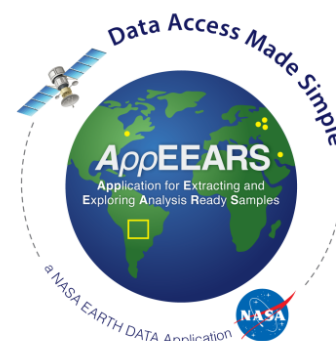# Tutorial: Accessing Landsat 8 Surface Reflectance Data with NASA's App**EEARS** Tool

Overview:

In the tutorial, we will access Landsat surface reflectance data ([Analysis Ready Data Collection 2](#)) using the Application for Extracting and Exploring Analysis Ready Samples (AppEEARS) web application.

Learning Objectives:

- Access data and practice using the AppEEARS Interface
- Explore two methods for extracting data from AppEEARS: area and point
- Submit a request for Landsat 8 data through AppEEARS
- Accessing visualizations of Landsat 8 surface reflectance data in AppEEARS

Prerequisites:

- Experience using remotely sensed data Earth/environmental science data is helpful
- Experience with spectral data is helpful, but not required
- Have an [Earthdata login](#)
  - Note: NASA data are free, but users will require an EarthData account to request data.

Background:

AppEEARS

[AppEEARS](#) offers a simple and efficient way to access and transform geospatial data from a variety of federal data archives. It enables users to subset datasets using spatial, temporal, and band/layer parameters. This web application allows users to preview and interact with their samples before downloading their data through interactive visualizations and summary statistics. AppEEARS also provides users with data values, as well as associated quality data values. AppEEARS is enables users to download different types of data:

- area (i.e., all of the pixels that fall within a given area, spatial areas via vector polygons.) data
- point (i.e., data from geographic coordinates, latitude/longitude)

Landsat 8

Landsat 8 captures data across 11 bands, each measuring a specific range of wavelengths on the electromagnetic spectrum. To see the breakdown of bands, their wavelengths, and common applications, visit the [Landsat 8 Band Characteristics section](#). Depending on the specific application, different combinations of bands and additional processing techniques may be used to extract the desired information from Landsat 8 data.

Total Estimated Time: <50 min

Materials:

- [Earthdata login](#)
- Laptop or Desktop computer
- Internet connection
- If the AppEEARS interface is not functioning, we have provided direct links to datasets.
  - [Access data](#) for both Area and Point Extraction

Introduction:

Set the Stage

Consider the following use case as we access Landsat data from the NASA AppEEARS tool.

User: Arnie, natural resource planner for Temple University, Philadelphia, PA

Use Case:

- Arnie was tasked to evaluate the green spaces around the campus to reveal changes and infer long-term trends of vegetation. Arnie must develop a proposal that includes a projection for campus beautification projects. Arnie heard of AppEEARS as a way to access NASA and USGS data for quick download. She's decided to use this tool to:
  - Access Landsat 8 surface reflectance data band combination 5, 4, 3 to evaluate vegetation data for Temple University's campus.

Temple University, Philadelphia, PA
Credit: Steven-L-Johnson, no changes

Data Requirements for the Use Case:

- Area extraction (Temple University footprint)
- Point extraction for greenspaces of interest
- Temporal and Spatial Subsetting
- Optional: Data from multiple datasets and missions (e.g., weather-related data)

Instruction:

Get Started

1.   Navigate to the AppEEARS app here: https://appeears.earthdatacloud.nasa.gov/
2.   Click the **Sign In** button at the top right of the page.

3.   Enter your Earthdata Login information and log in.

Explore AppEEARS

1.   Explore the main ribbon of tools at the top of the landing page. At the top of the screen you will see the options to **Extract**, **Explore**, or get **Help**.

2.   Select the **Extract** dropdown presents you with the options to get the data by area or point.

Create an Area Request

1.   For the following example, we will click **Extract** from the AppEEARS main menu, then select **Area**.
2.   In the **Extract Area Sample** box, you have the following three choices:

(a)   **Start a new request** – start a new request for a new area and new time period.

(b)   **Copy a previous request** – Reprocess or edit parameters of an existing sample with new information.

(c)   **Upload a request file** – upload a JSON file to populate a new sample with the input parameters from any previous point sample request. JSON files are included in the download bundle for completed requests.
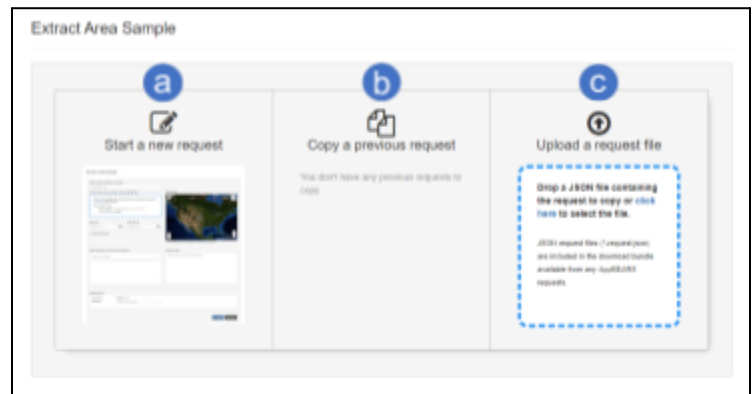
3.   In this example we will select **Start a new request**.

💡 *You must click on the picture or the link in the picture.*

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4. Enter a name for your sample in the box, indicated with the yellow ellipse. Type a name for the request you are going to request, (i.e., "ex. Surface Reflectance, July 2023, Temple University").

Be intentional when assigning names to your request by using the location, time, and/or measurement information). You will be able to retrieve these reminders about your retrievals and it is helpful to have this useful information upfront, in case you forget the details.
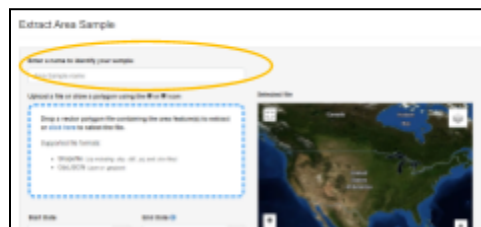
Spatial Requirements

You can define your region of interest in three ways:

d Upload a vector polygon file in shapefile format (can upload a single file with multiple features or multipart single features). The .shp, .shx, .dbf, and .prj files must be zipped into a file folder to upload.

OR

Upload a vector polygon file in GeoJSON format (can upload a single file with multiple features or multipart single features). (Sample .geojson for Temple University is available in the Sample Data section.)
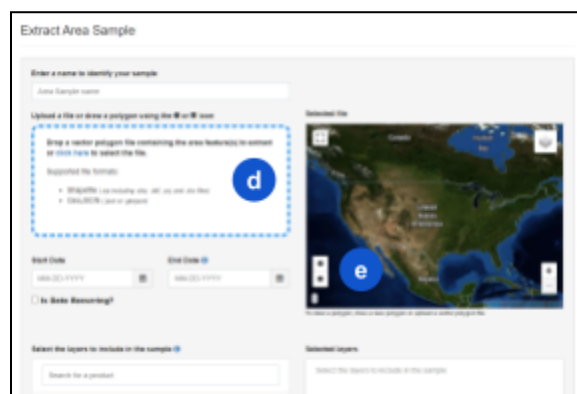
e Draw a polygon on the map by clicking on the bounding box or polygon icons (single feature only).

1. For the purposes of this exercise, we will select option **e**. In the map box, zoom to your desired geographic Area of Interest (AOI), Temple University, by using the + symbol or by double clicking in the AOI.

If you need help finding Temple University from this map view, visit the Google Map linked here to familiarize yourself with the estimated location.

2. Click on the **polygon** ⬟ (not bounding box ■) on the map interface and draw your polygon over Temple University, Philadelphia, Pennsylvania in the map box.
   ○ Click on the map to add each vertex. Double Click to close the shape. It will appear as a highlighted shape over the area you selected.
   ○ To redo the shape, simply start drawing a new polygon and this will erase the current one.

You can change the visible layers by clicking on the icon in the upper right-hand corner of the map box.

If the place labels, borders or roads interfere with your map view, you can turn them off by hovering over the layers icon in the top right corner of the map box and deselecting the options.

Date Requirements

1. Input your date range by entering a **Start Date** and **End Date** (MM-DD-YYYY) or clicking on the Calendar icon and selecting dates in the calendar. If the date range is recurring, select the checkbox, identify a date range (MM-DD) and then specify the year range using the slider.
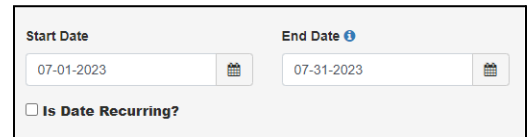
2. Input the Start and End Date for your month of interest: **07/01/2023 to 07/31/2023**

Dataset Requirements

AppEEARS offers access to a variety of mission data products.

1. Type the satellites, instruments, or parameters in the layers box. Suggestions will populate in a dropdown menu where you can select all or individual items. Clicking the **+** symbol will add them to the **Selected layers** pane. Layers from multiple products can be added to a single request.

   A. If you are unsure about the data products available in AppEEARS, you may access the list of products by one of the following:

      I. Select the *Information* icon next to *Select the layers to include in the sample* above the search bar to access a list of available products.

   II. Return to the top navigation and select **Help**, then select **Available Products**.
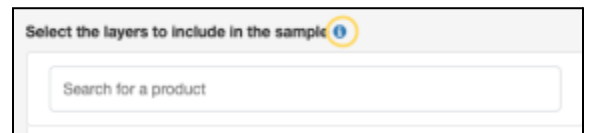
   B. Currently, AppEEARS contains the following Landsat data products: Analysis Ready

Data (ARD) and Harmonized Landsat and Sentinel-2 (HLSL30). For more information

about these data products, visit the [Landsat Data Products](#)section. For this exercise, we will browse and access Landsat Analysis Ready Data (ARD) data products.

2. Under *Select the layers to include in the sample*, type the phrase "Surface reflectance." A list of product layers will appear in the box.

3. Select *Landsat ARD Landsat Collection 2 ARD Surface Reflectance - Landsat 8 L08.002, 30m, 16 Day, (2013-03-18 to Present)* to add to the *Selected layers* list.
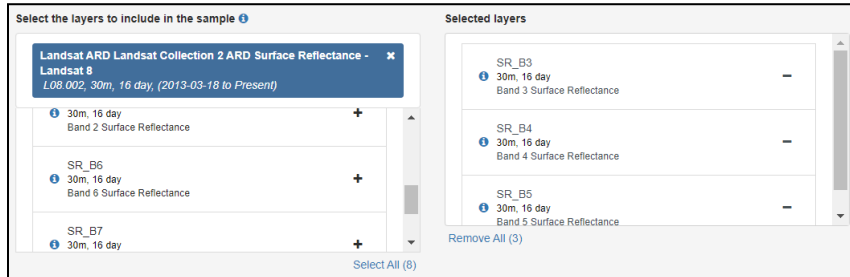
4. Click the layer(s) from which you would like to extract data. Scroll until you see the following options to add the bands 5-4-3. Click on the "+" sign to add each layer into your cart. The layers you select will appear in the *Selected layers* box. For more information on a specific layer, click on the Information icon 🛈 next to a layer name.

   A. SR_B5 (L08.002)
   B. SR_B4 (L08.002)
   C. SR_B3 (L08.002)

5. There are two output file formats available in the **Output Options** section.

   A. Georeferenced Tagged Image File Format (GeoTIFF)
      ○ Geographic Tagged Image File Format (GeoTIFF) is based on the TIFF format and is used as an interchange format for georeferenced raster imagery. GeoTIFF is in wide use in NASA Earth science data systems.) If GeoTIFF is selected, one GeoTIFF will be created for each feature in the input vector polygon file for each layer by observation.
   B. Network Common Data Form version 4 (NetCDF-4)
      ○ If NetCDF-4 is selected, outputs will be grouped into .nc files by product and by feature.

   *Select GeoTIFF for* **File Format.**

6. There are multiple projections available. Select *Geographic* **for Projection.**

   A. The interface will display specific information about each coordinate reference system. This information includes the Datum, the European Petroleum Survey Group (EPSG) code, and PROJ.4 string used for the transformation.
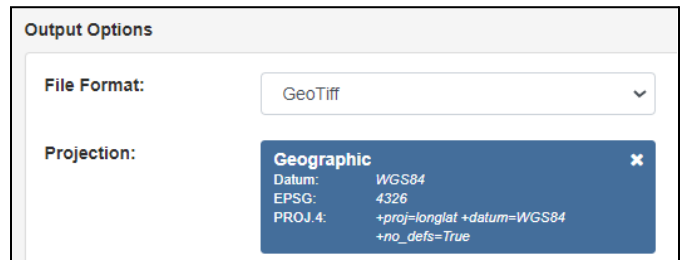
7. Click **Submit** at the bottom right to complete the request.

8. Once the request has been submitted, you will see a banner like the following, if the request is successful. Note: If your request was not successfully submitted, a red banner will appear explaining why your request failed.

> ✓ The area sample request was successfully submitted. An email notification will be delivered once the request is complete.
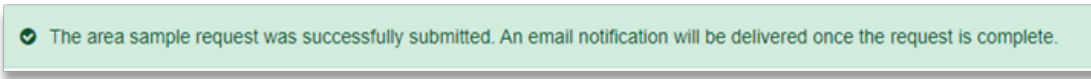
- ● The time required to receive the results of your request will vary depending on the temporal range, number of points, and products/layers selected. For extremely large requests (> 1M values) you will need to split your request into two or more smaller requests.
- ● You will receive an email notifying you of a successful submission from lpdaac@usgs.gov. The email contains request details and how to properly cite AppEEARS. You will receive an additional email once your request has completed processing, which will include links to explore and download your request.

9. Once the request is submitted, you will be able to check on the status of that request in Explore Requests. As soon as the request is submitted and received it will be **Queued**. When the request begins processing it will show a progress bar.

Explore Requests

Please see *Sample Request Retention* for details on expired requests.

Showing requests 1 - 2 of 2

« Prev 1 Next »

Request	Type	Status	Details	Date Submitted	Date Completed	
Temple University Demo	Area Sample	Queued	ⓘ	05-23-2024 5:43:25 PM EDT	05-23-2024 5:43:26 PM EDT	📊 ⬇ 🗑

10. Click the Information icon ⓘ in the Details column to view details about the request. The percentage bar under the Status column indicates that your request is processing and the overall progress in completing your request.

Manage, Explore, and Download the Results

1. You will get an email when the request is complete. At this time, access the **Explore Request** page to review, interact with, and explore the data. This page contains your sample request history. On this page you can view the name and type of your requests, the status of the requests (e.g., Pending, Processing, Done, Error), the details of the requests, the submission date of the requests, and the date that each request was completed.
2. Once the status of your request displays **Done**, users will have a variety of options available:

   i.   Click the **View** icon 📊 to view and interact with your results. This will

> take you to the **View Area Sample** page.
3. Click on the **Request** dropdown option at the top of the page to view the sample extraction details (e.g., Date Range, Product/Layers, Input Shapefile, Output File Format/Projection and Request ID).
    - Users have visualizations to explore data: (Note: visualizations are not publication-quality visualizations but are available for quick insights before downloading data.)
        - **Layer Stats Tab**

    - The Download Icon 📥 to download the results (.zip).
        - There are a couple of ways to download the data
            - Visit the Explore Screen, select the dropdown for the Request. Click the Download [📥 Download] button
            - Or visit the Explore navigation and select **Explore Requests**, and select the download 📥 icon.
        - The Download Area Sample page contains two sections:
            - Supporting Files -Supporting files include text files of the input granules used to complete your request and a readme file. A JSON file that can be used to generate the exact same parameters for a new request and CSV files that contain information on each products' quality data are also included. Click on any of the file names to download them.
            - The sample request output GeoTIFF or NetCDF-4 files
   - The Delete icon 🗑 to remove the request from your history.

Viewing the Results:

Users have access to different visualizations to explore their retrieved data; these depend upon the type of extraction selected. (Note: these are not publication-quality visualizations but are available for quick insights before downloading data.) The Area Extraction Result features a Layer Stats Tab to aid in your analysis of these data.

Create a Point Request

If you would like to extract point samples, follow the instructions below.

1. From the AppEEARS menu, click the Extract dropdown option and then click Point Sample.
2. After clicking Point Sample, you will be given three options:
3. Enter a name for your sample in the box.
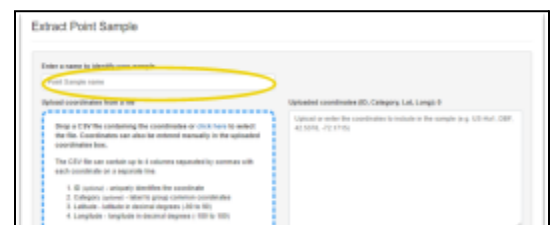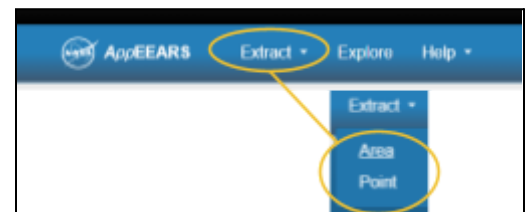
Spatial Requirements

1. Insert the coordinates of your AOI in one of the following methods:
   a. Upload or drop a CSV file containing lat/long coordinates.*
   b. Manually enter the coordinates of your AOI in the right hand box under "Uploaded Coordinates". Inputs must be entered so that each row represents a single site and each column is separated by a comma.*

   💡 *If you do not know the coordinates of green spaces for Temple University, consider using the following:*

Name of Green Space	Coordinates
Beury Beach	39.981588, -75.154273
1828 N Park Ave	39.980904, -75.156423
1801 N Broad St	39.981212, -75.154050
2001-59 N 13th St	39.983620, -75.153837

   c. Zoom to your AOI on the map box (bottom right), select the **Point icon Map** point draw icon and then click on a location. (Note: You may not be able to zoom to your AOI at the resolution necessary.

   💡 *You can change the visible layers by clicking on the icon in the upper right-hand corner of the map box*

2. The coordinates will automatically appear in the **Uploaded coordinates** box.

   💡
   - *You can remove any of the coordinate points from the map by deleting the uploaded coordinate from the box.*
   - **When entering coordinates manually or uploading a .csv file, a total of four columns can be added to the input, where two of the columns must be latitude and longitude coordinates in decimal degrees. In addition to the latitude and longitude columns, two additional columns can be added (e.g., a site name column and/or a land cover category) to describe each site.*
   - *If you have multiple points near each other, they might appear as a green circle with the number of points in that area. Click on the circle in order to zoom in on the specific points.*
   - *Click the map pin to see information about the point.*

Date Requirements

1. Input date range. If the date range is recurring, select the checkbox and the year range slider will appear.
2. Input the **Start Date** and **End Date** for your month of interest: **07/01/2013 to 07/01/2023**

Dataset Requirements

1. Next, type the satellite or instrument name, if known.
   - Under *Select the layers to include in the sample,* type the phrase "Surface reflectance." Suggestions will populate in a dropdown menu where users may select all or individual items.
2. Select *Landsat ARD Landsat Collection 2 ARD Surface Reflectance - Landsat 8 L08.002, 30m, 16 Day, (2013-03-18 to Present).*
3. From there, scroll until the following options appear. Add the bands 5-4-3 by clicking on the "+" sign to add each layer into the cart.
   - SR_B5 (L08.002)
   - SR_B4 (L08.002)
   - SR_B3 (L08.002)
4. Click the **Submit** button on the bottom left of the **Extract Point Sample Box**.
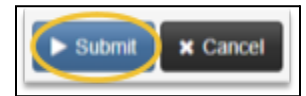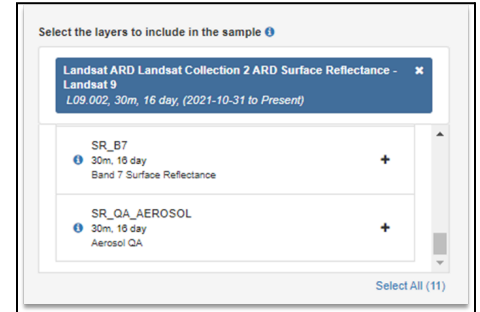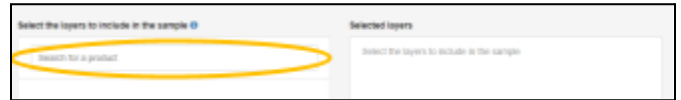
Note: AppEEARS requests take time to process. Consider reviewing the GIS Data Pathfinder to learn how to use GIS to run analyses and visualize data.

Interact with the Results

1. The results will arrive in an email with results with the subject line "AppEEARS Request Complete" to the email address used to create an Earthdata Login. Small requests usually take 15 min or less; larger requests may take an hour or more.

   Users may track the progress of a request and access the data at https://appeears.earthdatacloud.nasa.gov/explore .

2. Follow the **Explore** link in the completed request email (or via the **Explore** menu tab on the AppEEARS homepage) to review, interact with, and explore the data.
   a. Note: Sample requests are available to download for 30 Days after completion. After this period of time, the output data are removed, and will no longer be viewable or downloadable. However, users may resubmit the request for processing by using the **Resubmit** button.
   b. Output data files returned by AppEEARS have the following naming convention: <ProductShortName>.<Version>_<LayerName>_doy<Year><JulianDate>_<AppEEARSFeatureID>.<FileFormat>
   c. Example output file name (.tif): L08.002_SR_B5_CU_doy2023196_aid0001.tif

3. Click the **View** icon to view and interact with the results. This will take users to the **View Point Sample** page.

4. Click on the **Request** dropdown option at the top of the page to view the sample extraction details (e.g., Date Range, Product/Layers, Point Coordinates, and Request ID).
5. Users have different views of the data visualization: (Note: these are not publication

quality visualizations but are available for quick insights before downloading data.)
- ○ Temporal Comparison Tab
  - ■ Time Series Plot
  - ■ Stacked Time Series Plot
- ○ Layer Comparison Tab
- ○ Categorical Overview Tab (Interactive Aggregated view of data)

- Select the Download Icon to download the results (.zip).
  - ○ There are a couple of ways to download the data
    - ■ Visit the Explore Screen, select the dropdown for the Request. Click the Download button
    - ■ Or visit the Explore navigation and select **Explore Requests**, and select the download icon.
  - ○ The Download Point Sample page contains three sections:
    - ■ Bundle zip file - The output bundle file contains all supporting and sample files in a compressed zip file. The zip file can be downloaded by clicking the Download Zip icon near the top of the page.
    - ■ Supporting Files - Supporting files include text files of the input granules used to complete your request, a readme file, and a JSON file that can be used to generate the exact same parameters for a new request. Click on any of the file names to download them.
    - ■ The sample request output CSV files
- The Delete icon to remove the request from your history.

Viewing the Results

Users have access to different visualizations to explore their retrieved data; these depend upon the type of extraction selected. (Note: these are not publication-quality visualizations but are available for quick insights before downloading data.)

Point Extraction Result
- Temporal Comparison Tab:
  - ○ Time Series Plot
  - ○ Stacked Time Series Plot
- Layer Comparison Tab

Create Your Own GeoJSON

To quickly identify the geographic coordinates of your AOI, in this case, Temple University, visit geojson.io by Mapbox.
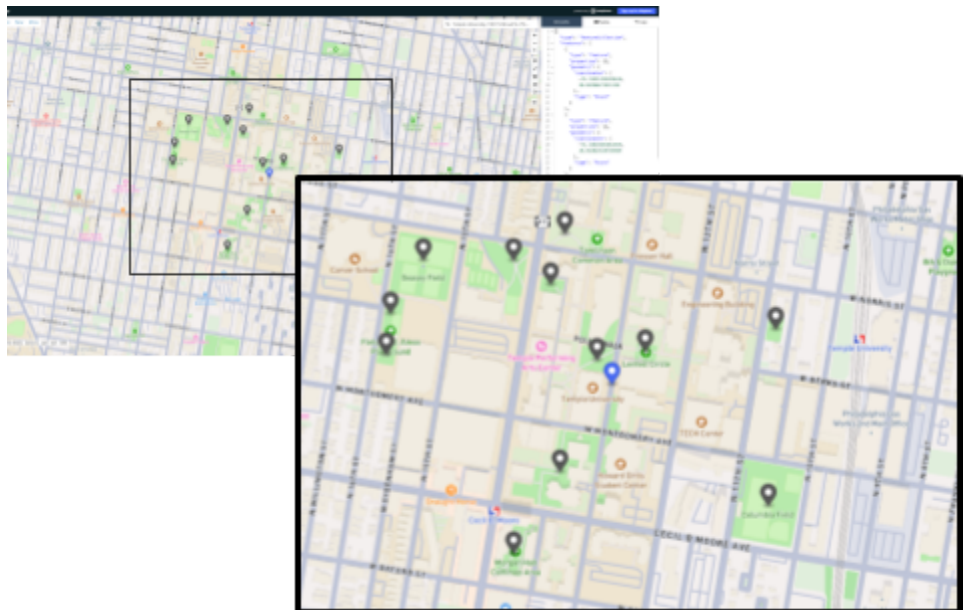

In the **Search** feature, type "Temple University." Select the pin tool to drop points on the university's green spaces where you wish to retrieve geospatial coordinates to use with your request for Landsat data via AppEEARS (or use the sample data below). Copy the data to a notepad or spreadsheet from the right panel, labeled as **</>JSON.** Clean the data to only include the Longitude and Latitude for the AOI.

Sample Green spaces on Temple University:

Longitude, Latitude
-75.1603733, 39.98131432
-75.16026601, 39.98202954
-75.15951499, 39.98296672
-75.15745506, 39.98296672
-75.15745112, 39.97783142
-75.15660108, 39.98254286
-75.15638217, 39.97925903
-75.15626922, 39.98343007
-75.15553459, 39.98122388
-75.15442952, 39.98137186
-75.15161857, 39.9786671
-75.15144691, 39.98175825

Landsat Data Products available in AppEEARS

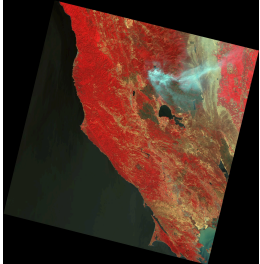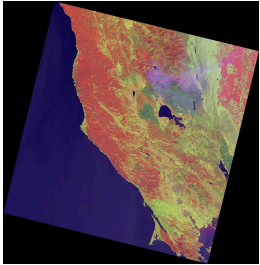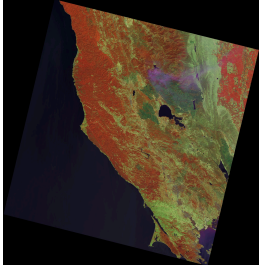| Landsat Product	Description
Analysis Ready Data (ARD)	• Available in tiled grid reference system instead of path/row format • Consists of 5000 x 5000 pixels and is smaller than a scene • Ideal for use in monitoring and assessing landscape change • Available for conterminous United States, Alaska, and Hawaii
Harmonized Landsat and Sentinel-2 (HLSL30)	• Harmonized Landsat Sentinel-2 (HLS) • The combined measurement enables global observations of the land every 2–3 days at 30-meter (m) spatial resolution. • Provides consistent surface reflectance (SR) and top of atmosphere (TOA) brightness data from a virtual constellation of satellite sensors.

Landsat 8 Band Characteristics & Uses

*Of its 11 bands, only those in the very shortest wavelengths (bands 1–4 and 8) sense visible light – all the others are in parts of the spectrum that we can't see. STELLA instrument bands compared to Landsat 8 work from the spectral bands (1, 2, 3, and 4) up to the Near- Infrared (NIR) band (5).

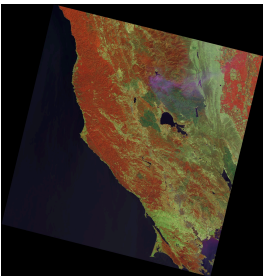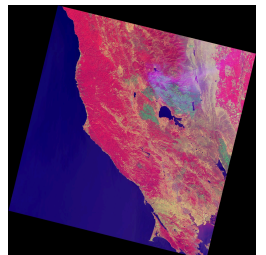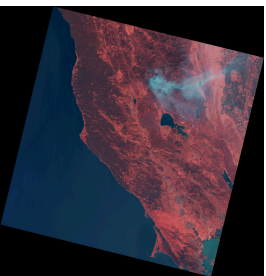| Band	Wavelength (μm)	Description	Common Uses of this Band	Spatial Resolution
Coastal Aerosol (1)*	0.43 - 0.45	Deep Blues & Violets	Coastal studies, aerosol detection	30 m
Blue (2)*	0.450 - 0.51	Blue Light	Water quality, vegetation analysis, bathymetric mapping, identifying soil from vegetation	30 m
Green (3)*	**0.53 - 0.59**	**Green Light**	**Vegetation health, land cover classification, plant vigor**	**30 m**
Red (4)*	**0.64 - 0.67**	**Red Light**	**Vegetation, vegetative slopes, natural color composites**	**30 m**
Near-Infrared NIR (5)	**0.85 - 0.88**	**Reflected Near-Infrared**	**Plant health assessment, biomass estimation, shorelines**	**30 m**
Shortwave infrared SWIR 1 (6)	1.57 - 1.65	Short-Wave Infrared 1	Vegetation moisture, soil moisture, penetrates (thin) clouds	30 m
Shortwave infrared SWIR 2 (7)	2.11 - 2.29	Short-Wave Infrared 2	Mineral identification, geology, penetrates (thin) clouds	30 m
Panchromatic PAN (8)*	0.50 - 0.68	All Visible Colors (High Resolution)	Improved spatial resolution of other bands, creating detailed maps, sharper image definition	15 m
Cirrus (9)	1.36 - 1.38	Reflected Near-Infrared	Cirrus cloud detection	30 m
Thermal Infrared TIR (10)	10.8 - 12.3	Thermal Emittance (100m)	Land surface temperature, soil temperature	100 m
Thermal Infrared TIR (11)	11.5 - 12.5	Thermal Emittance (100m)	Land surface temperature, soil moisture	100 m

Landsat 8 & 9 Band Comparison
to the STELLA Instrument

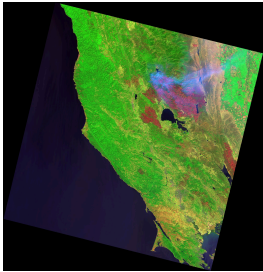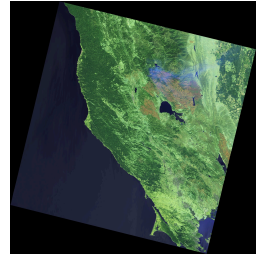| Landsat 8/9			STELLA
Bands	**Wavelength (micrometers)**	**Resolution (meters)**	**Band overlap**
Band 1 - Coastal aerosol	0.43-0.45	30	400-420, 425-445
Band 2 - Blue	0.45-0.51	30	450-470, 475-495, 500-520
Band 3 - Green	0.53-0.59	30	550-570, 575-595
Band 4 - Red	0.64-0.67	30	635-655
Band 5 - Near Infrared (NIR)	0.85-0.88	30	850-870
Band 6 - Shortwave Infrared (SWIR) 1	1.57-1.65	30	
Band 7 - Shortwave Infrared (SWIR) 2	2.11-2.29	30	
Band 8 - Panchromatic	0.50-0.68	15	
Band 9 - Cirrus	1.36-1.38	30	
Band 10 - Thermal Infrared (TIRS) 1	10.6-11.19	100	5,460 - 14,000
Band 11 - Thermal Infrared (TIRS) 2	11.50-12.51	100	5,460 - 14,000

Common Landsat 8 Band Combinations

Band Combination	Name	Common Applications of this Band Combination Application	Sample Display
4-3-2	Natural Color Composite	"True" color visualization; simulates what human eyes "see"; may appear "hazy" due to atmospheric interference	
4-3-1	Bathymetry	Estimating suspended sediment; useful in coastal bathymetric, and aerosol studies	
5-4-3	**Color Infrared (CIR)/ NIR False Color**	**Vegetation/Forest/Wetland health (highlight healthy vegetation (appears bright red); commonly used for measuring disturbed ground**	
5-6-2	Vegetation	Health	
5-6-4	Water/Land	Water bodies, barren land, ice	

Band Combination	Name	Common Applications of this Band Combination Application	Sample Display
5-6-4	Water/Land	Water bodies, barren land, ice	
5-7-1	Air Quality/Bathymetry False Color	Track particulates, shallow water	
6-3-2	Geology/False Color	Barren landscapes	
6-5-2	Agriculture/False Color	Crop and vegetation; barren land	
6-5-4	False Color (Vegetation)	Analysis	

Band Combination	Name	Common Applications of this Band Combination Application	Sample Display
7-5-2	Forest Fire/False Color	Burn scars	
7-5-4	Shortwave Infrared	Density of vegetation	
7-6-2	Geology	Geological landforms, lithologic features, and faults	
7-6-4	Shortwave Infrared/False Color (Urban)	Urban structure analysis; commonly used for identifying features like buildings and roads.	

Common Landsat Band Combinations

Images: Landsat 8 Path 46 Row 27 acquired August 23, 2020. Band numbers displayed as R,G,B.
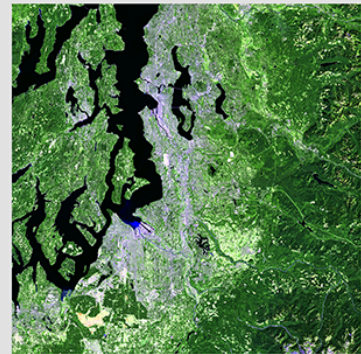
Natural Color

Landsat 8/9 OLI	4,3,2
Landsat 7 ETM+	3,2,1
Landsat 4-5 TM	3,2,1
Landsat 4-5 MSS	N/A
Landsat 1-3 MSS	N/A

Color Infrared (CIR)

Landsat 8/9 OLI	5,4,3
Landsat 7 ETM+	4,3,2
Landsat 4-5 TM	4,3,2
Landsat 4-5 MSS	3,2,1
Landsat 1-3 MSS	6,5,4

False Color (Urban)

Landsat 8/9 OLI	7,6,4
Landsat 7 ETM+	7,5,3
Landsat 4-5 TM	7,5,3
Landsat 4-5 MSS	N/A
Landsat 1-3 MSS	N/A

False Color (Vegetative Analysis)
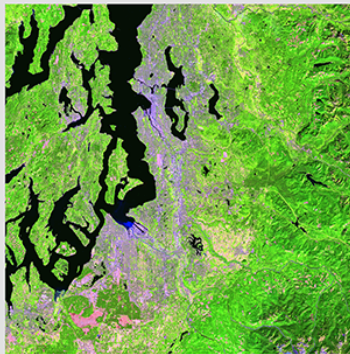
Landsat 8/9 OLI	6,5,4
Landsat 7 ETM+	5,4,3
Landsat 4-5 TM	5,4,3
Landsat 4-5 MSS	4,3,2
Landsat 1-3 MSS	7,6,5

Shortwave Infrared
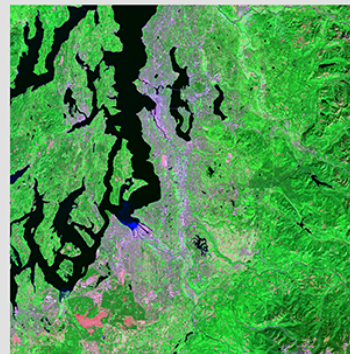
Landsat 8/9 OLI	7,5,4
Landsat 7 ETM+	7,4,3
Landsat 4-5 TM	7,4,3
Landsat 4-5 MSS	N/A
Landsat 1-3 MSS	N/A

Source: https://www.usgs.gov/media/images/common-landsat-band-combinations