Impact of California's Wildfires on the Vegetation Index and Cloud Cover

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Abstract

Wildfires are a natural part of California's landscape but this year the fire season in California and across the Western Region of the United States started earlier. And each year that passes, wildfire seasons are gaining intensity and damages are more devastating. Climate change is considered a key to this devastating phenomenon. In this work we use LANDSAT 8 imagery to study the vegetation loss and the burn scars caused by the wildfire season of California 2020. Normalized Difference Vegetation Index (NDVI) was performed to visualize and obtain data of the vegetation loss in the different cases that we study. During this research project, researchers are expected to become familiarized with the different tools and sensors that can be used in the ENVI program. Not to mention, various analysis and calculations based on processed images are expected to be conducted.

I. Introduction

The purpose of the investigation is to apply the knowledge obtained during the laboratory aspect of the course "GEOL 4048: Geological Applications of Remote Sensing". With the knowledge obtained we will be able to analyze images by means of the program ENVI. With the results of this research, we hope the findings could be applied to real life situations and included in scientific memoirs.

The state of California has been ravaged by wildfires within the last decade. Some of these wildfires have consumed thousands of acres of farmland, forest and even residential areas. In the year 2020, there has been a slight uptick to the quantity of wildfires and their intensification. Moreover, this year the largest wildfire in recorded history of the state of California, devastated over 1,032,648 acres. This specific wildfire was analyzed as a part of this research project.

The *scientific question* poised to be answered during this research project is: Throughout recent years, there has been an increase in the occurrence of Wildfires in California; What environmental conditions have led to the development of the Wildfires at such a dangerous and rampant pace, and what have been the effects on the impacted lands?

II. Objectives

The objective that was established at the beginning of this research project was to further understand the impact of the numerous wildfires in the state of California. Within the research project, we observed the different aspects of wildfires that included the cloud cover of the smoke and the impact on the environment (Vegetation Index). To be able to achieve this objective, we analyzed and processed historical images of wildfires that have affected the vast domain of the state of California.

III. Methodology

The methodology used in this research project was:

Processing images in terms of active areas affected by wildfires with areas that are not prone to being impacted. The satellite used in this research was LANDSAT-8. The following bands were utilized during the processing of the images: Short Wave Infrared (SWIR), Near-Infrared (NIR), and Blue.

In order to analyze the Vegetation Indexes in various images, we used the NDVI formula listed below.

$$\boldsymbol{NDVI = (NIR-Red)/(NIR+Red)} \quad (1)$$

IV. Results/Discussion

The year of 2020 has been the largest wildfire season recorded in California history. As of November 4th, 2020 over 9,069 fires have burned 4,359,517 acres. Five of the twenty largest wildfires in California history were part of the 2020 wildfire season. Intensity has been increased by drying and heating from human-induced climate change as well poor forest management. Costs are estimated around more than $2.059 billion(US).

After selecting and analyzing images, we processed images from three different cases of wildfires that affected the state of California. The following wildfires were the cases analyzed and processed: 1) LNU Lightning Complex Fires, 2) SCU Lightning Complex Fires and 3) August Complex Fire. Within these 3

cases, the processed images with the selected variety of bands from the sensor, allow researchers to identify the wildfire "scars" that are visible after the fire has been extinguished. By further analyzing these "scars", scientists can predict the nature of wildfires and their impacts.

Case 1

The LNU Lightning Complex Fires is currently the fourth-largest wildfire in the recorded history of California. Burned across the Northern of California, Lake, Napa, Sonoma, Solano, and Yolo Counties. It started on August 17th to October 2nd, 2020.

The following image was captured on August 25th, 2020.

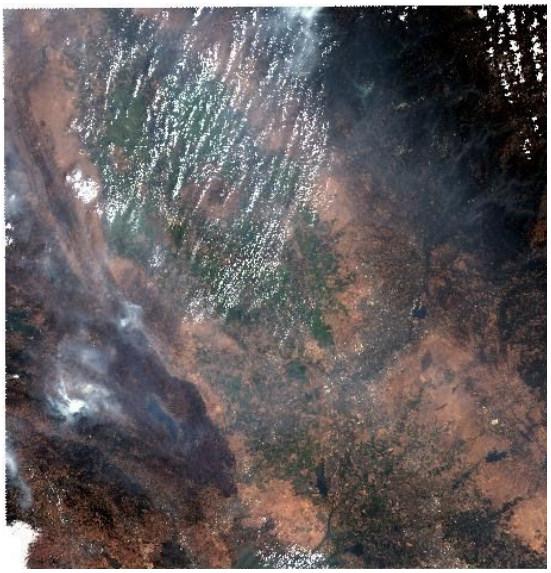

Fig 1

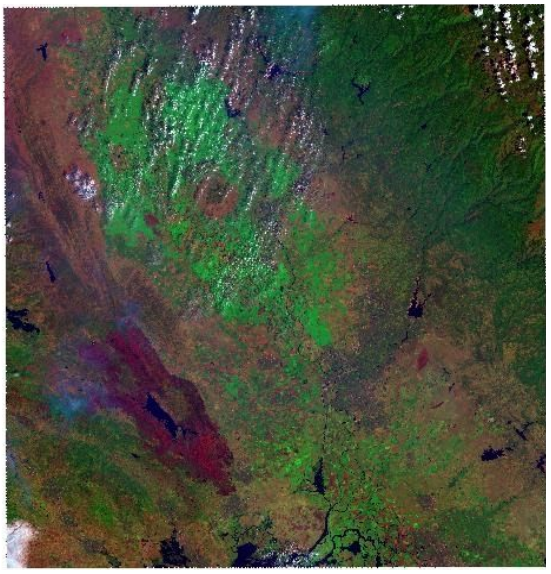

Fig 1.1

In Figure 1 we have a natural color image obtained with the combination of bands 4, 3 and 2. Which are Red, Green and Blue. We can observe the fire currently happening in the image. We decided to use this combination to have a clear view of the scenario happening in a natural color. The combination of bands used in Figure 1.2 are bands number 7, 5 and 2 which are SWIR 2, NIR and Blue. This combination is often used to see the forest fire burn scars. The burn scars are in color red while the smoke from the fire can be distinguished in a blueish color.

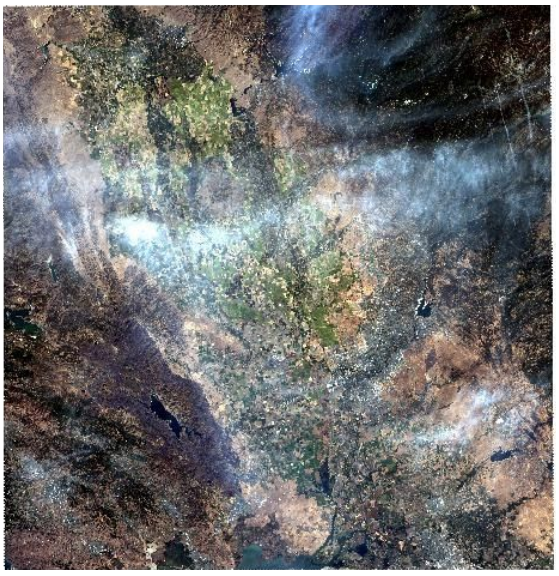

Fig 2

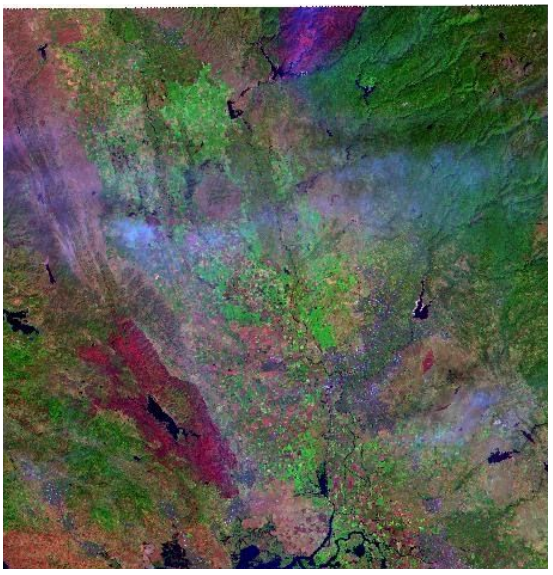

Fig 2.1

In the images above we used the same combination of bands to obtain a natural color image as seen in Figure 2 and the same band combinations as before for Fig 2.1. These images were captured on September 26th, 2020.

As a final result we decide to compare both images from August and September to see the change in the vegetation and also the scars created by the fires.

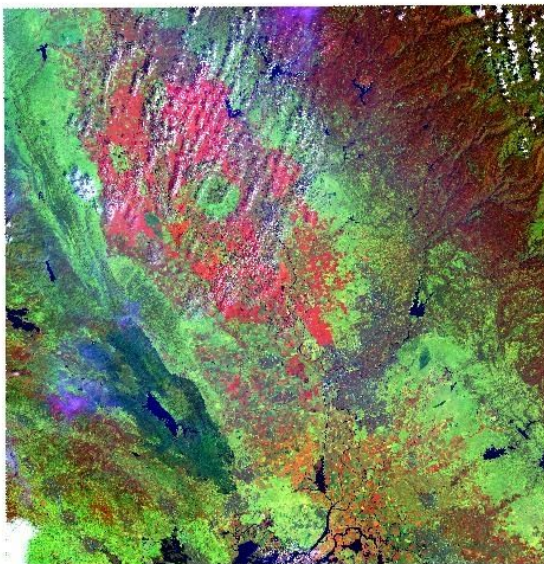

Fig 3

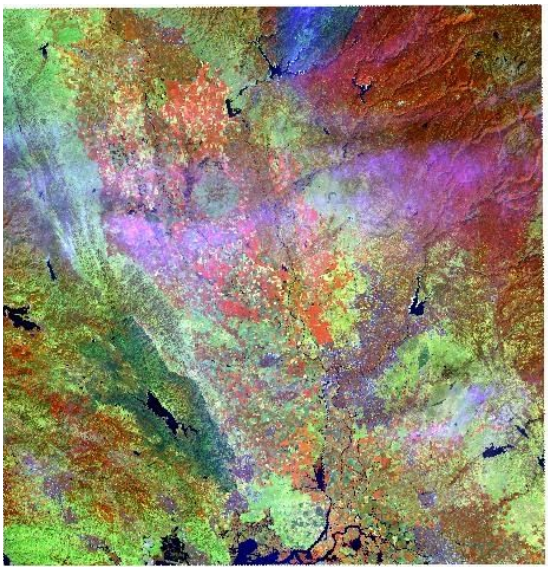

Fig 3.1

We use a combination of bands 5, 6 and 2 which belong to NIR, SWIR (short wave infrared) and Blue. This combination is known as healthy vegetation. Note how vegetation really pops in red, with healthier vegetation being more vibrant. The loss of vegetation is very visible while the burn scars are bigger than expected.

Using the NDVI formula we compared the Vegetation Index between both images.

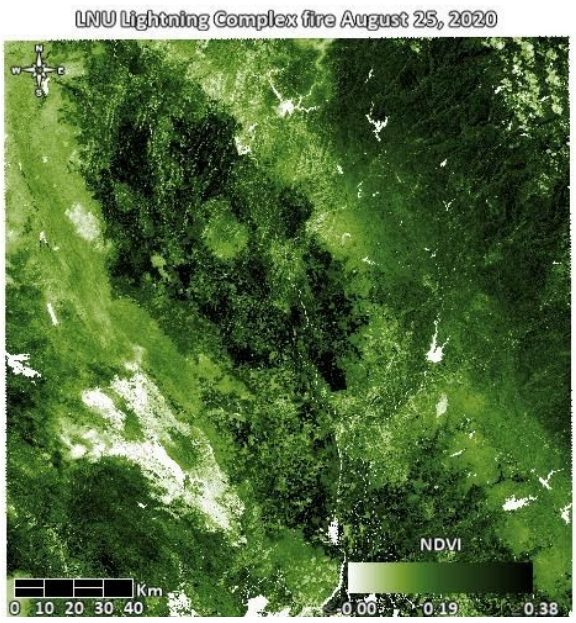

Fig 4

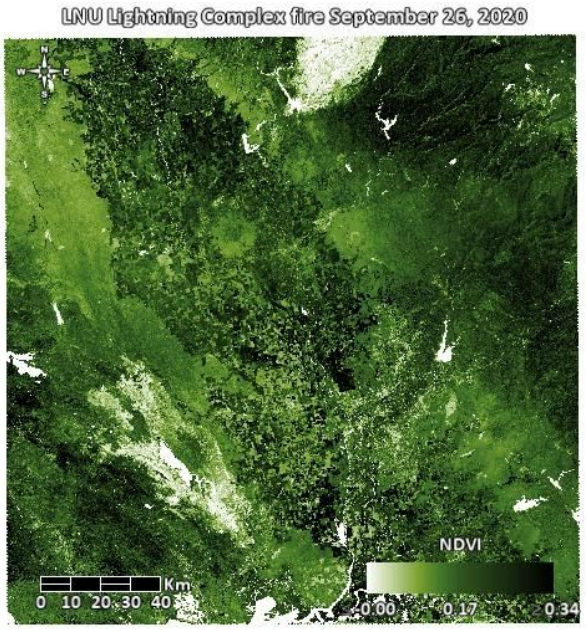

Fig 4.1

NDVI DATA-LNU Lightning Complex fires

Coordinates	Initial Value	Final Value
39°41’7.58”N.122°20’38.43”W	0.090237	0.093547
39°38’30.63”N.121°114’8.03W	0.162164	0.006544
39°8’51.06”N.122°10’26.73”W	0.344602	0.198979

In conclusion the value of the Vegetation Index decreased, clearly indicating that an extended area of vegetation was lost due to the long period of fires.

Case 2

The SCU (Santa Clara Unit) Lightning Complex fires is the third-largest wildfire recorded in California's modern history. It started on August 16th and ended on October 1st, 2020.

Fig 5

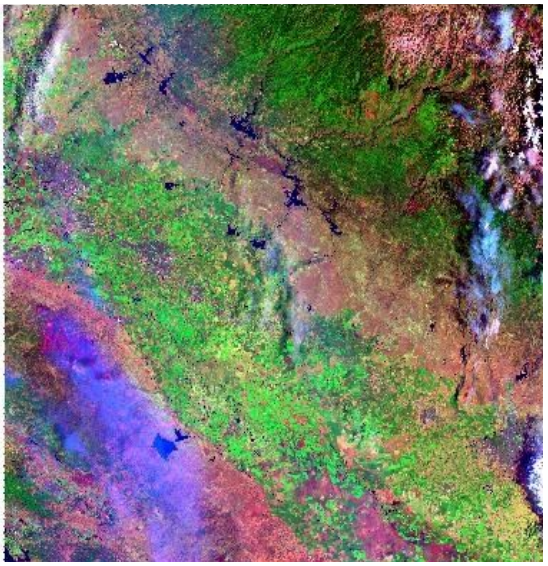

Fig 5.1

In this image from August 18th, 2020, we can observe the different fires burning and the smoke coming from them.

Fig 6

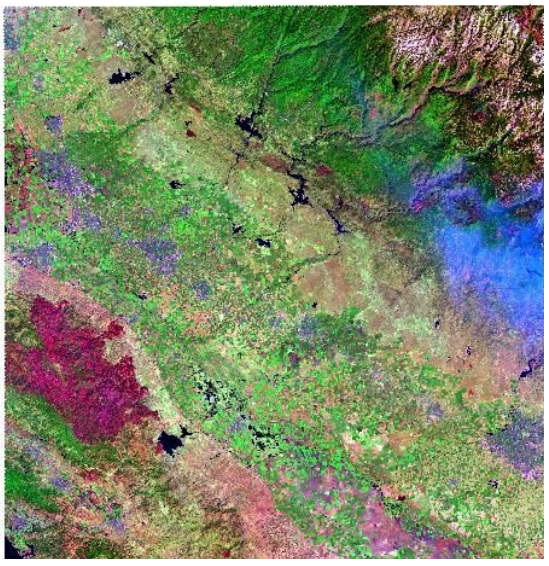

Fig 6.1

In this image of September 19th, we can observe the color green losing brightness.

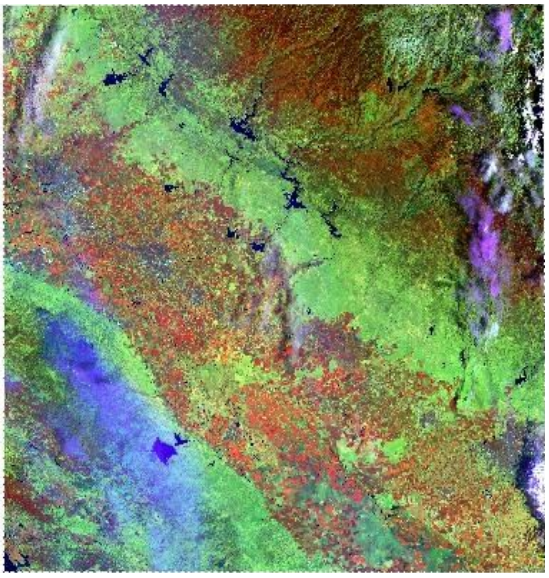

Fig 7

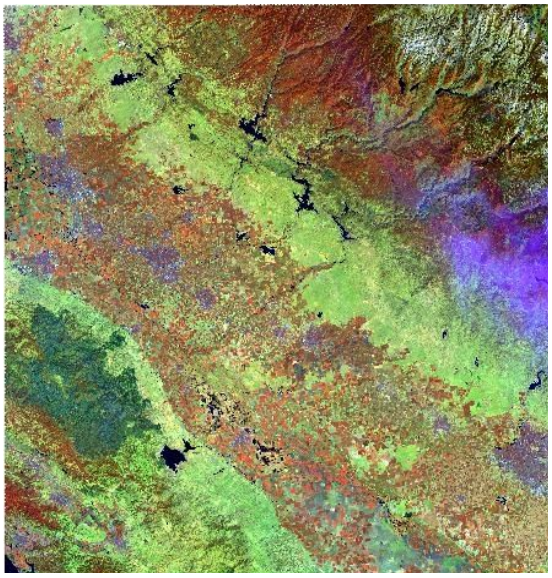

Fig 7.1

In the comparison of the two images we can see how the fire is still burning even though it has been a month since the fire started. Also we can identify the areas which have been affected.

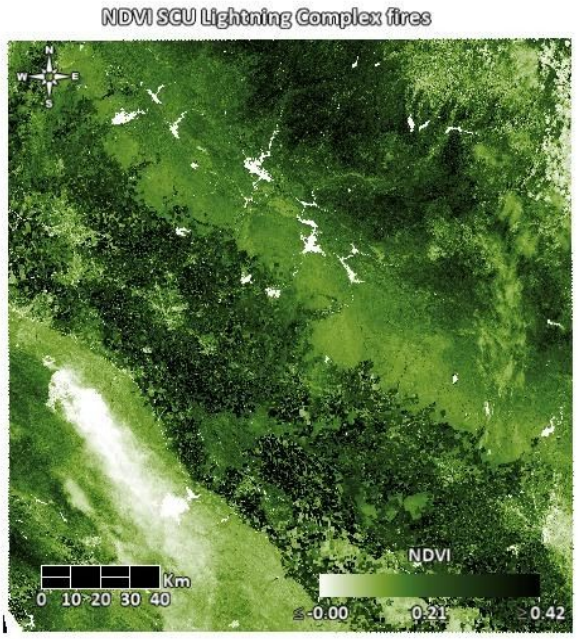

Fig 8

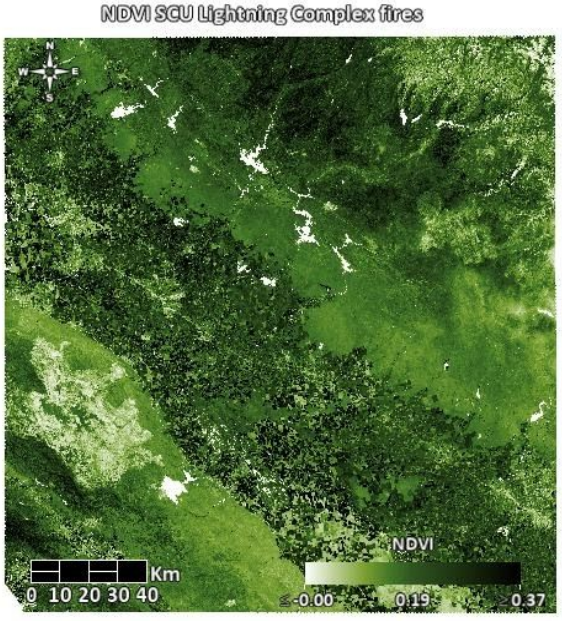

Fig 8.1

NDVI DATA-SCU Lightning Complex fires

Coordinates	Initial Value	Final Value
37°31’13.61”N.121°29’42.74”W	0.169483	0.063747
37°9’21.08”N.120°47’44.01”W	0.517822	0.305887
37°34’7.33”N.120°25’23.32”W	0.179258	0.176061

In conclusion the value of the Vegetation Index decreased, clearly indicating that an extended area of vegetation was lost due to the long period of fires.

Case 3

The August Complex was a massive wildfire that burned in the Coast Range of Northern California, in Glenn, Lake, Mendocino, Tehama, Trinity, and Shasta Counties. The fire started on August 16th and ended on November 12th, 2020.

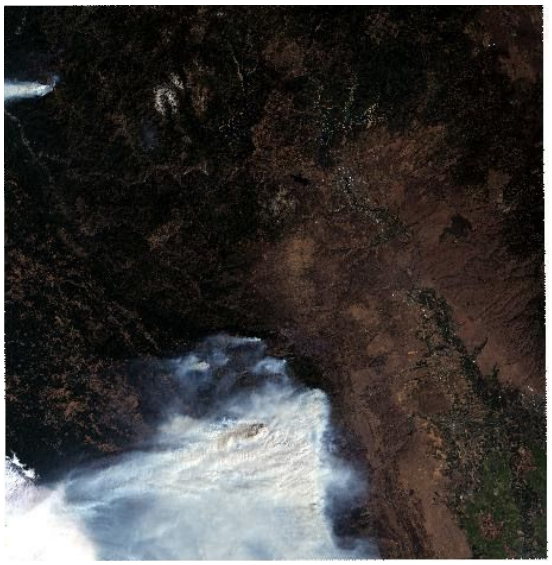

Fig 9

Fig 9.1

Image taken on September 1st while the fire volume was increasing.

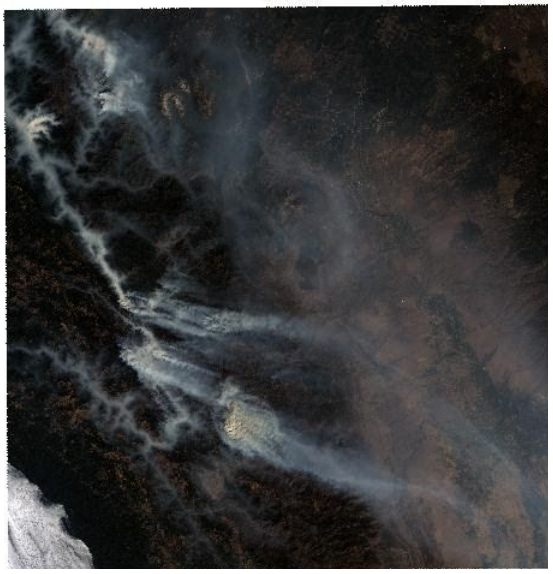

Fig 10

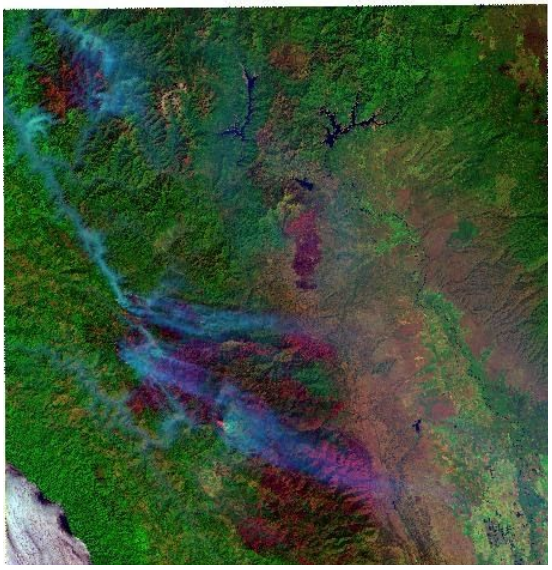

Fig 10.1

One month after the first image we obtained one from October 3rd where the fire had spread toward the north area. There is a decrease in green areas and the burn scar is bigger.

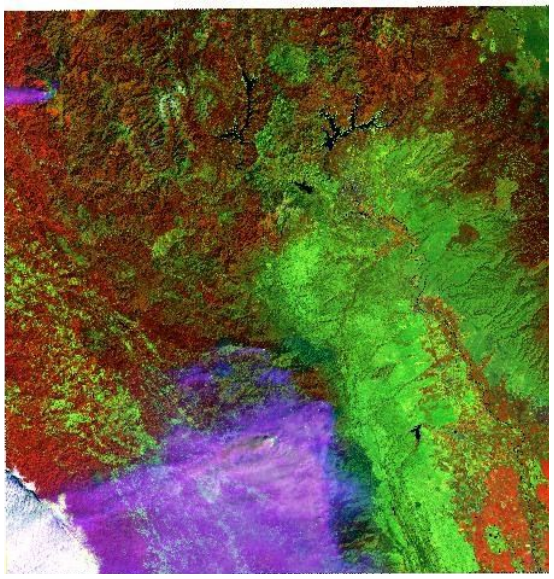

Fig 11

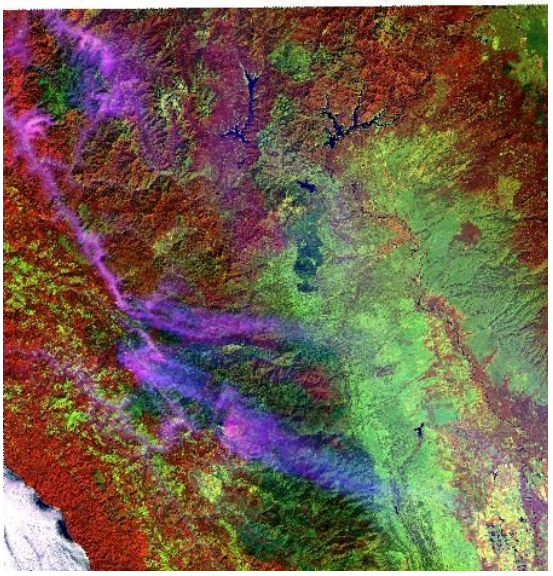

Fig 11.1

In the healthy vegetation images the color red which indicates vegetation, has lost brightness, meaning that there was a big impact in the area.

Fig 12

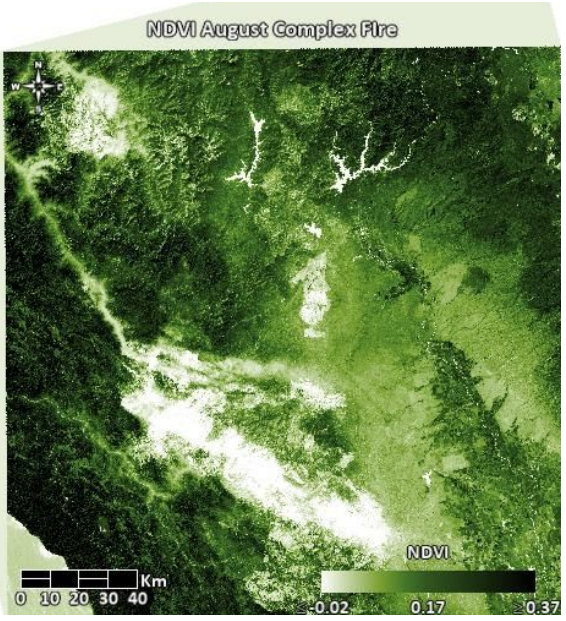

Fig 12.1

NDVI DATA-August Complex fire

Coordinates	Initial Value	Final Value
40°6’18.24”N.123°1’4.91”W	0.130682	0.035547
40°16’20.45”N.123°17’16.16”W	0.423839	0.245869
40°43’43.62”N.123°4’46.88”W	0.371835	0.310424

We can observe how in every case the NDVI value has been minimized. Taking different coordinates where the vegetation has been affected by the fire and comparing them to the image before the fire we obtain the decreasing value.

V. Conclusion

The *scientific question* poised at the beginning of the research was answered in terms of the processing of various images, which in turn showed a change in the vegetation index, visible fire "scars", and the effects to the surrounding lands. One of the most prominent outcomes of this research is the impact of climate change and the human factor in driving climate change to drastic measures. Not to mention, the poor forest management within the state of California plays a factor in the vastness that these wildfires spread to. In general terms, the tendency of the Vegetation Index in all 3 cases is a decreasing trend. This phenomenon could be due to the fact that the vegetative material was consumed by the uncontrolled and prolonged wildfires.

However, during the investigation we encountered some setbacks due to the scope of images taken by various predetermined sensors. These setbacks include, but are not limited to: 1) Area of land in the parameters of the image did not include land that we wanted to analyze. 2) The images would not load in the program ENVI and could not be processed. 3) A limited amount of images were available on public forums.

VI. Recommendations

At the end of this research project, we observed that some modifications could be made in order to improve the workflow of the research. In accordance with our results, some recommendations that could be made to a range of research projects are: 1) Have an established parameter for Time Management and establish measurable benchmarks throughout the research project. 2) Be better familiarized with the program ENVI and all of its tools. 3) Focus on one field of study instead of multiple aspects. 4) Extend the time frame for research, in order to have a fully developed study during the project. 5) Set objectives/methodology that can be modified throughout the research project, in order to broaden the scope of the investigation. 6) Promote respect towards the environment during your research project, in order to have a sustainable planet.

VII. References

1. California Department of Forestry and Fire Protection (CAL FIRE). (n.d.). 2020 Incident Archive. Retrieved November 10, 2020, from https://www.fire.ca.gov/incidents/2020/
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