CHANGES IN LAND PARCEL DIVISIONS AND RESIDENTIAL WATER DEMANDS IN THE SALMON CREEK WATERSHED SINCE 1863

Official map of Sonoma County, California, 1900

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Intermittent streams in northern California are fascinating in that they provide complex homes for salmon, allowing these fish to choose the best habitats depending on their changing needs year round. During the wet season, streams swell and flow more rapidly- they need space to spread out. During the dry season, streams partially dry up, sometimes becoming a series of unconnected, individual pools. Salmonids need cool temperatures, and rely on different kinds of habitat at different times. Salmon use deep pools, large woody debris, and overhanging banks to escape wading birds and terrestrial predators, and as shelter from fast currents during floods. Human activities that alter the dynamic nature of such stream habitats place salmon survival at risk.

1 INTRODUCTION

The Salmon Creek Watershed is located in the southwestern coastal region of Sonoma County in northern California.[1] Approximately 35.3 square miles in total area, the watershed includes the towns of Bodega, Occidental, Freestone, and Salmon Creek.[1] With its steep topography and its erosive soils, the watershed has a low groundwater water storage capacity and is identified as a water scarce region.[1]

Within the Salmon Creek Watershed, 95% of the land is currently privately owned.[2] A 2010 study found that 73% of all water use in the watershed was for residential purposes.[1] Water supplies for the watershed's inhabitants include groundwater wells, springs, and direct instream diversions.[1] But under a Mediterranean climate, characterized by hot, dry summers and cool, wet winters the water supply in the Salmon Creek Watershed is often insufficient to meet local human demands during the dry season.[1]

In the Salmon Creek Watershed, coho salmon and steelhead trout were known to be robust to variable climate and ocean conditions and to Native American fishing practices for thousands of years.[1,3] This changed in the last century however.[1] Although there are few official records that document fish populations in the watershed, anecdotal evidence suggests that wild steelhead populations diminished after the 1970s.[3] In 1996 the last wild coho was seen in the stream.[1] While the reduction of steelhead and the extirpation of coho have many causes, all forms of water extraction for human use have direct and indirect cumulative impacts on the fish in these local streams.[1]

My goals for this research project were to document the change in the number of parcel divisions and to estimate the change in total residential water demands for the

watershed, in the last 150 years. I explored the connection between land use, residential water demands, and salmon. This work became the first step in an analysis that relates salmon survival to residential land use change.

2 METHODS

2.1 Changes in the number of parcels

I used Sonoma County parcel maps to determine the change in the number of parcels within the Salmon Creek watershed in the last 150 years. I obtained original 1863, 1900, 1934 and 1980 Sonoma County parcel maps from UC Berkeley libraries and a 2014 Salmon Creek Watershed parcel map produced by the Gold Ridge Resource Conservation District in Sonoma County (Table 1). I photographed and digitally scanned the parcel maps and used these images to create new adapted maps for this study. I overlaid an outline of the Salmon Creek Watershed obtained from GIS shapefiles developed by Prunuske and Chatham, Inc. on the images of the original maps using Photoshop C6, an image-editing computer software.[2] I printed the adapted maps and I manually counted the number of parcels within the watershed outline on each map. For the 1863, 1900, 1934, and 1980 maps, I counted owner name or identification number labels when the lines outlining parcels were unclear. For all the maps, I counted parcels whose areas were more than fifty percent within the watershed outline.

2.2 Estimated residential water demand changes

I defined residential water demand as the average amount of water used for the home. I estimated the change in residential water demands in the last 150 years using two different water demand factors, or water demand averages: 7,000 gallons per residence per year and 90,000 gallons per residence per year. Using anecdotal experiences shared by local residents, I determined the first average to be appropriate for the earlier period of 1863-1934, before water-intensive appliances and landscape irrigation became common. Similarly, I selected the second average, which is based on a professional 2003 study that determined more recent water use trends specific to the Salmon Creek watershed area, to reflect water use for the later period of 1980-2014.[4] For every parcel that I counted in 1863, 1900, 1934, 1980, and 2014, I assumed that there was one residence per parcel. I estimated the total residential water demand for each study year by multiplying the number of parcels I counted with the corresponding residential demand factor.

3 RESULTS

3.1 Changes in the number of parcels over time

The number of parcels within the Salmon Creek Watershed steadily increased between 1863 and 1980, and most notably increased in the last thirty years from 1980 to 2014 by more than 400% as shown in Figure 1.

3.2 Estimated residential water demand changes over time

I estimated that residential water demands proportionally tracked the growth of parcels from 1863 to 1934 and from 1980 to 2014. The most distinct increase in residential water demands occurred between 1934 and 1980, when demands increased by 25 times as shown in Figure 2.

4 IMPLICATIONS

High development trends for the Salmon Creek Watershed are most notable after the 1970s. A 2003 pilot study of groundwater conditions in Sonoma County identified the Joy Road study area, which was defined as a 9 square mile area that is partially located within the northeastern part of the Salmon Creek Watershed, to primarily consist of residential land use with some vineyards.[4] The pilot study determined that between 1974 and 2000, a 26 year span, the Joy Road area experienced a 113 household increase.[4] During the same time, the Joy Road area had a 107 parcel increase, with a rate of 4 additional parcels per year.[4] From my research, I determined a parcel increase rate of 23.7 parcels per year for the entire Salmon Creek Watershed during a 34 year span from 1980 to 2014. The Salmon Creek Watershed is 4 times the size of the Joy Road study area. While development in the Joy Road area is more concentrated than the development in the rest of Salmon Creek Watershed, their rates of parcel growth during the same time period is proportionally comparable.

The 2003 pilot study states that increases in water demands should be proportional to residential growth.[4] The Sonoma County Permit and Resource Management Department estimates that there is potential for further development in the Joy Road area, with space for 159 more units.[4] This additional development would lead to an estimated water demand increase of 51 million gallons per year.[4]

Increased residential growth in other areas of the Salmon Creek Watershed are likely to intensify local water scarcity problems as well as further degrade the fish habitat in local streams. Even though we don't know exactly how residential use compares to streamflow, we suspect that streams are drier overall as a result of residential

diversions, and agricultural diversions also likely play a role. During the wet season, rainwater is not allowed to recharge groundwater in paved, urban areas and is instead drained out in the form of flash floods. Consequently, stream banks erode. During the summer, streams have less water by default. Low summer streamflow is further exacerbated by continuous human demands. When streams experience reduced summer flow, they can dry completely or have pools that become smaller and consequently warmer. The combined indirect effects of human activities on streams lead to the the loss of salmon habitat complexity year round.

Members of the Salmon Creek Watershed and surrounding areas can protect their land from future residential development by placing their land in a land trust or adding it to a local park. While it may not be feasible to limit further development entirely, efficient development where more growth does not necessarily translate to more water use can be promoted. This involves practicing water conservation strategies such as enhanced groundwater recharge, water use monitoring, and the use of rainwater harvesting technologies, among others. Additional water conservation recommendations adequate for the Salmon Creek Watershed area can be found in the 2010 Salmon Creek Water Conservation Plan and the 2010 Salmon Creek Integrated Coastal Watershed Management Plan. On a statewide level, the first groundwater regulation legislation in the history of California will be implemented in the next decade. Salmon Creek Watershed residents can become involved in the formation of a local groundwater sustainability agency (GSA).

5 RECOMMENDATIONS FOR FUTURE STUDIES

5.1 Using more maps

In this study, I looked at roughly 30-40 year intervals of time (1863, 1900, 1934, 1980, 2014). In order to obtain a more complete representation of the growth in the number of parcels in the last 150 years, I recommend looking for maps between the 1934 and 1980 time period in order to reduce the 46 year gap in my study. Also, given that the most rapid rate of parcel growth occurred between 1980 and 2014, it would be worthwhile to follow this period more closely.

5.2 Improving residential water demand estimates

While I felt it important to consider that water consumptive activities in a rural home varied during different times, these specific activities and the amount of water each of these activities required were difficult to track, especially for the period of 1863-1934. As a result, for the period of 1863-1934, I estimated average water use for a rural home in

the Salmon Creek Watershed based on the experiences of rural residents who hauled water for daily home use. These residents had similar daily water consumptive activities that ranged from cooking, and bathing, to raising animals for food purposes. When estimating residential water demands for this period, I was limited to these methods. Additionally, for all years studied (1863, 1900, 1934, 1980, 2014), I assumed that each parcel represented one residency. With this assumption, I may have under- or over-estimated the number of residencies actually existing for every year I studied.

Improvements to my water demand estimates could include obtaining more anecdotal water use information specific to the watershed from 1863-1934 and using more accurate numbers of total residencies for all years studied.

5.3 Linking residential water demands to streamflow

Future research could look at how residential water use compares to summer stream volume. This could include modeling streamflow under different water and land-use scenarios, including increased rainwater harvesting conservation, and groundwater recharge.

6 CONCLUSION

I explored the linkage between land use, residential water demands, and salmon populations. I used historical Sonoma County parcel maps to document the change in the number of parcel divisions within the Salmon Creek Watershed in the last 150 years. From 1863 to 1980 the number of parcels in the Salmon Creek Watershed rose at a fairly steady rate, adding an average of about one new parcel per year. Between 1980 and 2014 this rate increased dramatically as 805 parcels were added in 34 years, translating to a growth rate of 23.7 new parcels per year. My residential water demands were roughly estimated to track residential growth proportionally. Furthermore, with the lack of consistent fish data for the Salmon Creek Watershed, I was not able to look at residential development and salmon populations simultaneously for the same time periods. Despite the limitations of this study, my analysis provides a baseline for future studies looking at historical rural residential water demands in northern California and their links to salmon survival.

7 ACKNOWLEDGEMENTS

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funded organization that helps to translate community research questions into projects that university students can carry out.

8 REFERENCES

1. Salmon Creek Water Conservation Plan. Prunuske Chatham, Inc. June 2010.
2. Salmon Creek Integrated Coastal Watershed Management Plan. Gold Ridge RCD and Prunuske Chatham, Inc. June 2010.
3. Harrison, Katherine, “Salmon Creek Oral History Project” in Salmon Creek Estuary: Study Results and Enhancement Recommendations , Appendix, Prunuske Chatham Inc., 2006
4. Pilot Study of Groundwater Conditions in the Joy Road, Mark West Springs, and Bennett Valley Areas of Sonoma County, California. Kleinfelder, Inc. September 2003

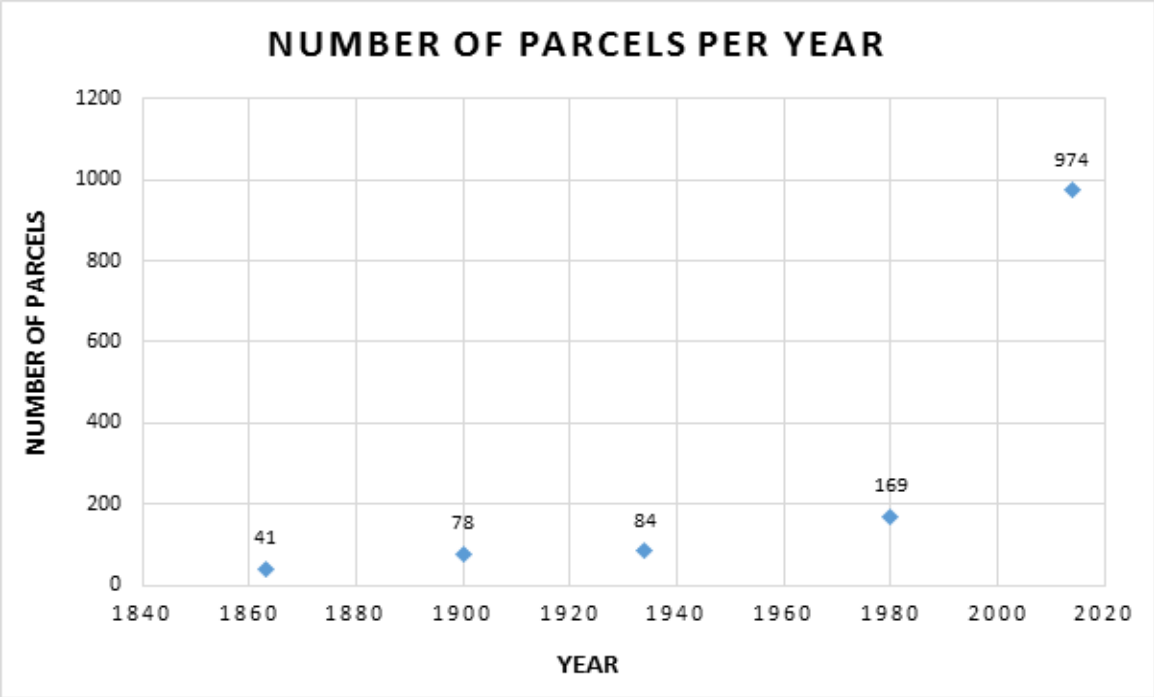
9 APPENDIX

9.1 Table 1. Citations and locations of original maps used

Year	Citation	Location
1863	Map of Sonoma County, California / made and published by A.B. Bowers, in accordance with an act of the Legislature, approved 28 March 1863.	Earth Sciences and Map Library, UC Berkeley
1900	Official map of Sonoma County, California: compiled from the official maps in the county assessor's office, with additions and corrections to June 1st, 1900 / by L.E. Ricksecker, City Engineer of Santa Rosa, ex County Surveyor and W.B. Walkup, publisher.	Bancroft Library, UC Berkeley
1934	Official map of Sonoma County, California/ Compiled and drawn from official records, by E.A. Peugh, County Surveyor.	Earth Sciences and Map Library, UC Berkeley
1980	Sonoma County property ownership maps, plat book & guide 1980	Earth Sciences and Map Library, UC Berkeley
2014	Map by Gold Ridge RCD, 31 March 2014	Gold Ridge RCD

*The maps created for this study, which were derived from the original maps listed here, are stored by the Salmon Creek Watershed Council.

9.2 Figure 1. Graph showing the number of parcels in the Salmon Creek Watershed



9.3 Figure 2. Graph showing the estimated residential water demands for the Salmon Creek Watershed