2019

The Impact of Terrain and Other Factors on Wild Fires

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Abstract - Wild fires have become an annual concern in the United States, and despite the vast amount of resources and manpower used to combat the spread of wild fires, the success rate tends to vary. With this in mind, a research project has commenced which is primarily aimed at discovering the relationship between environmental factors and wild fire growth, or lack of growth. This research analyzes data available in the Google Earth Engine and includes geographical features such as roads, elevation, and other factors like humidity and wind. Using Google Earth Engine programs, the goal is to establish meaningful relationships between a fire's growth and various environmental elements. The investigation will be largely focused on individual fires as a means to establish a correlation between the environmental factors and the development of wild fires. It is conceivable that a closer look at these different relationships will increase the understanding of how these factors can influence wild fires, and consequentially, lead to the use of improved strategies that will result in potentially higher success in the combatting of future wild fires.

This research was undertaken as a means to investigate the effects that surrounding terrain can have on wild fires. This was achieved by using two different types of classifiers, a CART (classification and regression trees) classifier and a Random Forest (Rifle Serial) classifier to predict the terminal edges of individual fires using proximity to roads, elevation, and slope as training data. With this approach, I expected the classifiers to be more accurate the more of an effect these features had on the wild fires.

The fire data set I worked with was the MOD14A1.006 Terra Thermal Anomalies & Fire data set, which was at a scale of 1000 meters per pixel. Originally, the data came in a collection of images, or raster objects, with an image for each day for the last 19 years. The first thing I did with this data was to filter the data down to one year, specifically 2012, and assign the day of the year it was created as a value in the data itself. This, then, allowed me to reduce all 365 images for the year into one image which recorded the last day that a fire was detected in a location (Fig. 1). Next, I used Google Earth Engine's canny edge detector on this maximum image to find the terminal edges of each fire, which would work as a simple present or not present class for the classifiers.

The road data was available only as a set of lines describing each road in the United States. Using conversion tools available in Earth Engine, I converted this set into a single image detailing every local, secondary, and primary road, as identified by the U.S. Census Bureau. To facilitate the use of this data in a classifier, I used this image to create a new image that described each pixel's minimum distance from a piece of road. I also was able to quickly obtain an image for elevation and use the terrain tools in Google Earth Engine to easily obtain a slope image as well.

With this data now available, I semi-randomly selected three fires of various sizes with which I could train the classifiers. Ideally, I would have used many more fires at this point; however, I began encountering memory errors when I used more than a few fires in my analysis. Once I had these fires selected, I standardized the scale for the data to 1000 meters and trained the classifiers. Once trained, I had each classifier generate a confusion matrix (see Fig. 1), from which I could get the accuracy of the classifiers, and in turn, deduce how useful elevation, slope, and roads are for predicting the terminal edges of wild fires.

Unfortunately, since I used such a small sample size, the accuracy of my classifiers may have been artificially inflated to some degree. Therefore, I cannot in good conscience make any specific claims based off of this research. However, since the accuracy, if affected, would be enhanced across all the data equally, I can still recognize the relative effects of terrain features within my set of samples. Using this rationale, the results I achieved showed that, when roads, elevation, and slope are used to predict a wild fire's terminal edges, the accuracy increases for smaller fires and decreases for larger fires (see Fig. 2). Therefore, I can safely conclude that these factors have a stronger ability to stop a fire when the fire is earlier in its burn period rather than later in its burn period.

These results imply that there is a clear correlation between the studied terrain factors and a fire's terminal edges. As a result, this project serves to demonstrate the need for further investigation into these relationships. In addition, it provides a clear starting point from which others could begin their investigations.

Figure 1:

Fire A (Cart)	No edge	Edge
No edge predicted	744	204
Edge predicted	98	299

Fire A (R Forest)	No edge	Edge
No edge predicted	670	194
Edge predicted	172	309

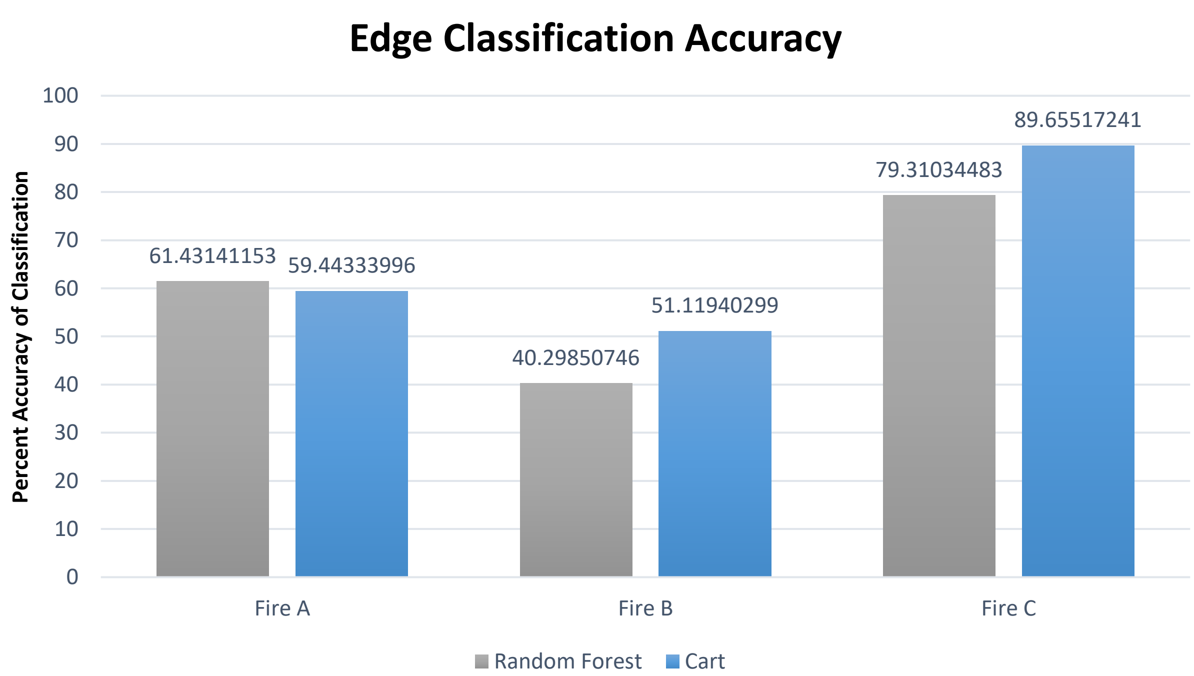
Fire B (Cart)	No edge	Edge
No edge predicted	702	131
Edge predicted	15	137

Fire B (R Forest)	No edge	Edge
No edge predicted	653	160
Edge predicted	64	108

Fire C (Cart)	No edge	Edge
No edge predicted	146	15
Edge predicted	15	130

Fire C (R Forest)	No edge	Edge
No edge predicted	133	30
Edge predicted	28	115

Figure 2:



Data Set Citations

NASA LP DAAC at the USGS EROS Center. (2019, April 9). MOD14A1.006: Terra Thermal Anomalies & Fire Daily Global 1km. Retrieved from the Google Earth Engine Database

United States Census Bureau. (2018, July 19). TIGER US Census Roads. Retrieved from the Google Earth Engine Database

U.S. Geological Survey. (2019, February 16). GMTED2010: Global Multi-resolution Terrain Elevation Data 2010. Retrieved from the Google Earth Engine Database