Exercise 2: LandTrendr via Google Earth Engine

Objectives

- Explore the LandTrendr (LT) Google Earth Engine (GEE) User Interface
- Map the year, magnitude, and duration of a wildfire event
- Map the year, magnitude, and duration of mountain pine beetle infestation
- Explore time series graphs of vegetation indices in regions of forest disturbance

Overview of Topics

- Examine the Rim Fire with the LT-GEE Change Mapper
- Examine the Rim Fire with the LT-GEE Time Series Plotter
    - Create and evaluate the NBR, NDVI, NDMI, and TCB indices
- Examine mountain pin beetle infestation in the Arapaho-Roosevelt National Forest with the LT-GEE Time Series Plotter
- Examine mountain pin beetle infestation in the Arapaho-Roosevelt National Forest with the LT-GEE Change Mapper
    - Modify the Change Mapping parameters to a specific date range to identify the multiple years of disturbance

Tools Needed

- Google Chrome web browser
- Google Earth Engine Account: Sign-up here: https://earthengine.google.com/signup

Introduction

For this exercise we will explore LandTrendr (LT) in Google Earth Engine (GEE) for assessing time series of Landsat imagery. LT-GEE is a set of algorithms that can be used for change detection in a time series of images. The benefit of the LT-GEE Algorithm is that you can process many Landsat images "on the fly" with the computing power of Google, avoiding the need to download and process imagery yourself.

For this exercise, we will only outline the basics of the LT User Interface (UI), where there are tools available for you to use without the need to learn JavaScript (the computer programming language used within Earth Engine). We will examine a large wildfire to investigate rapid land cover change, and then we will examine a forested region affected by mountain pine beetle to highlight slower land cover changes.

Before you begin, please take a few minutes to review the LandTrendr information here: https://emapr.github.io/LT-GEE/landtrendr.html.

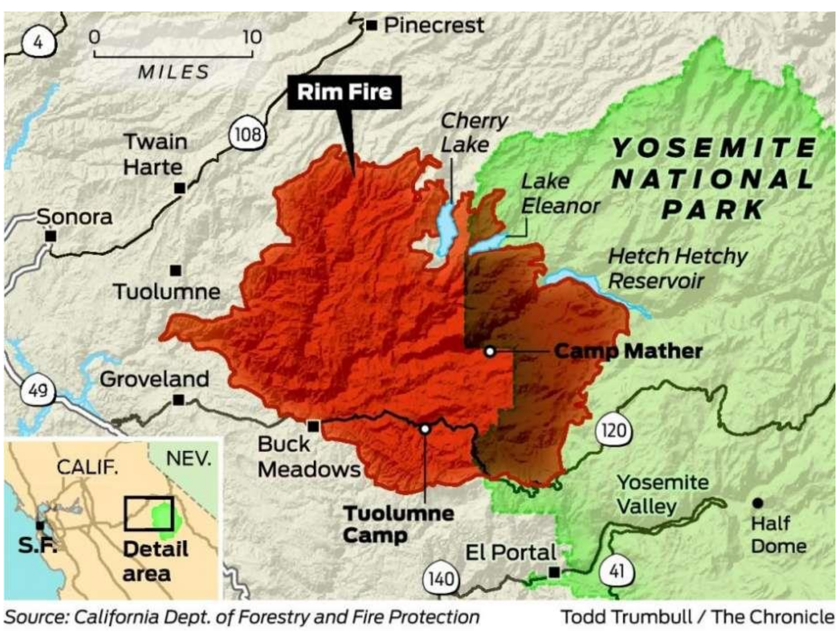
Also, for details about each LT-GEE UI feature and output, refer back to this site as we go through the exercise: https://emapr.github.io/LT-GEE/ui-applications.html

There are three UI applications: (1) Pixel Time Series Plotter, (2) Change Mapper, and (3) RGB Mapper. For this exercise, we will focus on the Change Mapper and the Time series plotter.

If you want more information on running LT-GEE scripts yourself, you can refer to this site: https://emapr.github.io/LT-GEE/index.html. There is a description of each item of the LT-GEE User Interface and example scripts.

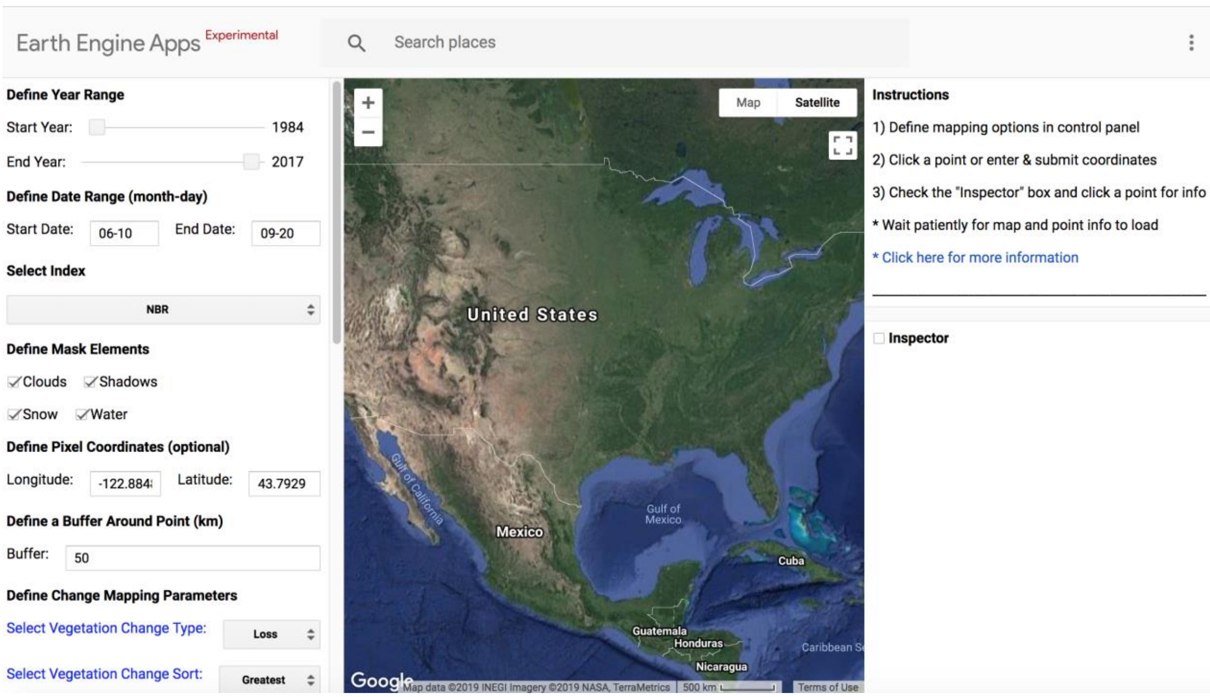
Part 1: Examining a Wildfire

For this portion of the exercise, we will focus on the Rim Fire that occurred near Yosemite National Park in 2013. This fire burned 257,314 acres, and at the time was the third largest wildfire in California's history.

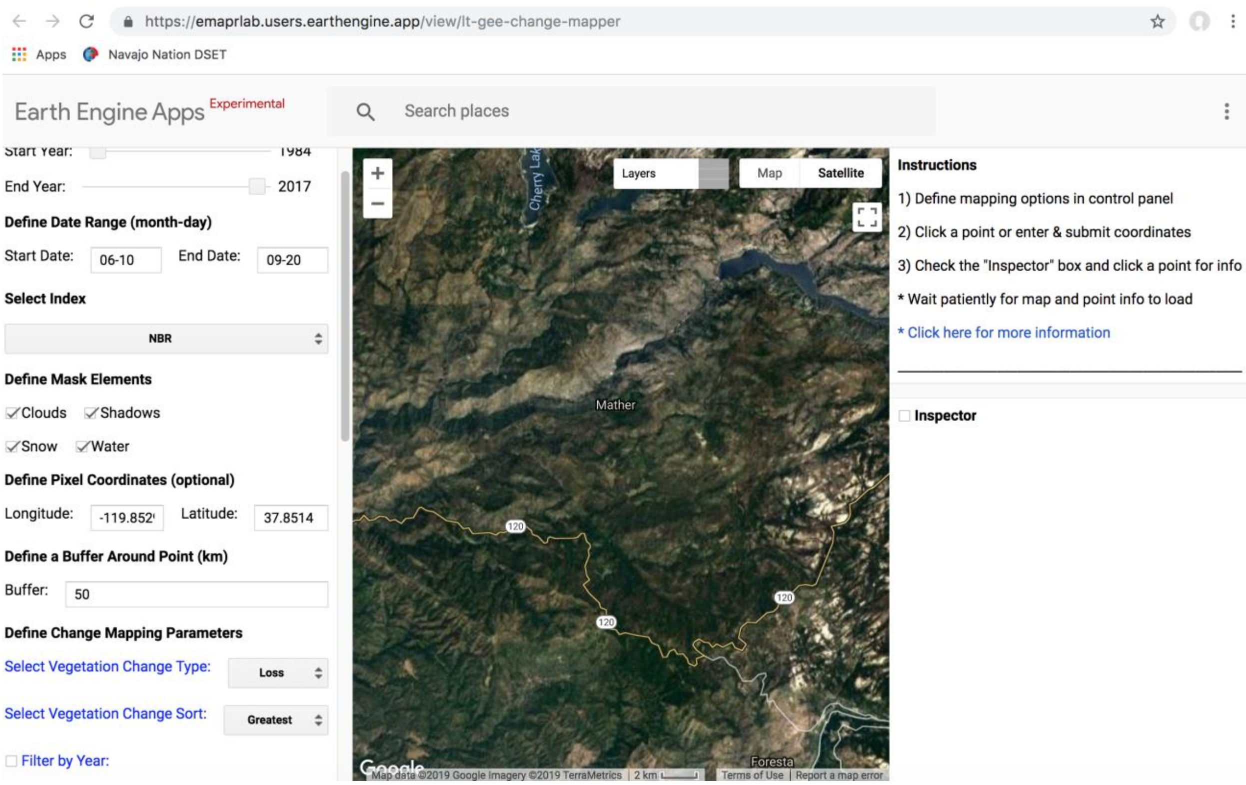


Change Mapper

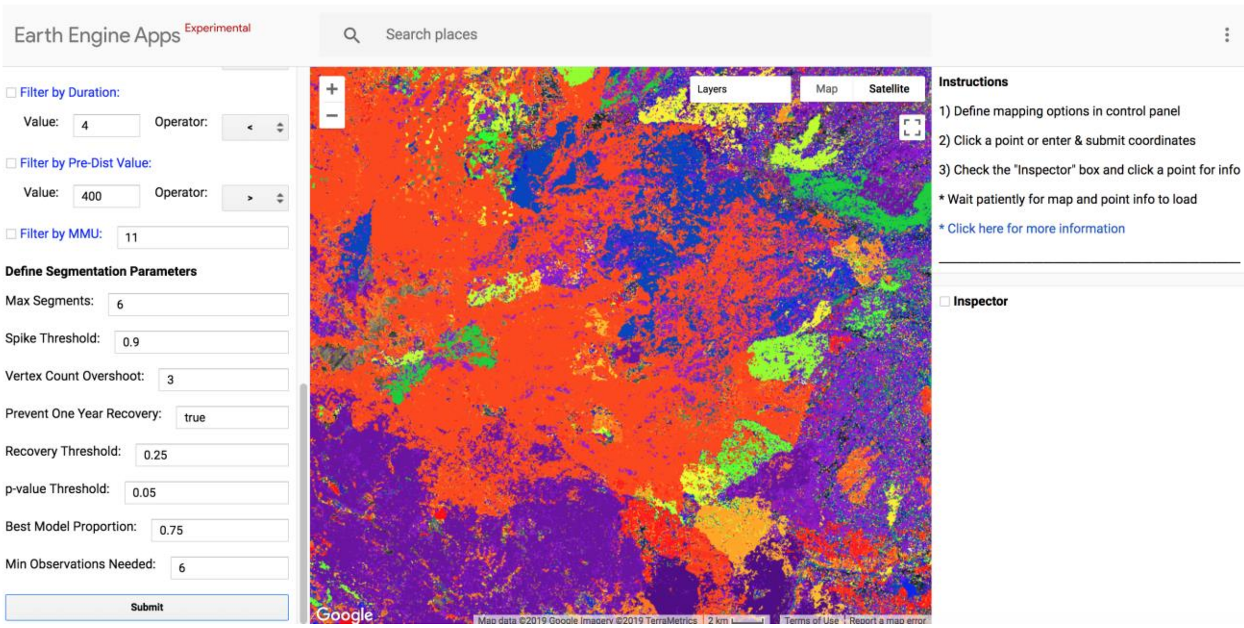
1. Open **Google Chrome** and go to the **User Interface LT-GEE** website: https://emapr.github.io/LT-GEE/ui-applications.html and read through the information about the **Pixel Time Series Plotter** and the **Change Mapper**.
    a. Scroll down to the **8.2 UI LandTrendr Change Mapper**, click on **GEE App link**
        i. This will take you directly to the **User Interface** page.



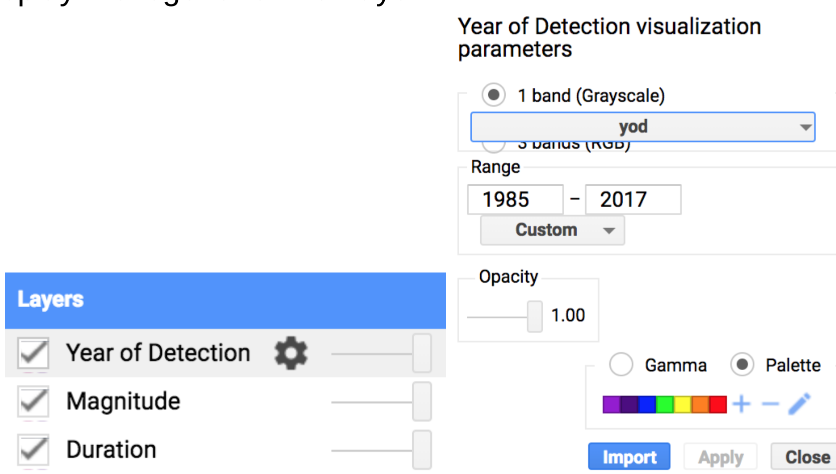
2. Review the features on the right side panel. If you have questions, you can always refer back to the UI main page.
3. Under the **Define Pixel Coordinates (optional)** section, enter -119.8529 next to **Longitude** and 37.8514 next to **Latitude**
4. Leave all other fields as default. Scroll down to the bottom of the right side panel and click **Submit**.
    a. You will immediately be taken to that location in the viewer



5. Wait for the page to load. This may take a few minutes or longer depending on your connection speed. There are multiple layers being processed at once.
    a. Notice the **Layers** box on the top of the map. The grey bars will turn all white when the processing is finished.



6. Hover over the Layers box along the top. You will then see that 3 layers were produced: **Year of Detection, Magnitude, and Duration**.
7. Hover over the **Year of Detection** until the gear symbol appears, then click on that to display the legend for that layer.

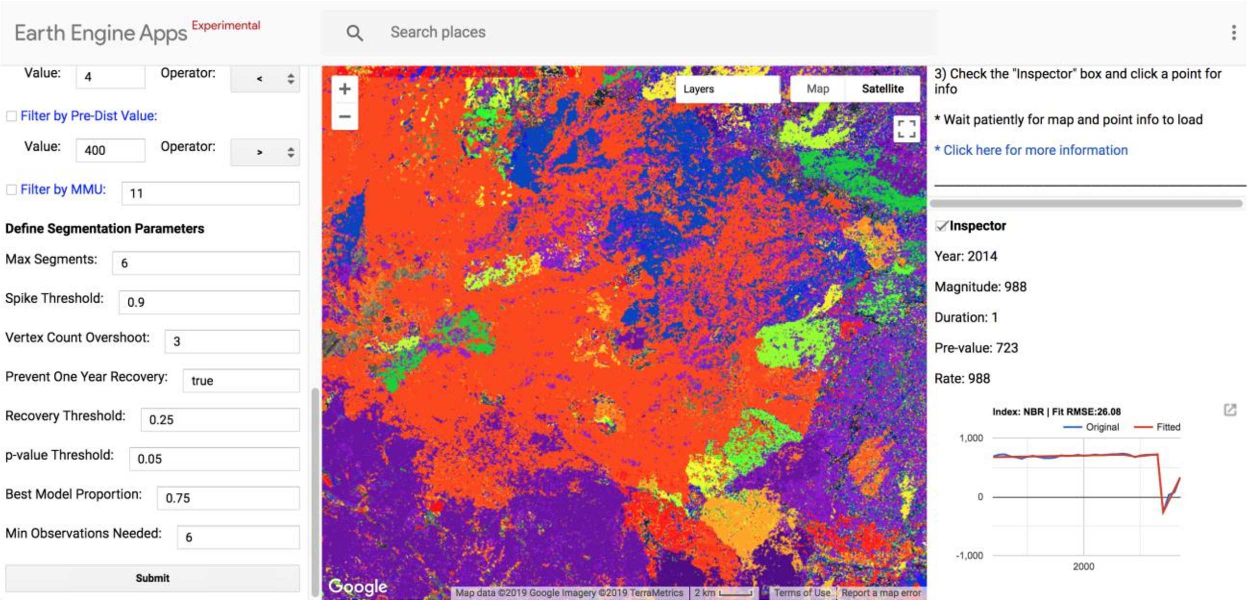


In the color bar on the bottom, the purples and blues indicate earlier disturbances and the oranges and reds indicate later disturbances. This is a highly fire-prone region, so the large patches of different colors primarily represent wildfires occurring between 1985 – 2017.

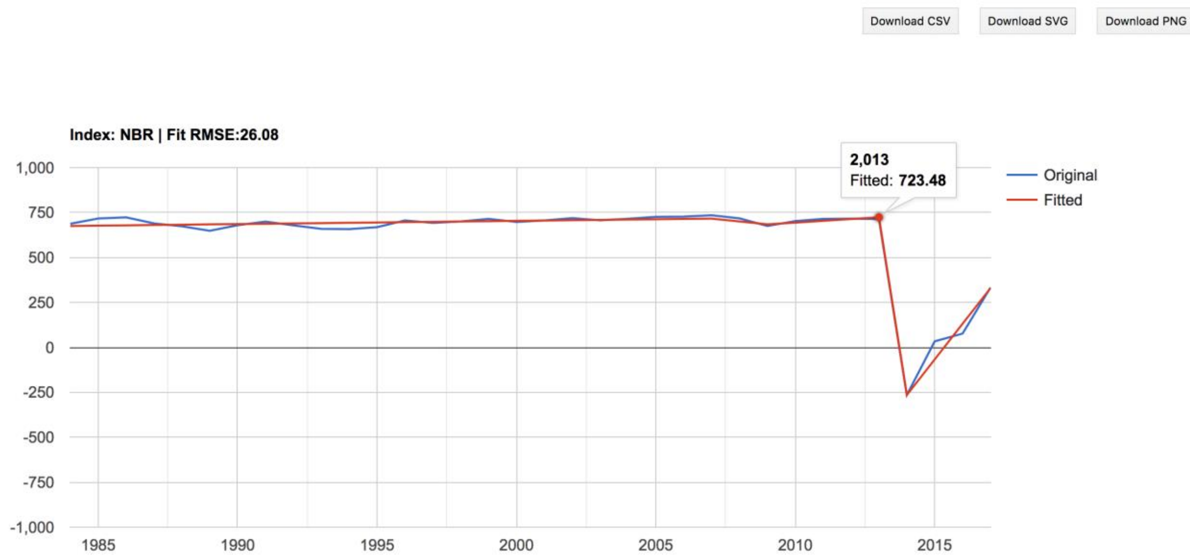
8. Close the **Year of Detection** legend.
9. To see when the disturbances occurred, click the **Inspector** box on the right.

10. Next, click somewhere on the map in the big, orange area. This large disturbance is the Rim Fire.

On the right you will see a graph appear (it may take some time to load) along with information about the disturbance, including **Year**, **Magnitude**, and **Duration**.



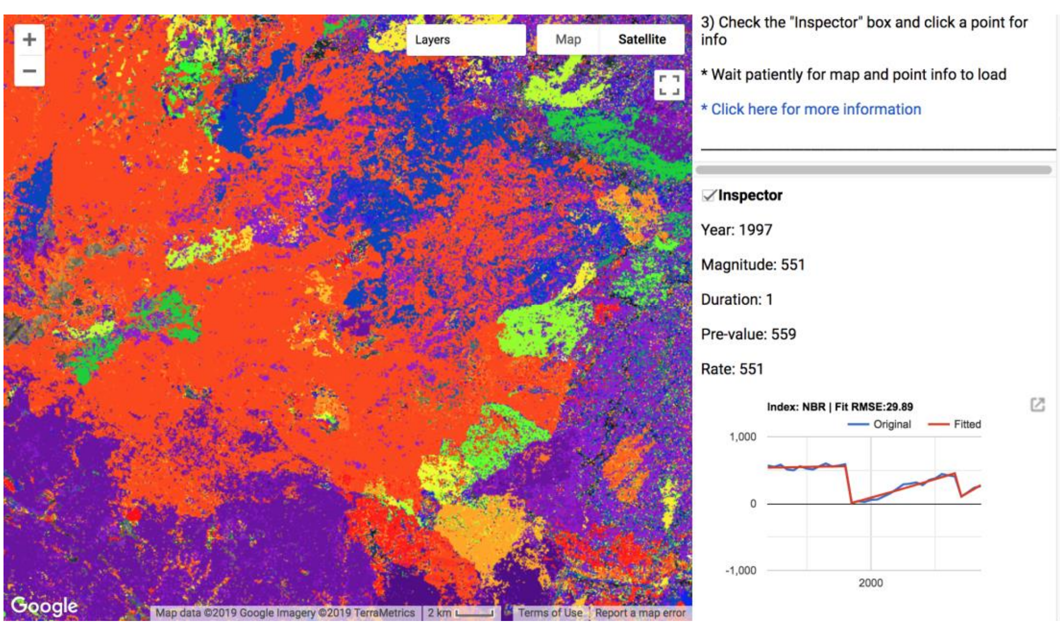
11. Click on the small box with the arrow in the upper right to show the graph in a separate window. Here you can see the Normalized Burn Ratio (NBR), where a higher ratio indicates healthy vegetation and a lower value indicates bare ground or recently burned areas. Hover your mouse over the graph to show the year and the NBR pixel value.
    a. *Note: Values should be multiplied by 1000 for ratio and normalized difference spectral indices (we multiply all the decimal-based data by 1000 so that we can convert the data type to signed 16-bit and retain some precision).*
12. Notice that this graph shows the NBR from 1984 to 2017
    a. You can see on the pixel displayed in this exercise that the NBR value in 2013 was 0.723 and the 2014 value was -0.264, thus indicating a burn in this region (high NBR = healthy veg, low NBR = burned).



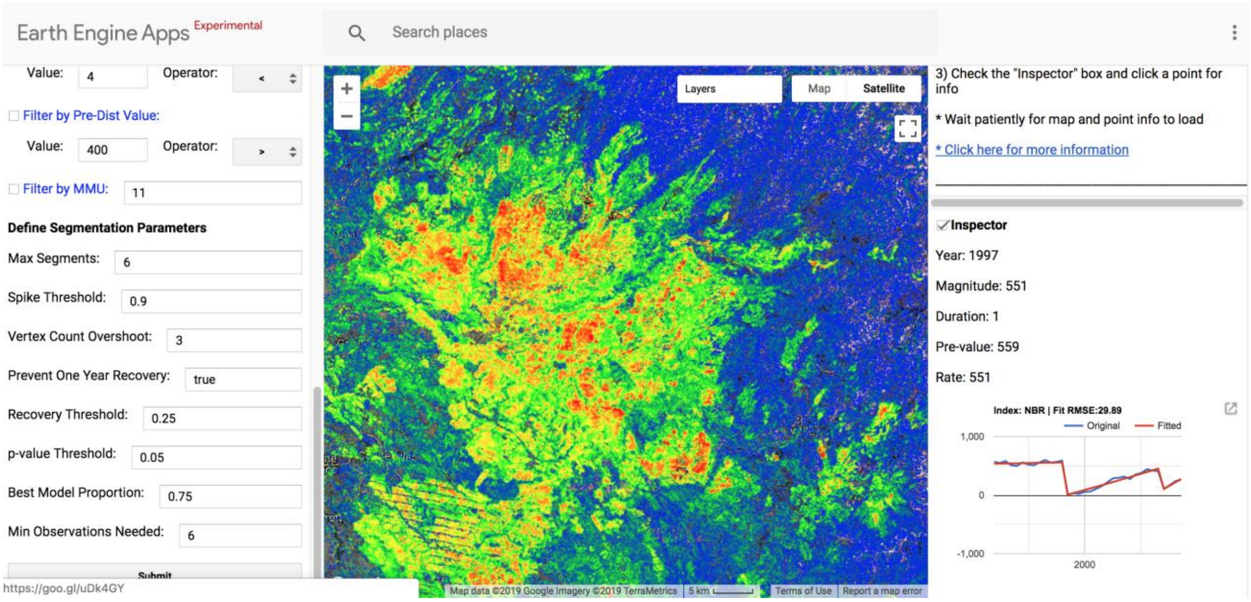
This large disturbance is the Rim Fire. You can also see the NBR values begin to increase after the fire, as regrowth occurs.

Notice that you can also download the values for this specific pixel as a CSV, SVG, or PNG.

13. Close the chart and go back to the **Change Mapper**. Click on one of the other colors to see when different disturbances occurred. For example, if you click on the blue region, you might see something like this:

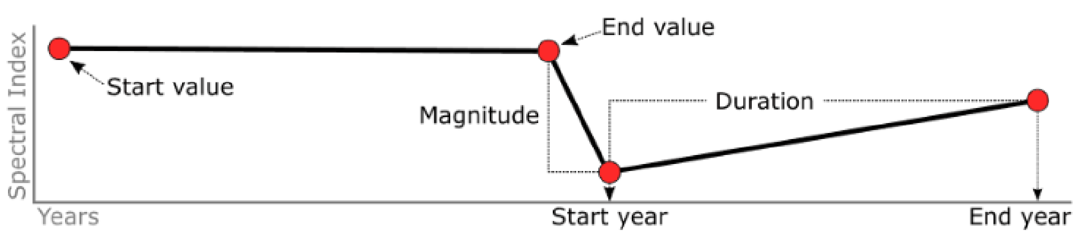


14. Turn off the **Year of Detection** layer by hovering over the Layers and deselecting the check box. Now you can view the **Magnitude** layer.
15. Click on the "**–**" sign in the upper left corner of the map once to zoom out, and wait for the map layers to reload.

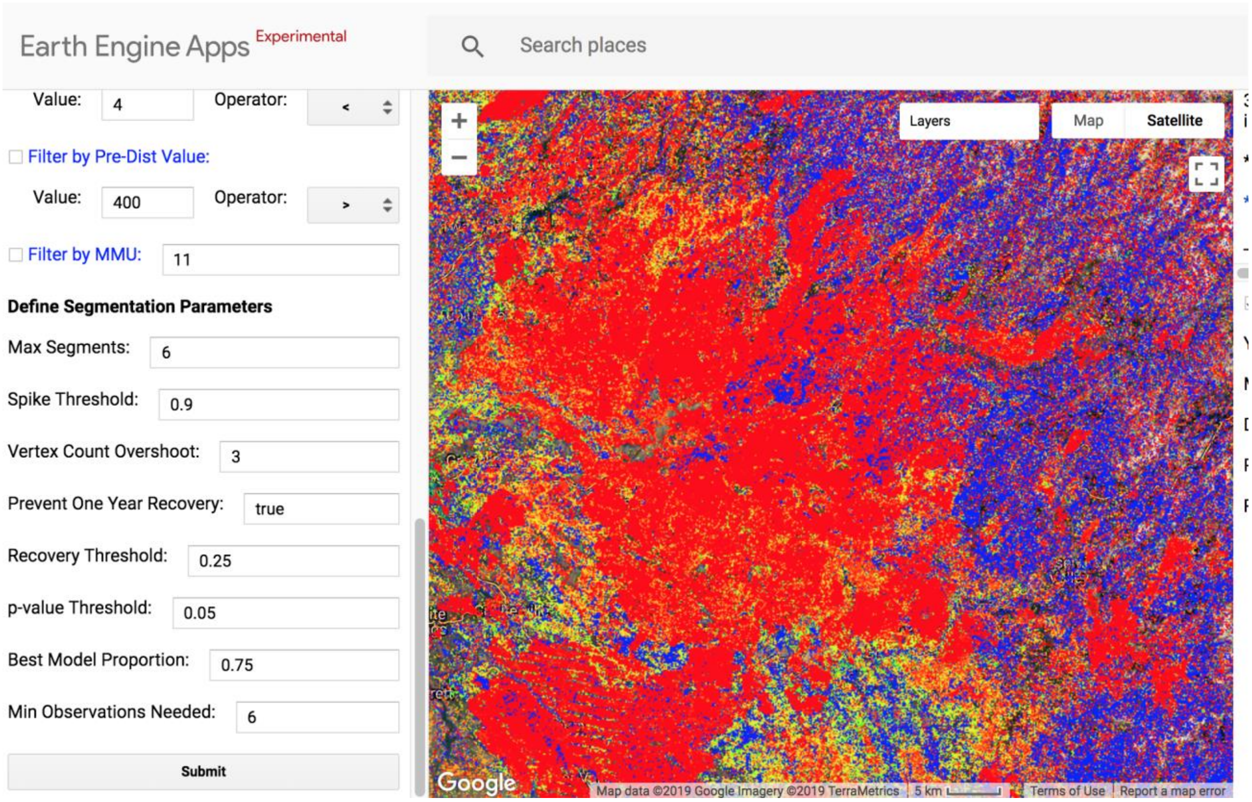


You can see the high intensity burn regions in red, and decreasing intensity in green and blue.

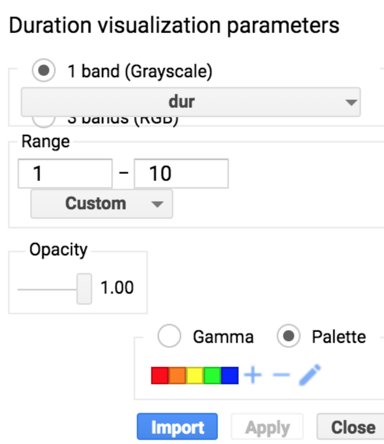
16. Turn on the legend for the **Magnitude** layer. Notice that the magnitude ranges from 0-1000. The magnitude of the disturbance is defined as the distance in spectral values (in this case, NBR values) between the beginning of the disturbance and the lowest NBR value reached.



17. Turn off the **Magnitude** layer so that you can just see the **Duration** layer. Take a look at the legend.

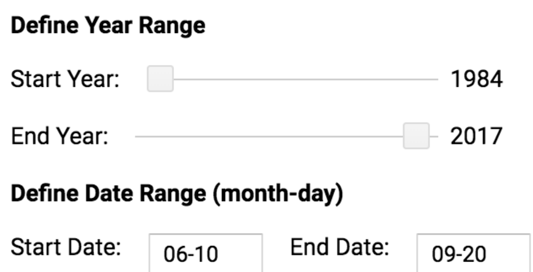


18. Turn on the **Duration** legend by hovering over the layer name and clicking on the gear icon. The duration values range from 1 – 10, representing the number of years that the disturbance occurred. The red and orange colors represent shorter duration disturbances, such as wildfire, while the green and blue represent longer duration disturbances, such as mountain pine beetle.



There are many other settings you can change in the **Feature Panel** on the left side of the screen. One item of the **Feature Panel** that is important to mention is the date range.

19. Take a look at the **Define Year Range** and the **Define Date Range (month-day)** options.



Notice in the **Define Year Range**, the data will be displayed from 1984 to 2017.

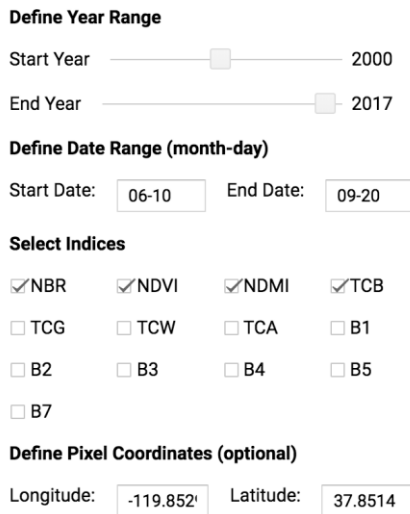
In the **Define Date Range (month-day)**, this is the date range within each year that GEE is using to generate a cloud-free image to represent the vegetation conditions for that year. Therefore, you do not know the specific date of the Landsat image that is being used unless you narrow your date search here. Instead, this is a composite image that may display different pixels from multiple dates each year within that time window (June 10 to September 20). This is a notably different feature of GEE when compared to other image processing software, where you choose the specific Landsat image for analysis. Therefore, depending on your study area and your specific interests, you may want to alter this parameter.

Pixel Time Series Plotter

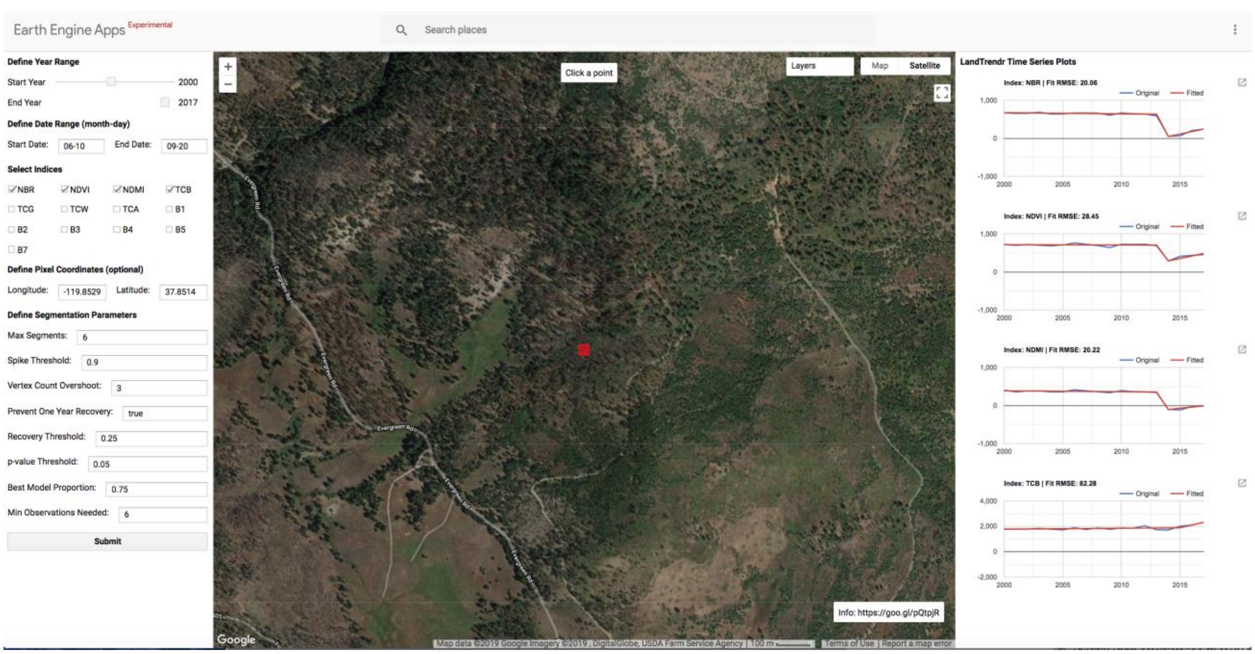
Now that we have visualized some of the dynamics of the Rim Fire burn, we can use the **Pixel Time Series Plotter UI** to compare multiple indices side-by-side.

20. Open a new tab or window (keep the last one open in case you want to go back for reference) and go to this website: https://emaprlab.users.earthengine.app/view/lt-gee-pixel-time-series
21. Under **Define Year Range**, change the **Start Year** to 2000, and change the **End Year** to 2017.
    a. Keep the **Define Date Range (month-day)** as default.

22. Under **Select Indices**, turn on the NBR, NDVI, NDMI, and TCB (tasseled-cap brightness) indices.
23. Under the **Define Pixel Coordinates (optional)** section enter -119.8529 next to **Longitude** and 37.8514 next to **Latitude**. These are the same coordinates we used in Part 1.
24. Keep all other settings as default. Scroll down and click **Submit**.

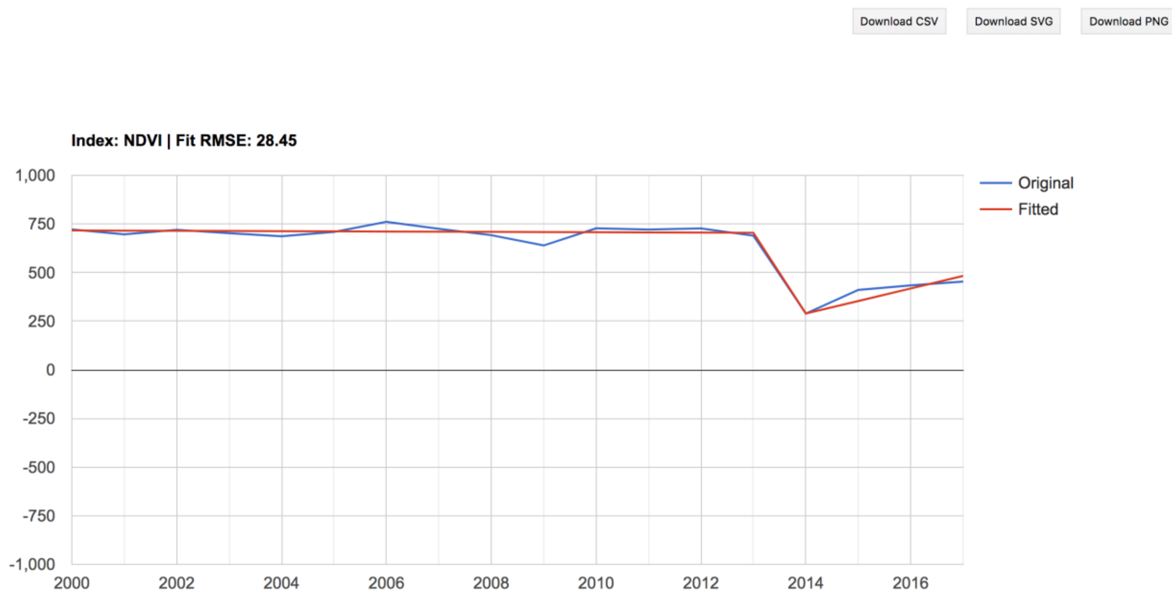


25. Wait for the map to load, and examine all the indices plotted on the right.



You should notice similar patterns in all three plots in the area of the burn, with notable decreases in the ratios in 2014.

26. Click on the small box with the arrow in the upper right of the NDVI plot (the second from the top).
27. Examine the pixel values. Notice these data are displayed from 2000 to 2017. Remember that the NDVI values are scaled and need to be divided by 1,000.



Feel free to explore this area a bit more with the Pixel Time Series Plotter.

Part 2: Examining a Mountain Pine Beetle Infestation

The mountain pine beetle is one of the most extensive disturbances in the western United States. In north central Colorado from 2002 – 2009 forest inventory data indicates that up to 87 percent of lodgepole pine trees were compromised by mountain pine beetle (Negrón and Cain, 2018). The map below identifies all beetle infestation from 1996 – 2016 in red, and specifically the Spruce beetle in blue in the Arapaho-Roosevelt National Forest (Negrón and Cain, 2018).

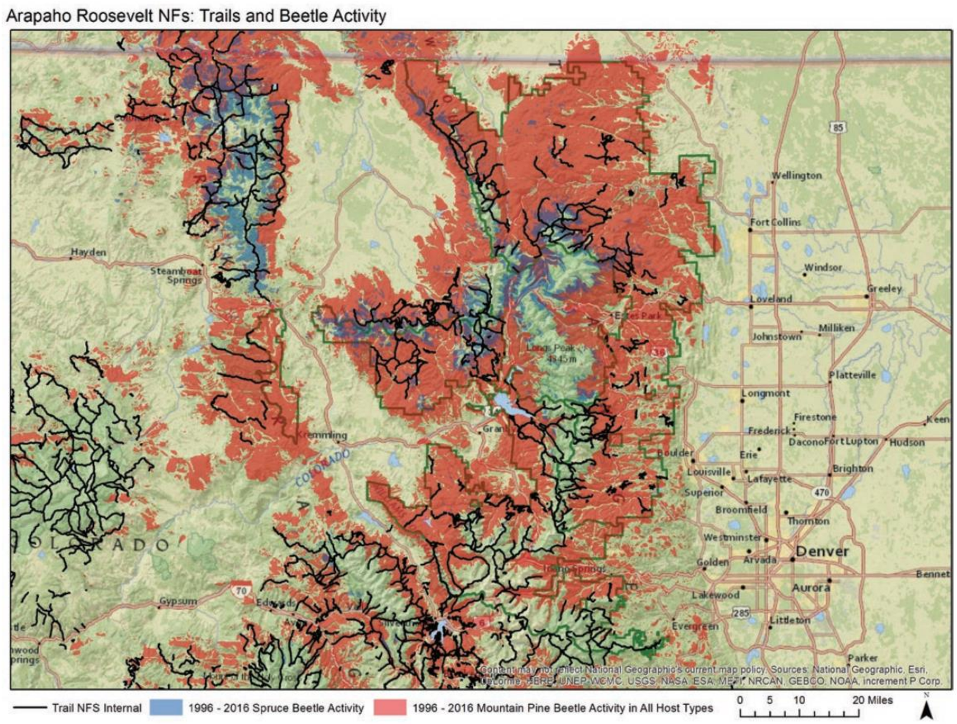
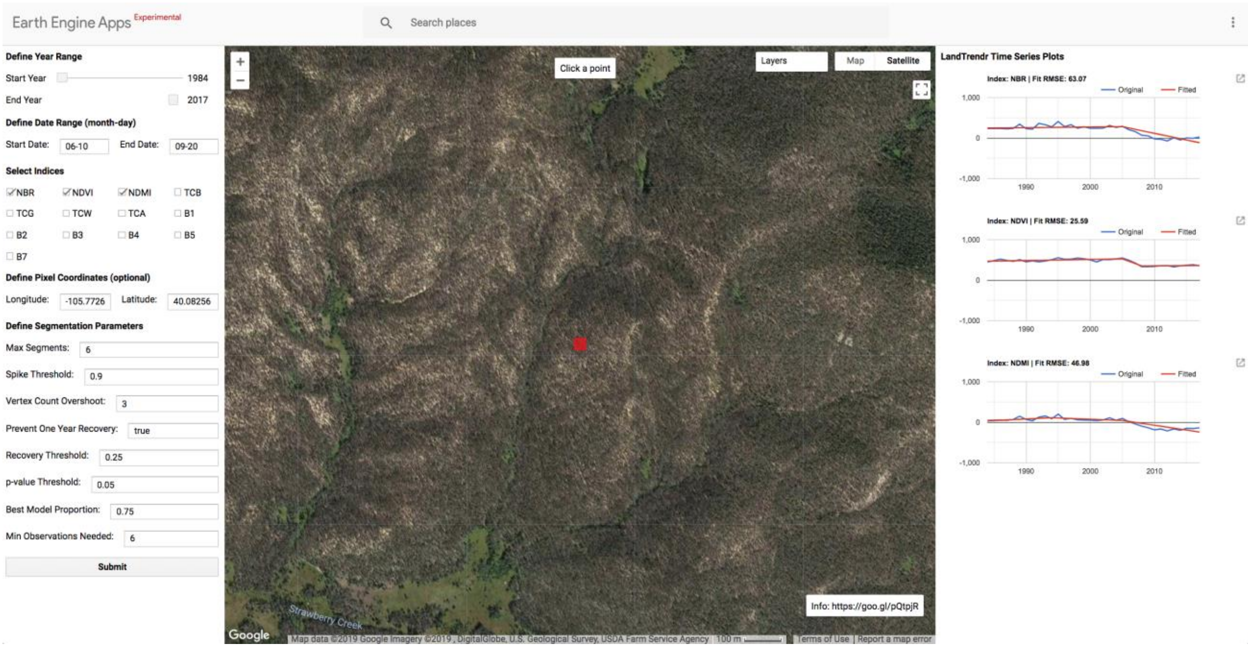


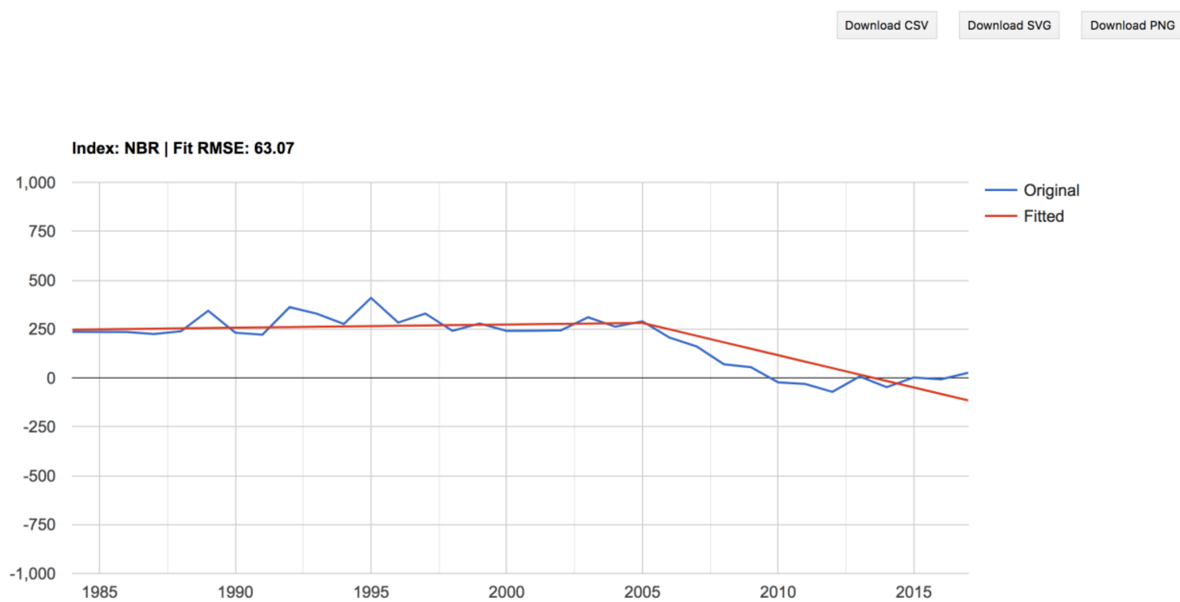
Figure 1. Hiking trails in the Arapaho-Roosevelt NF in northern Colorado and surrounded by bark beetle–caused tree mortality, Arapaho-Roosevelt NF. 1996–2016, USDA FS, Rocky Mountain Region. Forest Health Protection. 2017.

Now let's use the **Pixel Time Series Plotter** to examine the time series of values for this region.

1. Ensure you are using **Google Chrome** and visit the **Pixel Time Series Plotter User Interface** again: https://emaprlab.users.earthengine.app/view/lt-gee-pixel-time-series
2. Ensure the **Define Year Range** is set to: **Start Date** (1984), **End Date** (2017)
3. Keep the **Define Date Range (month-day)** set to default
4. Under **Select Indices**, choose NBR, NDVI, and NDMI
5. Under the **Define Pixel Coordinates (optional)** section enter -105.77267 next to **Longitude** and 40.08256 next to **Latitude**.
6. Keep all other settings as default. Scroll down and click **Submit**.

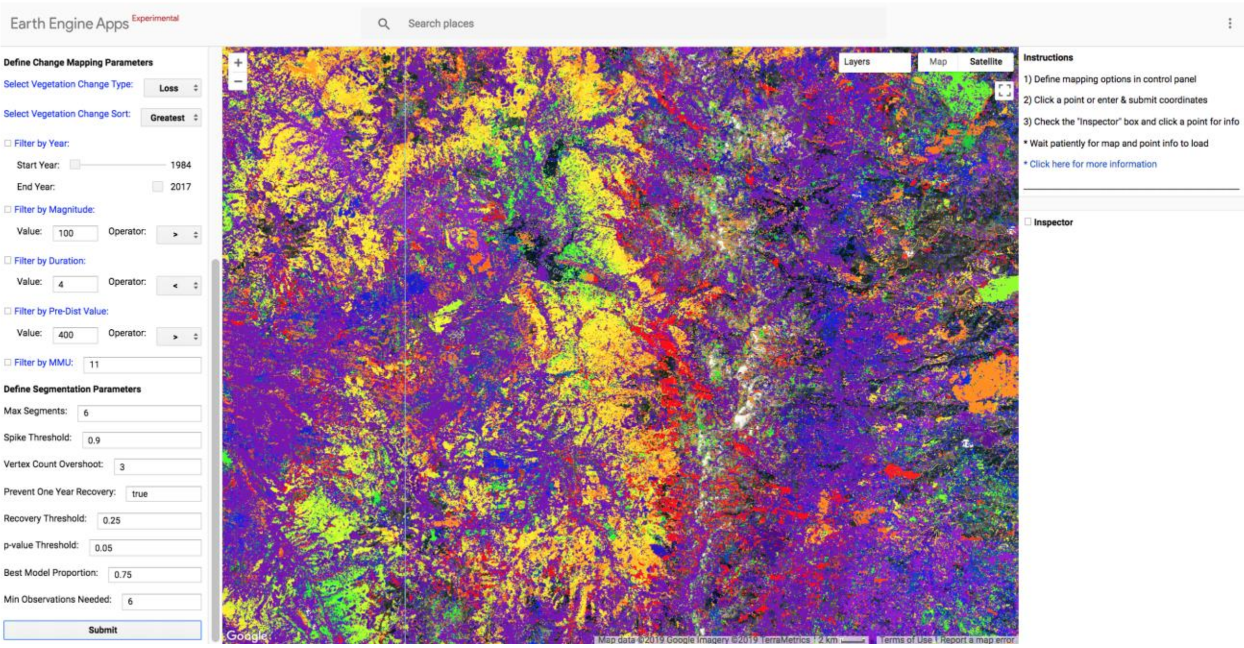


7. Click on the small box with the arrow in the upper right of the NBR plot.
8. Notice here that the data indicate a slower decline in NBR values from about 2005 to 2012. This is in contrast to the pixel we examined within the Rim Fire, where there was one year of sharp decline followed by some regrowth.



Now, let's take a look at this region using the **Change Mapper** again:

9. Ensure you are using **Google Chrome** and visit the **Change Mapper User Interface** again: https://emaprlab.users.earthengine.app/view/lt-gee-change-mapper
10. Keep the **Define Year Range** as default.
11. Under **Define Date Range (month-day)** change the **Start Date** to 07-01 and the **End Date** to 08-01 so that you are only examining changes in the vegetation health that occurred in July of each year.
12. Under the **Define Pixel Coordinates (optional)** section enter -105.77267 next to **Longitude** and 40.08256 next to **Latitude**.
13. Keep all other settings as default. Scroll down, click **Submit**, and wait for the map layers to load.



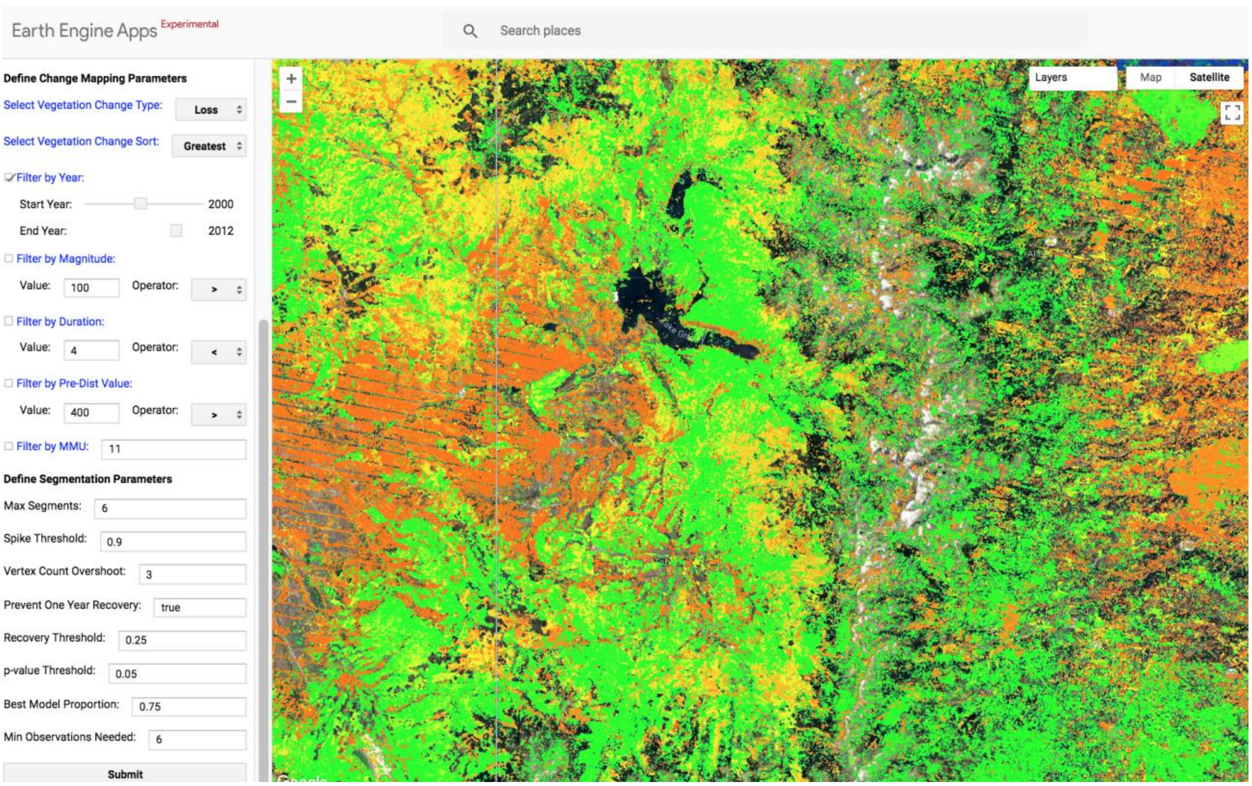
The first thing you may notice is that the **Year of Detection** is quite varied here. This means that disturbance in this region is occurring in many years.

14. Hover over the **Year of Detection** until the gear symbol appears, then click on that to display the legend for that layer.
15. Change the **Range** to: 2000-2017, click **Apply,** then **Close**. Wait for the map layers to reload.

You can also filter the date range within the **Feature Panel** on the left.

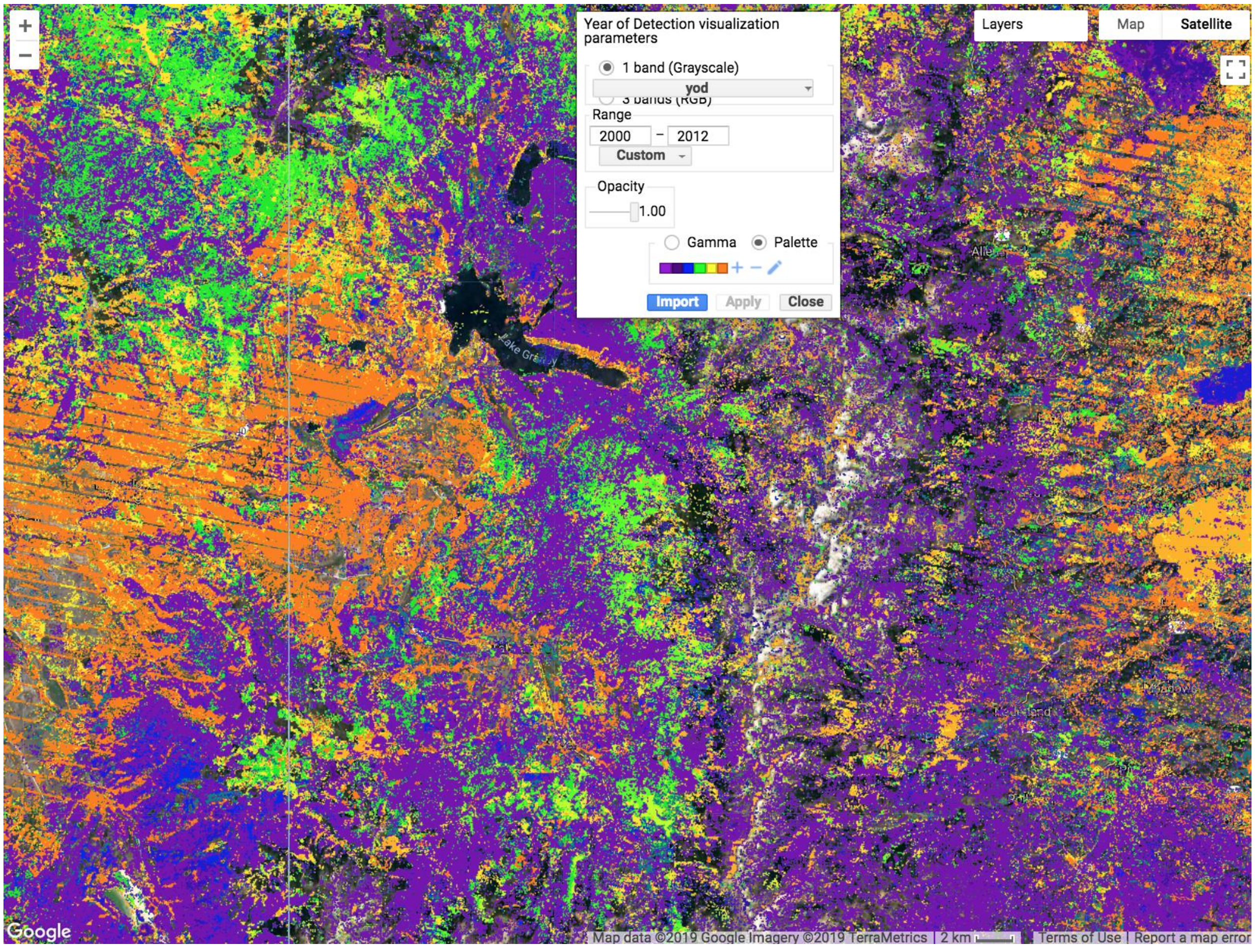
16. Under **Define Year Range**, change the **Start Year** to 2000 and the **End Year** to 2012.

17. Ensure the **Define Date Range (month-day)** is still set to: **Start Date** to 07-01 and the **End Date** to 08-01.
18. Scroll down until you see **Define Change Mapping Parameters**. Click on **Filter by Year** and use the slider bar to set the so the **Start Year** to 2000 and the **End Year** to 2012.
19. Keep all other settings as default. Click **Submit** and wait for the map layer to reload.



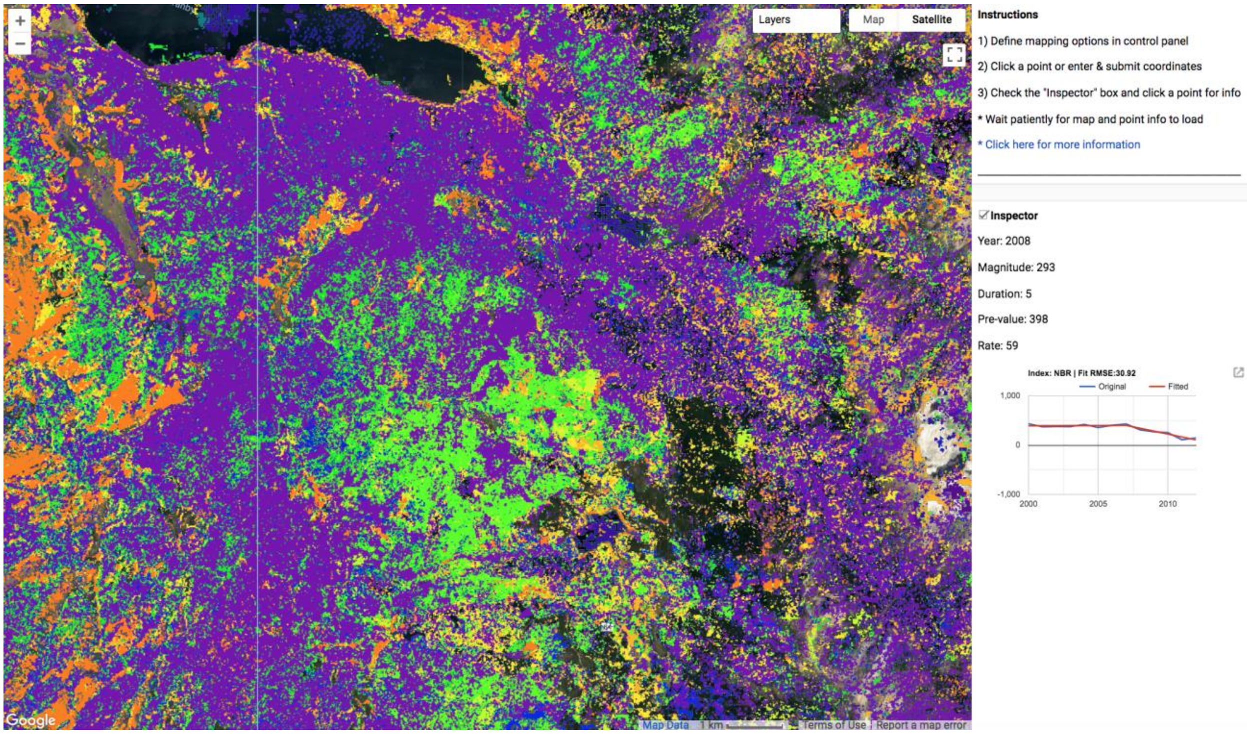
Much of the map appears green because although we filtered the years, the legend is still displaying the colors on a 1984 – 2017 timescale.

20. Open the **Year of Detection** legend. Change the **Range** to 2000 – 2012. Under **Palette**, click on the "**-**" sign to remove the red color. This will ensure there are six colors in the map, each representing two years of data. Click **Apply** and wait for the map to reload.

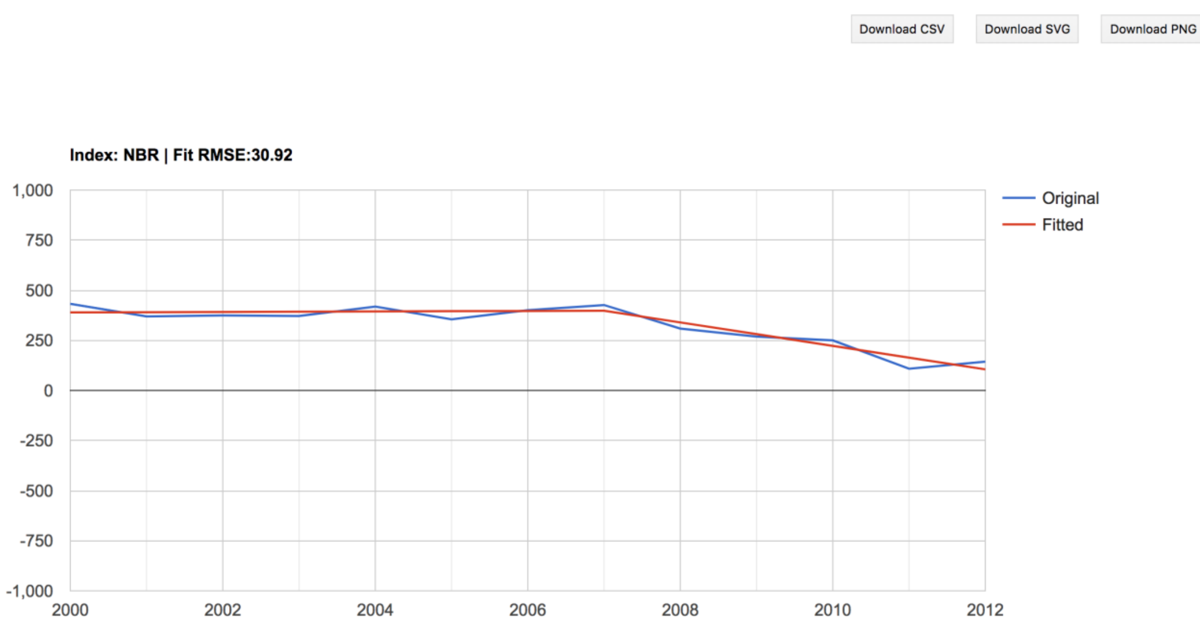


You will notice some of the change occurred in 2002 or prior (indicated in purple), but a significant amount occurred in the 2007 – 2008 timeframe too (indicated in green).

21. Click on the "**+**" sign twice to zoom into the region just south of Lake Granby, and wait for the map to reload.
22. On the right side, turn on the **Inspector** option.
23. Click on a green pixel on the map and take a look at the NBR time series graph on the right.

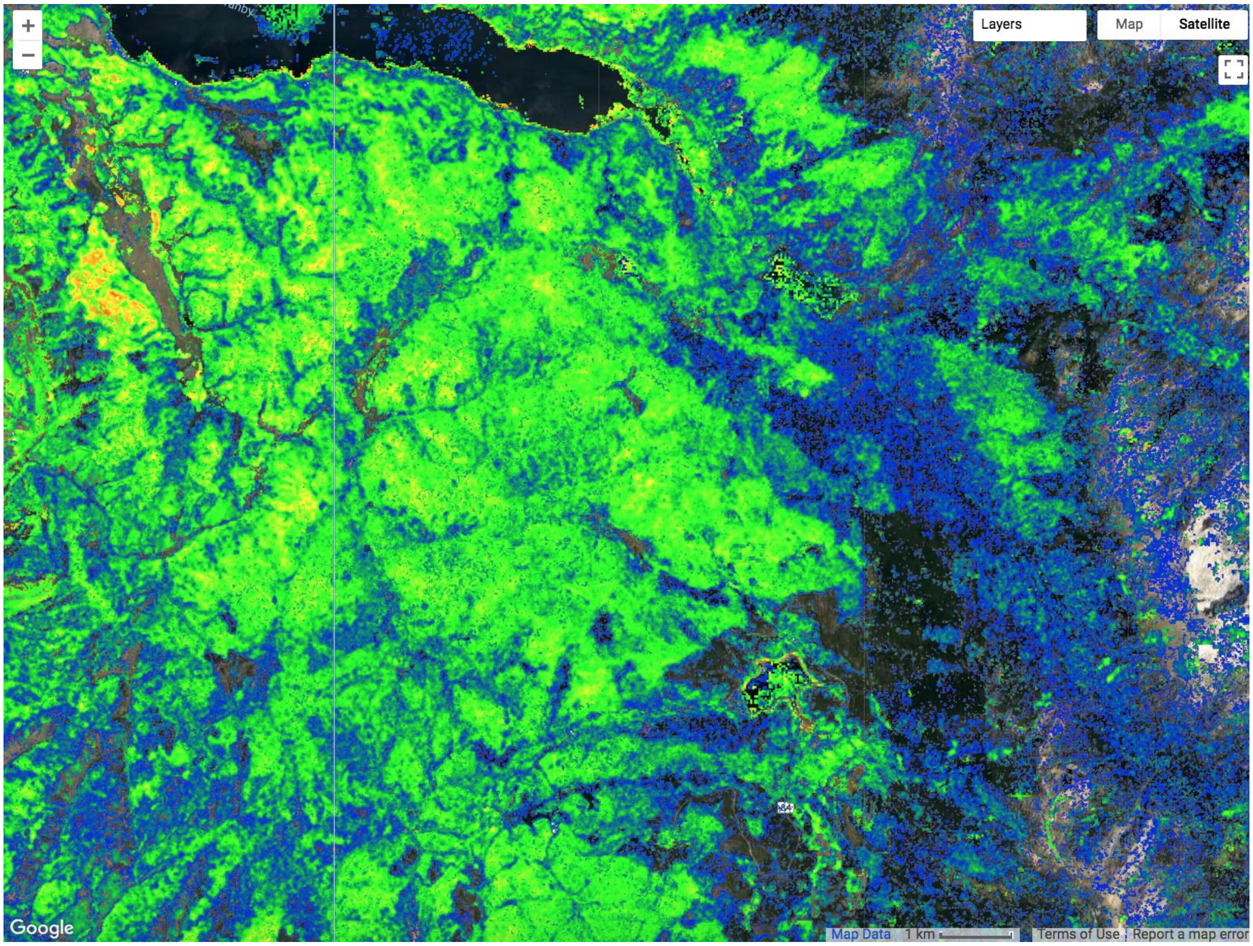


24. Click on the small box with the arrow in the upper right of the NBR plot to open the plot in another browser tab.



Now you can see that the plot has been filtered by 2002 – 2012, and there is a steady decline beginning around 2008.

25. Go back to the map viewer and turn off the **Year of Detection** layer.



Now you can also see that the magnitude of disturbance is low (as indicated in green), compared to the magnitude of disturbance of the Rim Fire, which was moderate to high (as indicated with oranges and reds). This is indicative of the slowly progressing change that we tend to observe with pine beetle infestation.

There are many other parameters you can explore in the LT-GEE UI and with the LT-GEE scripts. Please refer to the additional information about questions related to those modifications.

Conclusion

Time series analysis is an important technique for analyzing changes on the landscape over time. For forest disturbance, retrospective analysis of Landsat data can establish patterns of extent, duration, and magnitude in large regions. There are also many types of time series algorithms applied to Landsat data to analyze disturbance. In this exercise, we used the LandTrendr algorithm to target disturbance from a large wildfire event and from mountain pine beetle infestation. The LandTrendr UI with GEE allows users to generate maps of Year of Detection, Magnitude, and Duration with the Change Mapper interface. The Pixel Time Series Plotter allows users to create on-the-fly series of vegetation indices simultaneously for quick examination of a specific pixel of interest. Users can also modify many more segmentation parameters of the algorithm that we did not examine in this exercise. Finally, users can also use JavaScript within GEE to tailor the analysis to meet their specific needs.

Additional Resources

Introduction to the LT-GEE: https://emapr.github.io/LT-GEE/introduction.html

LT-GEE explanation of each of features: https://emapr.github.io/LT-GEE/ui-applications.html

LT-GEE Example Scripts: https://emapr.github.io/LT-GEE/example-scripts.html

Negrón and Cain, 2018, Mountain Pine Beetle in Colorado: A Story of Changing Forests, Journal of Forestry, doi: 10.1093/jofore/fvy032. https://www.fs.fed.us/rm/pubs_journals/2018/rmrs_2018_negron_j001.pdf

Cohen, et. al., 2017, How Similar Are Forest Disturbance Maps Derived from Different Landsat Time Series Algorithms?, Forests, doi:10.3390/f8040098.https://www.fs.usda.gov/treesearch/pubs/54976