Drought: Comparing Historical Data to understand the Recent Drought Impacts on the Tuolumne River

Megan Nguyen

Ecogeomorphology

UC Davis Center for Watershed Sciences

6/26/15

Intro to Drought

California has a Mediterranean climate which means it has a cold, wet winters and hot, dry summers. However, recent climatic trends show shorter winters and longer summers with less snow and more rain. The dictionary definition of a drought is a prolonged period of abnormally low rainfall and there are two main types: meteorological and hydrologic drought. A meteorological drought is a period of below normal precipitation and a hydrologic drought is a period of below average runoff (DWR 2015). Droughts occur gradually and the impacts are amplified as the drought period continues to extend. In California, there are two major river indices for the San Joaquin and Sacramento River. The index quantifies all unimpaired runoff flow in million acre-feet within a water year which spans from October to September of each year. The index value allows us to classify each year into 5 different water year types classifications: wet, above normal, below normal, dry, and critical. It is important to note that there is no classification for a normal year because precipitation trends are highly variable in precipitation and stream flow each year (Null 2013).

Since 2012, California continues to be in the largest drought period of the last forty years (DWR 2015). The average San Joaquin River index for the past 3 years is 1.68 which classifies this period as critically dry. The effects of climate change are apparent, California's weather patterns will continue to change and exacerbate the drought effects that can be observed statewide. By comparing historical precipitation and runoff data from the last forty years to identify critically dry periods, I can use this information to understand how the drought will impact the Tuolumne River.

Flow of the Tuolumne

The Tuolumne River headwaters begins at Lyell glacier found on top of Mount Lyell in Yosemite National Park. It then flows down into Hetch Hetchy Reservoir where it is pumped to San Francisco. The river continues to flow downstream into the Valley and eventually meets with the San Joaquin River flowing for a total of 149 miles from top to bottom. During the dry months of summer, the glacier gradually melts and feeds the Tuolumne River. This phenomenon is known as the snowmelt recession which can be seen on a typical hydrograph. However with climate change changing precipitation patterns, the glacier is not able to replenish itself. In fact, we are seeing a glacial recession more and more each year. Using discharge data I collected at Tuolumne Meadows, I hope to see how much water is flowing each year from the glacier and analyze if this data will reveal any significant information that will help us understand the drought impacts of 2015.

Mount Lyell and the Lyell Glacier August, 1901. Photo by G. K. Gilbert (courtesy USGS)

Same view in September 2011. Note that the eastern (left side of photo) lobe of the glacier is mostly gone.
Photo by Jonathan Byers

Methods and Analysis

The historical data period will span from the last forty years, 1975 to present. I will be using the San Joaquin River index and water year classification to categorize the last 40 years. After the historical data is collected, I will compare these findings to the field surveys conducted on the Tuolumne River to see if there are any significant impacts of the drought.

Table 1: The San Joaquin River Classification

Classification	Requirement
Wet	Equal to or greater than 3.9
Above Normal	greater than 3.1, and less than 3.8
Below Normal	Greater than 2.5, and equal to or less than 3.1
Dry	Greater than 2.1, and equal to or less than 2.5
Critically Dry	Equal to or less than 2.1

Table 1 shows the index value range that helps classify water year types set by the State Water Resource Control Board Water Quality Control Plan.

The Department of Water Resources published a chronological reconstructed water year hydrologic classification index. By taking these values, I created a graph to help visualize the classification.

Figure 2: San Joaquin River Index from 1975-2014

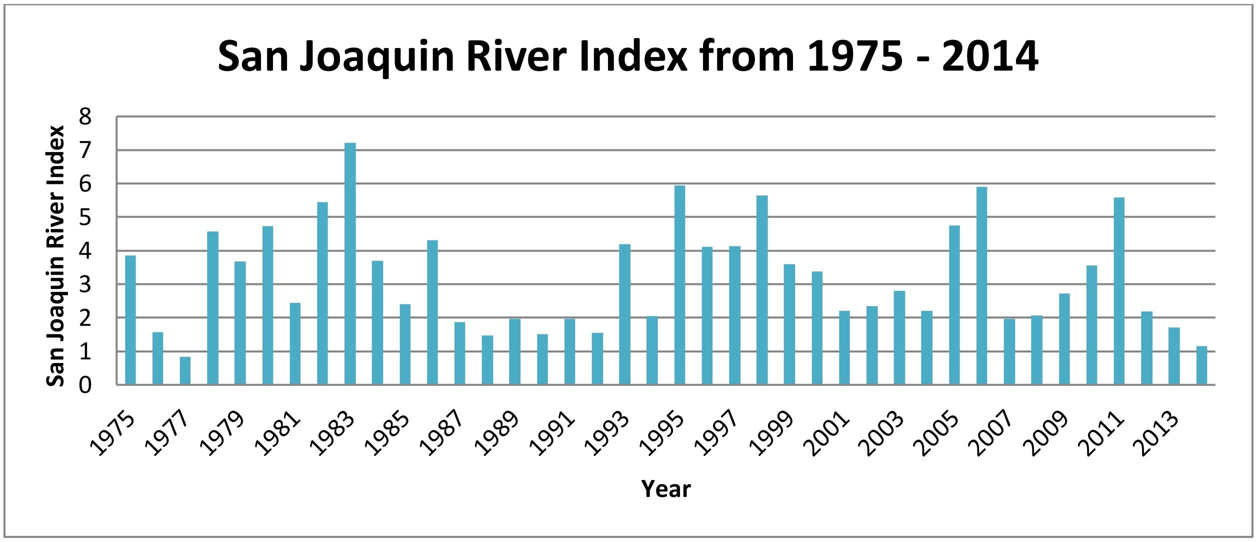
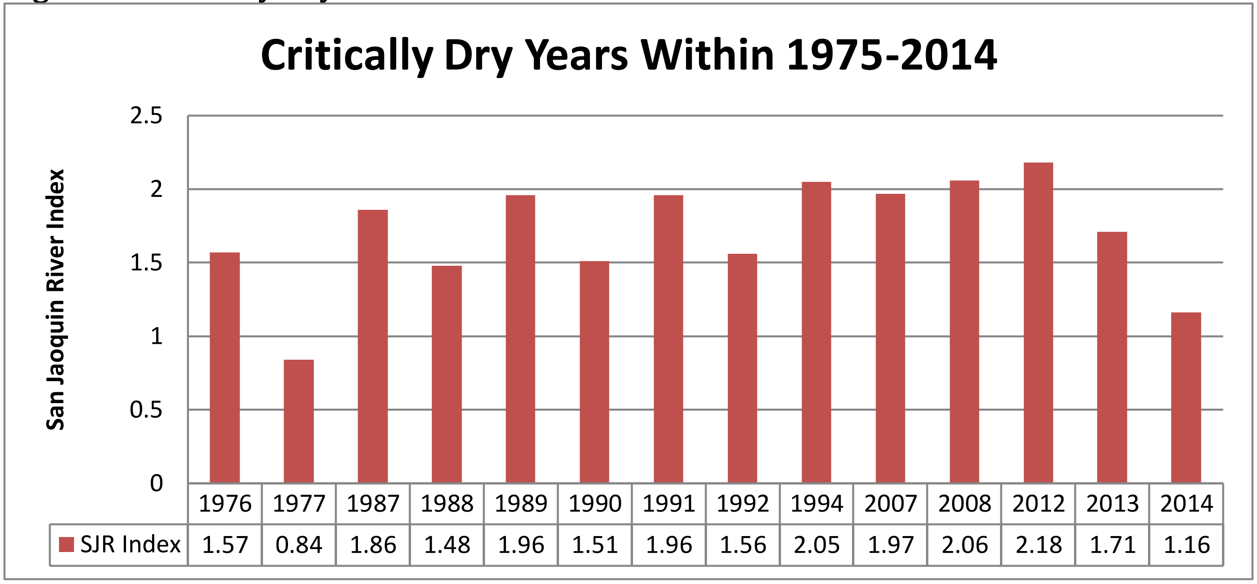


Figure 2 shows the index information from 1975 – 2014. Data is collected from the Department of Water Resources

Within these past 40 records, I extracted the years that were classified as critically dry, the years with the least amount of water.

Figure 3: Critically Dry Years Within 1975-2014

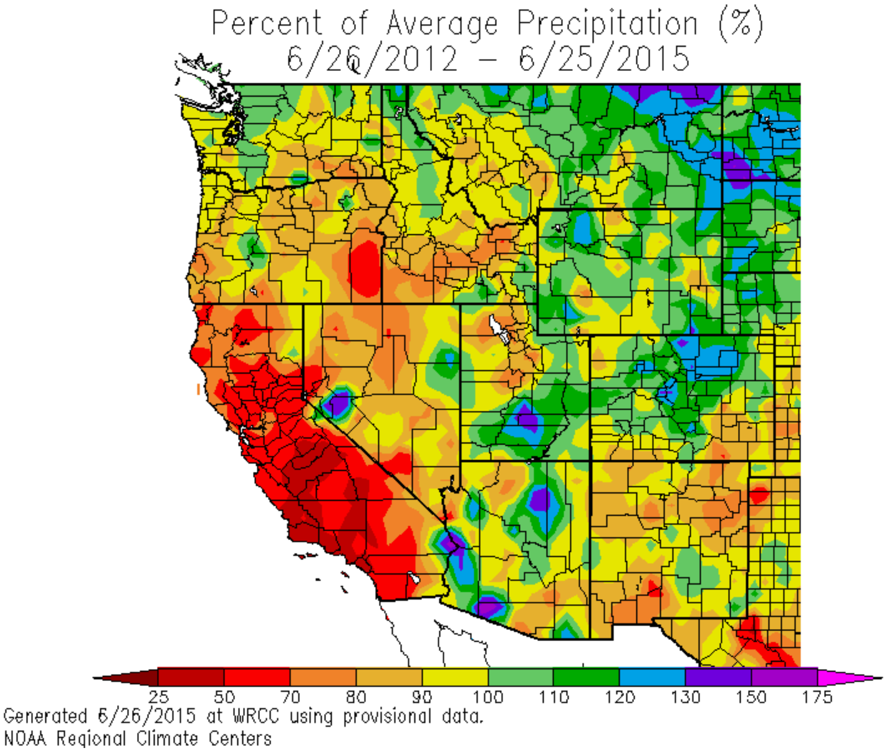


	1976	1977	1987	1988	1989	1990	1991	1992	1994	2007	2008	2012	2013	2014
🟥 SJR Index	1.57	0.84	1.86	1.48	1.96	1.51	1.96	1.56	2.05	1.97	2.06	2.18	1.71	1.16

Figure 3 shows the years that are classified as critically dry. Data is collected from the Department of Water Resources

The index for 2014 is the lowest since 1977 with a declining trend since 2012. In Figure 4, it is apparent that California has been severely lacking precipitation for the past three years. This is an unusual occurrence when compared to the Average annual precipitation in

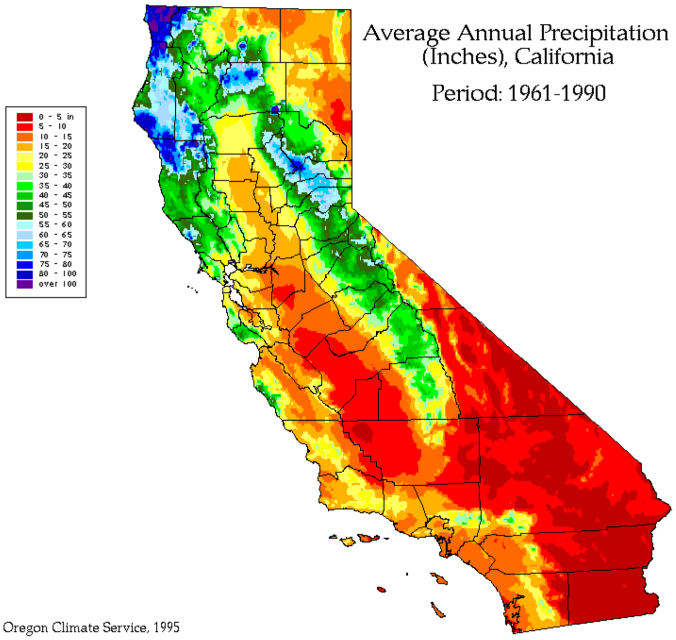
Figure 4: Percent of Average Precipitation for the Past 3 Years



Generated 6/26/2015 at WRCC using provisional data.
NOAA Regional Climate Centers

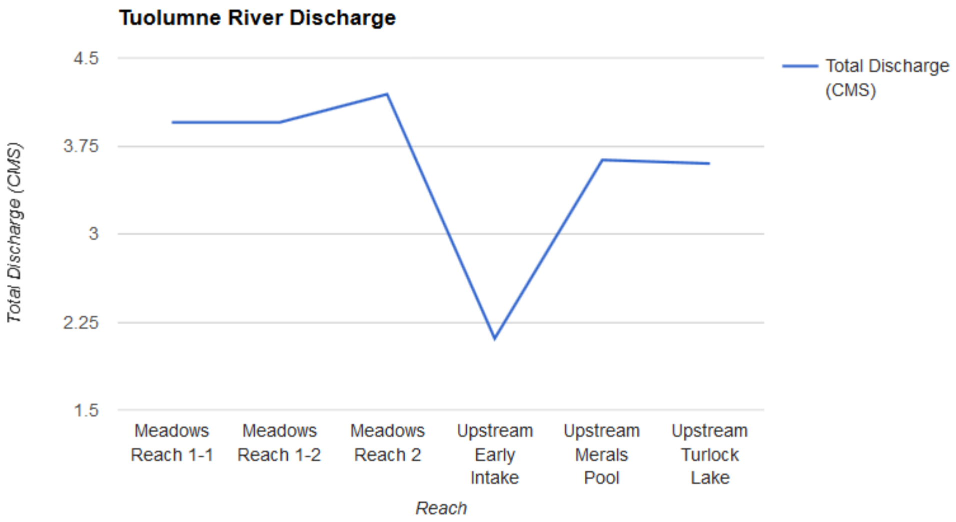
California from 1961 to 1990 as seen in Figure 5. Figure 5 shows that there are certain parts of California that receive less rainfall than other parts, but the entire state still has precipitation events, especially in Northern California. The current index prediction for 2015 using San Joaquin Valley index is 1.4, classified was critical.

Figure 5: Average Annual Precipitation (Inches) in California from 1961 - 1990



Oregon Climate Service, 1995

Using a wading rod, my team and I collected stream velocity which we used to calculcate total stream discharge up and down the Tuolumne River. The results yielded the following depicted in Figure 6.



It is hard to make a judgement from just a single dataset. However, we can use this data to compare to previous years to see if there is evidence of drought impacts present at Tuolumne Meadows.

Conclusion

The current drought period has existed for the past 3 years. The longer we experience the dry period, the worse our water conditions get. Looking at historical data, we can compare the severity level of the current drought period to the periods experienced in the past. Climate change continues to threaten receding glaciers which could jeopardize California's overall water supply. It is important for scientists and policymakers to understand the impacts of the drought in order to make informed decision of the future of California's water supply

Future Steps

If I had more time, I spend it looking for yearly average run off and precipitation data for each critically dry year and compare them to each other. Then I will perform a simple t-test to test the significance of severity across all critical years. Another approach I could take is to find snowpack and precipitation data of just 2015 and compare that to the total discharge of the Tuolumne River at different reaches. With this data, I can scale up this study to make assumptions across historically critical periods.

Acknowledgements

I'd like to thank the instructors of Ecogeomorphology: Dr. Peter Moyle, Sarah Yarnell, Ryan Peek, Carson Jeffres, Eric Holmes, Sasha Liedman, and Devon Lambert for their wisdom and

guidance. I’d like to also thank my fellow classmates who helped collect all the field data and made this trip unforgettable. And lastly, thank you to the Center for Watershed Sciences who made this trip possible.

Bibliography

Null, S. E., and J. H. Viers (2013), In bad waters: Water year classification in nonstationary climates,Water Resources Research, 49, doi:10.1002/wrcr.20097.

California Department of Water Resources (2009), California Water Indices. California Water Plan Update 2009. Vol. 4 Reference Guide.

Milly, P.C. et al., 2008. Stationarity is dead: whither water management? Science, 319, pp.573-574.

Cayan, D.R., E.P. Maurer, M.C. Dettinger, M. Tyree, K. Hayhoe. 2008. Climate change scenarios for the California region. Climate Change. DOI: 10.1007/s10584-007-9377-6.

Appendix I River index Calculation and Water Year Characterization. < http://www.hrc-lab.org/projects/projectpdfs/INFORM_REPORTS/FINAL_PHASE_I/HRC%20Technical%20Report%20No.%205%20-%20Appendix%20I.pdf>