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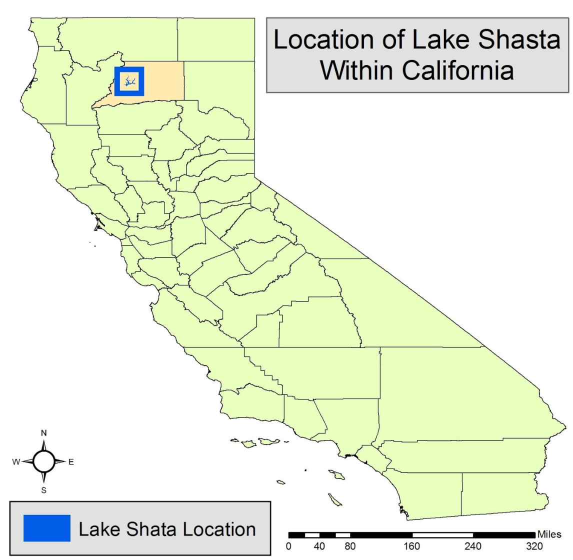
California Drought Seen Through Lake Shasta

Introduction

Shasta Lake is located in North Central California in Shasta County and has acted as the county's primary reservoir for decades. The lake itself is geographically located about 160 miles east of Eureka and is at an interface between the Modoc Plateau, Central Valley, as well as the Klamath Mountains meaning that it is in an extremely important location for a large amount of individuals. The area surrounding the lake, as well as itself, is almost completely underlain by rocks coming from both the Modoc Plateau and more importantly the rocks of the Klamath Mountains (Shasta Valley Wildlife Area, 2015). The topography of the region is actually highly dissected with the area being comprised mostly of canyons that consist of vertical relief ranging from the surface of Shasta Lake at 1,070 feet above mean sea level to ridges that are above 6,000 feet above mean sea level which is heavily a result of the actual properties of the rocks that are in the vicinity of the lake itself. Lake Shasta is approximately 46.87 mi² in area when at full capacity and is roughly 1,067 feet at surface elevation with its primary inflow of water coming from the Sacramento River as well as the Pit River.



Since California has become infamously known for its droughts and its vegetation has adapted to withstand dry conditions, it has become a reservoir of information for how vegetation and wildlife react to a long term drought. The main objective of this study is to conduct an analysis of Lake Shasta to identify as well assess the water level fluctuations that have been influenced by the longer term drought conditions which occurred between 2010 and 2014 (California's Drought, 2015). Specifically, we wanted to look at the the soil/water boundary around the lake in order to account for these changes. Any evidence of environmental change that we are able to discover through the processing of our data will be identified as either natural or anthropogenic. We are assuming in this instance that the soil/water boundary is the main indicator of water level fluctuation within Lake Shasta.

Methods

The data used in this project was sources from USGS Earth Explorer. The images used were collected from NAIP during 2010 and 2014 at 1 meter spatial resolution, 8-bit radiometric resolution, and a 4 band (red, green, blue, IR) spectral resolution. First we created our workspace by by making three subfolders labeled originals, working, and final within our project folder. We then bulk downloaded twenty-eight segments respectively of Shasta County data into the originals folder and opened ArcMap to begin mosaicing the twenty-eight tiff files together. Since we started off with twenty-eight tiff files we decided that it would be easier to work with then if we merged them all together into a single file: referred to as creating a “mosaic”. First we projected each of the rasters into the spatial reference of NAD 83, UTM Zone 10 North and saved them to our respective working folder. Next we opened ArcToolbox, selected “Data Management Tools”, then “Raster”, then “Raster Dataset”, and finally “Mosaic to New Raster”. Once this was done we added the twenty-eight tiff files as the “Input Rasters” in the “Mosaic to New Raster” dialog window and set the output location to within the working folder. Once this process was complete we had a single mosaiced .dat file. Once we had done this for both NAIP during 2010 and 2014 for Shasta, and had created two whole images, we opened them in ENVI 64-bit to use the NDVI tool to create reflectance values. With our two images opened within ENVI we first began working with the 2010 file. To start, we went to the ENVI toolbox and selected NDVI tool which opened the NDVI Calculations window and where we selected “Shasta2010.dat” as the input file. The NDVI Calculations Parameters window the opened up and we changed the bands to Red: 1 and Near IR: 4 and ran the calculations. After the calculations were complete we computed the quick statistics (min./max./mean/std.dev.) of the NDVI values of the entire image. Then we created a region of interest (ROI) of an area south of the lake and ran the statistics again. It was only after this was done that we then created an ROI for the shoreline of each respective image in order to determine the total miles that the lake spanned in the two different time frames that we picked (2010 and 2014). Since we were able to get the rough estimate of the shoreline length we were then able to estimate the actual water level that the lake was at for each respective year. This was done by using the data and information provided by Shasta Lake County which had rough estimates of water level based on shoreline length from data going as far back as 1985 (CDEC, 2015).

Results

The data presented below is based on the following bands that were coded as Red, Green, and Blue (RGB) for Landsat bands 3,4,5 and 4,5,3. The majority of the data that we acquired was from USGS Earth Explorer imagery which spanned from July 18, 2010 to July 27, 2014. The data that was collected was manipulated in order to indicate and show the degree to which the water level fluctuated within Shasta Lake during these two periods of time as a form of comparison. The bands were chosen in order to better represent water level fluctuations and in order to see a clear distinction between dry soil and the water boundaries.

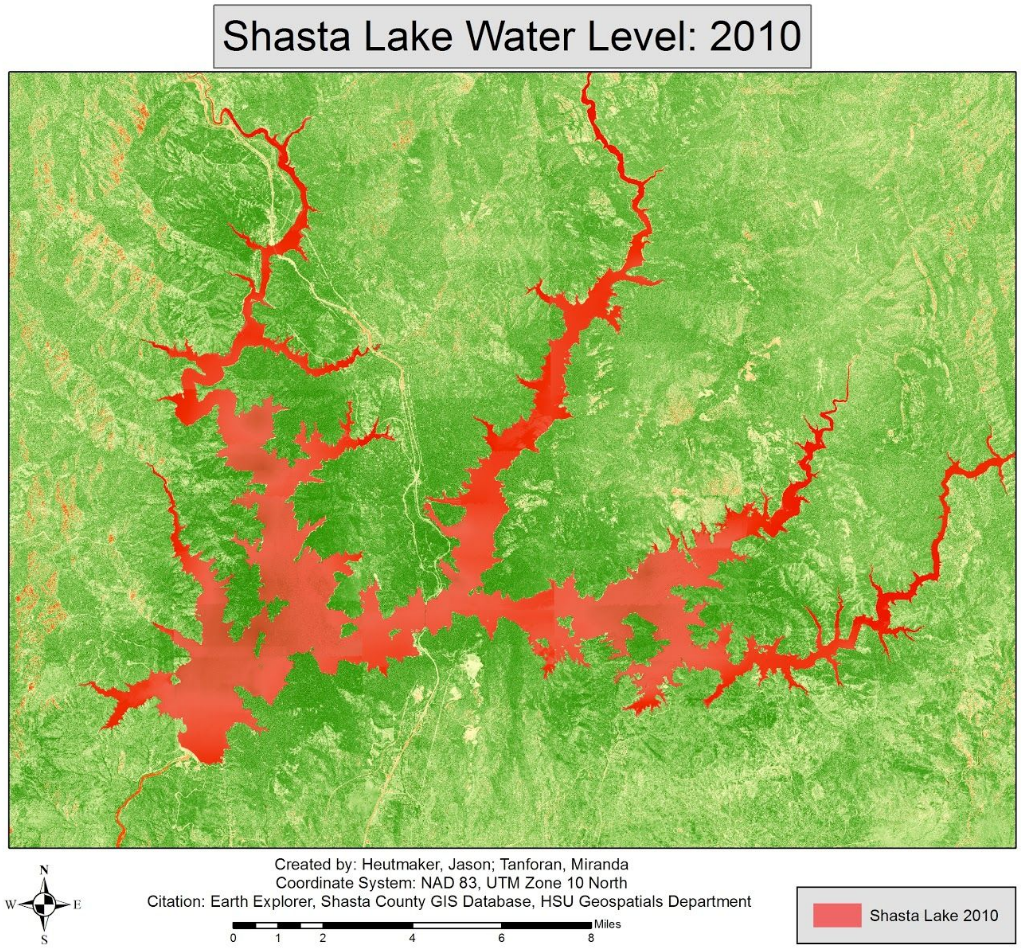


Figure 1. The Landsat data set from 2010 indicates the subtle soil and water boundaries along the shoreline of Shasta Lake. Notable shorelines are visible in the northern half of the Squaw Creek arm and the shoreline appears as light tan and brown. A sharp variation is present from the water (dark red and light red) and surrounding active vegetation (green). This image was acquired on July 18, 2010 when the reservoir was at approximately 68% capacity: based on the California Data Exchange Center (CDEC) data.

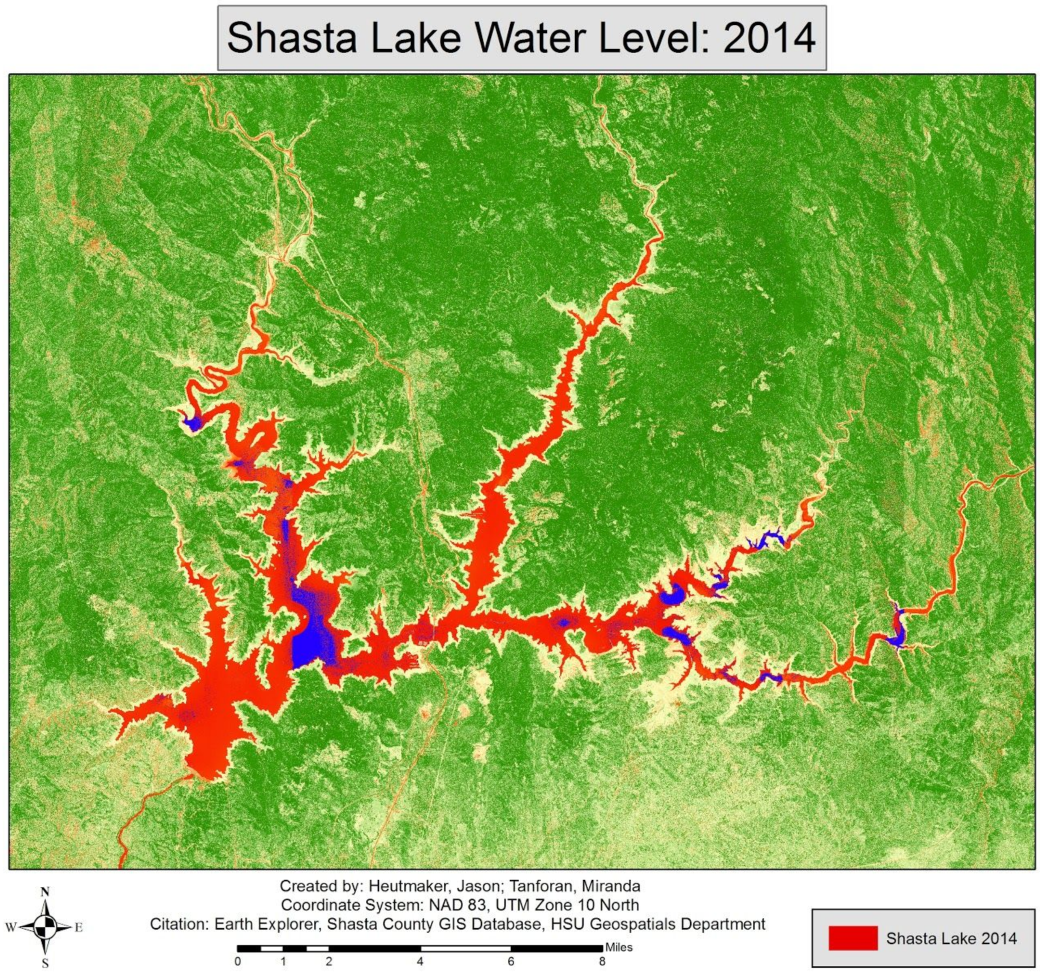


Figure 2. The Landsat data set from 2014 indicates the subtle soil and water boundaries along the shoreline of Shasta Lake in a composite image based on Landsat 8 Bands 4,5,3. The shoreline and water level appear to have drastically dropped from the year 2010. The shoreline has grown lake-wide, where the greatest increase is visible in the Pit River and Squaw Creek Arms. CDEC data indicates that the lake was at 32% capacity at the time this data was acquired.

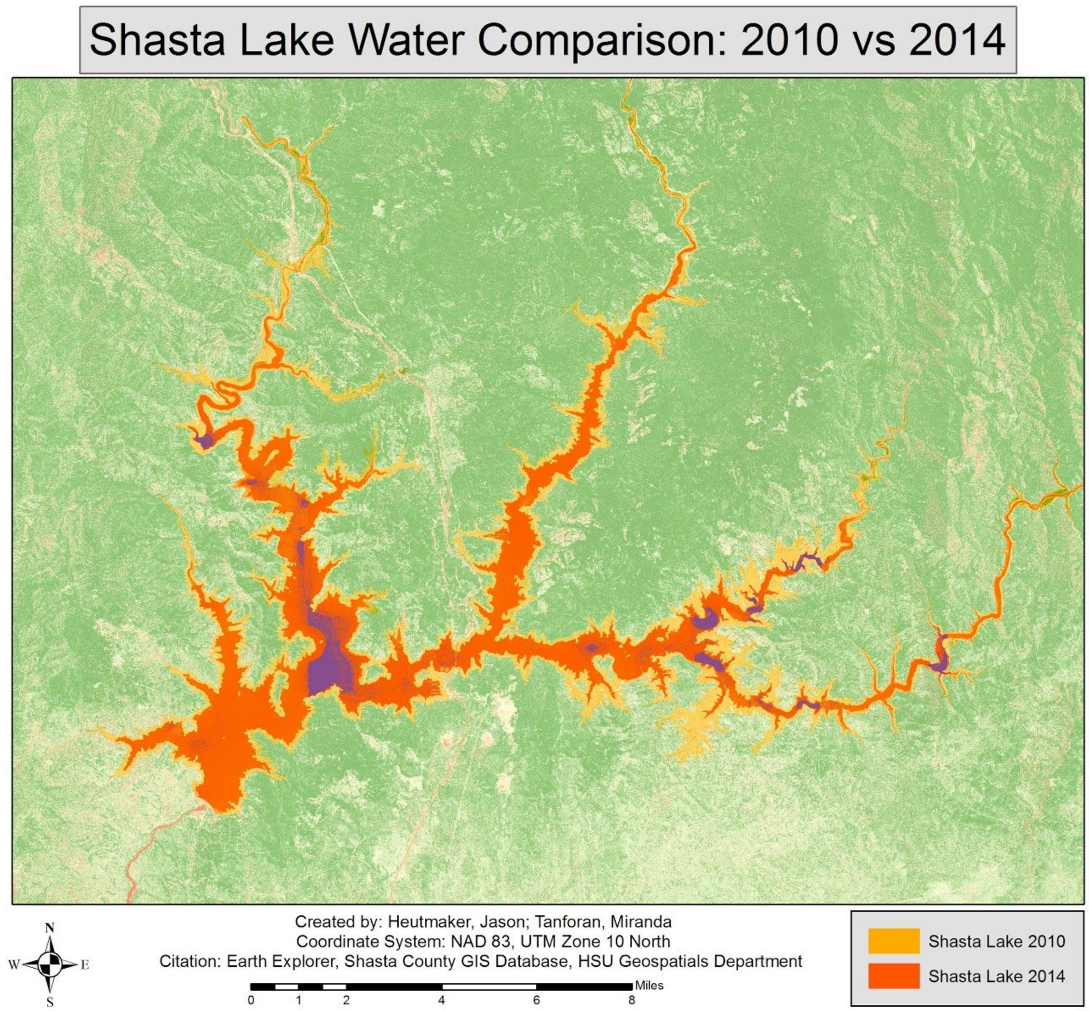


Figure 3. The Landsat data set from 2014 was overlaid on top of 2010 in order to better show the dramatic changes in the shoreline size.

Table 1.

Data Set	Min.	Max.	Mean	Std. Dev.
2010 NDVI	-1.0	1.0	0.117	0.150
2014 NDVI	-1.0	1.0	0.152	0.327
2010 NDVI ROI	-0.186	0.575	0.329	0.062
2014 NDVI ROI	-0.692	1.0	0.385	0.137

The computed results from ENVI show that 2014 had a greater amount of higher pixel values suggesting more healthy vegetation. However, it also has a larger standard deviation than 2010.

Table 2.

Date	Water Level (ft)	Shoreline Miles
2010 July 18	1049	347
2014 July 27	958	237

A correlation can be inferred between the elevation level of the water and shoreline length due to the drought (Shasta Lake Level, 2016).

Discussion and Conclusion

The peculiar thing about the pixel values is that, the mean of the drought year has a larger amount of bright pixels. Under NDVI, pixels that are closer to 1 indicate healthier vegetation. Based off of our results, it appears that 2014 has a greater amount of healthy vegetation than 2010. Since water is essential to plant health and survival, it is strange to see a drought year being more productive than a wet year. An explanation for this could be that it recently rained before the 2014 images were captured. Another explanation for the lower 2010 values could be from the sun-glare or other atmospheric disruption while the photos were being taken. We were able to conclude from the data we observed the the change in the overall amount of water in the lake decreased by 68% to approximately 32% filled. On top of this the length of the waters edge decreased by over 110 miles further supporting the fact that the prolonged drought in California has had enormous impacts on water levels, in the very least in Shasta and the surrounding counties. For future studies we recommend that more years be used (2010-2016) to show a progression of how the drought worsened over time or improved as well as a more detailed ROI for the shoreline. It would also be interesting to see if information regarding the inflow from the two major rivers into Lake Shasta decreased and to what extent this affected the water levels, and whether or not the dam played an artificial part in the lake overall water change. It would also be interesting to see if there were similar changes in dammed reservoirs across California. Further studies should be done to compare these findings to the rest of California and determine how large of an impact the drought has had on the vegetation and the wildlife that depends upon it.

References

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