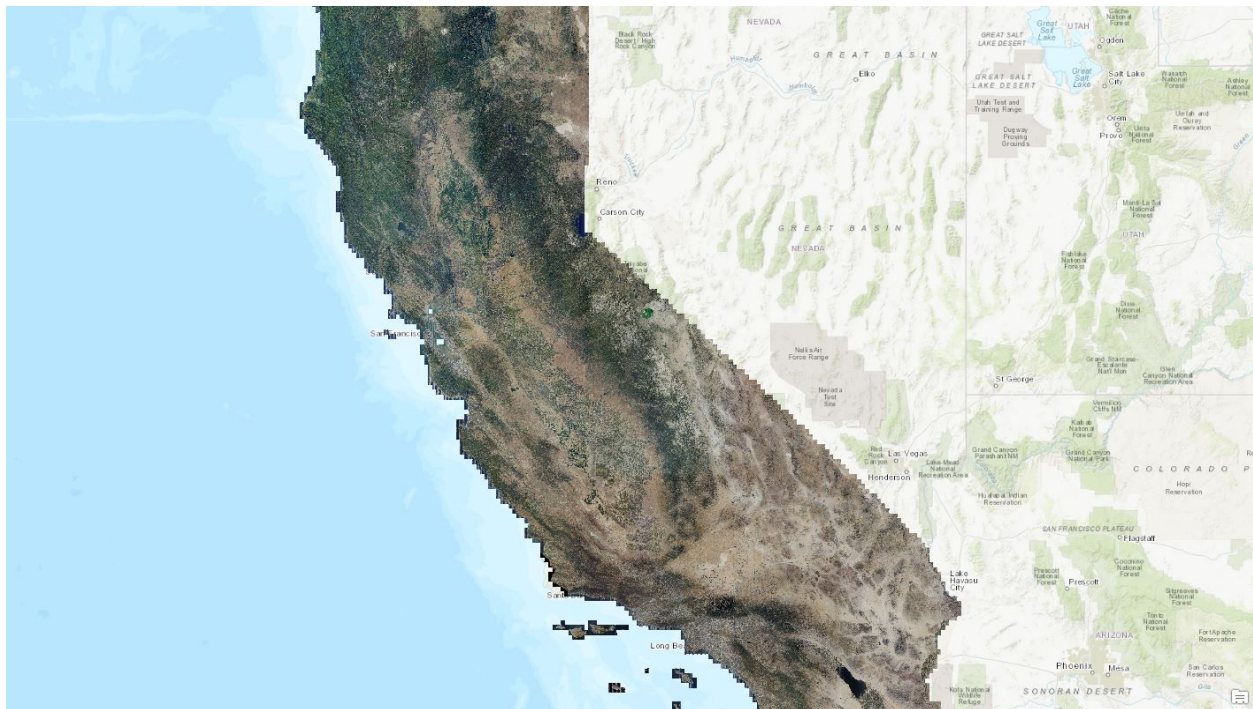


Showing Drought Stress In Sacramento Parks

As we all know, California has been in drought for quite some time. The Governor of California, Jerry Brown, officially declared a Drought State of Emergency on January 17, 2014. The drought had been ongoing and building before that declaration for at least five years. From this declaration all public and private entities were supposed to decrease their use of water. One area of water usage that was to be reduced dramatically was landscape irrigation. Sacramento, being the State Capital, should be at the forefront of water conservation efforts to set an example for the rest of the state. This being the case, most parks in Sacramento should show signs of stress, especially in the tree canopy and lawn areas.

For this project I have selected to analyze Capitol Park and the Old City Cemetery. Both are large green areas in Sacramento. These parks are managed by two different organizations. Capitol Park is managed by the State of California, Department of General Services, and the Old City Cemetery is managed by the City Parks Division of The City of Sacramento. The goal is to show canopy and lawn stress of the two parks by visually inspecting the NDVI analysis results from 4Band imagery of California, from 2009, 2012, 2016. These years were selected to show imagery from the beginning, middle, and towards the end of the drought.



This is an example of the 4Band imagery for California, showing the large extent. This area, being far too large to run the NDVI analysis in a timely manner, had to be clipped down to a more manageable size, so that the analysis process would take less time.



Clip examples of Capitol Park and Old City Cemetery

NDVI stands for Normalized Difference Vegetation Index. The chlorophyll in healthy vegetation reflects infrared wavelengths and green light and absorbs the red and blue light wavelengths.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

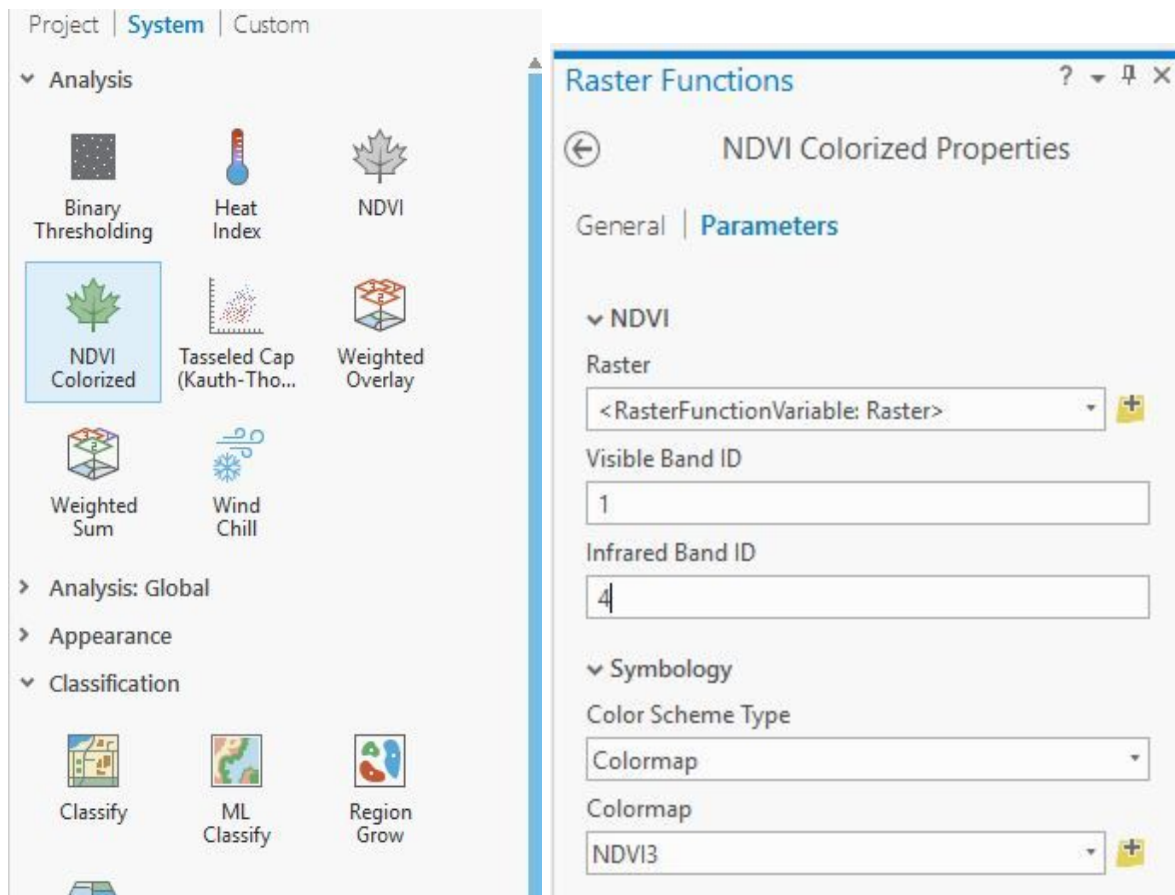
This equation generates values that fall between -1 and 1. Low reflectance in the red wavelength and a high reflectance in the IR wavelength gives a high NDVI value. High NDVI values equate to healthy vegetation. A low NDVI value means there is unhealthy vegetation or no vegetation. Using this analysis will help to show how the parks that were selected in this project may or may not have received more irrigation than the other and if NDVI is a good indicator for showing if irrigation levels may be more in one park as opposed to another.

To begin the process of analyzing the imagery a project was created in ArcGIS Pro. Data added to the project came from NAIP 4Band imagery from 2009, 2012, and 2016 of the whole state of California. To expedite the process of the NDVI analysis two parks were chosen and the imagery was clipped down to that imagery so that the whole state would not be analyzed when the process was initiated. Only Capitol Park and the Old City Cemetery were selected in the clipping process.



Old City Cemetery 2009 clipped 4Band imagery

After the clips were performed to limit the data processing to only the selected areas the NDVI analysis was initiated through the selection of the Raster Functions tool.



The Raster or image is selected from the list of image sets from the drop down list. The visible band entered is 1 for the red color band and 4 for the infrared band. After the information is entered the Create New Layer box is clicked to initiate the calculation. The result is then displayed in a new map layer that shows an NDVI colorized map image.



This is the NDVI colorized result of the 2009 4Band imagery of the Old City Cemetery. The darker green in the image corresponds with the tree canopy in the color image. This can be determined through close visual inspection of both maps, also by zooming in and out while viewing in ArcGis Pro. The orange and lighter orange corresponds to street surfaces and buildings.

The following is the clipped example of the clipped version of the 2009 4Band imagery of Capitol Park:



And then the corresponding NDVI colorized version:



From visual inspection a lot more green can be seen in this 2009 color image of Capitol Park and the NDVI image. As you can see the NDVI image really brings out and highlights the areas

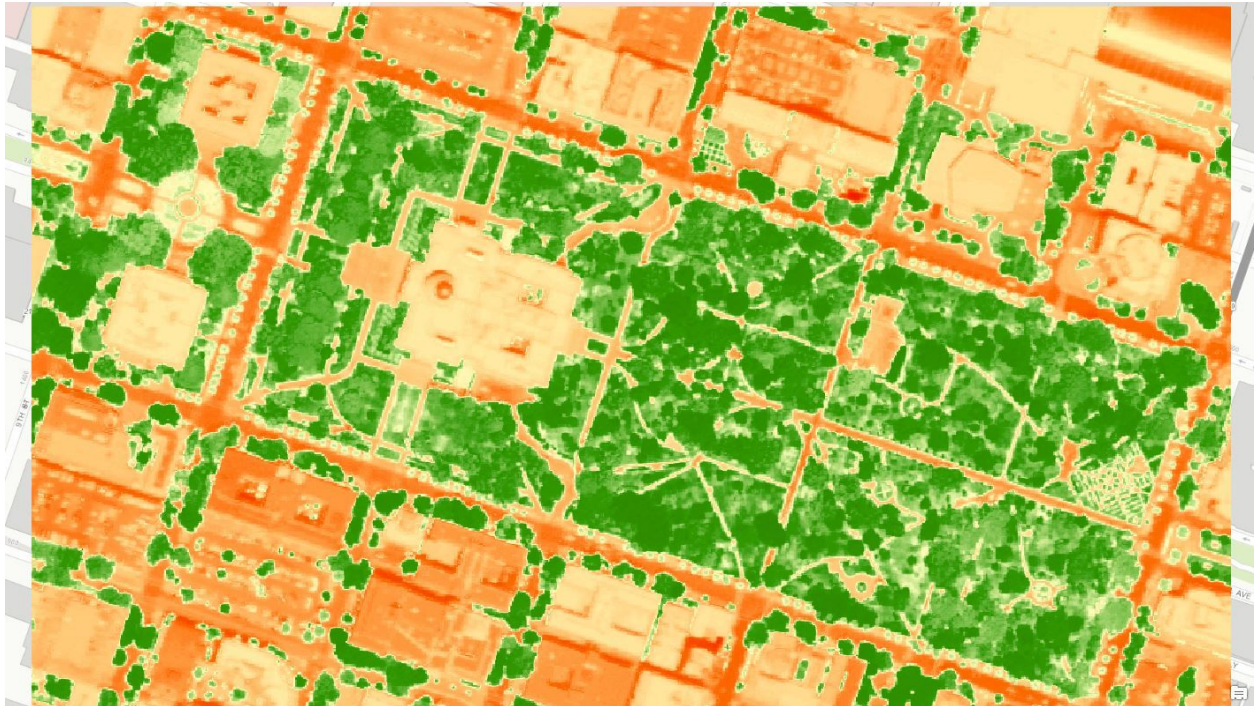
with no vegetation. Very little light green is seen within the park boundary. The light orange and dark orange correspond to areas of no vegetation and buildings.

In contrast, the 2009 NDVI color image of the Old City Cemetery shows more tan and light orange, especially towards the north side of the park. There is a lot more tan and light orange in the Old City Cemetery in 2009 than the 2009 image set of Capitol Park.

Here is the visible color image of Capitol Park from 2012:



And the NDVI color image from 2012:



As you can see the 2012 NDVI color image of Capitol Park is showing more tan and light orange, which may show more vegetative stress due to a decline in irrigation.

Next is the visible color image of the Old City Cemetery from 2012:



And then the NDVI colorized image of the Old City Cemetery from 2012:



A very significant increase in tan and light orange can be seen in this NDVI colorized image of the Old City Cemetery. Also the tree canopy is showing more stress with more lighter green color showing in the trees. The increase in stressed vegetation may be evident due to a decrease in the irrigation of this park. When the NDVI color image of the Old City Cemetery from 2009 is compared to the NDVI color image of the Old City Cemetery from 2012, a marked increase in stressed vegetation can be observed.

Now to move on to the 2016 visible color image of Capitol Park:



With the corresponding NDVI colorized image:



More tan and light orange can be seen within the park as well as lighter green in the tree canopy.

In the next images of the Old City Cemetery from 2016, even more stressed vegetation can be seen.

Visible color image, Old City Cemetery, 2016:



NDVI colorized image, Old Cemetery, 2016:



In this NDVI colorized image, almost every tree in the canopy is showing light green. All of the lawn areas are also a lighter green and tan.

Some problems were experienced during this project. When I first started the analyzation process, I neglected to clip the imagery to the specific areas that were to be analyzed. The first time I tried to run the NDVI tool in ArcGIS Pro I let it run for about an hour. While it was still running I reviewed my notes and realized that I had to perform and use the clipping tool to decrease the extent of the area that was to be analyzed. I then used the clipping tool on each area that was the subject of my project. After the clipping was done the NDVI analysis became much quicker. Also, I would have liked to have figured out the actual amount of “greenness” present in each NDVI colorized image. Instead of relying on just visual inspection I would have liked to have compared the two parks using a number amount or statistic to show that one park was receiving more irrigation than the other.

From the visual inspection alone, marked differences can be seen. The Old City Cemetery NDVI imagery shows much more drought stress in the vegetation than the same imagery of Capitol Park. Some conclusions can be drawn from this observation. The City of Sacramento seemed to be implementing a reduction in irrigation practices before the State managed Capitol Park. When you look at the NDVI images of 2009, the Old City Cemetery looks as if the irrigation was already being reduced. More stress can be seen starting in the 2012 NDVI imagery of Capitol Park and it also increases in the 2016 NDVI imagery. The increase in drought stress that can be seen in the Capitol Park imagery may also coincide with the emergency drought declaration made by the governor in 2014.

References:

"NAIP 4Band Layer 2009 California, NAIP 4Band Layer 2012 California, NAIP 4Band Layer 2016 California

<http://www.wildlife.ca.gov/Data/GIS/MapServices>

"Drought State of Emergency, January 17, 2014"

<http://water.ca.gov/waterconditions/declaration>

"What is NDVI (Normalized Difference Vegetation Index)?"

<http://gisgeography.com/ndvi-normalized-difference-vegetation-index>