Exercise 1: Extracting MODIS Time Series Data Using AppEEARS

Objectives

- Identify appropriate MODIS images for comparison with point and polygon data
- Use web-based tool to select and download MODIS data
- Visualize time series results and assess data quality
  Analyze and interpret time series data

Overview of Topics

- Extract point and polygon samples from MODIS data in AppEEARS
- Explore results in AppEEARS
- Download results and analyze in Excel
- Visualize results

Software/Tools Needed

- Please sign up for a free NASA Earthdata account:
  https://urs.earthdata.nasa.gov/users/new
- Microsoft Excel

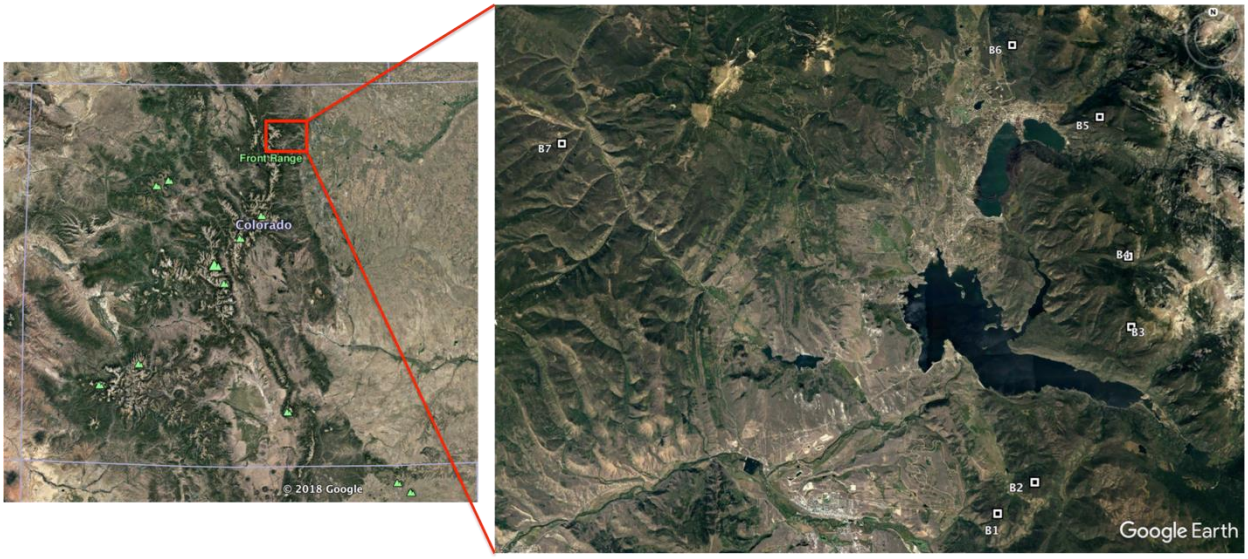
Associated Data

- Beetle.csv file -This file is a list of point locations in Colorado where beetle infestation has cause forest mortality
- SQUARE_ID17QK09.zip – This is a zipped shapefile of a polygon from the Ontario Breeding Bird Atlas

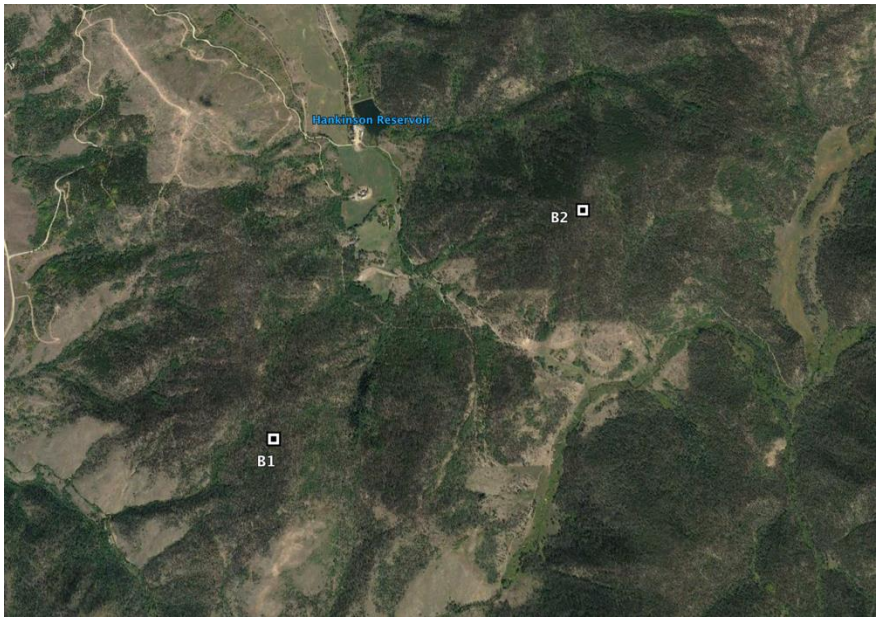
All associated data must be downloaded from the ARSET website here:
https://arset.gsfc.nasa.gov/land/webinars/time-series-19

Introduction

For this exercise, we will explore the Application for Extracting and Exploring Analysis Ready Samples (AppEEARS) for assessing time series of MODIS imagery. For this exercise, we will examine MODIS time series data that coincide with point data where forest disturbance has occurred. The Application for Extracting and Exploring Analysis Ready Samples (AppEEARS) allows users to conduct web-based analysis without the need to download MODIS datasets. We will use point locations of beetle infestation to analyze vegetation patterns from MODIS NDVI data from 2002 – 2018 within AppEEARS and Excel. In the western U.S. mountain pine beetle disturbances have been extensive, particularly in the has been Arapaho-Roosevelt National Forest. We will examine seven point locations that have been affected by the beetle infestation.



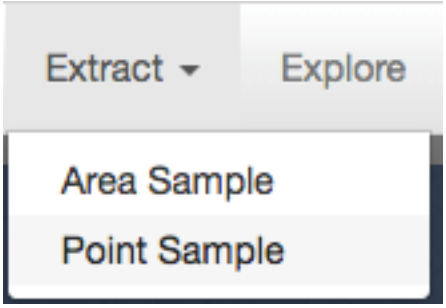
The figure above shows the location of the seven sites we will analyze in this exercise.



Here you can see sites B1 and B2, and you may notice these forested regions have a red/brown hue to them, indicative to beetle infestation.

Part 1: Analyzing Vegetation Disturbance with Point Data

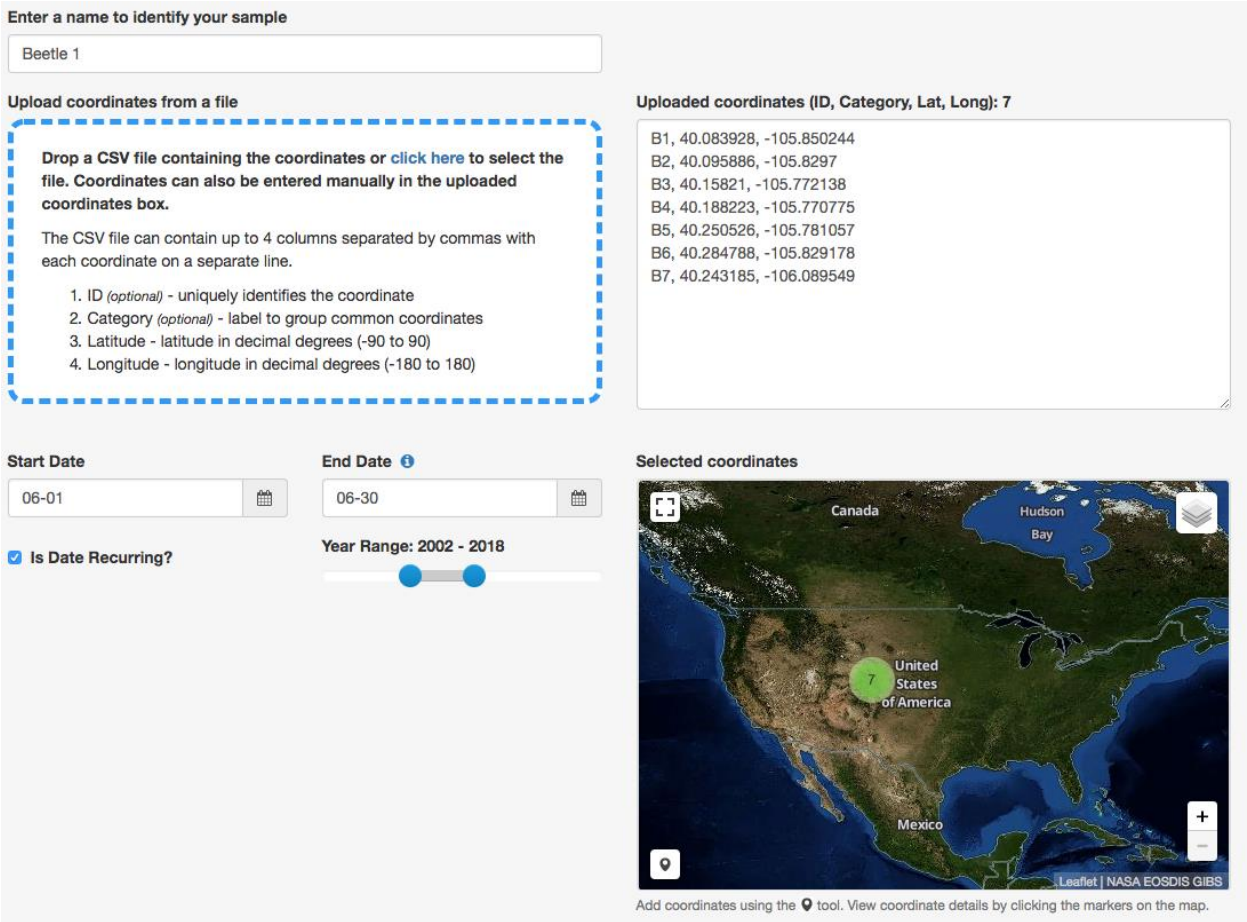
1. Go to the AppEEARS homepage https://lpdaac.usgs.gov/tools/appeears/ and click on **Launch**
2. Sign in using your NASA Earthdata login
3. From the top panel, select **Extract > Point Sample**



4. Click on Start a new request
5. Under Enter a name to identify your sample, type in Beetle 1.
6. Under **Upload coordinates from a file** you can either drag your .csv file into the box or you can click to upload it. Note the required format of the CSV file. It can contain up to 4 columns separated by commas with each coordinate on a

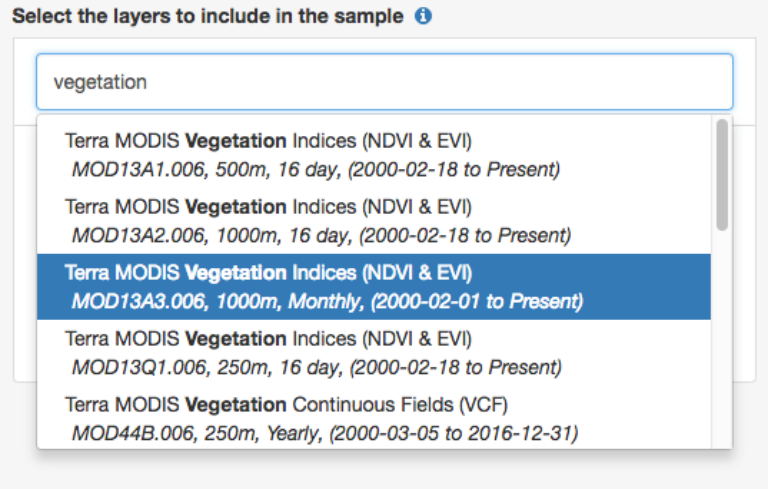
separate line. Upload Beetle_CO.csv. You will see it appear under **Uploaded coordinates** to the right.

7. To set the date, check the **Is Date Recurring** box. Then set the **Start Date** to **MM-DD** by clicking on the date box to the right. To change the month, click on the arrow pointing left until you reach June. Then, select June 1. Repeat for the **End Date** and put June 30.
8. Under **Year Range** move the blue dots on the time slider to 2002 – 2018

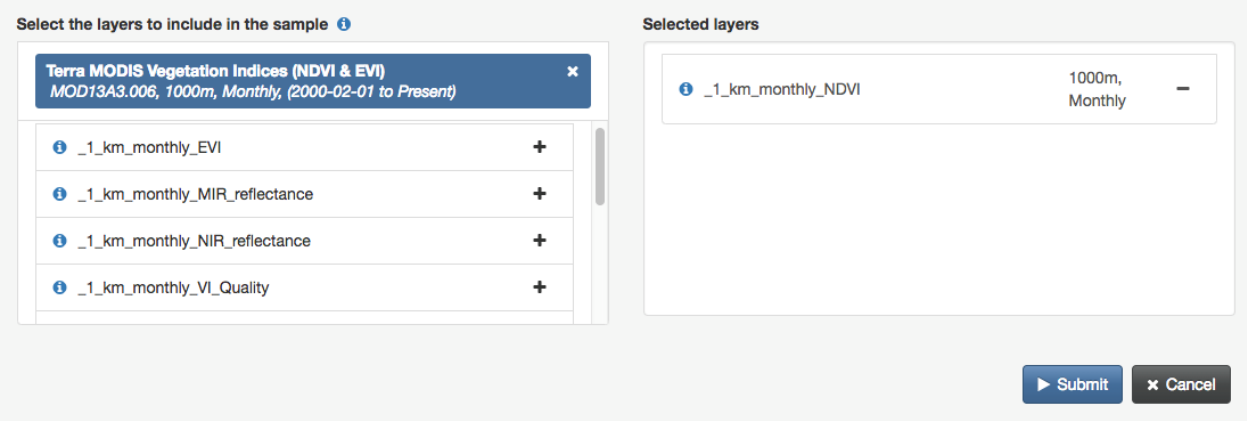


9. Scroll down until you see Select the layers to include in the sample

10. In the **Search for a product** box, type vegetation. You will see several MODIS products appear. Select **Terra MODIS Vegetation Indices (NDVI & EVI) MOD13A3.006**



11. Several options will appear in the box below. Select **1_km_monthly_NDVI** by clicking on the + to the right. That will add it to the **Selected Layers** box on the



right.

12. Click **Submit**. Once you do that, a message will appear at the top that says "*The point sample request was successfully submitted. An email notification will be delivered once the request is complete.*" You will also get an email confirming your request.

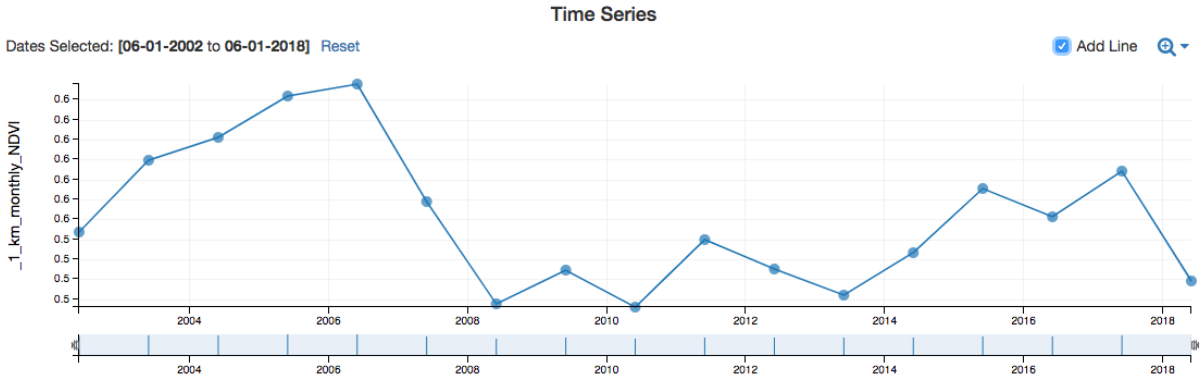
13. To check the status of your request, you can click on the **Explore** tab at the top of the page. The length of time for an AppEEARS request to process is dependent on a number of factors including size of the request and server traffic.

You will receive an email from LP DAAC once the request is complete. Next, we will explore the results of the point sample request using visualizations in AppEEARS

14. Once the processing is complete, view it in the **Explore Requests tab**. Click on your request: Beetle1.
15. Another page will appear called **View Point Sample**. The first tab is **Temporal Comparison**. This allows you to look at the time series for a single point.

16. In the **Site** dropdown list, keep the default (B1, 40.083928, -105.850244)
17. In the **Quality** dropdown list select **Show Good Quality**

18. In the Layer dropdown list, keep the default (MOD13A3_006_1_km_monthly_NDVI)
19. Scroll down until you can see the **Time Series** graph. Click **Add Line** on the top right.



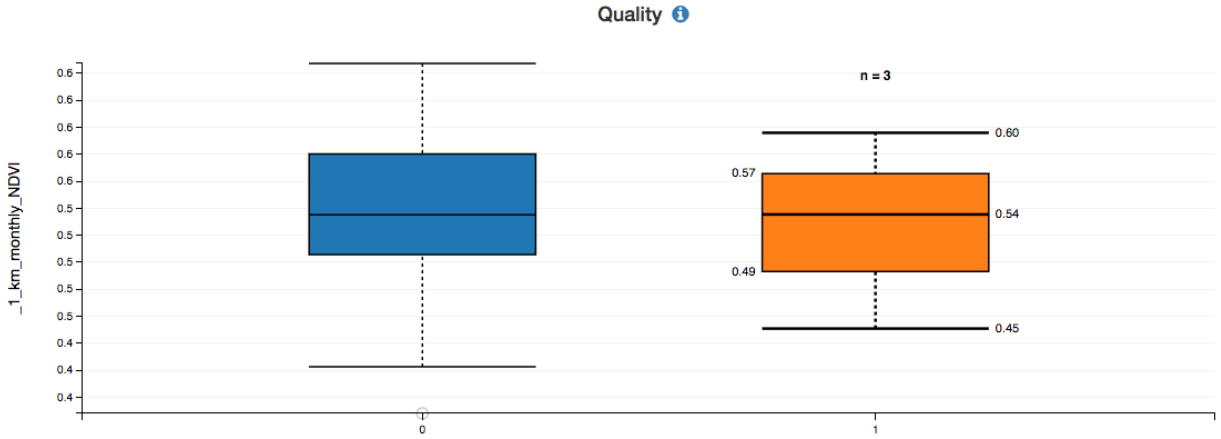
The **Time Series** graph shows NDVI values for the B1 point for 2002 – 2018, which varies between 0.5 and 0.6. Each point represents a MODIS NDVI value for the monthly composite observations in June. You can get the exact NDVI value by placing your mouse over a point.

20. Go back to the **Site** dropdown box and look at a few more points (B2– B7).

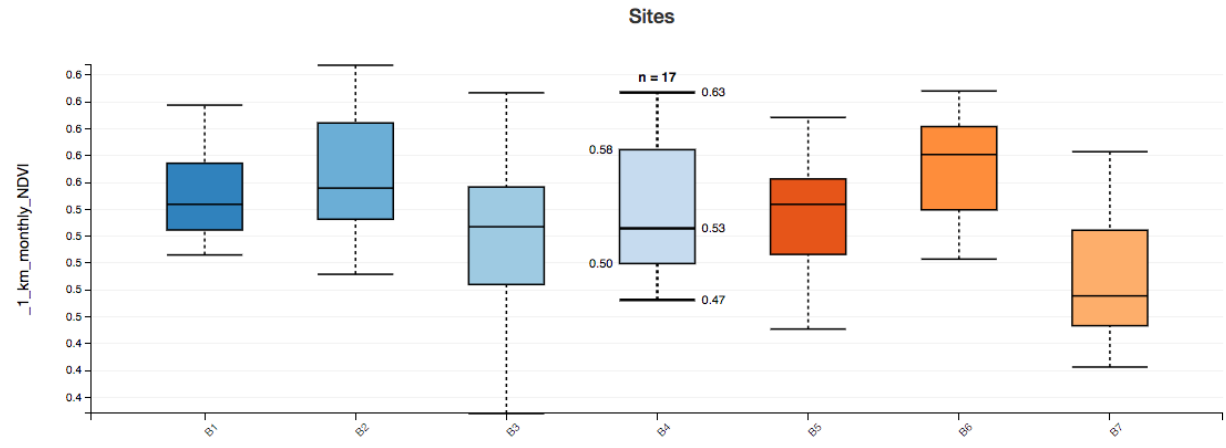
Looking at this graph you will notice the large decrease in NDVI values between 2006 and 2008, which is when the beetle infestation resulted in extensive forest mortality. As the forest recovers, you can see a slow increase in NDVI values between 2010 and 2018.

21. Scroll to the top of the page and click on the **Categorical Overview** tab.
22. Scroll down until you can see the **Quality** graph. This graph shows how many satellite pixels had Quality 0 (Good quality) and Quality 1 (questionable quality).

Put your mouse over the **Quality 1** box (orange) and you will see that there are 3 pixels with questionable quality (n=3)



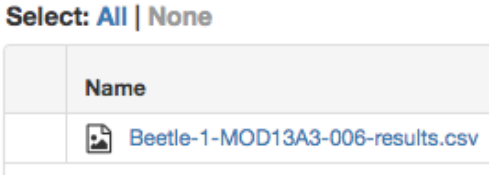
23. Scroll down until you see the **Sites** graph. This graph shows you the mean and range of NDVI values for each site. Put your mouse over each box to see those values.



24. To include only good quality pixels in the **Sites** graph, go back up to the **Quality** graph and click on the blue box, for value 1. That will turn off the orange box and only include pixels with good quality in the Sites graph. When the pixels with a Quality = 1 are removed from the Sites graph, the orange box-and-whisker will turn grey.

Download the Data & Analyze in Excel

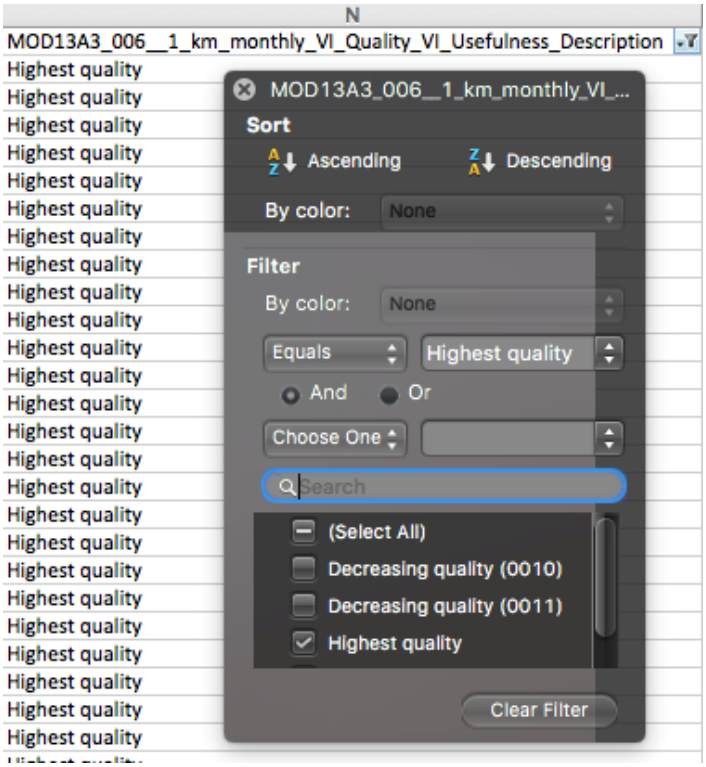
25. Click on Explore at the top of the window
26. On the far right of your Beetle 1 request, click the **download** button 
    The **Download Point Sample** page will appear. Under the **Select** section, click on your results: **Beetle-1-MOD13A3-006-results.csv**. A zip file will download to your computer.



27. In Excel, open Beetle-1-MOD13A3-006-results.csv.

This .csv file has many columns. The first thing we want to do is filter the results so we are only working with good quality pixels.

28. On the top of the Excel window click on **Data > Filter**. You will see dropdown boxes appear next to all your Row 1 headings  .
29. Go to Row **N** and click on the dropdown box. Click off **Decreasing quality (0010)**, **Decreasing quality (0011)**, and **Lower Quality**. You may need to increase the size of the filter window to see the Lower Quality option. Only **Highest quality** should be selected.

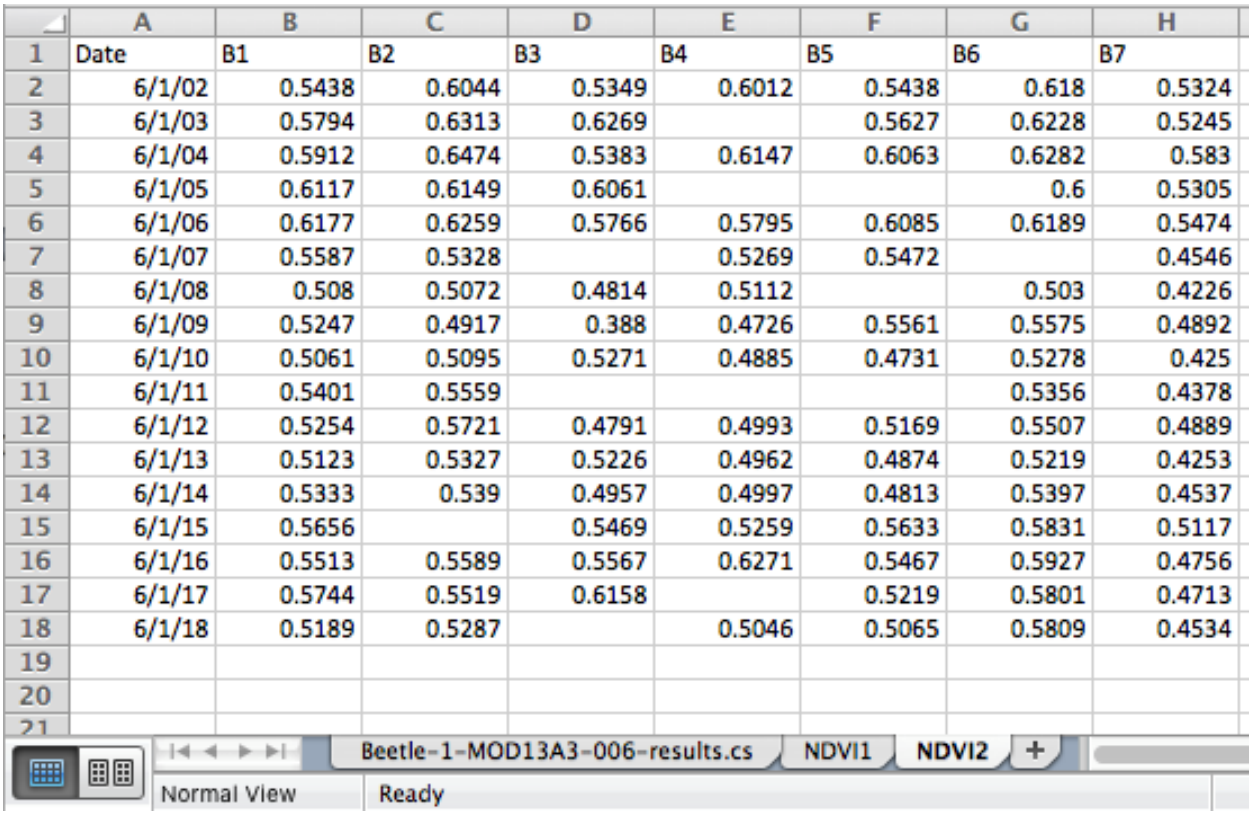


30. Select the entire spreadsheet (by clicking on the triangle on the top left), and copy and paste into a new Sheet.
    - You can add a new sheet by clicking on the "+" icon at the bottom of the Excel page.
31. Name this new sheet NDVI1, and save the entire file as Beetle1.xlsx
    - On the new sheet, ensure all the rows in column N are labeled as **Highest quality**.
32. We only need columns A (ID), D (Date) and H (MOD13A3_006_1_km_monthly_NDVI), Delete all other columns.

The excel sheet should now contain three columns. The ID represents the pixel where you have a point (B1 to B7, since there are seven sites). For each location, there should be a NDVI value for June 1st of each year from 2002 to 2018. As you scroll down the sheet you will notice some of the points have missing years. To easily visualize the data, you will need to add the missing years but you should leave the value cell empty. For example, point B2 is missing 2015.

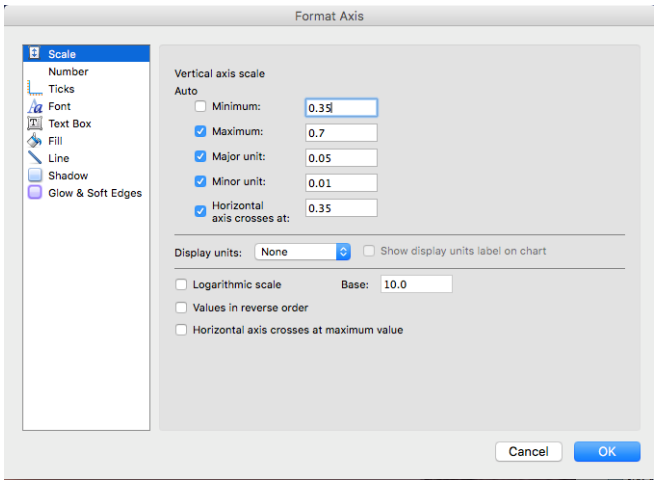
33. For each missing data point, add a row and insert the ID and the missing date. Here are the dates missing:
    - Site B2: 6/1/2015
    - Site B3: 6/1/2011
    - Site B3: 6/1/2007
    - Site B3: 6/1/2018
    - Site B4: 6/1/2003
    - Site B4: 6/1/2005
    - Site B4: 6/1/2011
    - Site B4: 6/1/2017
    - Site B5: 6/1/2005
    - Site B5: 6/1/2008
    - Site B5: 6/1/2011
    - Site B6: 6/1/2007
34. We will need to reformat the spreadsheet in order to graph the data. Add a new sheet by clicking on the "+" icon at the bottom of the Excel page, and name it NDVI2.
35. We need each pixel (B1 to B7) to be separated into distinct columns. Open another sheet and in the cells in Row 1 type each label into a consecutive column:
    - Column A: Date
    - Column B: B1
    - Column C: B2
    - Column D: B3
    - Column E: B4
    - Column F: B5
    - Column G: B6
    - Column HL: B7
36. From Sheet 1, copy and paste the dates 6/1/2002 through 6/1/2018 into Column A. Then copy and paste the NDVI values for each point (B1 through B7) into the appropriate columns on Sheet 2.

The newest tab on your spreadsheet should now look like this:

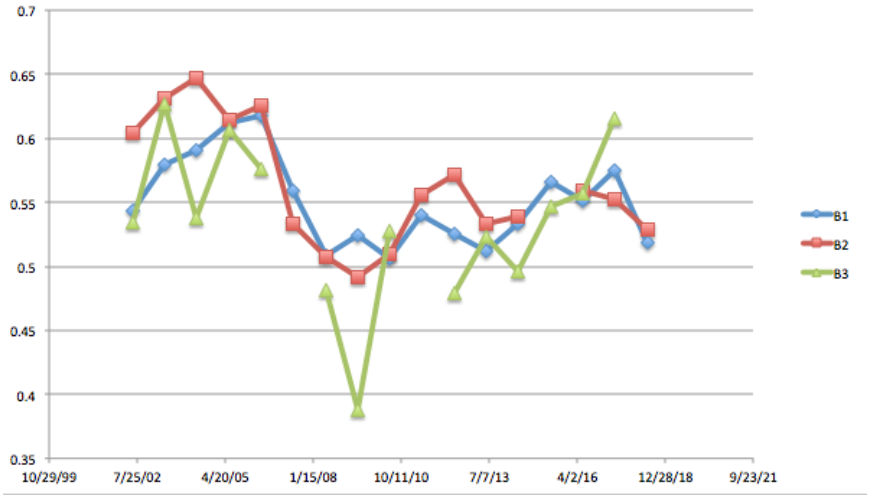


	A	B	C	D	E	F	G	H
1	Date	B1	B2	B3	B4	B5	B6	B7
2	6/1/02	0.5438	0.6044	0.5349	0.6012	0.5438	0.618	0.5324
3	6/1/03	0.5794	0.6313	0.6269		0.5627	0.6228	0.5245
4	6/1/04	0.5912	0.6474	0.5383	0.6147	0.6063	0.6282	0.583
5	6/1/05	0.6117	0.6149	0.6061			0.6	0.5305
6	6/1/06	0.6177	0.6259	0.5766	0.5795	0.6085	0.6189	0.5474
7	6/1/07	0.5587	0.5328		0.5269	0.5472		0.4546
8	6/1/08	0.508	0.5072	0.4814	0.5112		0.503	0.4226
9	6/1/09	0.5247	0.4917	0.388	0.4726	0.5561	0.5575	0.4892
10	6/1/10	0.5061	0.5095	0.5271	0.4885	0.4731	0.5278	0.425
11	6/1/11	0.5401	0.5559				0.5356	0.4378
12	6/1/12	0.5254	0.5721	0.4791	0.4993	0.5169	0.5507	0.4889
13	6/1/13	0.5123	0.5327	0.5226	0.4962	0.4874	0.5219	0.4253
14	6/1/14	0.5333	0.539	0.4957	0.4997	0.4813	0.5397	0.4537
15	6/1/15	0.5656		0.5469	0.5259	0.5633	0.5831	0.5117
16	6/1/16	0.5513	0.5589	0.5567	0.6271	0.5467	0.5927	0.4756
17	6/1/17	0.5744	0.5519	0.6158		0.5219	0.5801	0.4713
18	6/1/18	0.5189	0.5287		0.5046	0.5065	0.5809	0.4534
19								
20								
21								

37. Now you can graph the points and compare them to each other. To compare the first 3 points, select Columns A-D and Rows 1-18.
38. At the top of the Excel page, select **Insert > Chart > Scatter > Straight Marked Scatter**
39. The graph will appear next to the data. We would like to improve the graph by changing the range of the values on the Y-axis. Right-click on the Y-axis and select **Format Axis**. Next to the Minimum Bounds box, change 0.0 to 0.35. Click **OK**.



Now your graph should look like this:



Notice the decrease in NDVI values for each of the sites (B1 to B3) from about 2006 to 2009. You can also repeat step 34 for all of the sites or any specific sites you may be interested in viewing.

Part 2: Using Polygons to Create Remote Sensing-derived Environmental Descriptors

This portion of the exercise is based on a methodology from *Coops et al., 2009*, that used remote sensing-derived environmental descriptors of topography, land cover, and vegetation productivity to predict species richness of breeding birds in Ontario, Canada. To quantify avian biodiversity, they used bird statistics provided by the Ontario Breeding Bird Atlas (OBBA) project. The OBBA data are divided into 10 x 10 km cells. The authors combined the bird statistics with the following environmental descriptors derived from remote sensing data from 2000 – 2005.

Here we will be deriving the same or similar environmental descriptors from MODIS 2001 – 2005 imagery using AppEEARS for one of the 10 x 10 km cells including:

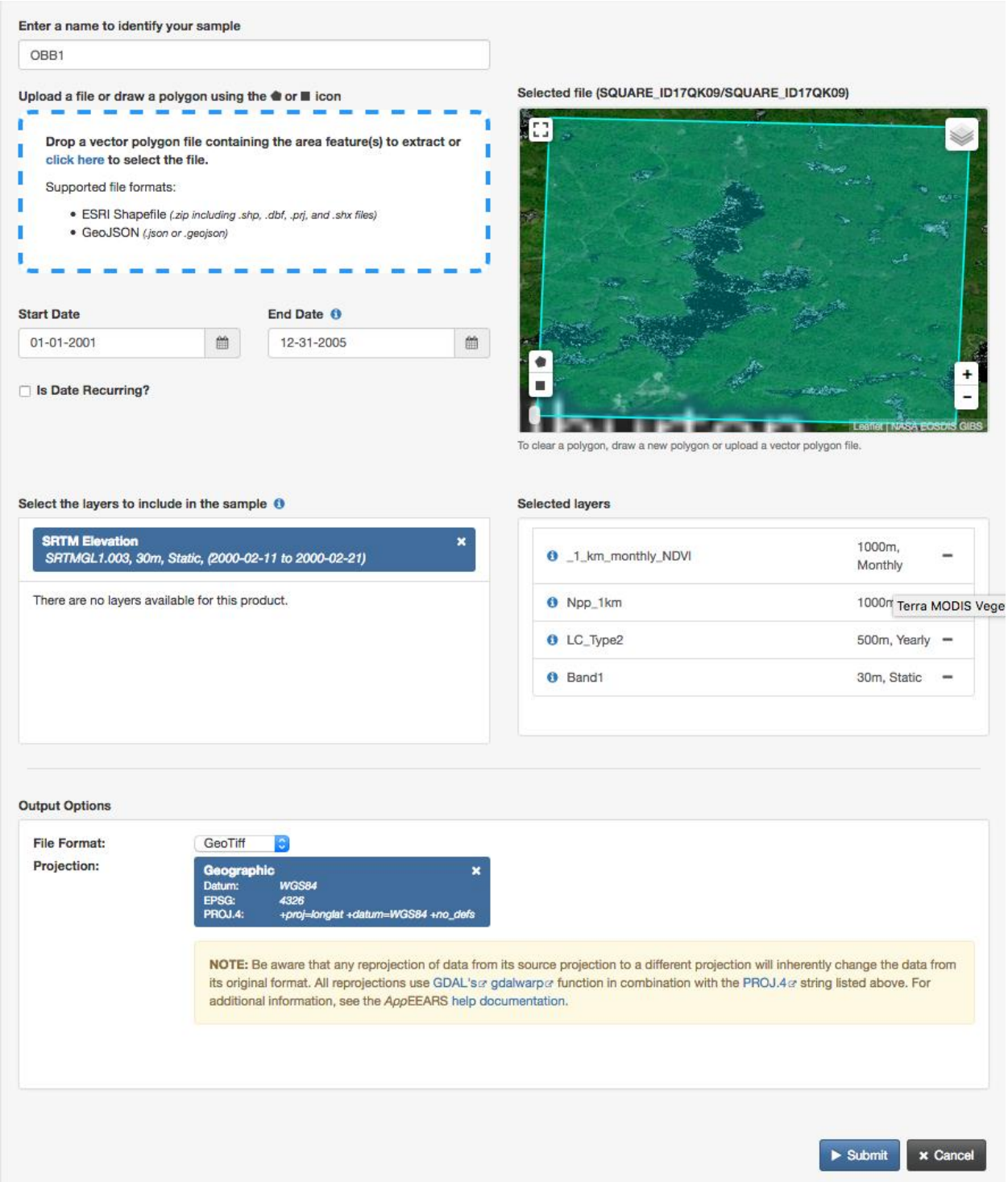
- Variation in topography (calculated as the coefficient of variation)
- Land cover
    - Dominant land cover class
    - Land cover dominance (percentage of the area covered by the dominant class
    - Land cover richness (total number of land cover classes within the cell)
- Vegetation dynamics
    - Total annual productivity – derived by summing monthly productivity for each year and then averaging over the total period of time.
    - Minimum level of perennial cover (seasonal greenness)
        - Relates to the potential of the landscape to support populations throughout the year.
        - Derived by calculating the annual minimum monthly NDVI and averaged over the total time period
    - Degree of vegetation seasonality (annual minimum cover)
        - Derived by calculating the coefficient of variation (CV) for NDVI. High CV values indicated seasonal extremes in climatic conditions, while low CV values typically represent irrigated pasture, barren land or evergreen forests.

1. If you are not already logged in, go to the AppEEARS homepage (https://lpdaacsvc.cr.usgs.gov/appeears/) and sign in using your NASA Earthdata login.

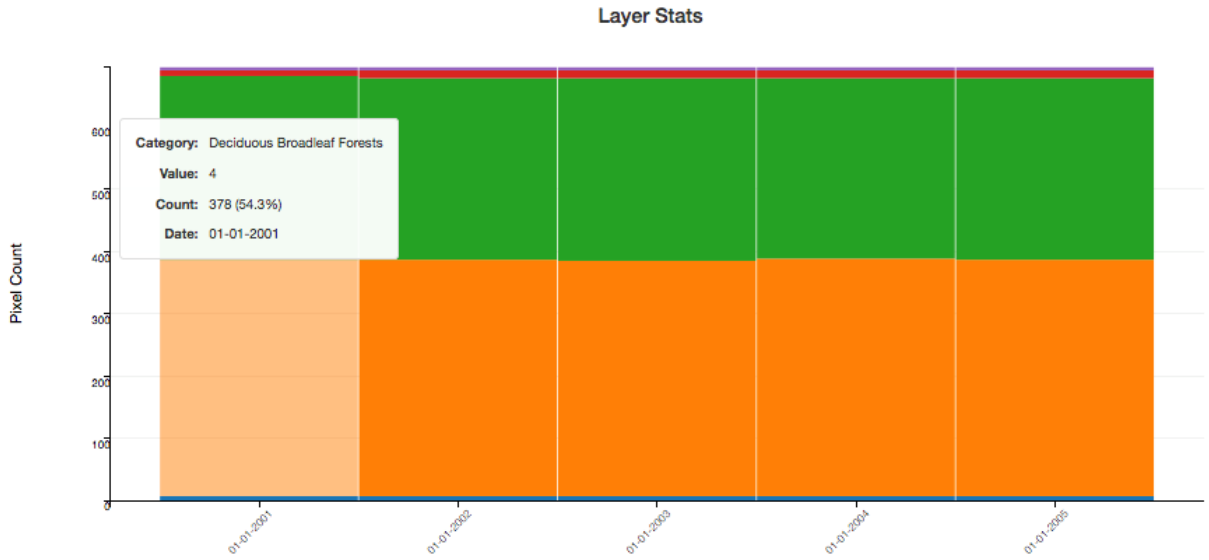
2. From the top panel, select **Extract > Area Sample**
3. Click on Start a new request
4. Under Enter a name to identify your sample, type OBB1
5. Under **Upload a file**, drag and drop **SQUARE_ID17QK09.zip**. You will see the polygon appear on the right.
6. Set **Start Date** to 01-01-2001 and **End Date** to 12-31-2005
7. Keep "**Is Date Recurring**" unchecked
8. Under **Select the layers to include in the sample** choose the following layers from these products.
    - You can find the products by typing in the product name in the search and selecting the appropriate data product. Make sure you click on the **+** next to the **Layer** to add it to the **Selected Layers** list on the right.
    - If you begin to type in the product name (in parenthesis below) the list will automatically generate the layer options. Then you can click on the specific layer to add it to the **Selected Layers** list. After you have added a layer, use the "x" in the product name to close that option.

Data Product	Layer
Vegetation Indices (MOD13A3.006)	_1_km_monthly_NDVI
Net Primary Production (MOD17A3.055)	Npp_1km
Land Cover Type (MCD12Q1.006)	LC_Type2
Digital Elevation Model (SRTMGL1.003)	Band1

9. Scroll down to **Output Options**
    - File Format: GeoTIFF
    - Projection: Geographic
    - Click Submit

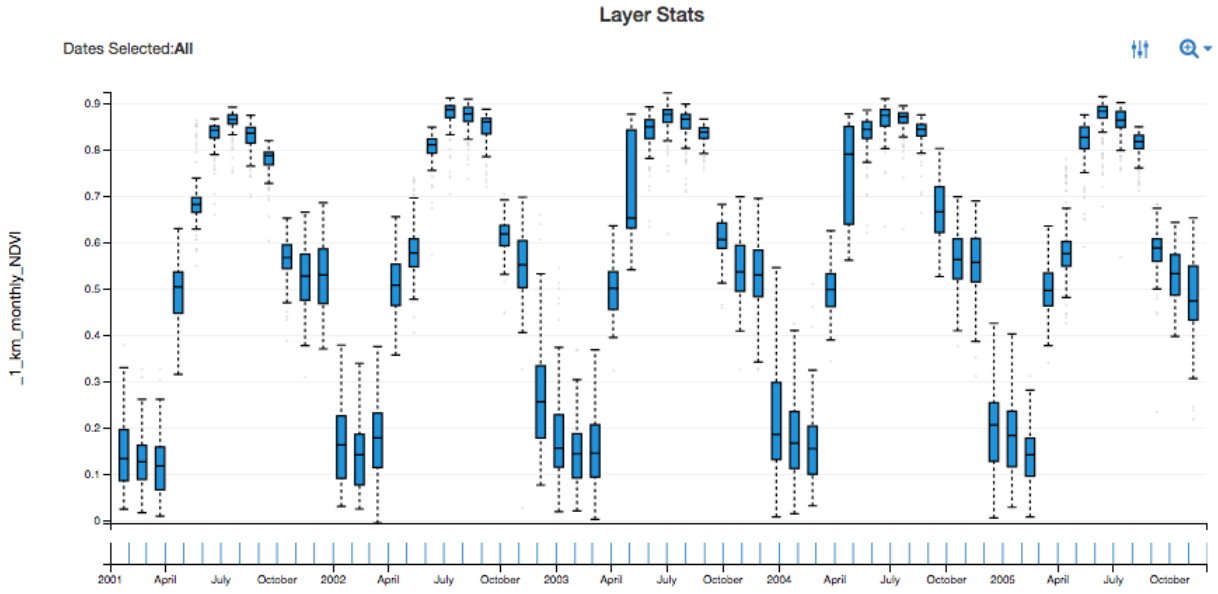

Enter a name to identify your sample
OBB1
Upload a file or draw a polygon using the ⬟ or ■ icon
Drop a vector polygon file containing the area feature(s) to extract or click here to select the file.
Supported file formats:
• ESRI Shapefile (.zip including .shp, .dbf, .prj, and .shx files)
• GeoJSON (.json or .geojson)
Start Date
01-01-2001
End Date
12-31-2005
Is Date Recurring?
Selected file (SQUARE_ID17QK09/SQUARE_ID17QK09)
Leaflet | NASA EOSDIS GIBS
To clear a polygon, draw a new polygon or upload a vector polygon file.
Select the layers to include in the sample
SRTM Elevation
SRTMGL1.003, 30m, Static, (2000-02-11 to 2000-02-21)
There are no layers available for this product.
Selected layers
_1_km_monthly_NDVI
1000m, Monthly
Npp_1km
Terra MODIS Vege
LC_Type2
500m, Yearly
Band1
30m, Static
Output Options
File Format:
GeoTiff
Projection:
Geographic
Datum: WGS84
EPSG: 4326
PROJ.4: +proj=longlat +datum=WGS84 +no_defs
NOTE: Be aware that any reprojection of data from its source projection to a different projection will inherently change the data from its original format. All reprojections use GDAL's gdalwarp function in combination with the PROJ.4 string listed above. For additional information, see the AppEEARS help documentation.
Submit
Cancel

10. After your request has been submitted, click on the **Explore** tab to view submission progress
11. Once the request is complete, click on OBB1
12. In the **Stats** tab, set the **Layer** to **MCD12Q1_006_LC_Type2**. This is the land cover data.
13. Scroll down to **Layer Stats**. Put your cursor over the orange box above the first date 01-01-2001. You will see:
    - Category: Deciduous Broadleaf Forests, Value: 4; Count: 378 (54.3%), Date: 01-01-2001

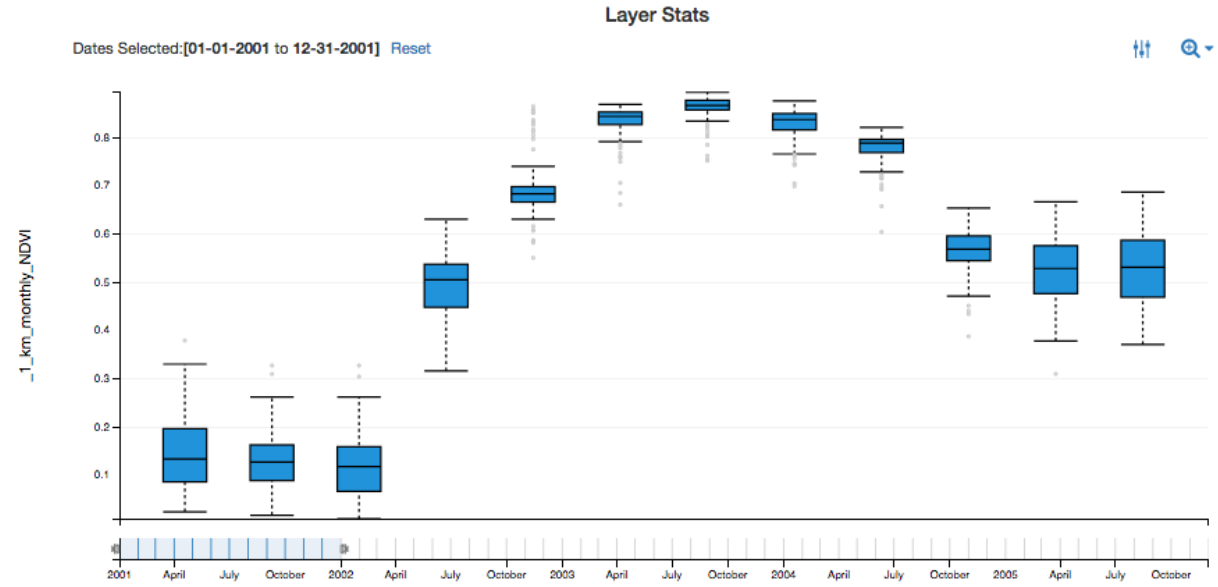


14. Do the same for the green and red boxes. For this OBBA tile, the dominant land cover type is “Deciduous Broadleaf Forests”
15. Scroll back up to the top. Under the **Layer** dropdown, select **MOD13A3_006__1_km_monthly_NDVI**

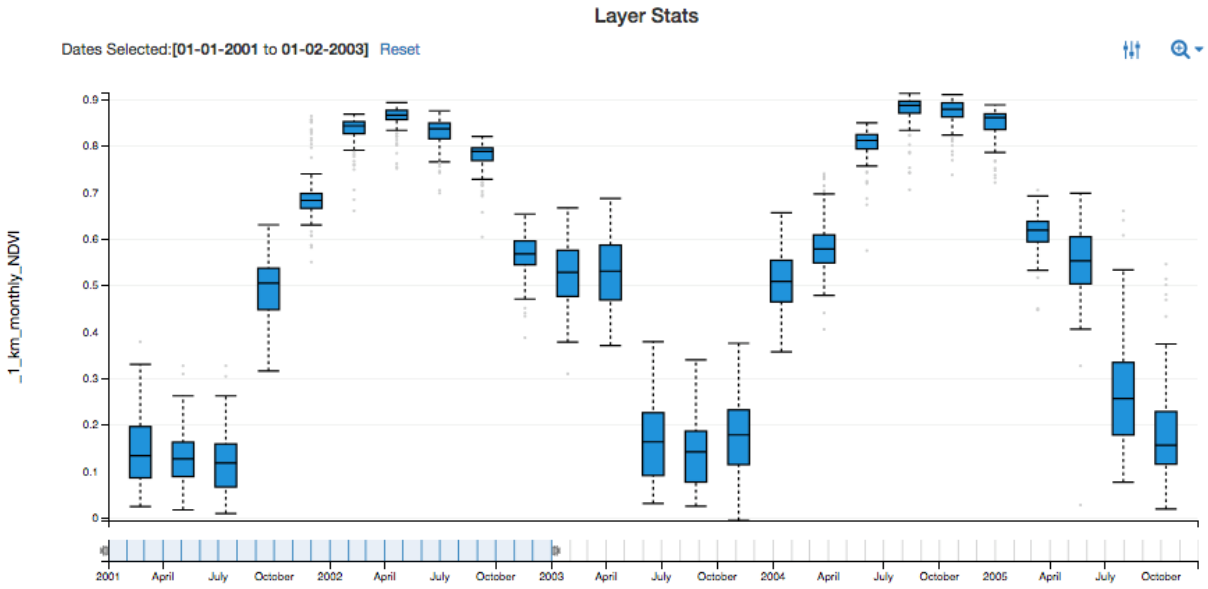
16. Scroll down to **Layer Stats**. This shows the distribution of NDVI over the 5-year time period for the tile.



17. Click on the Zoom to Year icon on the top right and select 2001. Now you can see the yearly phenology of this region more clearly.

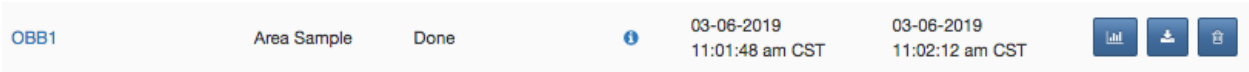


18. Along the bottom of the Layer Stats graph, move the highlighted window to include 2003. You can modify this feature to select specific years of interest within the entire time period.



19. Scroll down to view the **QA Stats** for the NDVI data. Use your mouse to hover over each section in the bar chart you will see information about the date, the quality and the number of pixels with that quality. The purple bars show the highest quality pixels.
20. Hover your mouse over the first blue bar above 01-01-2001. You will notice that 51 pixels have “Decreasing quality” for this date.

21. Go back to the top of the window and click on **Explore**. To far right of your request, select the download button.



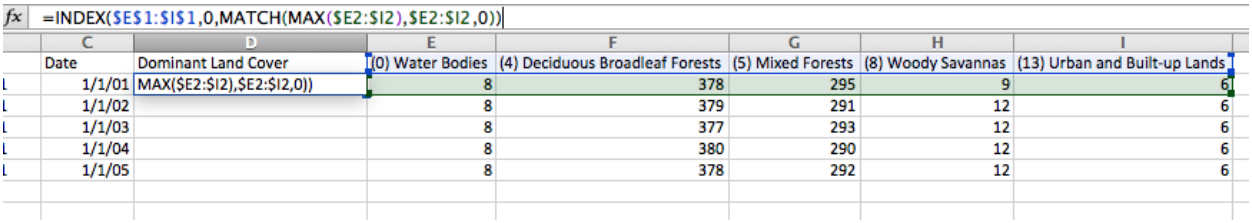
22. For this exercise we will only be using the statistics files. Note that if you scroll down to the selection box (where it says 0 Selected), you can download the MODIS data associated with this tile in a .tif format. Download the following statistics files and save them to your Time Series Exercise1 folder:
    - MCD12Q1-006-LC-Type2-Statistics.csv
    - MOD13A3-006-Statistics.csv
    - MOD17A3-055-Statistics.csv
    - SRTMGL1-003-Statistics.csv

These files contain statistics associated with the request including minimum/maximum, mean, standard deviation, and variance of the pixel values from the region of interest for each observation. For categorical layers like Land Cover Type, frequency distributions are returned in the statistics files.

Calculate Statistics for Land Cover Classes

23. Open the MCD12Q1-006-LC-Type2-Statistics.csv file in Microsoft Excel
24. Insert a new column after Column C (Date), labeled '**Dominant Land Cover'**

25. To select the dominant land cover type for 2001, enter the following formula in cell D2: =INDEX($E$1:$I$1,0,MATCH(MAX($E2:$I2),$E2:$I2,0)). Click Enter to apply the formula.



	C	D	E	F	G	H	I
	Date	Dominant Land Cover	(0) Water Bodies	(4) Deciduous Broadleaf Forests	(5) Mixed Forests	(8) Woody Savannas	(13) Urban and Built-up Lands
L	1/1/01	MAX($E2:$I2),$E2:$I2,0))	8	378	295	9	6
L	1/1/02		8	379	291	12	6
L	1/1/03		8	377	293	12	6
L	1/1/04		8	380	290	12	6
L	1/1/05		8	378	292	12	6

26. Copy formula to cells D3 – D6.

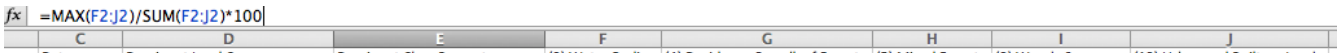
Note that the Dominant Land Cover Class is (4) Deciduous Broadleaf Forests for all 5 years

A	B	C	D
File	aid	Date	Dominant Land Cover
LC_Type2_2001001_aid0001	aid0001	1/1/01	(4) Deciduous Broadleaf Forests
LC_Type2_2002001_aid0001	aid0001	1/1/02	(4) Deciduous Broadleaf Forests
LC_Type2_2003001_aid0001	aid0001	1/1/03	(4) Deciduous Broadleaf Forests
LC_Type2_2004001_aid0001	aid0001	1/1/04	(4) Deciduous Broadleaf Forests
LC_Type2_2005001_aid0001	aid0001	1/1/05	(4) Deciduous Broadleaf Forests

Calculating Land Cover Dominance

(percentage of the area covered by the dominant class)

27. Insert a column after column D (Dominant Land Cover Class) and label it **Dominant Class Percentage**
28. In cell E2, type the following formula: =MAX(F2:J2)/SUM(F2:J2)*100.



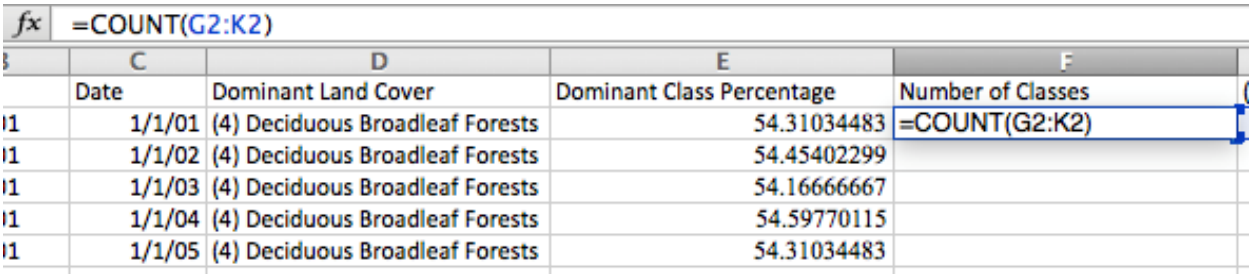
	C	D	E	F	G	H	I	J
	Date	Dominant Land Cover	Dominant Class Percentage	(0) Water Bodies	(4) Deciduous Broadleaf Forests	(5) Mixed Forests	(8) Woody Savannas	(13) Urban and Built-up Lands
L	1/1/01	(4) Deciduous Broadleaf Forests	=MAX(F2:J2)/SUM(F2:J2)*100	8	378	295	9	6
L	1/1/02	(4) Deciduous Broadleaf Forests		8	379	291	12	6
L	1/1/03	(4) Deciduous Broadleaf Forests		8	377	293	12	6
L	1/1/04	(4) Deciduous Broadleaf Forests		8	380	290	12	6
L	1/1/05	(4) Deciduous Broadleaf Forests		8	378	292	12	6

29. Copy the equation to cells E3 – E6.
30. Note that the Dominant Class Percentage is around 54% for each of the years analyzed.

C	D	E
Date	Dominant Land Cover	Dominant Class Percentage
1/1/01	(4) Deciduous Broadleaf Forests	54.31034483
1/1/02	(4) Deciduous Broadleaf Forests	54.45402299
1/1/03	(4) Deciduous Broadleaf Forests	54.16666667
1/1/04	(4) Deciduous Broadleaf Forests	54.59770115
1/1/05	(4) Deciduous Broadleaf Forests	54.31034483

Calculating Land Cover Richness
(total number of classes within the 10 km polygon)

31. Insert a new column after column E (Dominant class percentage) and label it **Number of Classes.**
32. In Cell F2, type the following formula: =COUNT(G2:K2)



Copy to cells F3 – F6.

- Note there are 5 classes in this polygon for each year
- Save the file as **Landcover.xlsx**

Next we will calculate the topographic variability

Open the SRTMGL1-003-Statistics.csv file in Microsoft Excel

33. In Cell Q1, type “Coefficient of Variation”
    - The coefficient of variation, the ratio of the standard deviation to the mean, measures the variability of the data in relation to the mean
34. In Cell Q2, calculate CV (take the standard deviation divided by the mean multiplied by 100). Type in this equation: =J2/I2*100
35. Save the file as **Topo_Var.xlsx**

Next, we will calculate variables for vegetation dynamics. This includes total annual productivity, minimum level of perennial cover, and degree of vegetation seasonality.

Total Annual Productivity

36. Open the **MOD17A3-055-Statistics.csv** file in Microsoft Excel
37. In Cell C7, type the ID for this grid cell: 17QK09
38. In cell D7, type 2001-2005
39. In cell I7, calculate the Mean NPP for the 5 years: =AVERAGE(I2:I6)
40. Save the file as **NPP.xlsx**

A	B	C	D	E	F	G	H	I
File Name	Dataset	aid	Date	Count	Minimum	Maximum	Range	Mean
MOD17A3_055_Npp_1km_doy2001001_aid0001	Npp_1km	aid0001	1/1/01	159	0.1214	0.5856	(0.1214,0.58	0.4593
MOD17A3_055_Npp_1km_doy2002001_aid0001	Npp_1km	aid0001	1/1/02	159	0.1668	0.6104	(0.1668,0.61	0.4849
MOD17A3_055_Npp_1km_doy2003001_aid0001	Npp_1km	aid0001	1/1/03	159	0.1802	0.7106	(0.1802,0.71	0.6003
MOD17A3_055_Npp_1km_doy2004001_aid0001	Npp_1km	aid0001	1/1/04	159	0.1866	0.7831	(0.1866,0.78	0.7104
MOD17A3_055_Npp_1km_doy2005001_aid0001	Npp_1km	aid0001	1/1/05	159	0.1657	0.639	(0.1657,0.63	0.5211
		17QK09	2001-2005					0.5552

Minimum Level of Perennial Cover (minimum NDVI)

41. Open the MOD13A3-006-Statistics csv file
42. In cell R2, type Minimum Annual NDVI
43. In cells S1-W1, type 2001,2002, 2003, 2004, 2005
44. In cells S2-W2, put the minimum NDVI value for each year. Find the lowest value in Column F (Minimum) for each year (column D). For example, The value for cell S2 (2001) will be 0.0098.
    - One way to complete this step is to use the MIN equation option and select all the minimum values from that year to find the lowest of the minimum values. For example, in cell S2 type: =MIN(F2:F13) and in cell T2 type: =MIN(F14:F25), and continue this process with the remaining cells U2 to W2.
45. In cell X1, type **5 Year Mean**. In cell X2, calculate the mean annual minimum NDVI for the 5 year period: =AVERAGE(S2:W2)

R	S	T	U	V	W	X
Minimum Annual NDVI	2001	2002	2003	2004	2005	5 Year Min
	0.0098	-0.0056	0.0031	0.0083	0.0056	0.00424

Degree of Vegetation Seasonality

(coefficient of variation of NDVI values) for each year

46. In cell Q1, type **CV**
47. In cell Q2 calculate the coefficient of variation for 1 January 2001: =J2/I2*100. Copy that formula to cells Q3 through Q61

48. In cell R3, type "**Mean CV**"
49. In cells S3-W3, calculate the mean CV for each year. For example in cell S3 put =AVERAGE (Q2:Q13)
50. Calculate the mean CV over the 5 years. In cell X3 put =AVERAGE(S3:W3)
51. Save the csv file as **NDVI.xlsx**

Q	R	S	T	U	V	W	X
CV	Minimum Annual NDVI	2001	2002	2003	2004	2005	5 Year Min
52.973342		0.0098	-0.0056	0.0031	0.0083	0.0056	0.00424
45.196003	Mean CV	18.826605	20.783281	19.355199	19.05685	17.843496	
56.975773							
12.657469							
8.7608069							
3.8599856							

As we have found using AppEEARS and some quick analysis in Excel, the environmental descriptors for the OBBA tile are:

- **Dominant Land Cover Class:** (4) Deciduous Broadleaf Forests
- Land Cover Dominance: 54.37%
- **LCT Richness:** 5 (land cover classes present in tile)
- Topographic Coefficient of Variation: 8.544516163
- Total Annual Productivity (NPP): 0.5552 kg C/m^2
- Minimum Level of Perennial Cover (NDVI): 0.00424
- Degree of Vegetation Seasonality (CV): 19.17308619

These variables, as noted in Coops et al., 2009, can be used to help explain the variance in bird species in this region. Through a combination of these remotely-sensed variables and in-situ information, species richness information can be gathered for future modeling studies or conservation planning.

Conclusion

The investigation of vegetation health over time can be used to examine forest disturbance, agricultural productivity, wildfires, and urban development. Additionally, the combination of multiple remotely sensed data layers over time can be an important technique for monitoring ecosystem variables and species richness. In this exercise, we used the AppEEARS tool to first investigate multiple points in the forests of the Colorado Rockies to identify tree mortality associated with mountain pine beetle infestation. The AppEEARS tool allows users to quickly investigate graphs of MODIS

NDVI values across multiple years for multiple points. In the second part of this exercise, we used the polygon option in AppEEARS and multiple datasets such as land cover and NPP to investigate metrics related to species richness of birds.

Additional Resources

AppEEARS Documentation: https://lpdaacsvc.cr.usgs.gov/appeears/help

Coops, N., M.A. Wulder, D. Iwanicka. 2009. Exploring the relative importance of satellite-derived descriptors of production, topography and land cover for predicting breeding bird species richness over Ontario, Canada, Remote Sensing of Environment: v. 113 pp. 668-679.
https://www.sciencedirect.com/science/article/pii/S0034425708003465

Ontario Breeding Bird Atlas (OBBA) project: http://birdsontario.org/atlas/.