NASA RECOVER 2.0 NDVI Baseline to Support Long-Term Post-Fire Monitoring

INTRODUCTION

Post-wildfire recovery is frequently assessed by comparing measurements or observations of pre-fire conditions to current conditions (post-fire). This may begin in as little as one day or one month following containment of a wildfire through 3-5 years following a wildfire. To assist the land manager, satellite imagery of pre-fire and post-fire conditions for the burned area can be used. In particular, imagery describing the photosynthetic activity of plants within the burned area can be especially helpful. Such imagery is typically created using a vegetation index such as the normalized difference vegetation index (NDVI).

This study used imagery from the Landsat sensor because of its long-term archive of earth observation data. Arguably, the first science-capable satellite sensor, Landsat 5 thematic mapper launched on March 1st 1984 and since that time, imagery from Landsat has been available nearly continuously with 16-day revisit intervals across the globe. Using Landsat 8 Operational Land Imager (OLI) this study assembled a decade (2013-2022) of NDVI imagery for the entire western United States (**Figure 1**). This long-term dataset –referred to as the NDVI Baseline-- is made available to support the NASA RECOVER Post-Wildfire Decision Support System (RECOVER) and the land managers that use RECOVER. This paper describes how the NDVI Baseline dataset was created and how the resulting web services and derived products can be accessed and used by the RECOVER community.

Figure 1. Extent of the area covered by the RECOVER 2.0 post-fire decision support system.

METHODS

Using Google Earth Engine (GEE) Landsat 8 OLI NDVI imagery was created and downloaded for WRS Paths 31-48 and Rows 26-38 (n = 175 unique path/row combinations, **Figure 2**))[1]. Each specific

[1] An example of this script is available by visiting: https://giscenter.isu.edu/research/Techpg/nasa_RECOVER2/zip/SCRIPT_GetNDVI_fromGEE.txt

path/row collection was queried in approximately five minutes. These data were then downloaded to Google drive requiring approximately 4-5 hours. This process was completed until all data were acquired and copied to the hard drive of the workstation dedicated to this project. The process required five months to complete. The resulting data folder contained 18,969 scenes and over 1.1 billion pixels of NDVI data.

These data consumed nearly 4 TB of hard drive space. To reduce the data footprint, without compromising the quality of the data and significant digits, all data were scaled using a factor of 10,000 and converted to signed 16-bit integer pixel depth using a semi-automated geoprocessing tool in ArcGIS Pro Model Builder (**Figure 3**). The resulting integer-ized data (INT) consumed 1.6 TB of hard drive space or approximately 50% of the original data footprint.

The INT data were copied to a server where ArcGIS Enterprise Portal with Image Server licensing was installed. Using ArcGIS Pro a Mosaic Dataset (MD) was created and populated with the INT NDVI data (EPSG: 102039).

This MD contained a data cube of both spatially and temporally stacked data with most scene footprints containing over 100 unique NDVI images. To enable this MD to function as a Multidimensional raster, the acquisition date for each NDVI image was added to the Footprint layer of the MD in Date data type format. The Build Multidimensional Info tool was then used in ArcGIS Pro to enable this data cube.

Once the MD with multidimensional functionality was created, summary statistics layers were derived from the data cube. The derived layers include mean, median, maximum, standard deviation, and both lower and upper bound NDVI values at 95% confidence. The latter two layers were derived by first multiplying the standard deviation layer by 1.96 and then applying this result to the mean layer using the minus and plus tools, respectively. All raster data were saved in TIF image format[2].

RESULTS AND DISCUSSION

The multidimensional mosaic dataset was completed and served as an image service on September 14th 2023. The summary statistics layers were also served as image services in September 2023. These web services are available by connecting to the GIS Center's Portal or by connecting directly to this service in ArcGIS Pro using the following ArcGIS Server URL https://giscenter.rdc.isu.edu/server/services (**Table 1**).

Table 1. Web service name and rest URL for the NDVI Baseline and derived summary statistics layers

Name/Metric	Rest URL
NDVI Baseline	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_Baseline/ImageServer
NDVI Mean	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_Mean/ImageServer
NDVI Median	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_Median/ImageServer
NDVI Maximum	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_Maximum/ImageServer
NDVI Standard Deviation	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_Standard_Deviation/ImageServer

[2] A more detailed document detailing the creation of the multidimensional MD is available here: https://giscenter.isu.edu/pdf/PDF_NASA_RECOVER2/MosaicDatasetMultidimensionalRaster.pdf

NDVI 95% CI Upper Bound	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_95PCT_CI_Upper_Bound/ImageServer
NDVI 95% CI Lower Bound	https://giscenter.rdc.isu.edu/server/rest/services/RECOVER/NDVI_95PCT_CI_Lower_Bounds/ImageServer

The NDVI Baseline services are very large and as a result, response within a web application is extremely slow, normally raising a timeout error under this usage. However, interacting with the NDVI Baseline image service within ArcGIS Pro desktop is much better and temporal profiles can be successfully created/viewed in approximately one minute.

The derived summary statistics image services are much smaller and hence, highly responsive. These layers can be used very effectively to understand post-fire recovery by comparing current NDVI values to the mean, median, and maximum layers and also determining where current NDVI values fall within the upper and lower bound layers. This can be accomplished readily within ArcGIS Pro using the Zonal Statistics tools where the zone area is identified by the wildfire polygon. A tutorial to guide the users in making these assessments is available from the NASA RECOVER 2.0 web page or by clicking here https://giscenter.isu.edu/pdf/PDF_NASA_RECOVER2/Tutorial_UsingNDVIBaseline.pdf