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Climate Change Impact Analysis on Forest Cover- Sequoia National Park

Abstract

It is safe to say that climate change has significant impacts on the forest ecosystems of California. In order to evaluate the effects that climate change has on forests, GIS analysis has been done on a focused area to compare forest cover over a time period of 19 years. The area of interest chosen is Sequoia National Park, which has Evergreen, Deciduous, and Mixed-conifer forests that constitutes the overall forest vegetation. Although there are many factors that could contribute to changes in forest cover, such as significant fire events, bark beetle infestation, and human related factors, this analysis addresses climate change and its relationship with forest cover. It was hypothesized that the amount of forest cover between the years of 1992 and 2011 would decrease in size. However, using ArcMap tools to quantify the amount of change not only proved the hypothesis to be correct, it revealed a shocking decrease of 11.67% in forest cover. Considering that this project analyzes data up to 2011, one could only imagine what the amount must look like presently considering the fact that new maximum temperatures are being reached with each passing year. Analysis of forest cover in California's pristine National Parks must be done in order to determine what the community might do now and in the future to respond to the threat of climate change.

Introduction

Climate change has been a factor we are increasingly seeing the signs of every year. California as a state has seen major effects of climate change in terms of drought and abnormal temperatures throughout most recent years. With that being said, long periods of drought could trigger synergistic effects on forests, such as insect infestation, fire suppression, and tree mortality (Guarin 2005). We know that climate change affects vegetation, but it is not always in direct negative ways. A recent report looked at climate changes' effect in the Sierra Nevada's specifically and suggested that climate change may negatively impact the growth of forest vegetation, but not all species. In this report, they discussed how some species in the Sierra Nevada's actually grow more in years of drought, such as the Western White and Jeffrey Pine (Aubry-Kientz & Moran, 2017). A mixed conifer forest like the ones that inhabit the Sierra Nevada mountain range in California, consists of many varying types of trees including oaks, pines, and incense cedars. Sequoia National Park is a place of varying diversity, containing trees from low elevation oak woodlands to pines that reside in alpine regions. With this characteristic of diversity richness in mind, it can make this place even more vulnerable to change since different types of habitats are sprinkled throughout the park. In terms of forest cover, Sequoia National Park contains all 3 different classified types of forest which are mixed, evergreen

(conifers), and deciduous (hardwoods) with evergreen trees dominating most of the park. In the last 20 years, on a global scale we have seen minimum temperatures rise which gives way to many unforeseen effects on the natural vegetation of Earth. The seemingly rapid changing climate can cause pests such as bark beetles to thrive much longer and can promote fires to burn more readily since some regions can be more dry due to increasing temperature extremes. In this project, we seek to see how much forest cover has changed in this vulnerable region of the Sierra Nevada and possibly synthesize some reason as to why there is such a change.

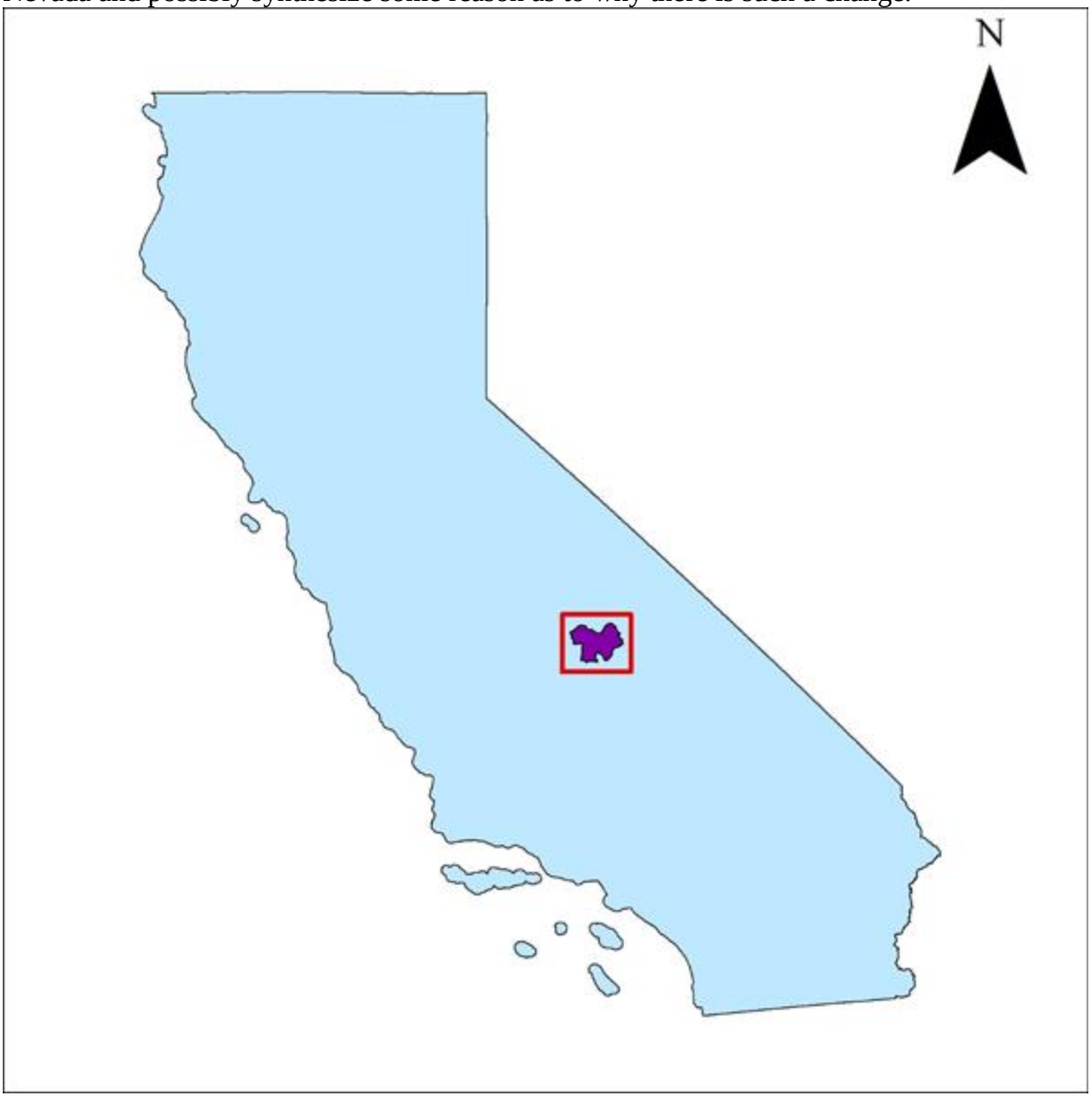

Figure 1. Location of Sequoia National Park (in purple) in relation to the state of California.

Methods

National Park Boundary Layer

The boundary layer of Sequoia National Park used in this project was found from the National Park Service vegetation inventory project. Because this layer had data that we did not need for our analysis, the **select by attribute** tool was used in order for us to retrieve just the park boundary from this layer. We selected 'Sequoia' from the "Select by Attributes" window, and exported this data into a new layer.

Land Cover Layer

In this analysis, land cover layers from 1992 and 2011 were used to evaluate how much climate change has had an effect on mixed-conifer forests of Sequoia National Park over a sizeable time period. We retrieved the land cover layers from the Natural Resources Conservation Service geodatabase. These layers contain raster data with a NICD cell size of $30m^2$. The spatial reference system of these layers is Albers Conic Equal Area.

In order to analyze forest vegetation ONLY from our selected land cover layers, the **select by attribute** tool was used. In the 1992 data layer, the attributes were classified by number values while the 2011 data layer attributes were classified by name. By comparing the attribute data of both layers, we concluded that forest vegetation for the 1992 layer is classified under 41, 42, and 43 as the attribute table corresponds with the 2011 layers' Evergreen, Deciduous, and Mixed forest. For the 2011 layer, in the "Select by Attributes" window, we double-clicked on "Landcover" within the box under Method and clicked on "Get Unique Values". The values that were selected were Evergreen, Mixed, and Deciduous. The following clause that we input is depicted below:

"Landcover" = 'Evergreen' OR "Landcover" = 'Deciduous' OR "Landcover" = 'Mixed'

For the 1992 layer, in the "Select by Attributes" window, we double-clicked on "Value" within the box under Method and clicked on "Get Unique Values". The values that were selected were 41, 42, and 43. The following clause that we input is depicted below:

"Value" = '41' OR "Value" = '42' OR "Value" = '43'

To extract the cells of the raster data that corresponds to the area of interest for this analysis, the **extract by mask** tool was utilized. The spatial analyst extension was enabled before using this tool. We input the 1992 land cover layer, "ncld1992", within the extract by mask window, and put the national park layer into the boundary. We named this "mask1992.img". The format selected was GRID. The output location for this step was put into our working folder. We exported this data into a new layer and renamed it "mask1". The extract by mask was also used for the 2011 land cover layer. We input "nlcd2011.tiff" within the extract by mask window, and put the national park layer into the boundary. We named this "2mask2011.img". After extract by mask tool was done, we exported the data into new layers.

In order to group together the different forest types as a single category, the **reclassify** tool was used. Within the reclassify window, our input was the "mask1992.img" and we changed our old values into "Nodata". The old values for this layer was 41, 42, and 43. We changed these values

and set the new value for all three to "1". We renamed this as "reclass_mask1992.img". We followed the same steps for the 2011 layer, and renamed this as "reclass2011.img".

To quantify how much forest vegetation has changed between the years of 1992 and 2011, the **field calculator** was used. The Edit mode must be enabled before applying the next steps. We started by adding a new field in the select by attribute table. This new field we input was "Area" and we selected "Double" from the drop-down menu next to "Type". The remaining setting were left on default and we clicked OK. In the attribute table, we right-clicked on "Area" and selected "Field Calculator". Under "Area", we following clause was input below:

[Count] X 900/10,000 = Hectares.

The percent change (loss) in forest cover between the two layers was calculated to be 11.67%.

Locator Map

The Sequoia National Park boundary layer found from the National Park Service website was used to show the location of the park in relation to the entire state of California.

Results

Through our analysis of the National Land Cover data gathered from Natural Resources Conservation Science agency, the difference between 19 years of data is more surprising than originally suspected. The amount of change in forest cover in this time frame alone encompasses 9,993.69 hectares (or approximately 24695 acres). Table 1 displays values that represent the amount of hectares of forest cover from both time periods (1992 and 2011). Forest cover constitutes deciduous, evergreen and mixed forests in both of the years the data was gathered from. In figure 1, any area where you can still see the blue color representing the year 1992's forest cover means that forest cover is now lost in comparison to the 2011 data. This means that it has either been burned in a fire, thinned/harvested, or possibly killed by pests or factors due to climate change. We expected to see some minor changes, but not an 11.67% decrease in forest cover in nearly 20 years. Climate data from the National Oceanic Atmospheric Administration was gathered to compare maximum temperatures as well as precipitation of both time periods. We hypothesized a trend of increase in maximum temperatures and a decrease in the amount of precipitation between the two time periods. The climate data revealed that 2011 was an abnormally wet year with more than twice the amount of precipitation during the winter months. The data also showed slight variation in maximum temperature and therefore was not a best fit representation of the trend between forest cover and climate data as shown in Figures 3 and 4. Overall, this analysis tells us that the change in forest cover is due to a culmination of factors, including climate change and human influenced changes on the landscape such as fire suppression which has led to much more severe fires killing off stands of trees. The areas in blue represent what has been lost up to 2011's data and majority of it seems to be near the west end of the park where the elevation is lower and is likely to be hit by more human influence and higher temperatures.

Table 1. Area of forest cover calculated in hectares in Sequoia National Park, California.

Year	Amount of Forest Cover (hectares)
1992	85,579.29
2011	75,585.60

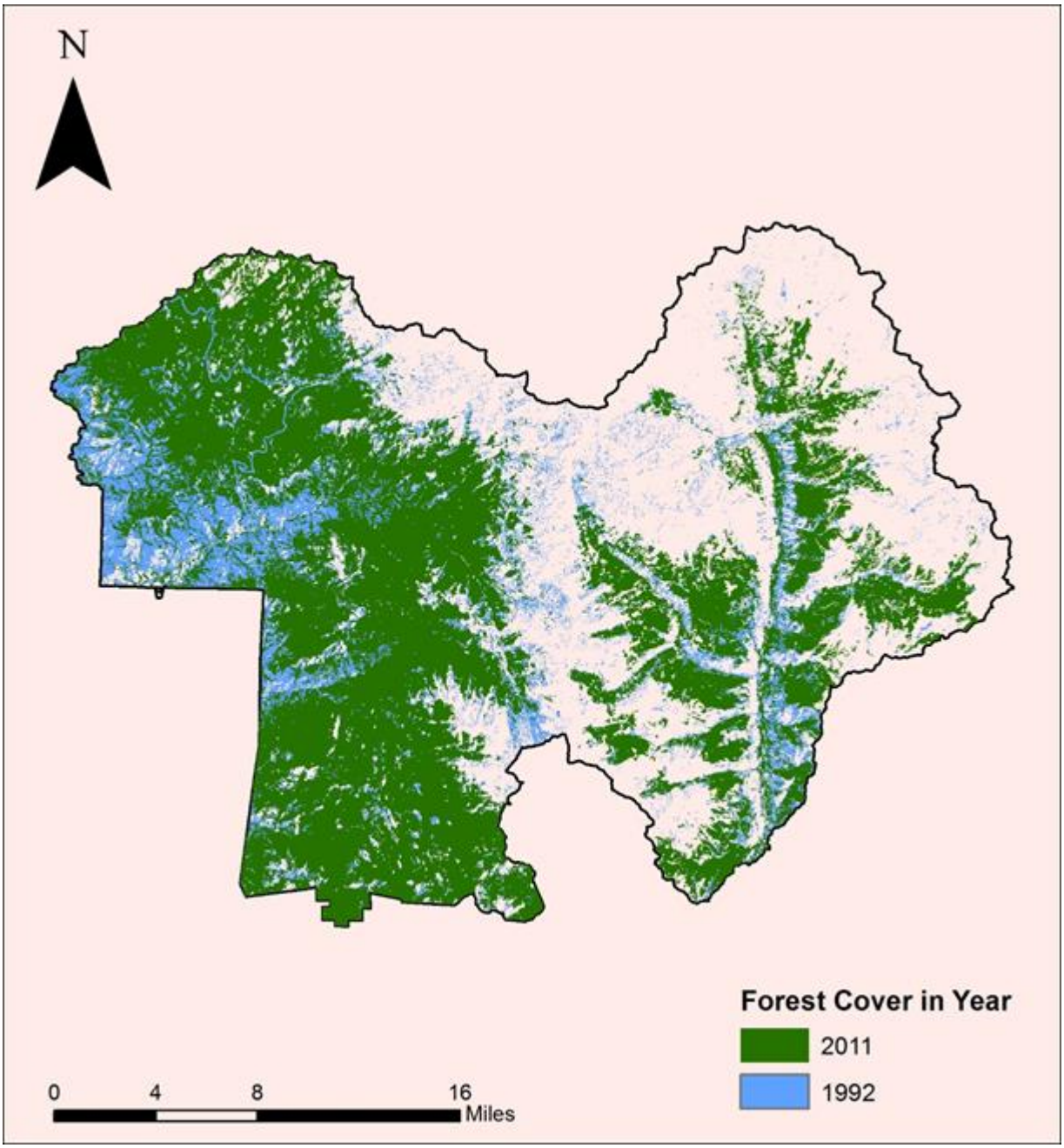

Figure 2. Map showing amount of forest cover in years 1992 and 2011 in Sequoia National Park, California, with data gathered from the National Land Cover Database.

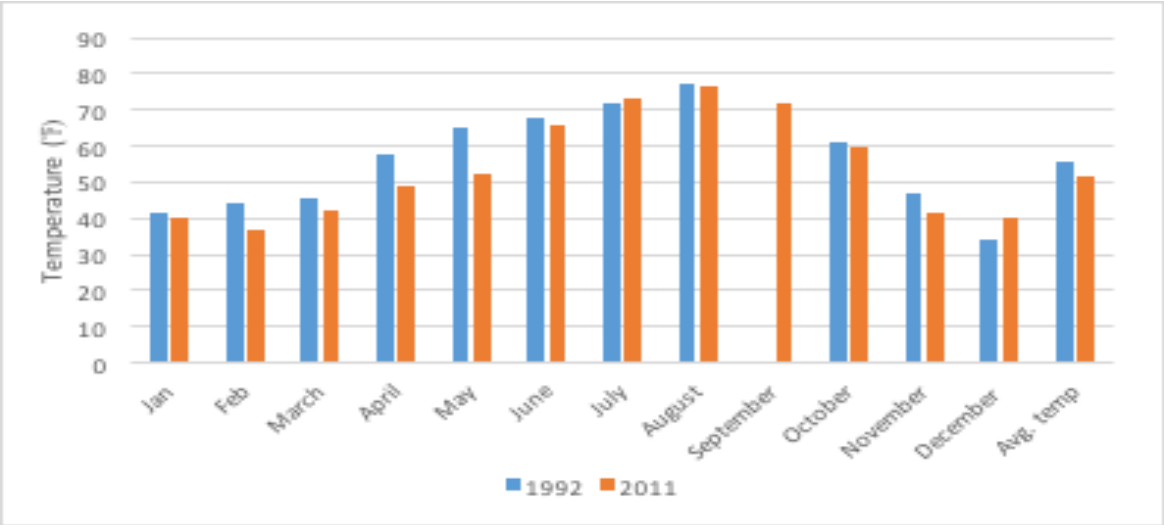

Figure 3. Bar graph showing the average maximum temperature by month for both 1992 and 2011 for Sequoia National Park, with data from the National Oceanic Atmospheric Administration website

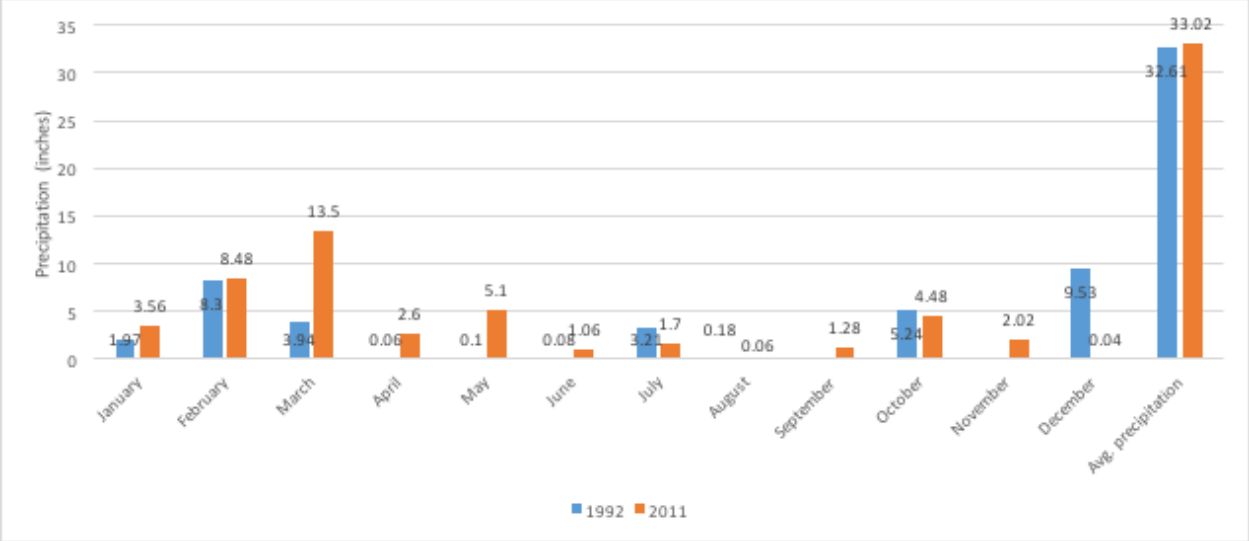

Figure 4. Bar graph showing the amount of precipitation by month in inches in the years 1992 and 2011 for Sequoia National Park, with data from the Western Regional Climate Center website

Conclusion

In this forest area cover analysis of Sequoia National Park, it is safe to say that humans have a strong influence on this drastic decrease in forest. To say it is from climate change exclusively is ignorant, but there is substantial reason to believe it is a major factor. As climate goes through more extreme changes, whether having more severe cold temperatures or longer seasons of high temperatures, it has influenced the growth patterns and the forests ability to react to fire when it does occur. Therefore, the loss of forest cover of 11.67% in our analysis can not be attributed to climate change strictly. Factors such as bark beetle infestations, more severe fires burning the landscape, and our own lack of resources to manage the forest have influenced it in a way where it can not regenerate like it used to. In retrospect, simply going off of the high temperatures and levels of precipitation from the 1992 and 2011 years is not a great gauge of climate change itself since it is a gradual process, but the seemingly extreme cool temperatures and heavy precipitation from those years is worrisome. If we could have analyzed climatic data differently, we would suggest looking at the yearly highs within the 19-year period. Even minor rises in averages could have big implications on any forest area which is why we would suggest closer analysis within each year. It would have also been useful to get more specific climatic data from specific areas like the riparian zone of the Kern river or the west side of the park that was lower in elevation since it was closer to the San Joaquin Valley. This may have given us a more realistic climate to compare to the amount of forest loss in those particular areas. If we continue at this rate of forest cover loss, the next generation may not have much to look forward to and these beautiful diverse landscapes could dwindle in size if we don't start taking precautionary forest management seriously in the next decade.

Acknowledgements

National Park Services Vegetation Mapping Project – Sequoia National Park

Natural Resources Conservation Science – Land Cover Data (1992 & 2011)

National Oceanic Atmospheric Administration- Climate Data

References

Aubry-Kientz, M., & Moran, E. V. (2017). Climate impacts on tree growth in the Sierra Nevada. Forests, 8(11), 414. http://dx.doi.org/10.3390/f8110414 Retrieved from http://ezproxy.humboldt.edu/login?url=https://search.proquest.com/docview/1977825367?accountid=11532

Guarin, A. (2005). Drought Triggered Tree Mortality in Mixed Conifer Forests in Yosemite National Park, California. Forest Ecology and Management, 218(1), 229-244. https://www.sciencedirect.com/science/article/pii/S0378112705004664