable, or a separate 12 V DC power cable, it is still possible for lightning damage to occur to the camera even when you use an Ethernet surge protector. This is why we recommend powering the camera via POE if possible.

Finding the camera on your network and viewing live images

Once your camera is powered on and connected to the network, you will need to find your camera's network address. To do this, you will use a computer connected to the same LAN (local area network) as the camera. We recommend you first verify your computer's internet connection—the easiest way to do this is to ensure that you can do a web search (e.g., Google) in your preferred browser.

Next you need to find the network (IP) address of your camera. The easiest way to do this is to install the Windows application StarDot Tools from the CD included with the camera or from their website:

<https://stardot.makekb.com/files/3/>

Run the program and click "refresh". The camera should be detected and the camera's IP address shown (you may have to run Tools as administrator in Windows, depending on your settings). See the Troubleshooting section below if the IP address is not automatically detected.

If you are configuring your camera with a non-Windows computer, there are other things you can do to find the IP address of the camera. From a Linux or Mac OS X terminal window you should be able to type the following command:

```
arp -a
```

to get a list of the MAC (Media Access Control) addresses and IP addresses of all the computers on the local network. The StarDot cameras have a MAC address that starts with 00:30. The camera's MAC

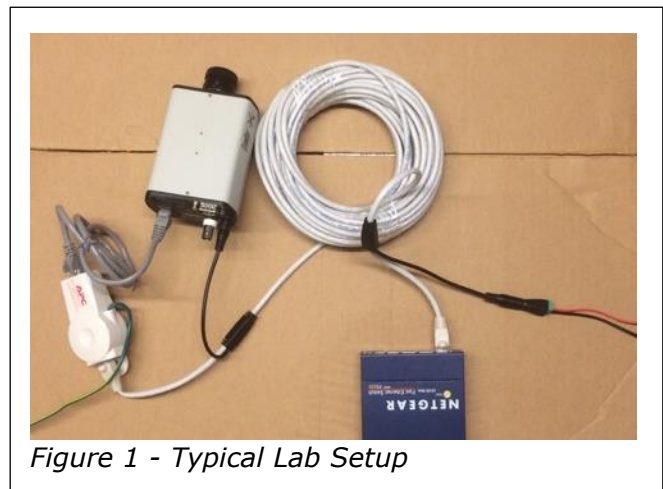


Figure 1 - Typical Lab Setup

address is also the same as its serial number, which is printed on the label on the underside of the camera. Check with your local network administrator for help with this step, if needed. There's also a lot of useful information about scanning your network on this web page:

<https://www.pcwld.com/how-to-scan-network-for-ip-addresses>

Once you have the camera's IP address (a series of four numbers, separated by periods, like this: 192.168.1.20), you should then be able to enter this address into your internet browser's address bar and a page should load with a blue background and a live image from the camera.

Most routers are configured to hand out addresses via DHCP so the camera will usually automatically join your LAN (local area network) once plugged in (remember, connect the network cable before you connect the power cable). In some cases, the local router may limit network access based on a list of approved MAC addresses. If this is the case, you will need to add the camera's MAC address to this list; contact your local network administrator for help.

Change the camera's default password

Once you can connect to the camera with a computer the first thing you should do is change the default password. At many universities, for example, all IP addresses that are handed out to connected devices are "public", in that they can be called not just from within the local network but from anywhere in the world. With a public IP address, we have had cameras hacked within 2-3 minutes of being connected to the network. If you are on a private network behind a router (e.g., your home internet connection) or institutional firewall you are probably fairly safe but in any case we recommend changing the password as soon as possible to something that is secure, e.g., a random combination of uppercase and lowercase letters, and numbers. Here are the steps:

- Point your browser at the camera's IP address
- Click the "config" link at the bottom of the live camera image
- Log in as user "admin", password "admin"
- Go to the "Security" tab of the interface
- Modify the "admin" password using the form. You will be logged out of the camera and will have to log back in using the new admin password.
- We recommend that you also record any password changes directly on the camera's housing (a Sharpie marker works well for this, as do P-touch labels).

Note: If necessary, you can use the "reset" button on the back of the camera to restore all factory settings. You will then need to change the password again. If you do a factory reset on a camera that has been configured using the PIT, you will need to reconfigure it.

Filling out the site survey

Before running the PhenoCam Installation Tool (PIT), you will need to provide us with some information so we can get your site set up on our server. Fill out the site survey here:

<https://phenocam.nau.edu/webcam/sitesurvey/>

If you don't have answers to some of the questions, you can leave them blank and send us an e-mail (PhenoCam@nau.edu) at a later time with this information. The critical information (sitename, site contacts, location, etc.) is needed for us to set up the site and to

ensure that you are able to receive automatic notifications from us (if, for example, your camera stops sending imagery, you will be notified; the location information, latitude and longitude, is also important for us to figure out when the sun is above the horizon). The sitename needs to be in all **lowercase** alphanumeric characters, and it should be somewhat descriptive. We can help you select a suitable sitename if needed, just send us an email (phenocam@nau.edu).

Once you have filled out the survey, will prepare the server directories for your site. You will receive an email from us once your site is set up on our server. **NOTE:** This email will be sent to the email addresses provided as the "site contacts" in the site survey form, and NOT to the email associated with the google account used to fill out the form.

Running the PhenoCam Installation Tool (PIT)

While the camera's web interface is useful for manual configuration, we have developed a set of scripts which by-pass the web interface and alter many of the camera's default settings. This includes installing custom scripts to upload images and associated metadata to our server. Using the PIT to do this configuration ensures that your camera is configured following our standard protocol.

To run the PIT, you will need the IP address of the camera, the admin password, and a name for your site/camera. **Before proceeding**, you should have established a site name, filled out the site survey, and received an email from us stating that your site is set up on our server.

Downloading the PIT

You will need to download the PhenoCam Install Tool (PIT) package, which you can find here as a zipfile or tar archive:

https://bluegreen-labs.github.io/phenocam_installation_tool/

Extract the compressed archive to a directory/folder on your computer. The PIT contains two main script files: PIT.bat and PIT.sh. If you are configuring your camera from a Windows machine, you will run PIT.bat. On Linux or OS X, you will need to run PIT.sh. In either case, you will run the script from a command shell or terminal window. If you haven't used the command line previously, you may want to ask your local network administrator for help.

Running the PIT

If you have verified that your computer has a functional internet connection (can you do a Google search?) and you are connected to the same local network as the camera (can you connect to the camera by entering its IP address in your browser's address bar?), then you are ready to run the PIT script. A detailed description of running the script is found on the PIT GitHub page. For convenience we summarize the procedure here.

The PIT script is run from the computer being used to configure the camera. To run the script, you will need a terminal window in which to type commands (cmd.exe on windows or Terminal application on Linux and OS X). Within the terminal, navigate to the folder where you stored the downloaded PIT files (using the change directory "cd" command). The basic command to run the PIT from a Linux or OS X terminal is:


```
sh ./PIT.sh IP USER PASSWORD CAMERA TIME_OFFSET TZ CRON_START CRON_END CRON_INT FTP_MODE
```

Or from a Windows cmd.exe prompt:

```
PIT.bat IP USER PASSWORD CAMERA TIME_OFFSET TZ CRON_START CRON_END CRON_INT FTP_MODE
```

In the line of code above, you will replace the text for each listed parameter to specify your camera's settings. The parameters are described below:

Parameter	Description
IP	IP address of the camera
USER	user name (admin - if not set)
PASSWORD	user password (on a new StarDot NetCam this is admin, but hopefully you've already changed it!)
CAMERA	the sitename of the camera
TIME_OFFSET	difference in hours from UTC of the time zone in which the camera resides (always use + or - signs to denote differences from UTC); in North America, use a - sign, e.g. -5 for Eastern Standard Time
TZ	a text string corresponding to the local time zone in standard time (e.g. EST)
CRON_START	hour to start the scheduled image acquisitions (e.g. 4 to start collecting images at 4 in the morning)
CRON_END	hour to end the scheduled image acquisitions (e.g. 22 to end collecting images at 10 in the evening)
CRON_INT	interval in minutes at which to take pictures (e.g. 30, for every 30 minutes, which is what we recommend)
FTP_MODE	active or passive FTP (default = passive)

An example of the command for a test camera configuration is given below:

```
./PIT.sh 140.247.89.xx admin admin testcam3 -5 EST 4 22 30 passive
```

This configures the camera 'testcam3', located in the EST time zone (UTC -5) to take images every half hour between 0400 and 2200 h.

Here's a brief summary of what the PIT script will do:

- Sets a default DNS (domain name server) server for the camera. What this means is that your camera will be able to connect to our server by calling

“phenocam.nau.edu” (the domain name) rather than “134.114.138.125” (the IP address associated with that domain name)

- Sets a default NTP (network time protocol) server for the camera. This will keep your camera’s clock running on time. Note that our cameras are always set to run on local standard time. **PLEASE DO NOT CHANGE THE CAMERA CONFIGURATION TO DAYLIGHT SAVINGS TIME.**
- Sets the image overlay strings. The overlay contains information about where and when the picture was taken. Although this information is also contained in the filename of each image, the image overlay is an important back-up — when and where the image was taken are the single most critical pieces of metadata for each image.
- Sets the default color balance. Note that we run all of our cameras on fixed white balance. **YOU CANNOT OBTAIN HIGH QUALITY DATA FROM YOUR CAMERA IF IT IS SET TO AUTOMATIC WHITE BALANCE.**
- Installs custom scripts to upload images
 - If the camera is a standard IR-enabled NetCam (marketed as a “day/night” camera), the script will upload back-to-back IR and RGB images, from which we can calculate “camera NDVI” in addition to Gcc (green chromatic coordinate)
 - The scripts will create and upload a metadata file with each image which contains full report of all the camera settings at the time the image was recorded.
- Installs a schedule to run these scripts (typically, every 30 minutes from 4 am to 10 pm, local standard time). **Note that the upload schedule is randomly offset from the half hour by a few minutes so that not every camera in the PhenoCam network is trying to simultaneously send images to our server.**
- Does a one-time run of the script to upload initial images and metadata.

The PIT script is designed to handle all the configuration of the camera—there aren’t any additional settings you need to change. You will know the PIT has run successfully if you see the following message:

```
Saving configuration files...
Configuration files saved.

#-----
#
# Done !!! - close the terminal if it remains open !
#
#-----
```

You can view the test images that were uploaded by the PIT by going to the following URL:

```
https://phenocam.nau.edu/data/latest/<sitename>.jpg
```

It may take ~15 minutes for your images to appear, as the upload directories are only scanned 4 times per hour. Also, the “latest” image is only updated if the image is not overly dark. If it has been 15 minutes and the latest image has not updated, contact your local network administrator. It may be that FTP traffic is being blocked. Your network administrator can help you resolve this. If you are still having problems, reach out to us.

Once the camera is set up in the field, let us know and we will make the site visible in the gallery, and the site page active. At that time, we will also remove from the archive any images taken during the setup period, e.g., pictures from your laboratory, office or garage.

Your camera's site page will be accessible at:

`https://phenocam.nau.edu/webcam/sites/<sitename>/`

If the script runs successfully, please do not change any config settings! Changing the FTP settings in particular (or even clicking the box that says "FTP Upload") will likely cause upload problems. (**Note that the scripts that are installed using the PhenoCam Install Tool will not populate the fields on the FTP tab: this is ok!**).

To do a hard reset of the camera to factory settings, look on the back of the camera for a small pinhole-sized opening labeled "reset". With the camera powered on, use a paper clip or pin to depress the recessed button for about 5-10 seconds. **NOTE:** In addition to setting all configuration settings to default, this will reset the admin password to the default value of "admin", so before doing anything else don't forget to again change the admin password to something more secure. It will also wipe out the PIT configuration, so you will have to re-run the PIT again.

It is not unusual for the PIT script to encounter some error when run. Note that typographical errors, incorrect syntax, etc. will not only prevent the scripts from running successfully, but also may cause more serious problems (potentially requiring a hard reset of the camera). We recommend you check your syntax very carefully if you are having problems running the PIT. If the PIT does not execute properly, the most likely explanations are:

- 1) User error. Either you didn't enter all of the parameters, or you didn't enter them in the correct order. Solution: try again!
- 2) Network Firewall. Your local network may block telnet and/or FTP traffic. Solution: talk to your local network administrator.
- 3) Improper setup. Your computer and the camera are not both connected to the same local area network (e.g., your computer is connected to a wireless network which is different from the wired network the camera is connected to). Solution: plug both computer and camera into adjacent network ports.
- 4) Telnet is not available. On newer versions of Windows and Mac OS, the telnet program is not installed. Solution: This is relatively easy to resolve, see the information on the PIT GitHub page ("Software Prerequisites"), or do a Google search for "enable telnet mac os" or "enable telnet windows."

If you are having repeated problems getting the PIT scripts to run properly, please make a note of any error messages (a screen grab is useful) and get in touch with us. We can work with you to get your camera properly configured.

PhenoCams at sites with WiFi only

As the StarDot cameras do not have built-in WiFi connectivity, the default PhenoCam installation process assumes the camera is physically connected to a local network through an Ethernet cable. However, there are a few workarounds to connect StarDot cameras to wireless networks. Here, we explain one method using a WiFi range extender. The device is also called WiFi repeater.

A WiFi repeater or extender is mainly used to extend the coverage area of your WiFi network. It works by receiving your existing WiFi signal, amplifying it and then transmitting the boosted signal. Most Wi-Fi repeaters also have at least one Ethernet socket by which can be used to convert a wireless connection to a wired connection. The TP-Link N300 Nano is an extremely compact device which works very well for this purpose and can be configured to function in a number of different modes.



Figure 3 - TP Link N300 Nano Router/ Bridge/ Range Extender/ Access Point/ Client

<https://www.amazon.com/TP-Link-Wireless-Portable-Travel-Router/dp/B00TQEX8B0>

To connect the camera to a wireless network, follow the below steps:

- 1) Plug the extender into an electrical outlet
- 2) Follow the documentation of your extender to connect it to your WiFi network.
- 3) Connect a laptop or computer to the new (extended) Wi-Fi network.
- 4) Test if you are online:
 - a. http test: Browse internet from your browser
 - b. ftp test: in command line enter ftp anonymous@phenocam.nau.edu to make sure you can connect to the PhenoCam ftp server
 - c. ping test: in command line enter ping 8.8.8.8 to make sure no packages are lost
- 5) If outputs from all the above tests seemed normal, that means your extender connections is online and can compatibly communicate with the PhenoCam server.
- 6) Connect the camera to the extender using an Ethernet cable, then connect the power cable to the camera.

Note: Based on our experience, WiFi extenders work in most cases where your wireless internet comes from a router with a SSID (WiFi network name) and password. However, they may not properly work on institutional (e.g. university) wireless networks where you are required to enter your username and password to connect to internet, or where you are required to re-authenticate every session.

It is increasingly common to use cell modems for data transfer. The Sierra Wireless RV50x is an excellent choice, and costs about \$600. Depending on the cell signal strength at your site you may want to choose a directional or omnidirectional antenna (\$100-\$200). Expect to pay about \$25 per month for a 1 GB data plan.

Camera Deployment

Camera housing installation

The camera housing we have used in the past is a Vitek (model VT-EH10) Indoor-Outdoor Enclosure, which is no longer available. Anything similar to this should be fine, such as this Ventech model:

<https://www.amazon.com/VENTECH-Weatherproof-Aluminum-Surveillance-Enclosure/dp/B015HSSMSQ>

There is a sliding mount inside the housing to which the camera attaches with a short screw. The sliding mount usually snaps into the rails on the bottom of the housing, but sometimes a screw is required to secure the mount to the rails. Please remember to remove the camera's lens cap before installing the camera! Note that the camera should be slid forward in its housing, so the lens is almost touching the window, to minimize the potential for reflections.



Figure 4 – Camera installed in housing

Guidelines for installing the camera in the field

Here are some basic guidelines to keep in mind during camera deployments:

- Phenology is one goal, but we'd also like good-looking pictures (sharp focus and a level horizon are preferred!)
- In the Northern Hemisphere, the camera should be pointed North to minimize lens flare and shadowing. In the Southern Hemisphere, the camera should be pointed South.
- The image should include a horizon, but the image should be more than 50% canopy and less than 50% sky; the ideal mix is about 80% canopy, 20% sky).
- The camera should point somewhat below the horizontal to obtain maximum canopy coverage and also spatial integration (a mounting height of 5-10 m above the canopy is generally good, but the specifics may depend on the nature of your tower, length of cables, etc.).
- Secure mounting and a stable field of view over time are essential for getting high quality data. Be sure to mount the camera in such a way as to minimize any camera movement, in a location that is unlikely to be disturbed. Make sure that all screws and nuts are tightened, and that the housing is securely latched closed. (And either use a cable gland or plug large holes in the housing with putty to prevent spiders and yellow jackets from moving in).

Figure 5 below illustrates the general set-up. The sample image from the Lac Clair site illustrates the ideal field of view.

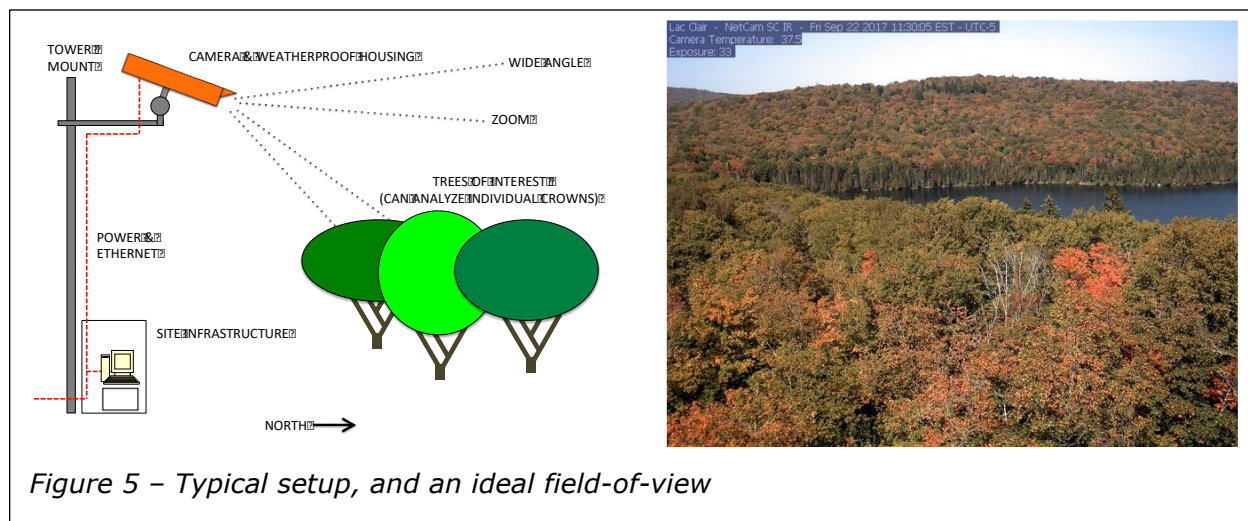


Figure 5 – Typical setup, and an ideal field-of-view

Focusing the camera

After installation you should fine-tune the focus depending on the distance from the camera to the vegetation of interest. We recommend practicing this in the lab so that you are familiar with the procedure prior to deployment.

Focus adjustments are best accomplished while viewing the camera image on a laptop that is connected to the same network as the camera. You will want to do this with the camera mounted on the tower so that you can verify that the field of view is as desired. Camera focus is quite sensitive and trying to set the focus by looking on your smartphone at images that have been uploaded to our server is not likely to be successful.

The standard lens we recommend is the 6.2 mm, which is relatively easy to focus, as it has just a single focus knob. The 4-10 mm zoom lenses sold by StarDot can yield great images, but with adjustable zoom, iris, and focus, it can be tricky to get the exact combination of zoom and focus that you want.

Here are the basic steps for adjusting the camera focus:

- On the camera's configuration pages, change "Resolution" to "688x480 NTSC Focus Mode" (last option in the drop-down under Image -> Processing) and hit "APPLY".
- Click on "Pop-up Live Image" in the upper right-hand corner to open a large image. In focus mode, only a fraction of the total image is displayed, but this way the refresh rate is very fast and it is quite easy to get the focus very sharp.
- Adjust the focus ring (again, it can be quite sensitive!) so that the image is sharp. You may find it helps to focus on a specific object in the image – such as a branch. Tighten the screw on the focus ring when finished. Change the resolution back to its original value ("1296x960 QFULL*" is the correct resolution for 5.0 MP cameras) and hit "APPLY".

Note: The StarDot NetCam SC 5 MP is marketed as a 5 megapixel camera, because the imaging sensor is 2592 pixels x 1920 pixels = 4.98 million pixels. But, the PIT will set the camera to run at the "¼ full" (QFULL*) resolution of 1.3 megapixels. Why? The reason for this is that because of the Bayer filter on the sensor, there are not 5 MP of resolution for **each** individual color channel. One-half of those 5 MP are green pixels, ¼ are red pixels,

and $\frac{1}{4}$ are blue pixels. Interpolation is then used to produce an image with 5 MP on each channel. This effectively increases the image file size four-fold, without substantially increasing the information content of the image. So, for efficiency, we operate cameras at $\frac{1}{4}$ full resolution.

Appendix A - Configuration Notes

As described above the PhenoCam Installation Tool (PIT) should adjust all the settings for your camera to standard values. **Please check with us before making any changes to settings** — in most cases, there is no reason for you to need to make changes. **We strongly discourage using any non-standard set-ups, and we don't have the resources to provide extensive troubleshooting for such cases.**

Exposure settings

If the vegetation in the camera's field of view is very dark, then the camera may over-compensate slightly and over-expose the rest of the image so that the vegetation is properly exposed. You can handle this in a few ways. One, include more sky in the image. Two, adjust the brightness level on the "Exposure" tab. Three, include more of the sky in the "Exposure Grid." We can help you determine the optimum setting for your site.

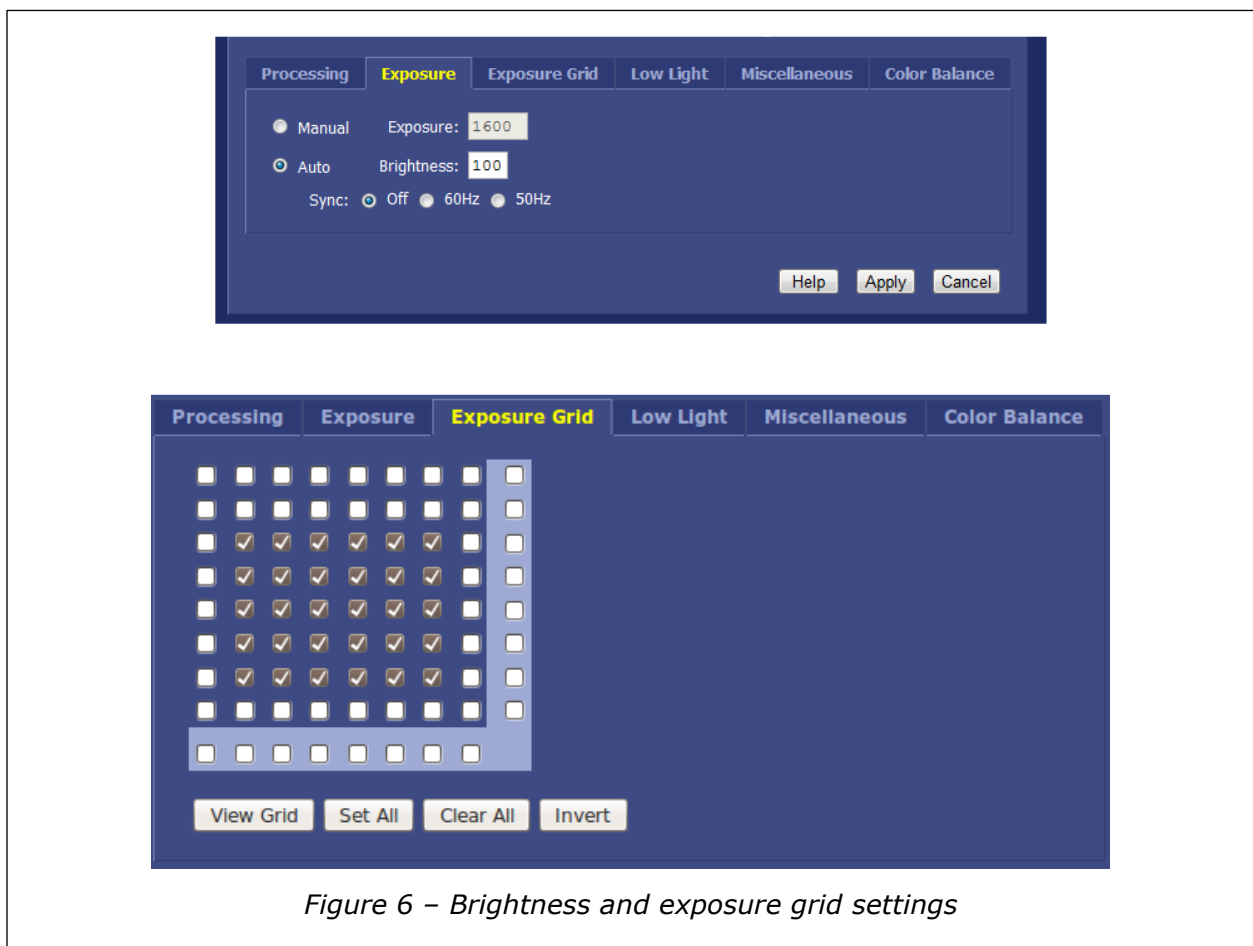


Figure 6 – Brightness and exposure grid settings

Color balance settings

The only way to get good-quality data from your PhenoCam imagery is if the camera is set to manual (also known as “fixed”) color balance (also known as “white balance”). For the 1.3 MP and 5 MP StarDot NetCam SC, the values below are appropriate (R 385, G 256, B 330). The 3 MP camera and the NetCam XL both use different sensors and different values may be needed. Contact us to discuss. **Please do not set your camera to automatic color balance.**

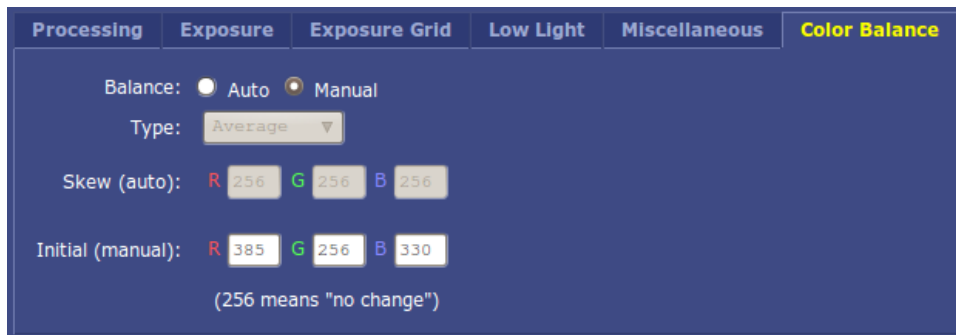


Figure 7 - Color balance settings

Appendix B – Purchasing the necessary equipment

The easiest way to buy the necessary equipment is to purchase a camera bundle, which includes camera, lens, cables, power supply, and housing, directly from StarDot. Please contact Anthony Watts <anthony@stardot.com> and ask for the “standard PhenoCam package and 6 mm lens”. You may save some money buying the camera through Amazon or B&H Photo, but availability on those sites has been limited for the last few years.

If you have AC line power and want to use power-over-ethernet to power the camera, we recommend this POE injector, which is about \$15. Any similar, 802.3af-standard POE injector should be fine.

<https://www.amazon.com/Autoranging-Switching-48V-0-5A-Injector-Security/dp/B00CWVYG50>

We recommend an Ethernet surge protector, which is about \$20. Note that only when you use POE will both the power and network wires be protected from lightning damage, and the surge protector’s green wire **must** be properly grounded. The combination of POE and a surge protector is the safest setup in areas where thunderstorms are common.

<https://www.amazon.com/APC-PNET1GB-ProtectNet-Standalone-Protector/dp/B000BKUSS8>

This is an inexpensive but decent camera housing:

<https://www.amazon.com/VENTECH-Weatherproof-Aluminum-Surveillance-Enclosure/dp/B015HSSMSQ>

Finally, don’t forget to get network cables of the appropriate length (on Amazon, “showmecables” is a good supplier; depending on your situation it may be worth spending the extra money to get cables that are rated for outdoor use or for direct burial, and you may want to order custom-length cables for a tidy installation) and you are good to go!

Appendix C - General troubleshooting

We recommend you keep an eye on the PhenoCam web page to check that images from your camera are updating regularly, that the window is not dirty or obscured, and that the camera field of view is still as desired (e.g., the housing has not shaken loose). We also monitor the frequency of image uploads from each site; if it has been several days since the last image, you can expect to receive an automated email from our server. Let us know if you need help with troubleshooting what's wrong. Given our limited ability to provide extensive troubleshooting, we suggest that you also seek help from your institution's network manager or IT specialist.

Cycle power to the camera

Many problems can be fixed simply by temporarily unplugging the ethernet cable to the camera and at the same time cycling the camera's power, being sure to plug in the Ethernet cable before the power if these are separate connections. You should also check that the green light on the front of the camera is on, and that the status light on the LAN router socket where the camera is connected is flashing green as well.

Connect to the camera in your browser

If you encounter issues, try to connect to the camera in your browser. Depending on your network, the IP address assigned to the camera may change periodically; run the StarDot Tools program if necessary. If you can't find the camera's IP address this way, let us know: we can check on the PhenoCam server to find the last address the camera uploaded from. If you can connect to the camera in your browser, and live images are being displayed, then everything is probably ok, although there may still be a firewall or DNS issue (see below).

Check the camera's log files and status page

If you can connect to the camera in your browser, but images are still not uploading properly to the PhenoCam web page, the last thing to try is to connect to the camera via Telnet and look at the log files. The camera is actually a compact stand-alone computer, running its own uClinux operating system. From a terminal window, connect to the camera:

```
>Telnet (enter: camera's IP address)
>User: (enter: admin)
>Password: (default is admin, but see notes above)
```

From the Uclinux prompt, type "cat /var/log/syslog" and then "dmesg"; these will output quite a few lines of text to your screen. Please copy the output into an email to us.

From the Uclinux prompt, type "logout".

Note: On newer versions of Windows and Mac OS, the telnet program is not installed. Do a Google search for "enable telnet mac os" or "enable telnet windows" and follow directions there.

You can also display the camera's "status" webpage by entering the following URL in your browser's address bar. Be sure to replace <address> with the IP address of your camera.

```
http://<address>/status.cgi
```

Firewalls and blocked traffic

If your local network is behind a firewall, the FTP (file transfer protocol) uploads to our server may be blocked. There are two potential reasons for this. First, PIT script sets the camera's default domain name server (DNS) to Google's public DNS (8.8.8.8). The local firewall will need to allow queries to this server so that names (phenocam.nau.edu) can be resolved to IP addresses (1334.114.138.125). However, some institutional networks do not allow external DNS queries. Check with your local network administrator; it may be necessary to change the DNS server information on the camera ("Network" configuration tab, Name Server, DNS1) from 8.8.8.8 to your local network's DNS. Contact us if you have questions.

It is also possible that certain types of network traffic are being specifically blocked by the firewall. You can ask your local network administrator whether outgoing FTP traffic is being blocked, or if you have a computer on the same network as the camera, you can follow the steps below, "Checking network access to our server" to test for this yourself. It is important to keep in mind that network firewall settings may sometimes change. We have seen instances where a camera was able to upload to our server successful for months, until firewall settings were changed and (for example) PASSIVE mode FTP was blocked. Your local network administrator should be able to help you determine whether the firewall configuration may have changed.

The PIT scripts also sets the NTP (network time protocol) timeserver to time.nist.gov. If the time on your camera seems off or not set, you should also check with your local network administrator to find out if NTP traffic is being blocked.

Checking network access to our server

The PIT scripts need to connect to the PhenoCam server (<http://phenocam.nau.edu/>). You should verify that you can connect to the server from the computer you will be doing the configuration from. If your computer can't contact our server, chances are good that the camera won't be able to either. A simple test is to see whether you can connect to our website with your browser.

You will also need to verify that your network allows outgoing FTP (file transfer protocol) connections. We have found, for example, that some government agencies and university "guest" networks often limit FTP traffic. To test this with your computer, you can FTP a file to the PhenoCam server (phenocam.nau.edu) using any FTP client available on your computer. Connect to the server using anonymous FTP (user: anonymous, password: anonymous), change directories to your camera's data directory (data/<sitename>/) and initiate a file transfer.

Please contact your local network administrator, or our support team, PhenoCam@nau.edu, if you need help with this.

Camera repairs

If the power light on the front of the camera isn't lit, or if it is orange instead of green, or if you cannot find the camera on your network, or you cannot connect to the camera in your browser, then the camera may need to be sent back for repairs (contact Anthony Watts <anthony@stardot.com> to obtain an RMA). Repairs following lightning damage are generally very reasonable, \$75-\$100, and far less expensive than buying a new camera, although sometimes repair is not possible.

Feedback and Corrections

This document is a work in progress. We appreciate any suggestions for improvement to, or clarification of, the above instructions. Contact the PhenoCam Project Team at PhenoCam@nau.edu!

Thank you again for your support of the PhenoCam project.