William Edmonson

GEOG 342

Spring 2015

BUTTE FIRE PIXEL-BASED CHANGE DETECTION ANALYSIS

PROJECT SUMMARY

This project was aimed at calculating the total area that was burned during the Butte Fire that began on September 9th, 2015 by using a change detection analysis. The Butte Fire occurred in Amador and Calaveras counties, took the lives of two civilians, destroyed 475 residences, 343 outbuildings, and damaged 45 structures. In this analysis LANDSAT_8 imagery was collected for September 6th, 2015 (before the fire) and September 22nd, 2015 (after the fire). Using the image analysis window in ArcGIS 10.3, several image processing tools were used in the analysis. The composite bands tool was used to combine, bands 2, 3, 4, 5, 6, and 7 of both the LANDSAT_8 images. The images were both then clipped to the area of interest of the burn scar to minimize processing time and save storage space. Next, the difference tool was used to calculate, on a pixel-by-pixel basis, the difference between the two images. An unsupervised classification was then performed on the output image from the Difference calculation. For the purpose of this analysis, the spectral signatures that best represented the burn scar area were classified and selected using the Raster Calculator Tool. The output raster was then reclassified to show only the burn scar area. In order to calculate the total area burned and better manage anomalies found in the final output, the raster was converted to a polygon using the Raster to Polygon tool. Polygons that appeared to falsely represent burn scar areas were deleted. The statistics tool was used to calculate the total acreage of the burn scar area. According to the analysis, the total amount of acres burned from the Butte Fire was 66,948 acres.

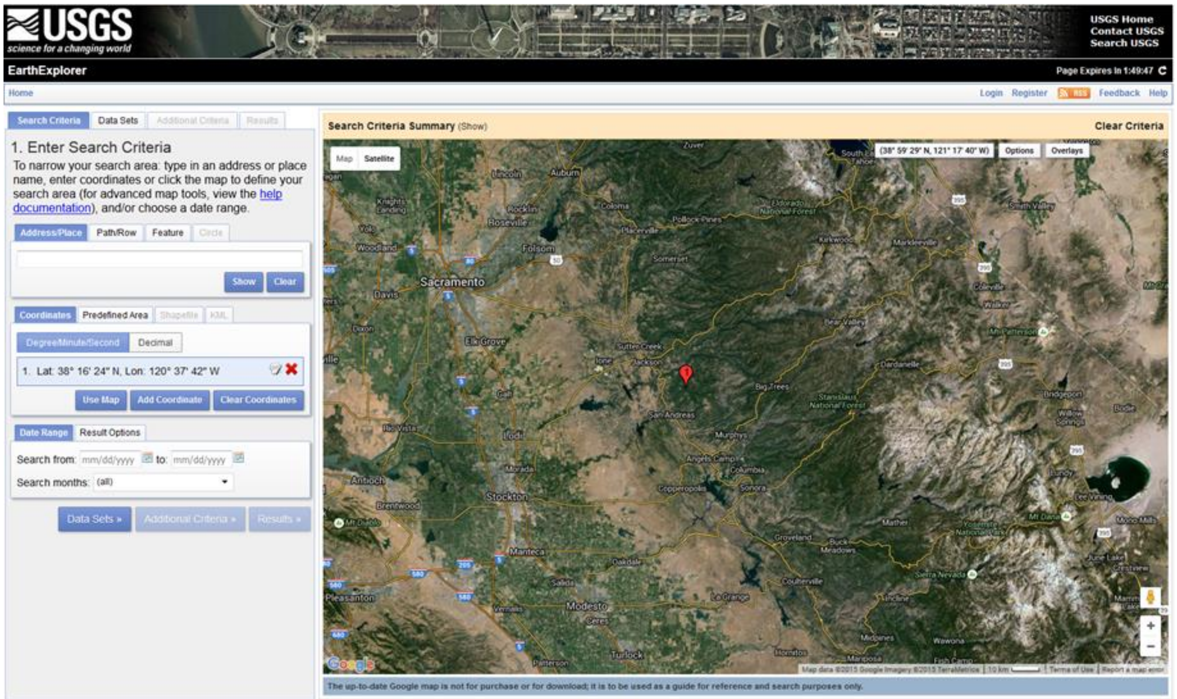
PURPOSE

The purpose of this project is to determine the total number of acres burned by deriving a final dataset that accurately represents the area burned of the Butte Fire using remotely sensed imagery. It is hopeful that the final dataset that is derived from the analysis can then be used for assisting in further analysis that pertain to the Butte Fire.

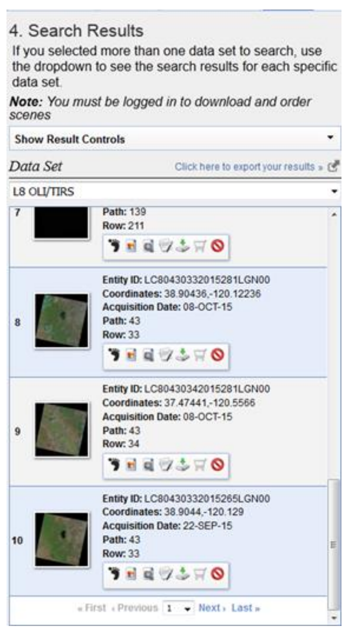
IMAGE PROCESSING TASKS AND ANALYSIS

DATA COLLECTION/PREPARATION

For this analysis, remotely sensed imagery needed to be obtained for the project area of interest. The general area of the location of the Butte Fire was selected in the map viewer (Figure 1.0). After selecting the general area of interest, using the data set tab, Landsat-8 imagery was selected because of its multiple band properties (Figure 1.1).



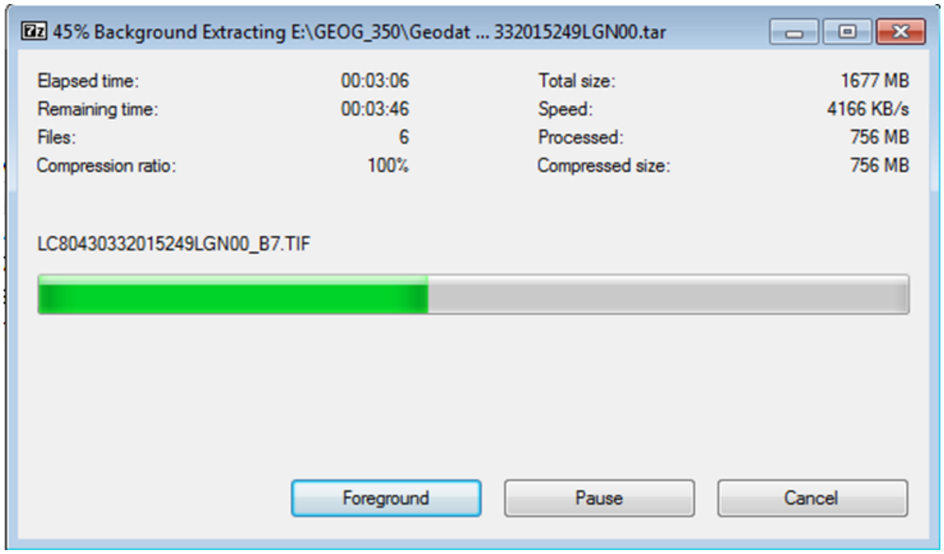
(Figure 1.0) *USGS Earth Explorer Web Page*



(Figure 1.1) *USGS Earth Explorer Data Set Search Results*

From the search results of the Landsat-8 satellite imagery, the datasets for September 6th, 2015 and September 22nd, 2015 were selected. The Butte Fire began in the late morning of September 9th, 2015. Each of the dates selected represent a date before the fire and a date after the fire was primarily contained. According to the CalFire website, the Butte fire was not deemed 100% contained until October 1st, 2015. However, the image of September 22nd, 2015 was the latest imagery with the best quality to perform the analysis. Based on knowledge of the area and no apparent burning in the September 22nd image, it is concluded that the majority of the fire was contained during this time period.

The imagery was downloaded in a zipped file and then extracted as a .tif image. (Figure 1.2)



(Figure 1.2)

The file consisted of 11 different datasets, each representing the 11 different images of each band taken by the Landsat-8 remote sensor. The different bands for Landsat-8 are shown below (Figure 1.3)

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Bands	Wavelength (micrometers)	Resolution (meters)
	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

(Figure 1.3) Table of Landsat 8 Bands

For the purpose of this analysis, only bands 2-7 were imported in ArcMap for use in the analysis. (Figure 1.4, 1.5)

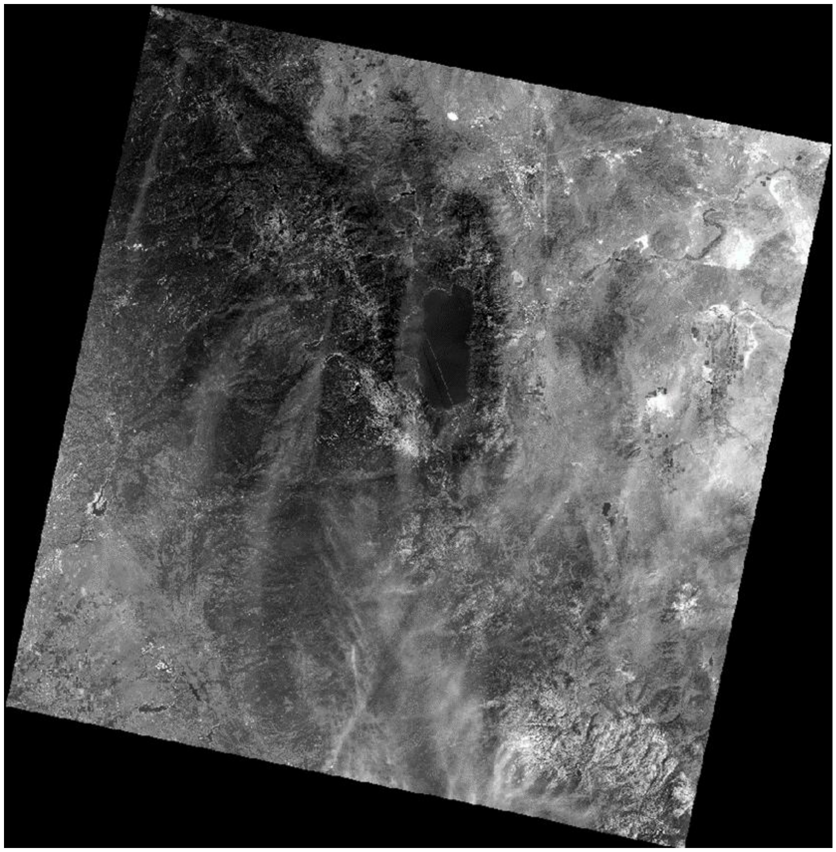


Figure 1.4 (Bands 2-7 of the September 6th, 2015 Image)

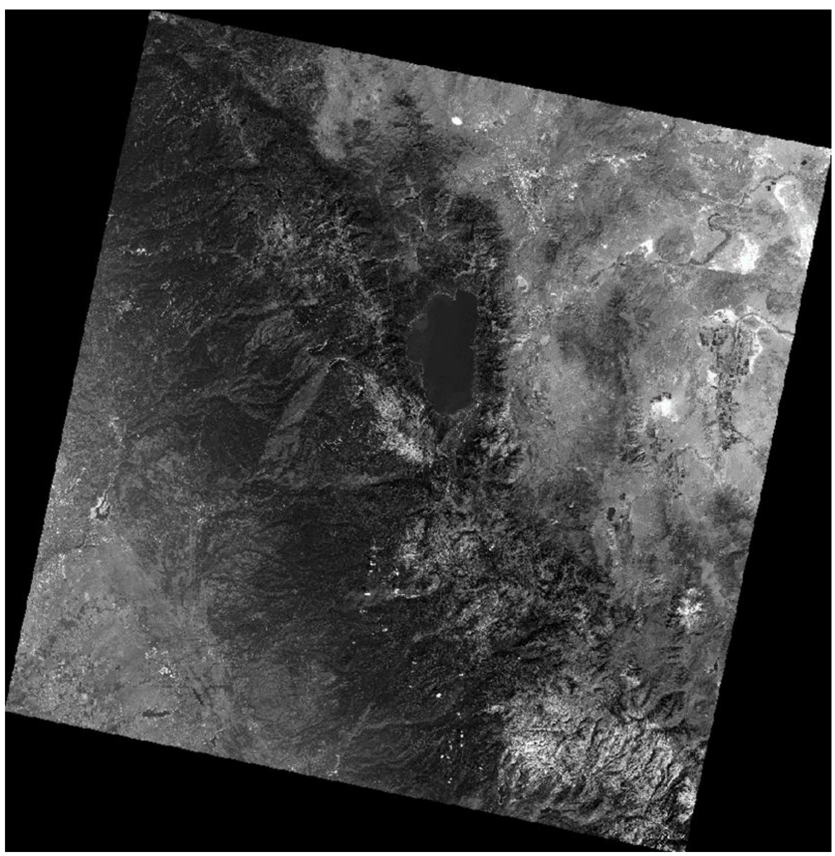
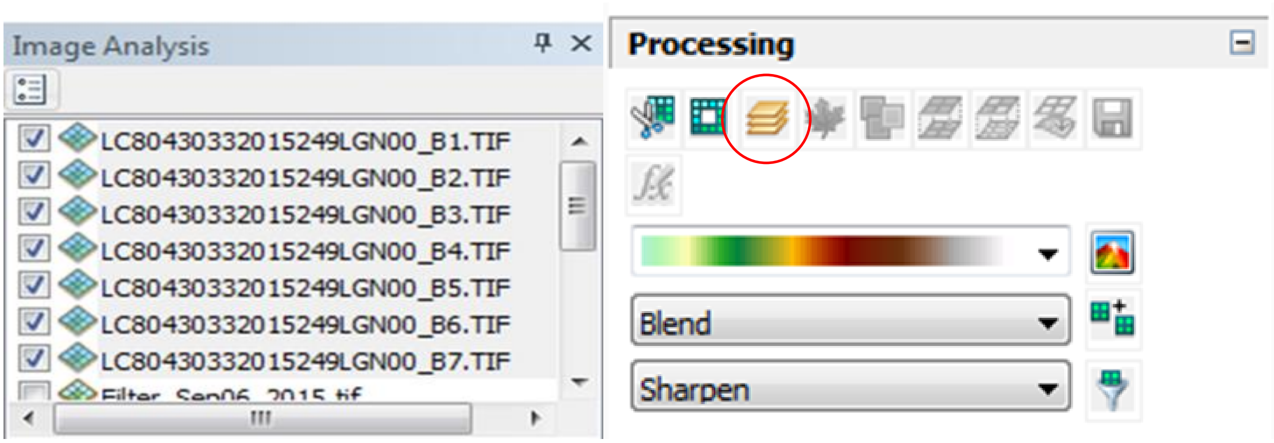
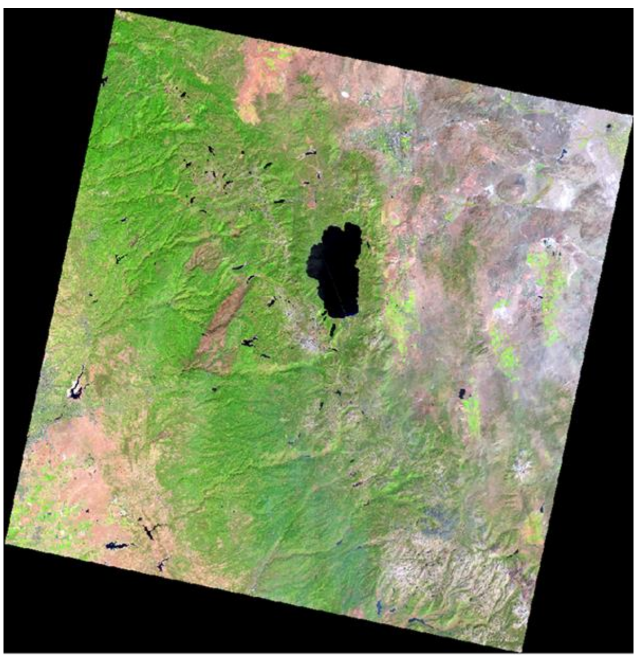


Figure 1.5 (Bands 2-7 of the September 22nd, 2015 Image)

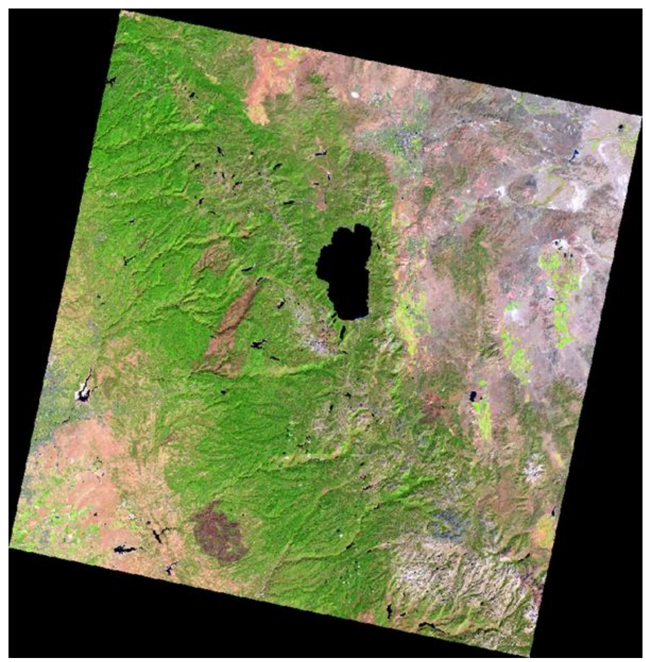
Using the image analysis window, the *Composite Bands* tool was used to combine individual band layers into one multiband layer. (Figure 1.6, 1.7, 1.8)



(Figure 1.6) Composite Bands Tool



(Figure 1.7) Composite Band Image Sep 6th

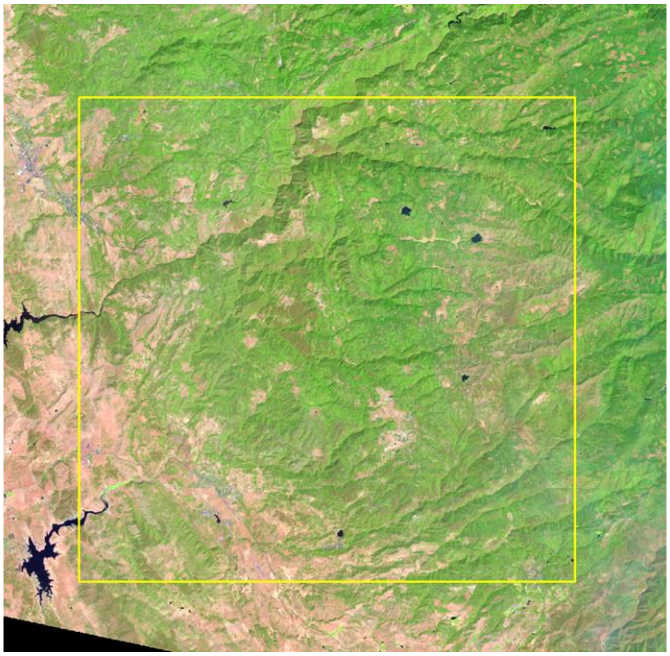


(Figure 1.8) Composite Band Image Sep 22nd

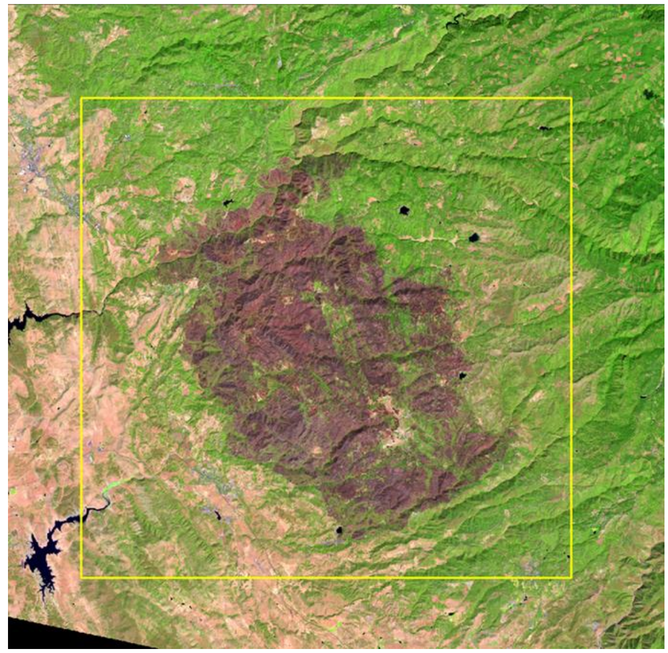
After each of the images were made into a single multiband image, the band combination of 6, 5, and 4 was used. By setting the SWIR, NIR, and Red bands to be displayed in the R, G, B band combination the healthy vegetation was made more apparent. Healthy vegetation in the near infrared spectrum is about twice as reflective as healthy vegetation in the green wavelengths in our visible spectrum. This enhanced the ability to better distinguish between vegetation and the burn scar area for the analysis.

IMAGE CLIPPING

After the composite band images were set to the appropriate band combination, a subset of the area of interest was performed using the Clip tool in the Image Analysis window. A polygon was drawn around the area of interest and used as the clipping feature (Figures 1.9, 2.0). The output images resulted in a composite band image of the area of interest defined by the polygon (Figures, 2.1, 2.2).



(Figure 1.9) Sep 6th Composite Image



(Figure 2.0) Sep 22nd Composite image

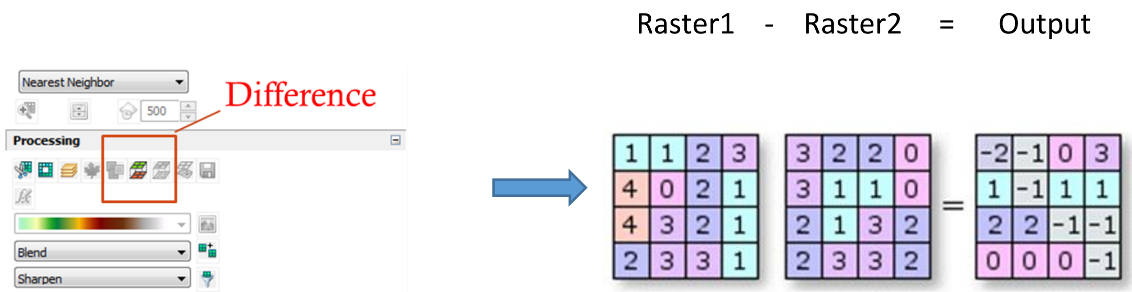
(Figure 2.1) Sep 6th Subset Image

(Figure 2.2) Sep 22nd Subset Image

Because each of the images were created as temorary image files, each image was exported to the appropriate geodatabase to make the image files permanent.

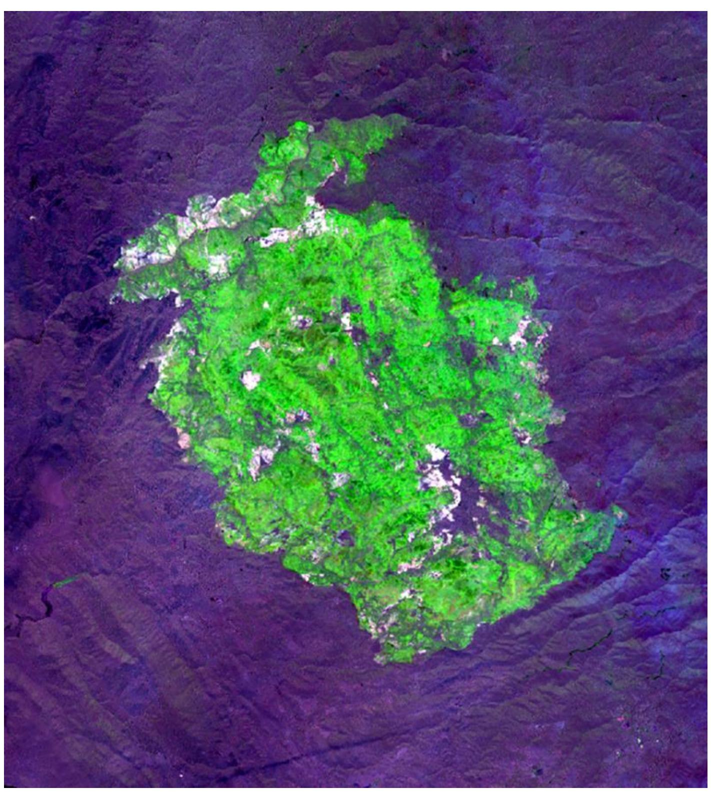
PIXEL-BASED CHANGE ANALYSIS

In order to detect the change between the two images, the Difference tool in the Image Analysis window was used. The difference tool performs a simple change detection algorithm by computing the difference between two raster or image service layers on a pixel-by-pixel basis (Figure 2.3).



(Figure 2.3) Basic function of the Difference tool.

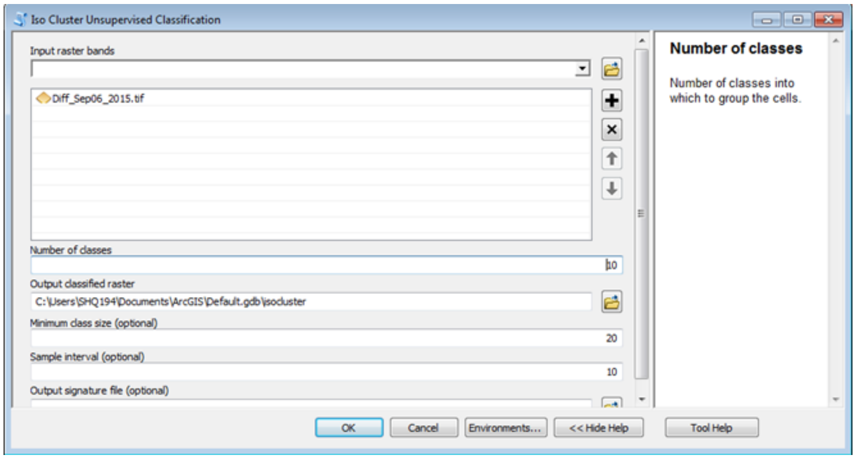
The result is an output image with pixel values based on the amount of change between the two different images. The output image was then give the 6,5,4 band combination to properly depict the change between the two different images. The final differenced image shows the areas that accrued the largest amount of change in the area of interest, clearly displaying the area that was burned from Sep 6th and Sep 22nd, 2015 (Figure 2.4).



(Figure 2.4) Difference image with 6,5,4 band combination

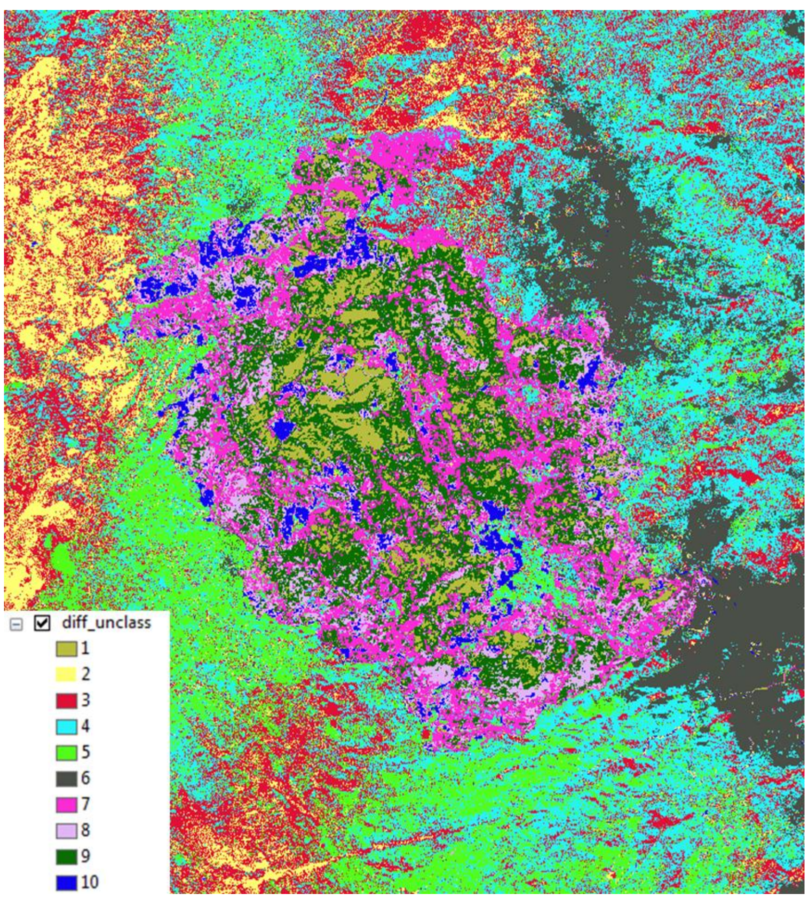
ISO-CLUSTER UNSUPERVISED CLASSIFICATION

In order to isolate the pixels that best signified the burned area, an Iso-cluster Unsupervised Classification was performed. The final difference image was used as the input image and a total of 10 classes were used (Figure 2.5).



(Figure 2.5) Iso-Cluster Unsupervised Classification

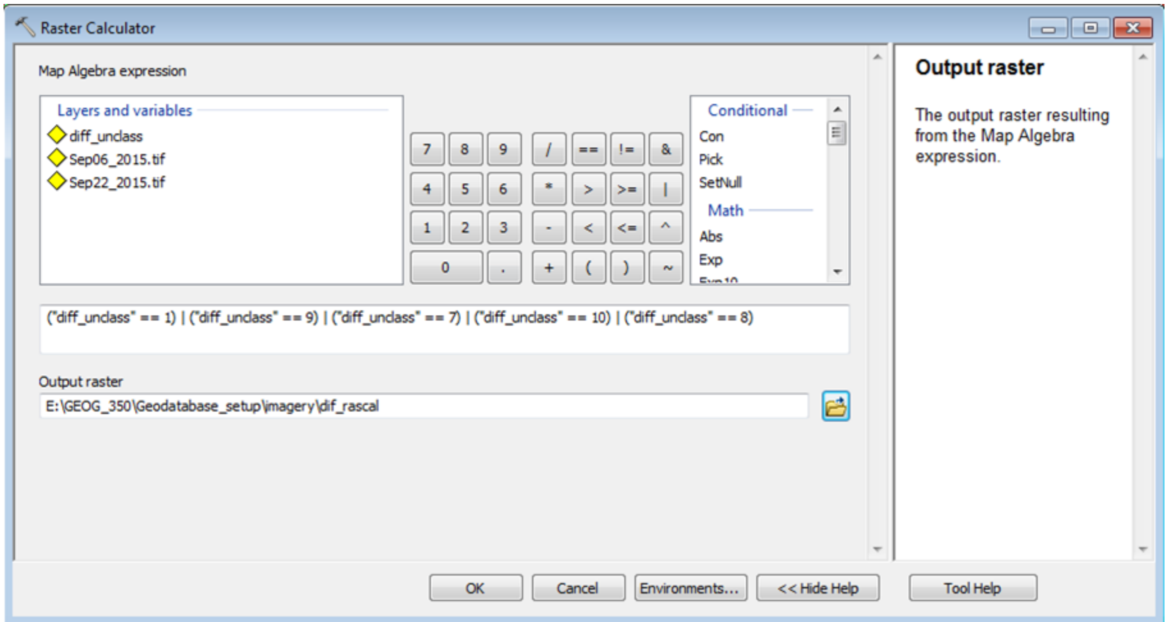
The output image displayed 10 spectral signatures of clustered pixels with similar pixel values (Figure 2.6). 10 spectral signatures was decided to be an appropriate amount based on the size of the area of interest and the analysis being performed.



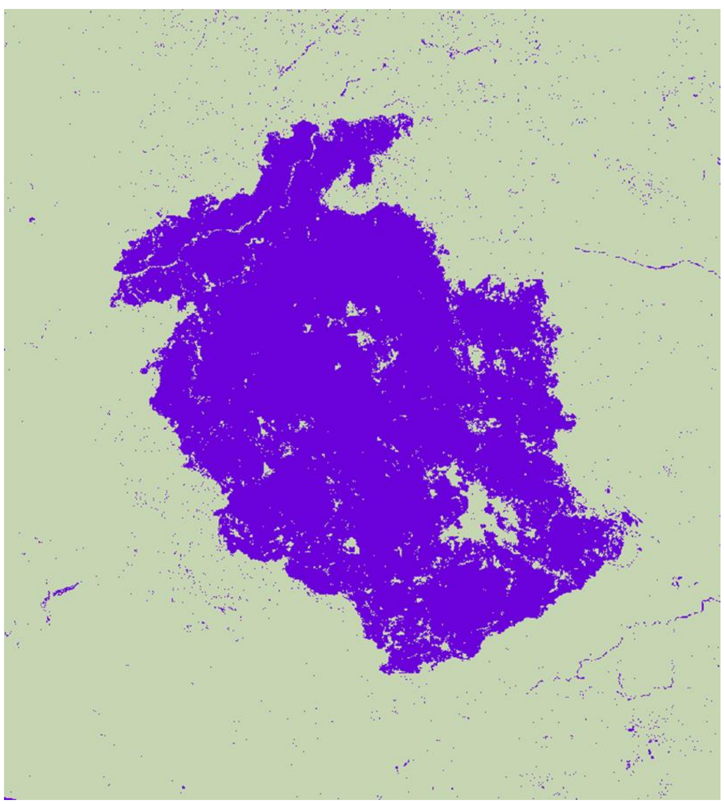
(Figure 2.6) Unsupervised Classification on the Difference Image.

DERIVING THE FINAL OUTPUT LAYER OF THE BURN SCAR AREA

After further analysis, using the image effects pane to compare the unsupervised classification to the difference and multiband images, 5 classes were selected that best represented the burn scar area. Because the burn scar area was the only area of concern for this analysis, the remaining spectral signatures were not classified. The Raster Calculator tool was used to select only the spectral signatures that represented the burn scar area resulting in an image that gave the selected spectral signatures a value of 1, and the remaining signatures a value of 0 (Figure 2.7, 2.8).

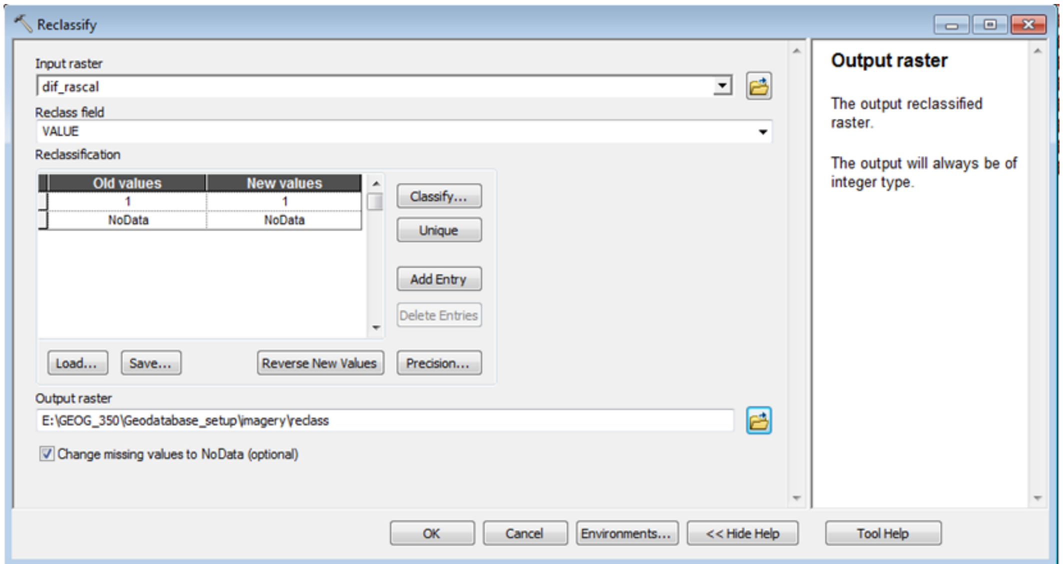


(Figure 2.7) Raster Calculator



(Figure 2.8) Output Image of Raster Calculator

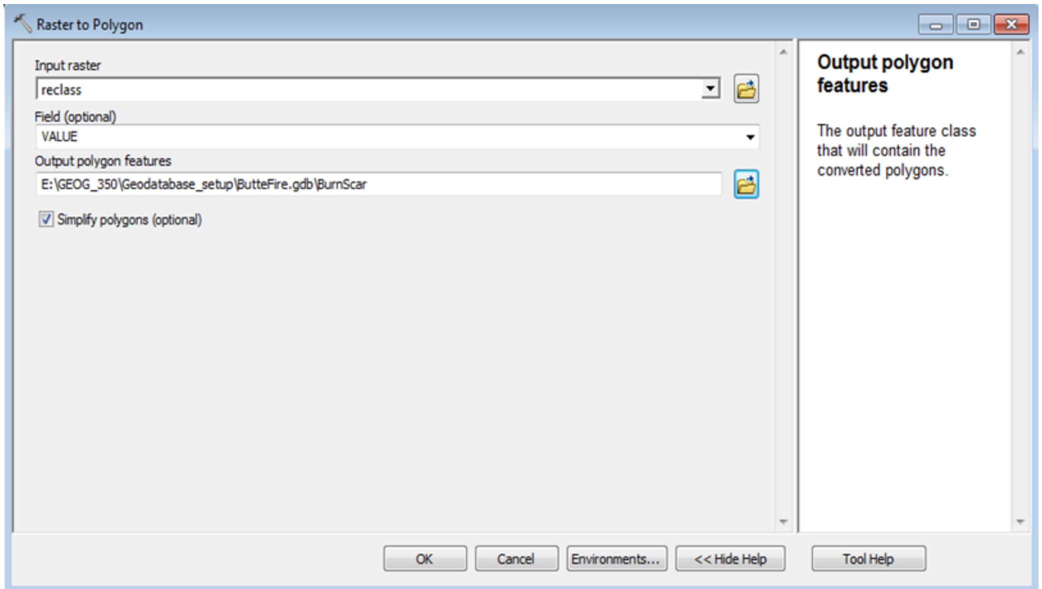
In order to isolate the pixels with a value of 1, the Reclassify tool was used. The parameters were set to classify all the pixels with a value of one as 1, and the remaining pixel values as NoData (Figure 2.9, 3.0).



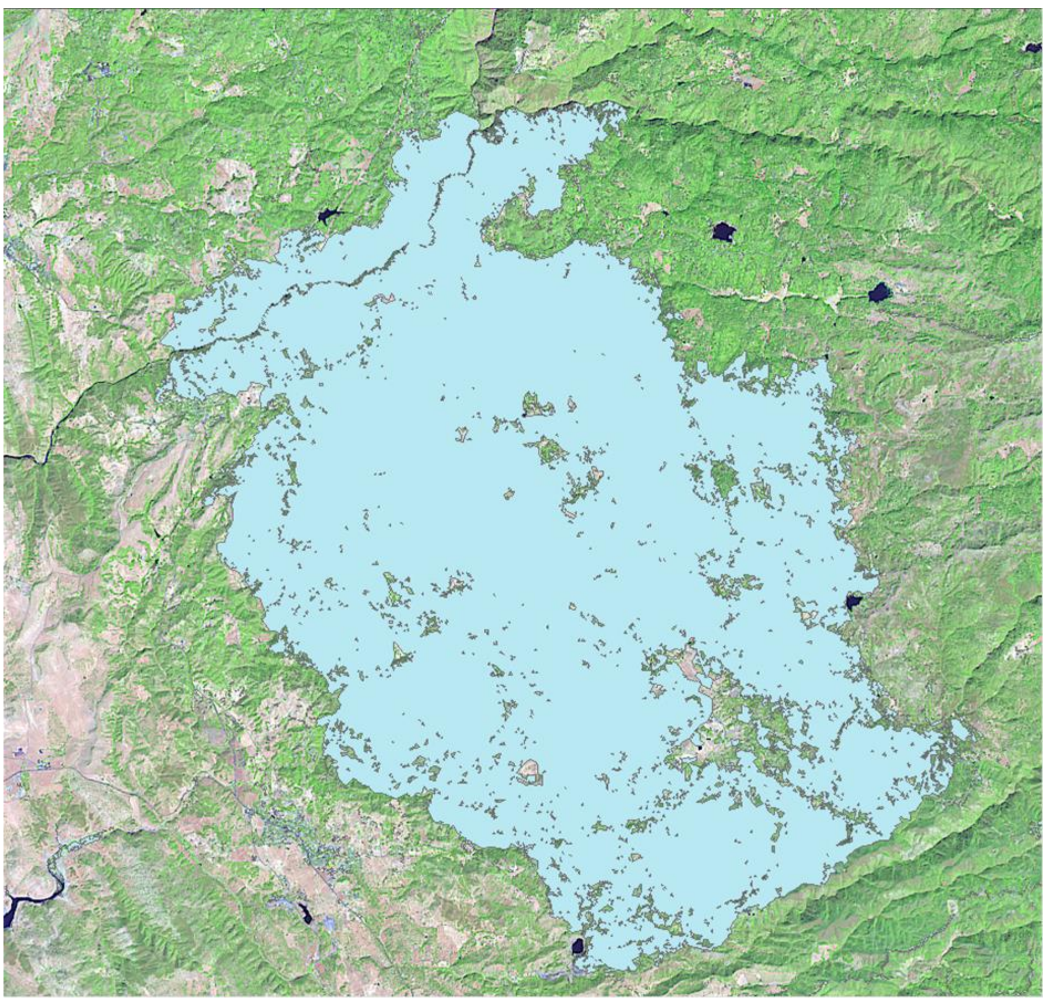
(Figure 2.9) Reclassification

(Figure 3.0) Output Reclassification Image

Now that the burn scar area was isolated, the image needed to be converted from a raster to a polygon to allow for area calculation of the burn scar area and to edit anomalies/false classification of pixels (Figure 3.1, 3.2). The Raster to Polygon tool, located in the Conversions Toolbox was used to perform this task.

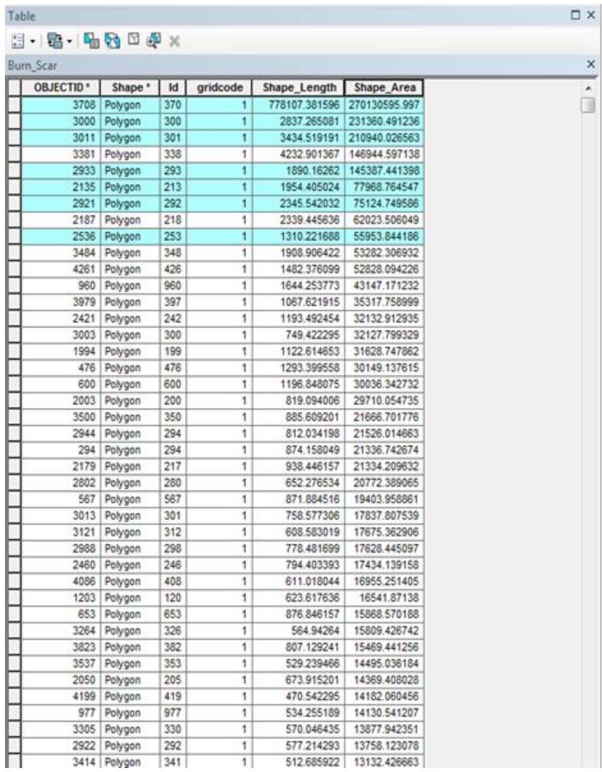


(Figure 3.1) Raster to Polygon Tool



(Figure 3.2) Output Polygon layer

After further analyzing the polygon area, several false classifications were apparent in the final output layer. To fix the anomalies in the data, polygons with small areas were excluded from the layer by using a query in the attribute table with shapes greater than 50,000 square meters. This number was selected by assorting the Shape_Area field in the final output layer in descending order. There was a clear pattern of polygons that were not significant based on the total square meters. The remaining polygons were then compared to higher resolution imagery and the difference layer to analyze the results. Some larger polygon areas were discovered to be falsely identified as burn scar area. These polygons were removed from the final output layer (Figures 3.3, 3.4, 3.5)

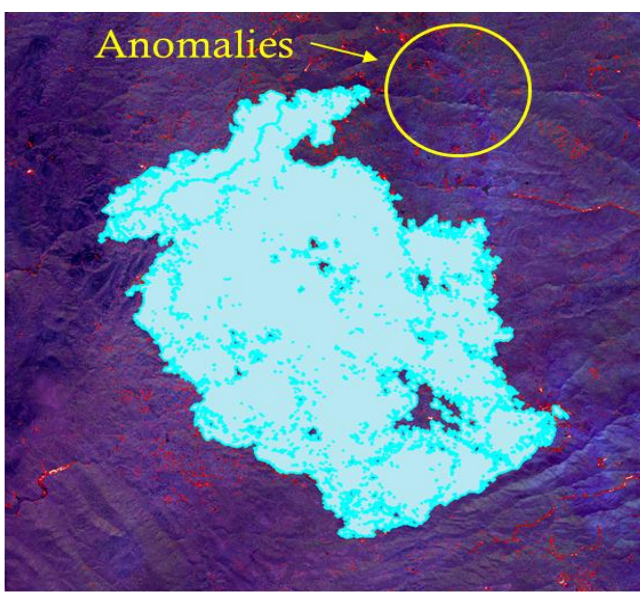


Table

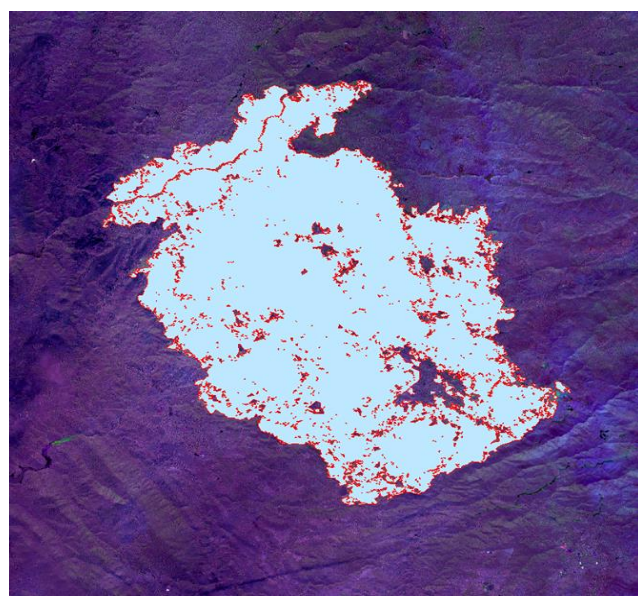
Burn_Scar

OBJECTID *	Shape *	Id	gridcode	Shape_Length	Shape_Area
3708	Polygon	370	1	778107.381596	270130595.997
3000	Polygon	300	1	2837.265081	231360.491236
3011	Polygon	301	1	3434.519191	210940.026563
3381	Polygon	338	1	4232.901367	146944.597138
2933	Polygon	293	1	1890.16262	145387.441398
2135	Polygon	213	1	1954.405024	77968.764547
2921	Polygon	292	1	2345.542032	75124.749586
2187	Polygon	218	1	2339.445636	62023.506049
2536	Polygon	253	1	1310.221688	55953.844186
3484	Polygon	348	1	1908.906422	53282.306932
4261	Polygon	426	1	1482.376099	52828.094226
960	Polygon	960	1	1644.253773	43147.171232
3979	Polygon	397	1	1067.621915	35317.758999
2421	Polygon	242	1	1193.492454	32132.912935
3003	Polygon	300	1	749.422295	32127.799329
1994	Polygon	199	1	1122.614653	31628.747862
476	Polygon	476	1	1293.399558	30149.137615
600	Polygon	600	1	1196.848075	30036.342732
2003	Polygon	200	1	819.094006	29710.054735
3500	Polygon	350	1	885.609201	21666.701776
2944	Polygon	294	1	812.034198	21526.014663
294	Polygon	294	1	874.158049	21336.742674
2179	Polygon	217	1	938.446157	21334.209632
2802	Polygon	280	1	652.276534	20772.389065
567	Polygon	567	1	871.884516	19403.958861
3013	Polygon	301	1	758.577306	17837.807539
3121	Polygon	312	1	608.583019	17675.362906
2988	Polygon	298	1	778.481699	17628.445097
2460	Polygon	246	1	794.403393	17434.139158
4086	Polygon	408	1	611.018044	16955.251405
1203	Polygon	120	1	623.617636	16541.87138
653	Polygon	653	1	876.846157	15868.570188
3264	Polygon	326	1	564.94264	15809.426742
3823	Polygon	382	1	807.129241	15469.441256
3537	Polygon	353	1	529.239466	14495.036184
2050	Polygon	205	1	673.915201	14369.408028
4199	Polygon	419	1	470.542295	14182.060456
977	Polygon	977	1	534.255189	14130.541207
3305	Polygon	330	1	570.046435	13877.942351
2922	Polygon	292	1	577.214293	13758.123078
3414	Polygon	341	1	512.685922	13132.426663

(Figure 3.3) Queried Data based on Shape_Area



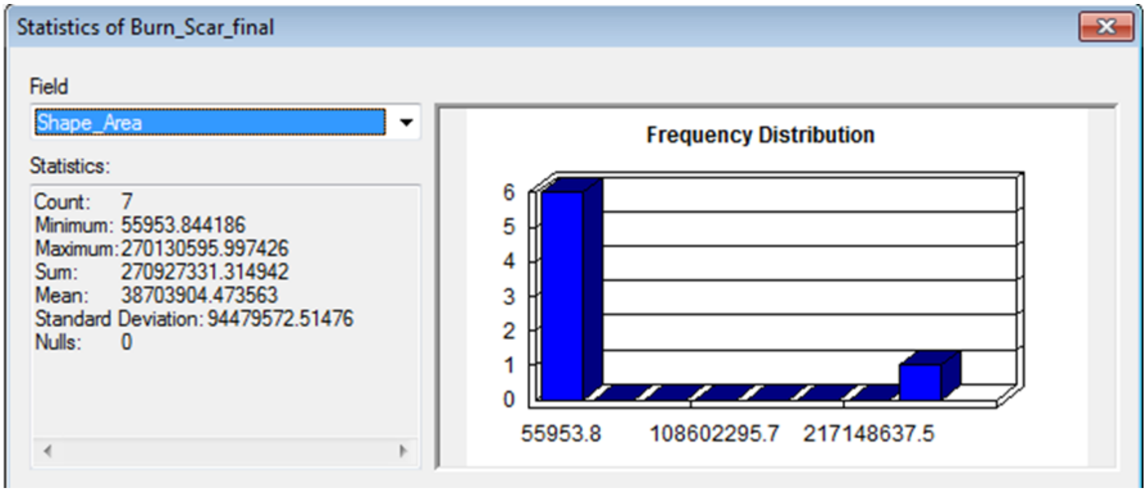
(Figure 3.4) Burn Scar Polygon with Anomalies Removed



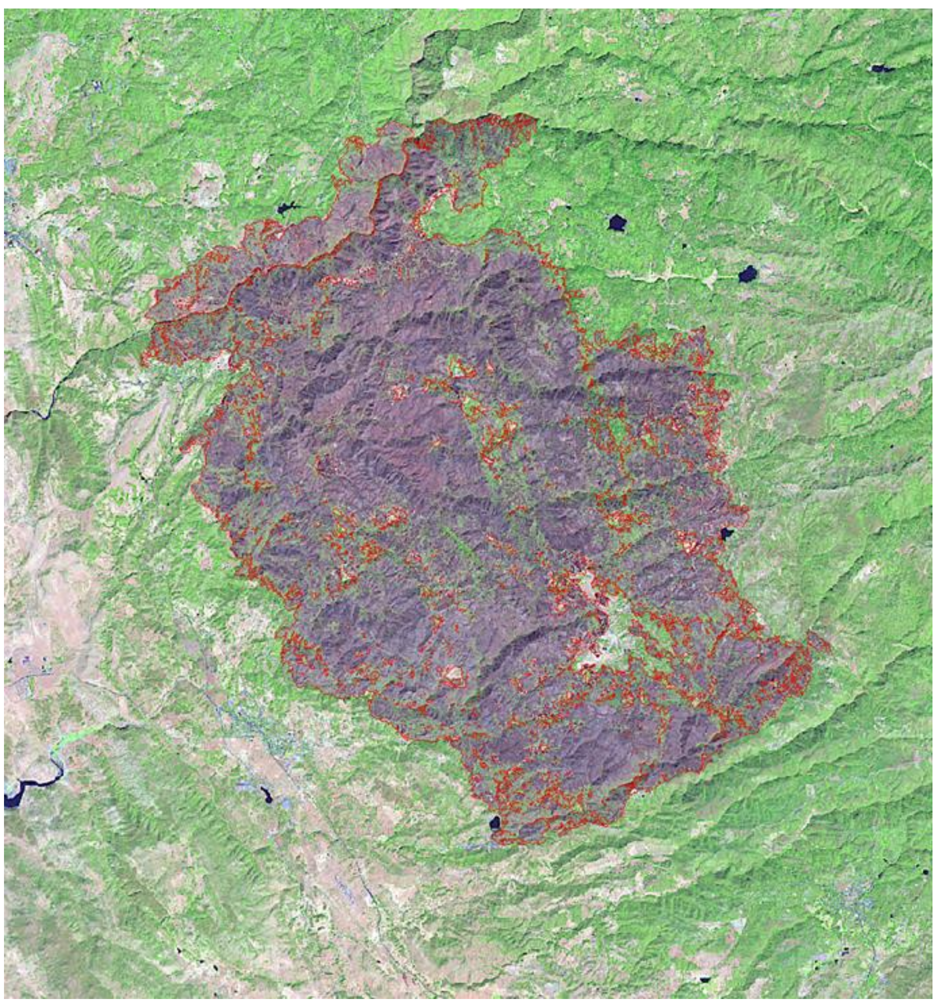
(Figure 3.5) Burn Scar Polygon without anomalies

FINAL CALCULATION OF THE BURN SCAR AREA

After removing all anomalies from the final burn scar polygon I was able use the statistics tool within the attribute table to calculate the total acres that were burned by the Butte Fire from September 6th , 2015 and September 22nd, 2015. The total amont of acres burned was calculated to be 270,927,331 square meters or approximately 66,948 acres (Figure 3.6, 3.7).



(Figure 3.6) Total Sum of Burn Scar Polygon.



(Figure 3.7) Final Burn Scar Polygon.

DIFFICULTIES/ISSUES ENCOUNTERED

During the process of using the composite bands tool, one issue did initially arise. For the analysis, only bands 2-7 were used in the composite bands tool. After doing some research on band combinations I decided to use the combination of 6, 5, and 4. However, when I chose this band combination it appeared as though it was in the wrong band combination. After further looking into why this was occurring, I discovered that ArcMap was automatically assigning Band 2 as 1, Band 3 as 2, Band 4 as 3, Band 5 as 4, Band 6 as 5, and Band 7 as 6. So by assigning the bands in the combination of 6, 5, and 4, they were actually being assigned as 7, 6, and 5. I simply fixed the problem by using the band combination of 5, 4, and 3 to correctly correspond with bands 6, 5, and 4 derived from the Landsat 8 sensor.

The next issue that was encountered was in the data collection phase. Imagery for the exact date of when the fire was deemed to be officially contained did not exist. There were several other images available with dates closer to the official containment date other than the one used in the analysis. However, these images had a significant amount of cloud cover and seemed to have other problems with the imagery when looking at the sample images provided. So the imagery with a date closest to the official containment date and no apparent problems in the imagery was used.

CONCLUSION

After comparing the final results with the official burned scar acreage listed on the CalFire website, the analysis seemed to be quite accurate. CalFire listed the Butte Fire as burning a total of 70, 868 acres, compared to 66, 948 acres concluded from the analysis. To better determine the validity of the analysis it would be helpful to have more information on how CalFire determined the total acreage burned by the Butte Fire. Using two different methods to determine the total acreage could easily cause a difference of 4,000 acres. Another factor that could be producing error in the analysis are the imagery dates that the analysis was performed. In the analysis, imagery that was collected on September 22nd, 2015 was used as the post fire image. However, the Butte Fire was not officially classified as contained until October 1st, 2015. Due to lack of quality imagery of that date in the specified area of interest, September 22nd, 2015 was the most accurate image that was available closest to the official containment date. Overall, I am pleased with the results of the analysis which proved to be as accurate as I expected. By understanding the workflow of this analysis, previous to performing it, I was certain that the end product would be fairly accurate. A pixel-by-pixel change detection proved to be a simple yet effective way to map change in an environment. Given more time, I would like to experiment with different band combinations to compare the outcomes. In order to conclude the true accuracy of this analysis a more in depth accuracy assessment would need to be performed.

RESOURCES

http://cdfdata.fire.ca.gov/pub/cdf/images/incidentfile1221_1956.pdf

http://blogs.esri.com/esri/arcgis/2013/07/24/band-combinations-for-landsat-8/