Fire Analysis: 2017 Atlas Fire

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Introduction

How much land was burned in the 2017 Atlas Fire? This was one of the fourteen large wildfires in Northern California in October 2017. For this project, I developed a method to determine the fire perimeter and measure the extent of the damage using the tools in ArcMap. To do this, I first classified a Landsat 8 image to find fire damaged areas. Then I created a workflow to turn the classified image into a polygon feature representing the fire perimeter. This workflow was captured as an ArcMap ModelBuilder model that could be used to apply the same process to other wildfire incidents.

Process

I will explain the process I followed in three parts: data acquisition, image classification, and analysis model.

A) Data Acquisition

The latitude/longitude coordinates of the Atlas Fire were found on the CAL FIRE incident information website.[1] I put the coordinates into a table in ArcMap and used Make XY Event Layer to create a layer with a point feature representing the fire location.

I used USGS EarthExplorer [2] to acquire Landsat 8 Level 1 imagery of the fire area. The area of interest is entirely within the Path 44 Row 33 image area. I examined images starting from the date the fire started, October 8, 2017, and found that the November 5 image had minimal cloud cover and was after the point that the fire had reached its largest extent (although it would not be declared fully contained until February 2018).

After downloading the Landsat scene, I used the Composite Bands tool in ArcMap to create a raster data set with bands 1-7 and 9. I did not use band 8 because it is mostly redundant with bands 2-4 and the higher resolution is not needed for this analysis. I did not use bands 10 and 11 because they also have a different resolution than the other bands and I did not find the thermal IR data improved the identification of burn scar areas.

B) Image Classification

To classify the image, I created training samples for recent burn scars, water, unburned vegetation, and unburned open/grass areas and then used the Maximum Likelihood Classification tool in ArcMap to classify the Landsat scene. I found that fallow or dry agricultural fields were often classified as burn scars with this training data, so I added another set of samples for these areas. This improved the classification but there is still some overlap between these two region types.

C) Analysis Model

My goal was to use the classified image to automatically determine the fire perimeter. To achieve this, I created a ModelBuilder model in ArcMap that implements the following steps:

1. The parameters for the model are a) the classified image, b) the layer with a point feature for the fire location, c) the region ID that corresponds to burn scar regions in the classified image, and d) an output location for the resulting feature class.
2. Used the Majority Filter tool to smooth the classified image, using four neighbor cells and majority replacement threshold.
3. Used the Expand tool to expand all burn scar areas by one cell to further smooth the image and connect very close regions.
4. Used the Set Null tool with the expression “Value <> %Burn Zone ID%”. This creates a raster with only the cells representing burn scar areas. All other cells become NoData.
5. Used the Raster to Polygon tool to generate polygon features for all connected regions.
6. In order to select by location, we need the burn area polygons to be in a layer, so I used the Make Feature Layer tool to load the result of the previous step into a layer.
7. Used the Select Layer By Location tool to select the feature from the burn area polygons layer that contains the point feature that represents the known location of the incident.
8. Used the Copy Features tool to copy the selected burn area polygon to the output feature class.

Analysis

The fire perimeter found by the process described for the Atlas Fire has an area of 44,012 acres. For comparison, a (presumably) hand-digitized map of the fire perimeter from NOAA [3] has an area of 51,589 acres and the official number from the CAL FIRE incident information is 51,624 acres.

Comparing the automatically generated perimeter and the official perimeter visually, the auto-generated perimeter matches fairly well. The major differences are: 1) the outer edge is more bumpy and convoluted, 2) there are holes in the interior of the polygon which the official perimeter does not have, 3) there are some places where the official perimeter extends out farther from the generated perimeter. In some cases, there are small patches of burn scar that were separated from the large main burn area, too far to be joined together by the process used. In other cases, little or no burn scar is evident, so these may be areas that were designated as within the perimeter by the fire control team but had low-intensity or no actual burn damage.

Conclusions

This process for automatically generating a fire perimeter was fairly simple and produced a good result for the 2017 Atlas Fire. It depends on the burned area forming a single contiguous region, so the same method would not work for a fire with multiple disconnected areas without modification. Also, the method depends on manual classification of the image, so it is not completely automatic.

An interesting next step to improve this method would be to explore ways of removing the holes from the generated fire perimeter and further smoothing the outer boundary. It would also benefit from improving the classification.

[1] Atlas Fire (Southern LNU Complex), CAL FIRE. Retrieved April 22, 2020. https://www.fire.ca.gov/incidents/2017/10/8/atlas-fire-southern-lnu-complex/

[2] EarthExplorer, USGS. https://earthexplorer.usgs.gov/

[3] 2017 Atlas Fire Map, Web Map by Scott.Rowe_noaa. Retrieved April 22, 2020. https://www.arcgis.com/home/item.html?id=e747497dcf744491bd55f8a090bdefd2