Groundwater and Poverty

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Background:

According to the United States Drought Monitor the state of California has been in a record-breaking period of drought since the year 2012. Only in recent months has the majority of California counties seen an increase in precipitation, snowpack, and reservoir levels, which indicates an end to the drought. However, one of the biggest problems that the state faces lies deep below the surface hidden from public view - groundwater reserves. The Groundwater Foundation defines groundwater as, "the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers." What this means is that majority of "available" drinking water is stored underground and is attainable through access to surface water reserves and well drilling. Surface water includes lakes, rivers, and reservoirs, while wells refer to public (state recorded) and private pumping of groundwater for a variety of reasons. In our research we found access to well data for over 4,000 wells in California, which listed their primary water use for irrigation and residential needs.

Going into this project we found that groundwater reserves supply 51% of the U.S. population with drinking water, and that six million people in California rely on groundwater as their main source of water. These six million people mostly reside in cities and counties associated within an agricultural setting rather than an urban setting. This information led to our research question, Do groundwater levels have any correlation to poverty? Can we predict which counties are the most at risk during a drought? We wanted to see if we could find a correlation between well use and the poverty percentage of the county it was located in, so that we could highlight which counties were the most at risk during times of drought.

Methods and Data:

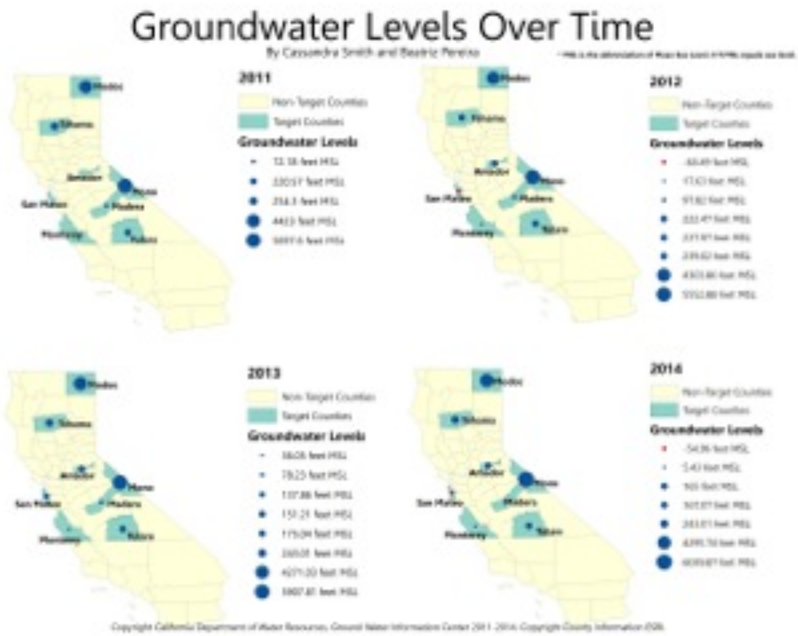
Data and Assumptions:

PERSONS IN FAMILY/HOUSEHOLD	POVERTY GUIDELINE
1	$11,670
2	15,730
3	19,790
4	23,850
5	27,910
6	31,970
7	36,030
8	40,090
For families/households with more than 8 persons, add $4,060 for each additional person.	

Each map included data from the US Census Poverty Rates. Above is the poverty threshold that the US Census based its poverty statistics off of in 2014. Each map also used data from the California Department of Water Resources Groundwater Information Center and county border lines from the mgisdata we downloaded from ESRI for our labs. The last map included data we found in arcGIS online that was created by the FracTracker Alliance using information from the Word-wide Hydrogeological Mapping and Assessment Programme, that mapped out the different types of aquifers underneath California.

When starting our maps, we had to deal with a few assumptions. The first was that the well data that we were able to obtain would be a good average for all the wells in the state. The CDWR probably only had access to public wells, and not every county would reveal their data every year. We also could not be sure that the same wells were being measured every year. For the poverty data we collected, the US census threshold is based on averages for the entire country, not just California, so we had to trust that the states averages were close to the national averages.

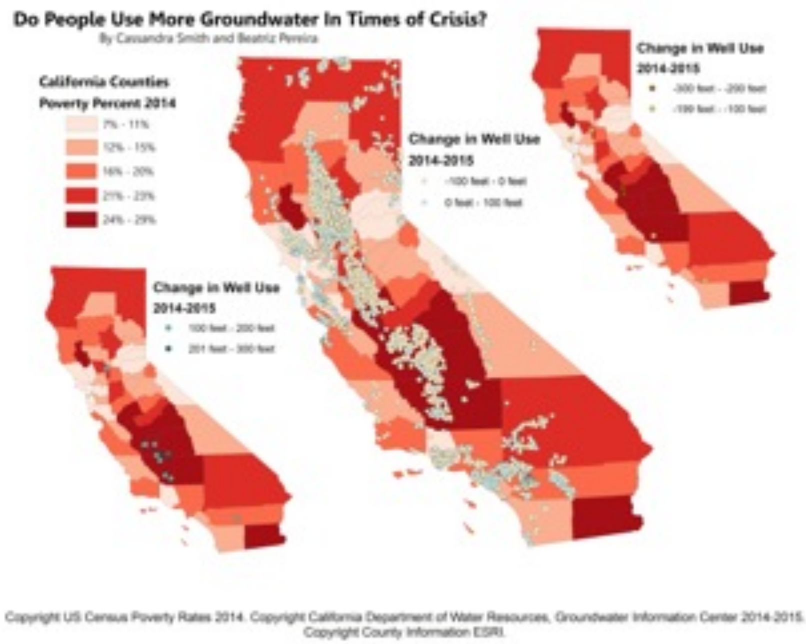
Map 1:



We downloaded water elevation data for the years 2011-2014 from the California Department of Water Resources. By using poverty data from the US census, we selected 8 counties that ranged in income, resources, and population to more accurately represent the entire state's well usage from 2011 to 2014. We separated out the wells by county for each selected county, averaged them, then created a graduated symbol map for each year to see change over time.

When it came time to analyze the map, we realized that the lack of data was more telling than the actual data. In 2011, 3 of the 8 counties did not make their well data public. This was before the public was really concerned about the drought - all we knew is that when we turned the tap on, water came out. As the drought became more severe, people started to become more concerned with water usage, so more data was made public due to demand. If you look at our map, the only county to show any extreme change was San Mateo. It went from -60 feet in 2012 to 137 feet in 2013, only to fall back down to -55 feet in 2014. Considering San Mateo has the lowest poverty rate of all the California counties, they have the resources to change water sources if one becomes depleted. The other counties we focused on, on average, stayed pretty consistent.

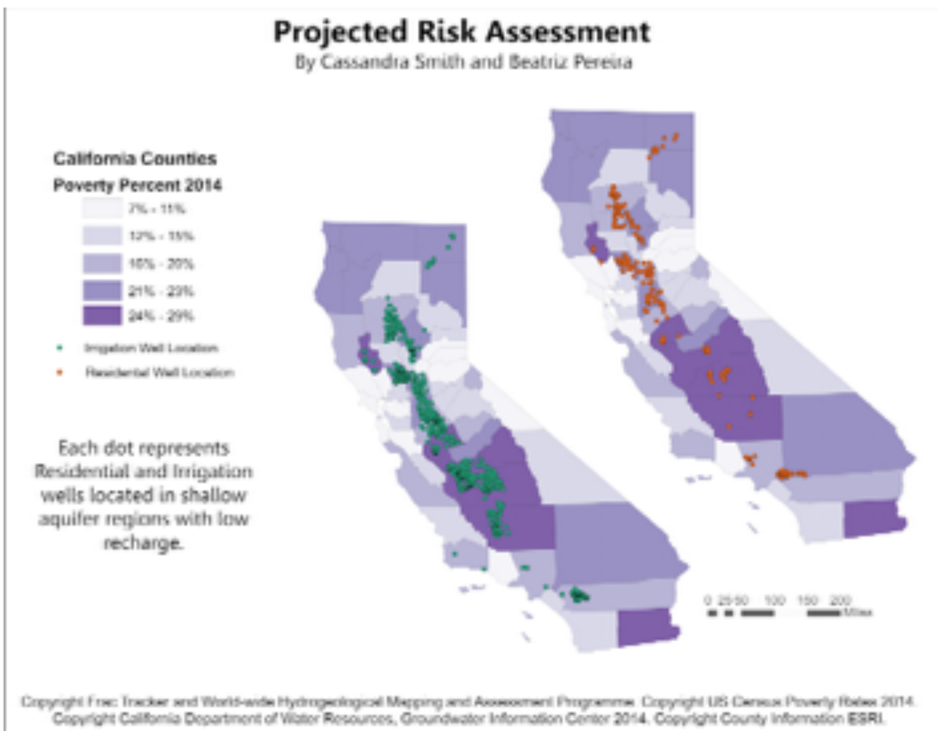
Map 2:



We used data from the 2014 US Census to map out poverty rates in all 58 California counties. The data was only offered as a standalone table, so we joined it with a shapefile of the California counties that we got from mgisdata, so that we could create a graduated color map of poverty rates over the state. We also downloaded the change in water levels in wells over the year of 2014. We created another graduated color map of the severity of the change in water levels and placed it over the map of poverty rates to see if there was any correlation. Because of the sheer amount of well data we had (more than 4,000 wells), we separated the data by categories of severity to make the map easier to read.

As you can see when looking at the map, there is not much of a correlation between well water level change and poverty. A large majority of the wells barely changed - the average was about -1ft. This was the pattern across the entirety of the state. The few counties that had wells that ranged in more than a -100 ft reduction were the same counties that saw a more than 100 ft increase in water.

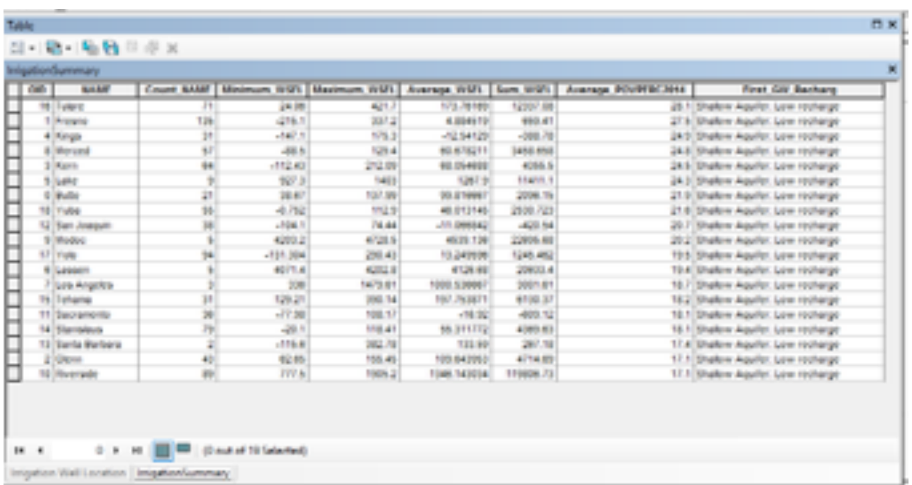
Map 3:



For our last map, we wanted to see if we could discover which counties were the most at risk when you took poverty, well use, and aquifer levels into consideration. We intersected the data from california counties, US census poverty rates for 2014, aquifer types, and well use. For irrigation we searched by attribute so that we would only have the wells that were located on a shallow aquifer with low recharge, above average poverty rates (about 17%), and that the wells were used for irrigation. For residential we did nearly all the same categories as above, but instead of irrigation we used residential use wells. We created layers from these selections and placed them on a map that showed a graduated color map of poverty rates to compare results.

As you can see when looking at our map, the most at risk wells are used for irrigation and located in the Central Valley. While there may not be a correlation between groundwater usage and poverty, the communities with the highest poverty rates are always hit the hardest during any natural disaster. The Central Valley has the highest poverty rates and is located above a shallow aquifer with a low recharge rate. The counties that need the most help are the ones with the least amount of resources.

Summary statistics for irrigation wells:



Table

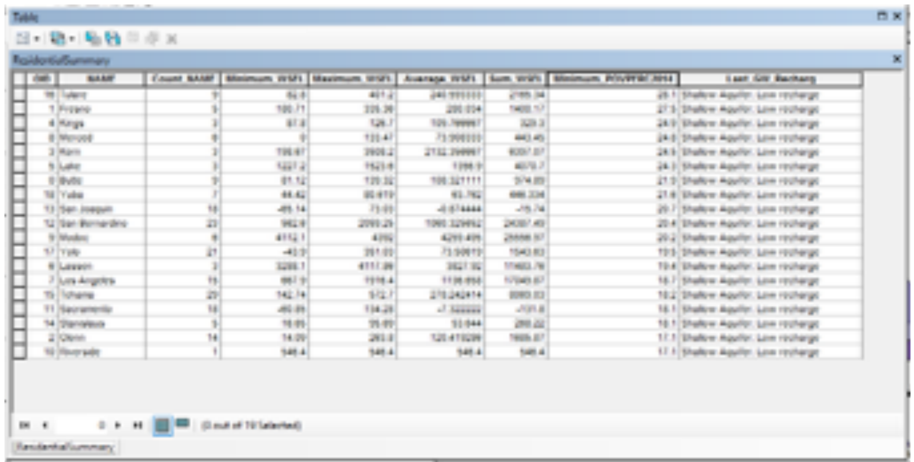
IrrigationSummary

OID	NAME	Count_NAME	Minimum_WSEL	Maximum_WSEL	Average_WSEL	Sum_WSEL	Average_POVPERC2014	First_GW_Recharg
16	Tulare	71	24.06	421.7	173.78169	12337.08	28.1	Shallow Aquifer, Low recharge
1	Fresno	126	-276.1	337.2	4.884619	693.41	27.6	Shallow Aquifer, Low recharge
4	Kings	21	-147.1	175.3	-12.54129	-300.70	24.9	Shallow Aquifer, Low recharge
8	Merced	57	-88.5	129.4	60.678211	3458.658	24.8	Shallow Aquifer, Low recharge
3	Kern	44	-112.42	212.09	93.054068	4056.5	24.5	Shallow Aquifer, Low recharge
5	Lake	9	927.3	1403	1267.9	11411.1	24.3	Shallow Aquifer, Low recharge
0	Butte	21	39.87	137.99	99.878667	2098.76	21.9	Shallow Aquifer, Low recharge
18	Yuba	55	-0.752	112.9	46.012146	2530.723	21.6	Shallow Aquifer, Low recharge
12	San Joaquin	38	-104.1	74.44	-11.099842	-420.54	20.7	Shallow Aquifer, Low recharge
9	Modoc	5	4203.2	4728.5	4635.136	22605.68	20.2	Shallow Aquifer, Low recharge
17	Yolo	94	-131.394	295.43	13.249936	1245.452	19.5	Shallow Aquifer, Low recharge
6	Lassen	5	4071.6	4202.8	4126.68	20633.4	19.4	Shallow Aquifer, Low recharge
7	Los Angeles	3	336	1473.81	1000.539967	3001.61	18.7	Shallow Aquifer, Low recharge
15	Tehama	31	129.21	390.14	197.763871	6130.37	18.2	Shallow Aquifer, Low recharge
11	Sacramento	36	-77.36	108.17	-16.92	-609.12	18.1	Shallow Aquifer, Low recharge
14	Stanislaus	79	-20.1	118.41	55.311772	4369.63	18.1	Shallow Aquifer, Low recharge
13	Santa Barbara	2	-115.8	382.78	133.49	267.78	17.6	Shallow Aquifer, Low recharge
2	Glenn	45	62.85	155.45	105.842052	4714.83	17.1	Shallow Aquifer, Low recharge
10	Riverside	89	777.6	1905.2	1346.143034	119806.73	17.1	Shallow Aquifer, Low recharge

(0 out of 19 Selected)

Irrigation Well Location | IrrigationSummary

Summary statistics for residential wells:



When we created the summary statistics above, you can see that the same counties pop up for both irrigation and residential wells. The 5 counties with the highest poverty rates (Tulare, Fresno, Kings, Merced, and Kern) are prominent on both lists. All 5 counties are large agricultural counties.

<u>Future Research:</u>

If we had unlimited time and resources, we would like to continue mapping out groundwater elevation for every county over every year, from 2011 to present, to see if water usage trends have changed over time, since the public has become increasingly aware of the drought. We would also take the time to go to the people in the counties that we discovered to be have the highest vulnerability to the drought and see how they actually cope in their daily lives.

<u>Conclusion:</u>

At the start of our project we set out to find a link between well usage/groundwater levels and poverty percentages of counties, so that we could figure out which counties have the highest risk of low groundwater levels during and after times of drought. However, at the end of the project we could not confirm a direct correlation between well water levels and poverty levels. Our research data showed that there was a stronger relationship between the geographical location of the well and whether or not the water table had a high or low recharge. Based on the geographical information we were able to infer that many of the counties that are located within the Central Valley are some of the most at risk locations during and after times of drought. Another factor that played into our results is that we did not have access to records and data of all the wells in California. Following the 1990 U.S. Census, citizens no longer had to report their source of water. Resulting in decades of unknow water data on private and inoperable wells that with knowledge and access to could have changed our results.

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