

NASA RECOVER 2.0 LONG-TERM POST-FIRE MONITORING TOOL

Introduction

The tools described in this tutorial allow you to automatically download current NDVI data for a specific wildfire area and compare that data to the long-term NDVI Baseline created for the NASA RECOVER project. **The first part of this tutorial describes a one-time setup** including cloning your current python environment (Part 1), swapping to the new cloned environment (Part 2), and installing the geemap open source python package (Part 3).

Part 4 (Using the Long-Term Monitoring Tool) can be run many times once the one-time setup (parts 1-3) has been successfully completed. If this has already been done, you could skip to Part 4 on page 5.

The long-term monitoring tool is part of all new RECOVER Data Packages created after May 1st 2024. If you do not have access to the long-term monitoring tool, please download it from:

https://giscenter.isu.edu/research/Techpg/nasa_RECOVER2/ZIP/RECOVER_LongTerm_Monitoring.zip


Once downloaded, extract the zip file to your PC (NOTE: Make note of the location of the *.atbx file as we will use it in Part 4 of this tutorial).

PART 1. Clone the Python Environment

Python virtual environments help to isolate your Python development projects from the system installed default Python environment. Many open-source Python packages such as geemap¹ (<https://geemap.org/>) are not included in the ArcGIS default Python environment. While it's usually not recommended for the ArcGIS end user to make changes to the default Python environment, Esri has provided the ability to clone the default python environment, and subsequently install additional Python packages that custom projects require. Using this approach, we will build a Python environment that works for both ArcGIS geoprocessing and open-source Python tools!

NOTE: if you already installed an ArcGIS Deep Learning package in the default Python environment, you will need to uninstall it before you clone it. This process is described in detail here:

https://giscenter.isu.edu/pdf/PDF_NASA_RECOVER2/RemoveArcGISProDeepLearning.pdf.

1. With a clean/default ArcGIS Pro python environment, we will create a new Python environment clone. To do this, go to  Start – ArcGIS – Python Command Prompt (right click) – More – Run as administrator (you may need to enter an administrator password).

You will see the Python Command Prompt window open with the directory of the ArcGIS default Python environment (arcgispro-py3) displayed. The parenthesis encloses the name of the activate Python environment, which is also known as the default environment.

```
(arcgispro-py3) C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3>
```

From the command prompt window, type **conda env list** and press ENTER

¹ Geemap is an open-source Python package for interactive geospatial analysis/visualization with Google Earth Engine.

```
(arcgispro-py3) C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3>conda env list
```

After a few seconds, you will see there are two Python environments listed. The arcgispro-py3 will be marked with a *, which means this is the activated Python environment at this moment.

```
(arcgispro-py3) C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3>conda env list
# conda environments:
#
base                  C:\Program Files\ArcGIS\Pro\bin\Python
arcgispro-py3         * C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3
```

2. Type the following command to create a cloned environment based on the current ArcGIS Pro default/activated Python environment. Be sure to include **--pinned** as part of this command (HINT: feel free to copy and paste this command into the command prompt window).

conda create --clone arcgispro-py3 --name arcgispro-py3_clone --pinned

It may take several minutes for the clone process to finish. The following will appear when cloning successfully completes. Please wait until the python prompt appears before proceeding.

NOTE: If you see any error messages, typically shown in a red colored font, you will need to fix these errors before proceeding. The most common error is a conflict with the Esri Deep Learning Libraries. To fix these problems please refer to

https://giscenter.isu.edu/pdf/PDF_NASA_RECOVER2/RemoveArcGISProDeepLearning.pdf

```
Source: C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro-py3
Destination: C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro_py3_clone
Packages: 362
Files: 27371
Copying pinned file from C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro-py3_clone\conda-meta\pinned to
Preparing transaction: done
Verifying transaction: done
Executing transaction: -
/ Uninstalling prior versions of arcgis widget
Installing C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro_py3_dl\lib\site-packages\arcgis\widgets\js\di
Up to date: C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro_py3_dl\share\jupyter\nbextensions\arcgis\arc
Up to date: C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro_py3_dl\share\jupyter\nbextensions\arcgis\arc
Up to date: C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro_py3_dl\share\jupyter\nbextensions\arcgis\ext
- Validating: ok

    To initialize this nbextension in the browser every time the notebook (or other app) loads:

        jupyter nbextension enable arcgis --py --sys-prefix

Enabling notebook extension arcgis/extension...
- Validating: ok

done
#
# To activate this environment, use
#
#     $ activate arcgispro_py3_dl
#
# To deactivate an active environment, use
#
#     $ deactivate

Retrieving notices: ...working... done
```

PART 2. Swap to the New Cloned Environment

3. First, we need to activate the cloned Python environment. To do this, type the following command in the python command prompt and press ENTER.

proswap arcgispro-py3_clone

```
(arcgispro-py3) C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3>proswap arcgispro-py3_clone
```

Notice the directory of the Python environment and the name of the Python environment within the parenthesis changed to our new cloned environment (arcgispro-py3_clone). If you want to swap back to the default ArcGIS Python environment, or any other Python environment that you have created, simply type the command **proswap [name of the Python environment]** then press ENTER.

```
(arcgispro-py3) C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3>proswap arcgispro-py3_clone
proswap: Set active ArcGIS Pro environment to C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro-py3_clone
(arcgispro-py3_clone) C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro-py3_clone>
```

We can double-check the current environment using the same command we used earlier **conda env list**. Notice the new arcgispro-py3_clone has been marked with a * which means it is the activated environment.

```
(arcgispro-py3_clone) C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro-py3_clone>conda env list
# conda environments:
#
base                  C:\Program Files\ArcGIS\Pro\bin\Python
arcgispro-py3         C:\Program Files\ArcGIS\Pro\bin\Python\envs\arcgispro-py3
arcgispro-py3_clone  * C:\Users\Di\AppData\Local\ESRI\conda\envs\arcgispro-py3_clone
```

PART 3. Install the open-source geemap package

4. We will install the open-source geemap with the following command.

```
pip install geemap
```

Press ENTER.

The installation process may take a few minutes. Please be patient.

As long as you see a message similar to the following, the install completed successfully:

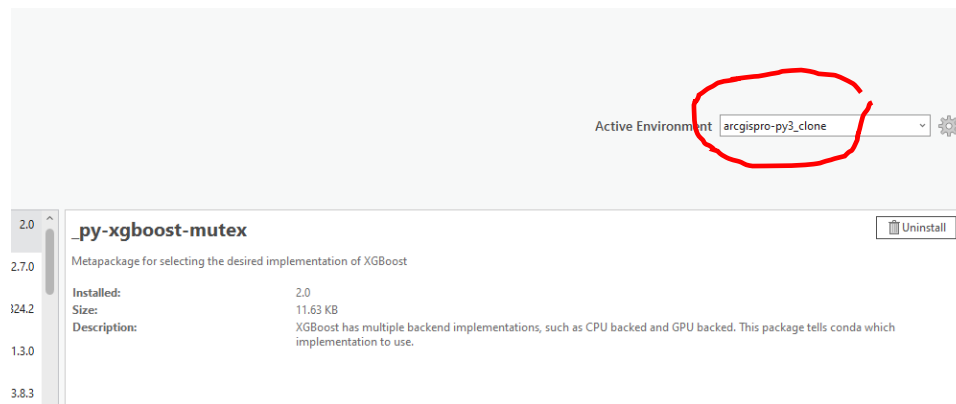
```
Successfully installed bqplot-0.12.43 branca-0.7.1 earthengine-api-0.1.397  
eerepr-0.0.4 folium-0.16.0 geemap-0.32.0 geocoder-1.38.1 google-api-core-  
2.18.0 google-api-python-client-2.125.0 google-auth-2.29.0 google-auth-  
httplib2-0.2.0 google-cloud-core-2.4.1 google-cloud-storage-2.16.0 google-  
crc32c-1.5.0 google-resumable-media-2.7.0 googleapis-common-protos-1.63.0  
httplib2-0.22.0 ipyevents-2.0.2 ipyfilechooser-0.6.0 ipyleaflet-0.18.2  
ipytree-0.2.2 jupyterlab-widgets-1.1.7 proto-plus-1.23.0 python-box-7.1.1  
ratelim-0.1.6 scooby-0.9.2 traitletypes-0.2.1 tzdata-2024.1 uritemplate-4.1.1  
xyzservices-2024.4.0
```

When completed, the command prompt will read: **C:\Users\[YOUR USERNAME]\AppData\Local\ESRI\conda\envs\arcgispro-py3_clone>**. Once this Python prompt appears, you can close the Python command prompt window as we have finished installation and setup for the Python environment.

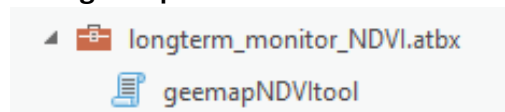
This completes the one-time installation and configuration. The next part of this tutorial can be run as many times as needed.

PART 4. Use the Long-Term Monitoring tool

5. You can access and use the Long-Term Monitoring toolbox in one of two ways in ArcGIS Pro.
 - a. Open and use the Toolbox from a RECOVER Data Package
 - b. Download the Toolbox from the RECOVER website
(https://giscenter.isu.edu/research/Techpg/nasa_RECOVER2/ZIP/RECOVER_LongTerm_Monitoring.zip)
6. In this tutorial, we will assume you are accessing the toolbox from an existing RECOVER Data Package (NOTE: For a tutorial on using the NASA RECOVER post-wildfire DSS and the Data Packages, [click here](#)).
7. Open ArcGIS Pro and launch a post-wildfire project like one described in the tutorial noted above.
8. Click the Project menu.
 - a. From the left-side of the screen click **Package Manager**
 - b. Check to ensure the Active Environment is arcgispro-py3_clone.



- c. Once you have confirmed the Active Python environment, return to the main map window.
9. From the **Catalog pane**, navigate to the **Folders** section.
10. Navigate into the project folder and locate the LongTerm_Monitor_NDVI.atbx
 - a. Open the toolbox
 - b. Double-click the tool named **geemapNDVItol**.



11. You will be prompted for seven input parameters.
 - a. Your GEE Authentication Method (a dropdown menu with option of username, or projectID).

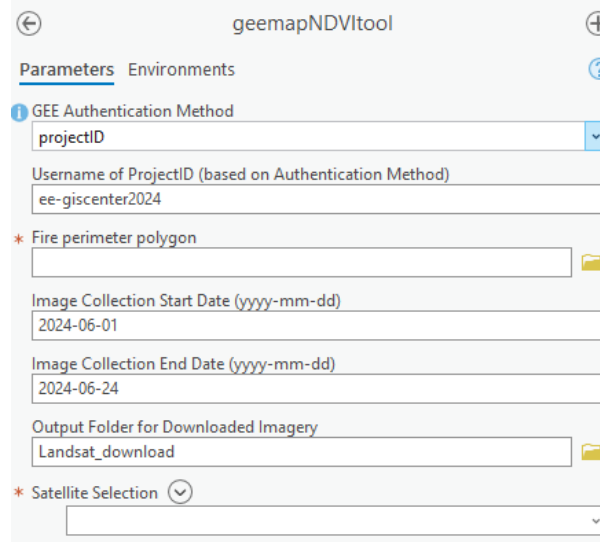
If you use the username authentication option, do not enter your entire email account but only the username portion (e.g., giscenter2024 and not giscenter2024@gmail.com). The Username authentication option will use default GEE cloud project naming conventions to authenticate your GEE account.

If you choose to use projectID authentication, make sure you know your unique projectID. If you are not sure of your projectID, click <https://console.developers.google.com/> and sign into your account. Your GEE cloud projects will be listed and you can look up the project ID there.

Make sure the GEE username matches *your* Gmail or Google account username as you will be required to authenticate this account shortly. If you do not have an account, [click here](#) to access our tutorial on creating a Google Earth Engine (GEE) account.

- b. Your username or projectID
- c. The fire perimeter polygon in format of feature class or shape file (the fire polygon extent will be referenced by the tool for image collection search)
- d. The image collection start date (in the format of yyyy-mm-dd)
- e. The image collection end date in the same format (yyyy-mm-dd)
- f. The folder where you want to save the new NDVI output layer
- g. The satellite you would like to acquire NDVI data from. Your selection can be any combination of Landsat 9 (LC09), Landsat 8 (LC08), and/or Sentinel-2 referred to as COPERNICUS/S2.

Some of the parameters have example/default values in place as shown below



The screenshot shows the 'geemapNDVIttool' interface with the 'Parameters' tab selected. The parameters are as follows:

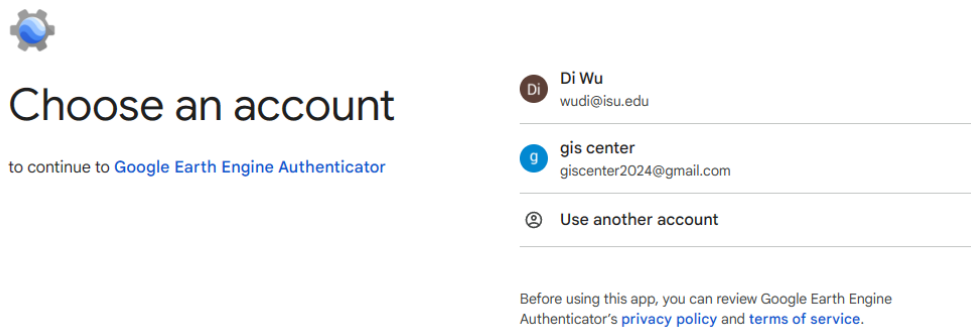
- GEE Authentication Method:** A dropdown menu with 'projectID' selected.
- Username of ProjectID (based on Authentication Method):** A text field containing 'ee-giscenter2024'.
- * Fire perimeter polygon:** A text field with a folder icon to its right.
- Image Collection Start Date (yyyy-mm-dd):** A text field containing '2024-06-01'.
- Image Collection End Date (yyyy-mm-dd):** A text field containing '2024-06-24'.
- Output Folder for Downloaded Imagery:** A text field containing 'Landsat_download' with a folder icon to its right.
- * Satellite Selection:** A dropdown menu with a downward arrow icon.

NOTE: The start date parameter identifies the first date on which the tool will search for imagery. You can use any date such as six months or one year following the date of the fire.

If the spatial coverage or cloud coverage of the returned image is not suitable, modify your image collection date range to exclude the returned date. There are likely to be many different images available within a given time period, and you're not guaranteed to get the "best" image on the first try.

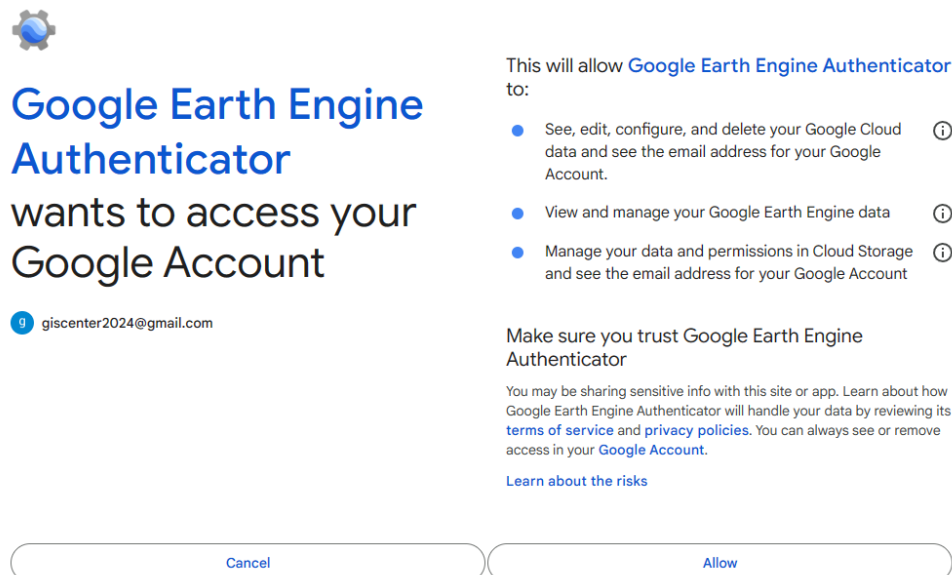
12. Click Run and the tool will begin processing.

If this is your first time running the tool, you will need to authenticate your GEE cloud project/account. A web browser window will pop up but may be hidden behind other windows so be sure to watch for it. Select the account you would like to work with. In this example I selected the giscenter2024@gmail.com account shown in the figure below. You will need to select the account appropriate for you.



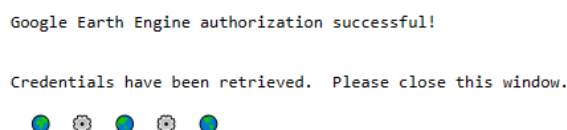
In this tutorial, you can use the giscenter2024@gmail.com account for GEE authentication as this account has been already registered for GEE cloud projects and has been setup as a user managed service account. NOTE: If this is the first time you used giscenter2024, click 'Use another account', and then type user name as **giscenter2024**, password as **Monday@1**.

Next you will see the following screen:




Click Allow.

Lastly, you will see the following message in the browser.



BTW, if you navigate to C:\Users\[YOUR USERNAME]\.config\earthengine\ on your computer, you will see a credentials file was generated in this folder.

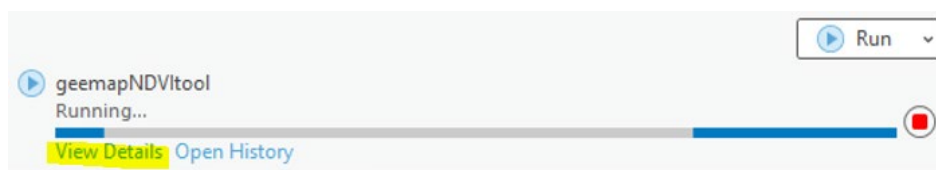
Name	Date modified	Type	Size
 credentials	3/25/2024 1:13 PM	File	1 KB

The credentials file is generated after you complete GEE authentication. If you plan to continue using the same account on the same computer for this tool, you won't be prompted for authentication again. But if you switch computers, or if you would like to use a different GEE account, you will need to make sure that the directory C:\Users\[YOUR USERNAME]\.config\earthengine\ is empty and does not contain any previous credential files. If this is not the case, you will likely receive an error and the tool will fail to run. FYI, the error message will be similar to the following:

```
ee.ee_exception.EEException: Caller does not have required permission to use project ee-wudi. Grant the caller the
roles/serviceusage.serviceUsageConsumer role, or a custom role with the serviceusage.services.use permission, by visiting
https://console.developers.google.com/iam-admin/iam/project?project=ee-wudi and then retry. Propagation of the new permission may take a few
minutes.
```

13. Following successful authentication, the tool will continue to run.

- It's recommended to click View Details to review progress under the Message tab of the tool while it is executing.



Here is a sample message and an explanation of the output to help you understand the workflow.

Parameters	Environments	Messages (22)
<div> <div></div> <div></div> <div></div> </div> <p>Start Time: Thursday, May 30, 2024 12:16:51 PM</p>		
the earth engine project is ee-giscenter2024		Authentication
the cloud project has been successfully authenticated		
the current map extent is		Map extent for retrieving image
-116.8019846609533		
45.45595130581027		
-116.6360093928949		
45.60974364938809		
the image will be retrieved between 2024-05-01 and 2024-05-29		Time period for retrieving image
Image will be retrieved from:		Satellite for retrieving image
COPERNICUS/S2;LANDSAT/LC08/C02/T1_L2;LANDSAT/LC09/C02/T1_L2		
retrieving LANDSAT/LC09/C02/T1_L2 image		Image retrieving from selected satellite
The retrived image date is: 20240510		and NDVI downloading
The cloud cover score is 1.7		
D:\longterm_monitor\Landsat_download\LANDSAT_LC09_C02_T1_02_NDVI_20240510.tif has been downloaded		
retrieving LANDSAT/LC08/C02/T1_L2 image		Image retrieving from selected satellite
The retrived image date is: 20240509		and NDVI downloading
The cloud cover score is 1.06		
D:\longterm_monitor\Landsat_download\LANDSAT_LC08_C02_T1_02_NDVI_20240509.tif has been downloaded		
retrieving COPERNICUS/S2 image		Image retrieving from selected satellite
The retrived image date is: 20240505		and NDVI downloading
The cloud cover score is None		
D:\longterm_monitor\Landsat_download\COPERNICUS_S2_NDVI_20240505.tif has been downloaded		
Succeeded at Thursday, May 30, 2024 12:17:02 PM (Elapsed Time: 10.88 seconds)		

There could be an error if the image collection start date and current date are too close together and no imagery can be found within the time period. If so, you will see a warning in the Message window. Similarly, you will see the same error if these dates are the same. An example of this type of warning message is shown below:

the image will be retrieved between 2024-05-01 and 2024-05-01

WARNING!!!No image in the study area was found during the specific time period. Please include a longer search period!

Succeeded at Monday, June 3, 2024 1:09:35 PM (Elapsed Time: 2.49 seconds)

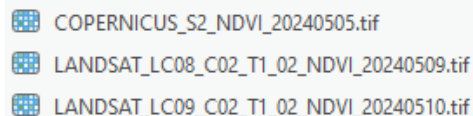
Another possible error in process can occur when the NDVI image exceeds the GEE size limit for direct download. Using Landsat as an example, the maximum coverage area is about 120 km by 120 km (14,400 km² or approximately 3.5 million acres). If you receive the following warning, you will need to select a smaller area to download (see Part 4, step 11c).

WARNING!!!Request image size is greater than 32MB. Please select a smaller area.

NOTE: the NDVI values are scaled to match RECOVER NDVI baseline data. To return to unscaled data you can multiply the NDVI layer by 0.0001 (i.e., use the TIMES tool and the value 0.0001)

PART 5. Using the new NDVI Data

14. From the Catalog pane in ArcGIS Pro, navigate to the output folder used when you ran the tool.
15. You will see NDVI image layer(s) as in the example below. The NDVI image names include your satellite selection as well as the actual data of acquisition.



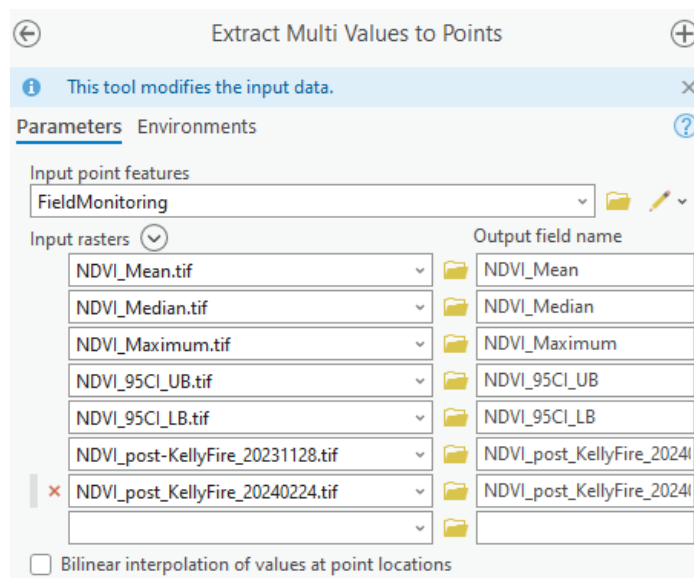
For example, LANDSAT_LC09_C02_T1_02_NDVI_20240510.tif indicates that the NDVI was calculated from a Landsat 9 image collected at 20240510.

NOTE: If you wish to rename this layer, right-click the layer from the Catalog pane and choose rename. However, bear in mind the date when the imagery was collected and the NDVI conditions on that date are very important to understanding post-fire recovery.

16. Right-click this image and choose Add to Current Map.
17. Using these data and the NDVI Baseline data provided in the Data Package, you can compare current conditions to the long-term NDVI Baseline on a pixel-by-pixel basis using the minus tool (e.g., [NDVI Baseline Median] minus [CurrentNDVI]).

NOTE: Data Package processed after September 2023 you contain the NDVI Baseline Mean, Median, Maximum, and both the upper and lower bounds data at 95% CI about the mean. Comparing current NDVI conditions to the NDVI Baseline Median is an excellent starting point.

18. Alternatively, you can use point sampling to make a comparison. In this instance you may already have point locations from previous visits to the field or you may wish to create a new point feature class in the project geodatabase to contain specific points of interest in the fire area.
 - a. Sampling NDVI values at point locations can be accomplished very easily using the Extract Multi Values to Points geoprocessing tool. Using this tool, you can extract NDVI values from each of the NDVI Baseline layers as well as one or more “current” NDVI layers. An example is shown below.



- b. Running this tool will provide tabular information to help you understand how the fire area is recovering based on post-fire conditions. An example of the output and the attributes added to the point sampling feature class is shown below.

CID	NDVI_Mean	NDVI_Median ▾	NDVI_Maximum	NDVI_95CI_UB	NDVI_95CI_LB	NDVI_post_KellyFire_20240224	NDVI_post_KellyFire_20240224_10399
1	3691	4281	4853	6450.206	931.7939	7132	6710
1	3364	4058	4445	6144.612	583.3879	7069	6729
1	3407	3957	4305	5976.574	837.4258	7166	6711
1	3053	3779	4200	5559.106	546.8938	6542	6366
1	3045	3696	4218	5757.783	332.2166	2937	2818
1	3057	3634	4554	5486.929	627.071	6220	6289
1	3053	3586	4060	5477.933	628.0671	478	665
1	2841	3508	3938	5492.144	189.8564	3653	2957
1	2772	3454	4002	5156.642	387.3586	2766	2132

- c. You can easily export this table to an Excel spreadsheet using the Table to Excel geoprocessing tool.

19. Additional spatial analysis of these data can and should be completed as you monitor the recovery of each wildfire. These data, along with field verification and other monitoring techniques and post-fire treatments will help ensure the ecosystem returns to a health condition as soon as possible.

We hope you have learned how to access Landsat satellite imagery to support your post-wildfire efforts. If you have any suggestions to improve the NASA RECOVER system, please let us know by emailing webekeit@isu.edu.