US House of Representatives, Natural Resources Committee
Subcommittee on Oversight and Investigations
RE: Virtual Meeting July 15,2021 on Coho salmon and 6PPD-quinone
Testimony of Witness Sue Kuehl Pederson, Self Represented
Answers to QFRs, August 12, 2021

Questions from Committee Members

Oversight Hearing titled, *"Are Toxic Chemicals From Tires And Playground Surfaces Killing Endangered Salmon?"*

Questions from Rep. Louie Gohmert for Ms. Sue Kuehl Pederson, Fisheries Biologist

1. *You mentioned that there are already many well-established tools for filtering pollutants from streams. Can you go into more detail about the best methods?*

ANSWER: Dear Honorable Congressman Louie Gohmert of Texas,

Over approximately the past 40 years, I estimate several thousand scientists and engineers in the Pacific Northwest have refined tools for improving streams and aquatic habitats, with demonstrated success. Concepts such as "adaptive management" and "best available science" have been instrumental in building on previous lessons learned, which continues in this field. Collaborative efforts among diverse agencies and organizations, as in this study, have aided the collective process and progress.

Your question about "best methods" is rather difficult to answer because of the extensive amount of work already done, and the challenge of no two streams being alike. Here is a very small, non-exclusive sample of some sweeping technical documents that guide salmon stream restoration on the west coast, and include names and organizations that may be helpful:

2004—King County Best Available Science, Chapter 7, Aquatic Areas
https://your.kingcounty.gov/dnrp/library/2004/kcr1562/BAS-Chap7-04.pdf

2010—California Salmonid Stream Habitat Restoration Manual, 4th Edition
https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=22610&inline

2012—Stream Habitat Restoration Guidelines, Washington Dept Fish & Wildlife
https://wdfw.wa.gov/sites/default/files/publications/01374/wdfw01374.pdf

That said, my own habitat restoration experience tells me that in many Northwest streams, much can be done to improve salmon streams based on relatively simple concepts. Usually the first consideration is evaluating accessible, continuous fish passage, which can be enhanced by removing or lowering culverts and creating steps ("ladders") to help adult salmon swim up over high falls of water. Equally important is providing sufficient flows of adequate clean water at appropriate temperatures, and areas of clean, oxygenated gravel for spawning.

Achieving these goals requires stabilizing areas of erosion, modulating flashy stormwater flows, and filtering pollutants or controlling their sources. This hearing focuses on pollutants, but I want to emphasize that all these attributes are important in a functioning salmon stream. Good project planning can sometimes allow multiple goals to be achieved with a singular modification. For example, a well-placed biofiltration swale, perhaps in the form of a sloping grassy ditch with compost-rich banks, could slow stormwater while also filtering out pollutants before they reach a stream.

Dr McIntyre's testimony for the July 15, 2021 hearing noted that she used biofiltration to successfully remove 6PPD-quinone from stormwater. Her team accomplished this experimentally by filling columns with sand and compost, then routing stormwater through the columns. After passing through the columns, the 6PPD-quinone was removed from stormwater. This is an encouraging finding, because it suggests that strategically placed filters or berms of such materials could protect streams from 6PPD-quinone entering streams via stormwater.

Wetlands are recognized as very good filters for cleaning up aquatic pollution. Wetland plants are known to absorb some harmful chemicals, and their roots stabilize soils, preventing erosion. (Wetlands are protected by regulations administered by the US Army Corps of Engineers, under Sections 404 and 401 of the Clean Water Act, as well as state laws.)

Detention ponds are often required of developers who create large buildings and/or impervious surfaces like parking lots. The ponds collect stormwater runoff and release it slowly into the soil or through evaporation. Alternatively, permeable paving surfaces have been introduced that would allow stormwater to sink into the ground below pavement, thus allowing the ground to accept and filter stormwater. Permeable surfaces may require maintenance if the pores in the surface become clogged.

The hyporheic zone of a stream is where the stream bottom interacts with groundwater and subsurface materials and organisms. Hyporheic processes have been studied and evaluated for their role in pollutant removal and enhancing oxygenation in streams. I am aware that two segments of urban Thornton Creek in Seattle are being experimentally geoengineered for improving hyporheic functions in the disturbed stream bottom. This is a promising area of research that originated in more pristine mountain streams. Here is a link to more information:

Undated (post 2009)—Hyporheic Zones and Mountain Streams, US Forest Service
https://www.fs.fed.us/pnw/lwm/aem/projects/hyporheic.html

Vegetated buffers along streams continue to be the standard "first defense" for slowing or keeping stormwater away from streams and reducing erosion on streambanks. Various plants perform various functions in different situations. For example, Pacific willow *(Salix lasiandra)* trees or shrubs have a mat-like root system that grows well in moist conditions on sunny slopes. Here is a standard planting guide from 1993 that continues to be very useful for choosing plants near streams:

1993—Slope Stabilization and Erosion Control using Vegetation, WA Dept Ecology 1993
https://apps.ecology.wa.gov/publications/documents/9330.pdf

In a nutshell, a simplistic plan to reduce stormwater pollutants and enhance habitat in a generic urban salmon stream would probably include these tools, which I consider best methods:

- Gradient observations or mapping, to understand steepness and the general lay of the land along the length of the stream. This will help identify places that allow stormwater to enter the stream, and thus where modifications such as biofiltration are needed.
- Identification and elimination of passage blockages such as hanging culverts or waterfalls. Geoengineering plans would factor in substrate materials and minimizing disturbance and erosion. In-stream work would be performed while salmon are not in the stream.
- Water quantity and quality assessment, with an understanding of areas of erosion and pollution entry that require intervention such as:
    - Bank stabilization methods (geoengineering and/or appropriate plantings)
    - Biofiltration – generally, routing stormwater through materials like sand, compost, mulch, or using other systems like wetlands, in order to filter out pollutants and slow down stormwater flows before they enter streams. Placement of biofiltration is key to intercepting stormwater.
    - Vegetative buffer plantings and detention ponds to collect, slow and filter stormwater runoff from roads, parking lots and other impervious surfaces.
    - Green infrastructure (see following links for explanations). These tend to provide overall, incremental improvement to stormwater management.

What is Green Infrastructure? Environmental Finance Center, Syracuse University
https://www.esf.edu/outreach/gi/documents/Environmental_Finance_Center_Brochure.pdf

What is Green Stormwater Infrastructure? The Nature Conservancy, Washington Nature
https://www.washingtonnature.org/cities/stormwater/green-infrastructure-infographic

On a related note, I would like to explain there are myriad regulatory agencies that weigh in on salmon stream projects, making it difficult, time-consuming and expensive to obtain all the permits needed for a stream habitat restoration project. Any of these agencies or organizations could be involved in a Washington state permit process:

FEDERAL NOAA Fisheries - regulates salmon under the US Dept of Commerce
US Fish & Wildlife Service - regulates trout under the US Dept of the Interior
US Forest Service – regulates stream buffers under the US Dept of Agriculture
US Environmental Protection Agency (EPA) administers the Clean Water Act
US Army Corps of Engineers – permits for wetlands and navigable waters
US Bureau of Land Reclamation near their projects

TRIBAL Native American tribes manage their own lands and natural resources, stand up for their tribal fishing rights and habitat interests across the state, and influence natural resource permitting accordingly

WA STATE	WA Dept Fish & Wildlife – Hydraulic Project Approval permits WA Dept Natural Resources – Forest Practices Act permits WA Dept Ecology – works with EPA on water quality regulations and permitting
COUNTIES	Administer zoning and Growth Management Act (GMA) regulations
NGOs	Many non-governmental organizations (NGOs) influence decisions on permitting

So the first hurdle in restoring or protecting a salmon stream is navigating the permitting maze and spending significant amounts of money on permits. I suggest trying to develop a more efficient, economical way of getting through this step. Perhaps a centralized permitting system, that incorporates regulations across agencies, would make stream restoration and enhancement project permits easier to obtain.

2. As you discussed, the December study has not been replicated and that science is not designed for one and done research. a. Can you please elaborate the reason or the reasons for it not having been replicated?

ANSWER: Dear Honorable Congressman Gohmert,

My understanding, from conversations with former colleagues, is that this study differed from previous stormwater composition analyses in that medical grade assay equipment was used for high resolution mass spectrometry (HRMS) of stormwater. This allowed the researchers to determine far more compounds at a time, which significantly cut down on the research effort needed to identify over 2000 components of stormwater. This was a new approach that in my opinion deserves replication by other researchers, to substantiate the validity of the methods. Perhaps the availability or cost of such equipment might be a limitation for replicating this study?

Otherwise, I don't know why this study has not been replicated yet. Early local news reports in December 2020 speculated that there would soon be follow-up studies to validate the findings, and perhaps add to them. That's what usually happens after groundbreaking research such as this. Perhaps COVID-19 got in the way. I wonder if the large consortium of organizations involved in this study simply made others who might pursue replication feel that they were already part of the action. I would think that agencies or institutions in other states like OR or CA might be interested in replicating this study, to build confidence in the original results and the new methods used. And I would think the researchers involved in this study would welcome such validation.

I found a substantial amount of online discussion about replication in scientific research. Here are some examples:

Replication Crisis, Wikipedia (general history and overview)
https://en.wikipedia.org/wiki/Replication_crisis

Importance of Replication Studies, Enago Academy, May 2021
https://www.enago.com/academy/importance-of-replication-studies/

The Earth is Flat (*p* > 0.05): Significance Thresholds and the Crisis of Unreplicable Research, National Center for Biotechnology Information, July 2017
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5502092/

This last resource concludes,"Part of an apparent crisis of unreplicable research is caused by the way we use statistics for analyzing, interpreting and communicating our data." The authors warn that it is unreasonable to expect the same "p-values" (a statistical measure) from both an original study and a replication of it. They suggest a more qualitative comparison between the two sets of results is preferable, as replicability is "nuanced."

I am reading the book, Reproducibility and Replicability in Science (National Academies Press, 2019) to further my own understanding of current views on scientific replication. (Link: https://www.nap.edu/read/25303/chapter/1) Figure 7-1 below is from this book, Chapter 10, page 157, accompanying a discussion of "Public Trust in Science." Over time, trust in science has remained relatively stable. My opinion is that traditional standards of the scientific method (sometimes now referred to as "open science"), including the encouragement of replicated research, add to such public trust.

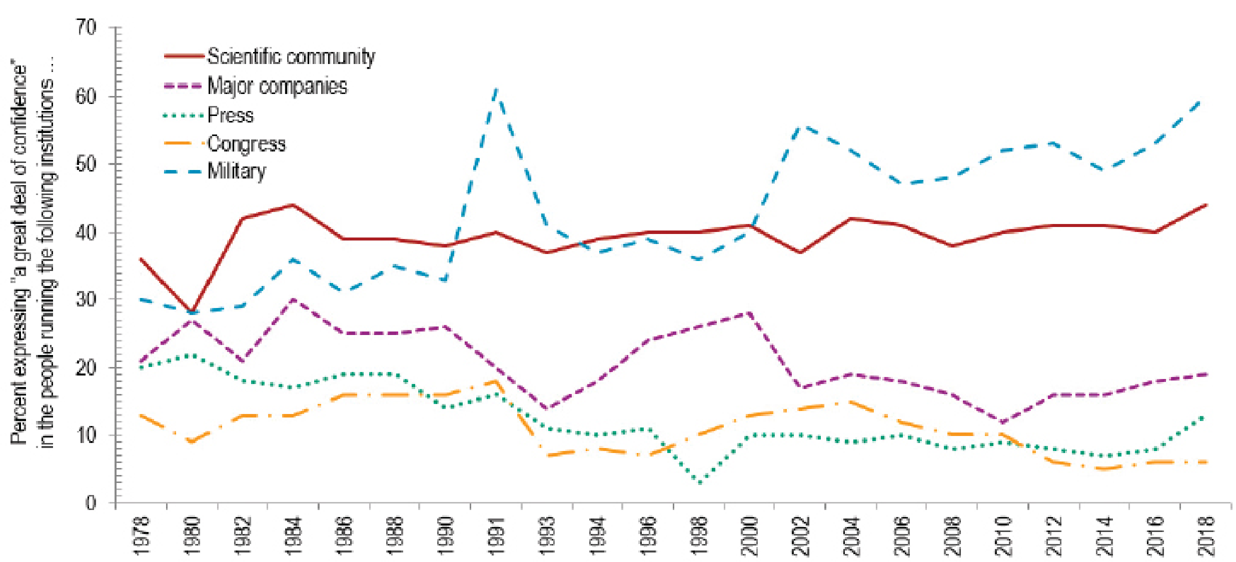


FIGURE 7-1 Levels of public confidence in selected U.S. institutions over time.
SOURCE: National Science Foundation (2018e, Figure 7-16) and General Social Survey (2018 data from http://gss.norc.org/Get-The-Data).

b. Are there any examples you can think of where after doing additional research the original conclusions changed? If so, why did the results change?

ANSWER: Dear Honorable Congressman Gohmert,

I'm sorry, I cannot think of situations where this did NOT happen. Science is iterative and therefore knowledge is constantly building or changing. Sometimes the original conclusions can be off, due to an unintended factor in study design or perhaps methods gone wrong, and a subsequent study sheds light on that. Sometimes the situation being studied is changing, and the original conclusions are no longer applicable. It's still good information, either way, even when results are the opposite of expected. Because we are always learning more. That's what I love about science.

c. What is your suggestion for remedying "one and done" studies?

ANSWER: Dear Honorable Congressman Gohmert,

In my (distant) past experience, follow-up studies seemed to happen as a matter of course. One study's results would generate questions leading to more study. The scientific community seemed to pick up the ball and run with it to replicate, and therefore validate, new and interesting research. That's what kept us going. I wonder if the internet and our Information Age causes some level of curiosity burnout.

Funding plays an important role. In this case, perhaps a Request for Proposals should be announced, by agency(ies) concerned with water quality and salmon survival. The RFP should clearly state that the scope of the study is to replicate the Tian et al. study using similar methods, including use of medical grade, high resolution mass spectrometry (HRMS) to analyze stormwater components.

The Seattle Times published this article on August 10, 2021, "Seattle Bridges, rail, airports: What's Washington state's cut of the Senate's $1 trillion infrastructure bill?" They report the bill includes $89 million in grants to the EPA, to assist in restoring Puget Sound. That could be a good source for funding to replicate and expand the variables studied by Tian et al.

Questions from Rep. Paul Gosar for Ms. Sue Kuehl Pederson, Fisheries Biologist

1. Are there characteristics about Seattle urban streams that are unique for salmon?

ANSWER: Dear Honorable Congressman Paul Gosar of Arizona,

Seattle's urban streams tend to be small, and relatively low in salmon production (adults number in the hundreds). Most have been, or are in the process of being restored after decades of damage due to development or industrial pursuits. Important values include enjoyment and environmental education for humans. Connectivity to larger bodies of water (Puget Sound, Lake Washington) means stream quality stretches beyond a watershed.

Stream Restoration – Seattle has implemented numerous urban stream restoration projects, in efforts to reverse damages from past habitat impacts. These are ongoing projects in varying degrees of completion, but successes are numerous. These five streams, ranked by size, are the main focus of Seattle Public Utilities' urban creek restoration efforts: Thornton, Longfellow, Piper's, Taylor and Fauntleroy. Some have attracted new recruits of Puget Sound coho and chinook salmon, which are listed as threatened under the Endangered Species Act. I've learned from colleagues that most streams are exhibiting coho pre-spawning mortalities, although I have not seen a tally by location. Here is a 2007 report on efforts to restore these streams: https://www.seattle.gov/util/cs/groups/public/@spu/@conservation/documents/webcontent/spu01_003413.pdf

Factors affecting Seattle's urban streams:

Precipitation – Seattle is known for its rainy climate. Of course that's good for salmon, because the rain feeds the streams and lakes. However, any solid impervious surface, such as the roof of a building, a street or a parking lot, creates stormwater runoff rather than natural absorption into the ground. Effective stormwater management requires collecting and/or routing runoff, slowing it down and cleaning it up before it enters streams. Here is an article on stormwater management efforts in Seattle:
https://nacwa50report.org/SuccessStories/Seattle-Public-Utilities

Hilly Terrain – The many hills in Seattle create additional challenges for slowing down stormwater runoff.

Human Population Growth – My research on this matter prompted me to look at 10-year population density growth in 9 cities along the west coast (Anchorage, Vancouver BC, Seattle, Portland, Eugene, Redding, Sacramento, Los Angeles and San Diego). I'm attaching an Excel file with graphs of both population density growth (source: worldpopulationreview.com) and precipitation (source: usclimatedata.com) for these cities. The results show a marked difference between Seattle's population density increase of 27.6% over a decade, and the other 8 cities. Seattle's growth rate is about twice that of Portland, Eugene and Sacramento; three times the rate of Vancouver BC and San Diego; and five times that of Los Angeles and Redding.

From these data sources, Seattle's latest population density is 9,260 people per sq mi, which is higher than Los Angeles (the second-largest city in the US) at 8,495/sq mi. The only city in this selection with a higher density than Seattle is Vancouver BC, with 13,590/sq mi. Note that Vancouver's area is 46 sq miles while Seattle's is 84 sq miles. Both Seattle and Vancouver are limited in area due to being surrounded by water.

The implications are that, with such a high population growth rate, Seattle's stormwater volumes have most likely increased due to more impervious surfaces. That, in turn, would put pressure on any stormwater processing features, and could ultimately affect stream water quality. I'm not aware of any studies being done on the relationship between high population density growth and impacts to salmon streams in Seattle, but this seems intuitively relevant to me.

Transportation – After living there myself from 1983 to 2005, I can personally report that the City of Seattle delayed development of efficient mass transit for many decades, unlike the San Francisco Bay Area (BART, began service 1972) and Portland, OR (MAX, began 1986). I remember voting in Seattle three times for monorails or other dedicated routes that did not rely on buses stuck in surface traffic. Citizens approved all three proposals, but the City repeatedly declined to take action and told voters we didn't know what we were asking. As a result, Seattle's streets and bridges are often jammed. Recent development of light rail (Sounder Transit) in Seattle will help, although the 27.6% population growth rate over the past decade has probably already used up much capacity. All this traffic could be affecting stormwater management in Seattle, especially if concentrations of 6PPD-quinone from tires are not being filtered or blocked from reaching our streams.

Lack of Estuary Habitat – This research got me thinking about another possible impact to Seattle salmon. I have not seen discussions of whether the abrupt transition between freshwater streams/lakes in Seattle and Puget Sound's saltwater may cause challenges for local salmon. This might affect outmigrating juvenile salmon, going abruptly from freshwater to saltwater, or adults going abruptly from saltwater to freshwater. Ordinarily, an estuary of brackish water would provide more time for these transitions, when salmon gills transform to adjust. Could this be an unstudied factor in Seattle salmon impacts?

THANK YOU, Honorable Congressmen Gohmert and Gosar, for these insightful, interesting questions that gave me an opportunity to research the answers. I hope my responses are helpful. I appreciate the honor of serving this Committee and my country.

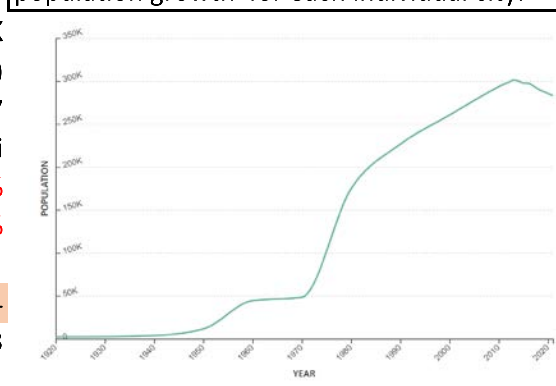
Sue Kuehl Pederson

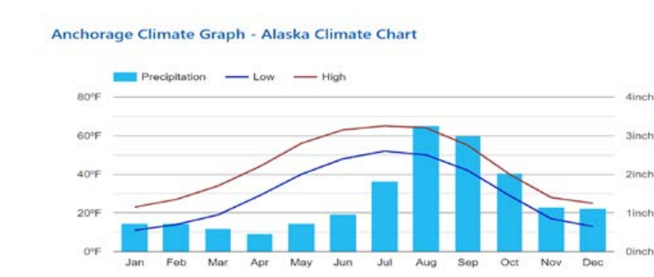
West Coast Cities (North to South) - Population Density Growth
Source (population) accessed 8/5/2021: World Population Review
Source (precipitation) accessed 8/6/2021: https://www.usclimatedata
Sue Kuehl Pederson, Witness

NOTE: Vertical scale is not uniform among all population graphs. Lines show the trend in population growth for each individual city.

NOTE: Climate charts have been manually adjusted to compare approximate precipitation amounts (scale on right side, inches) between cities.

CITY (99501)	**Anchorage, AK**
POP	282,958 (2020)
SQ MI	1,707
DENSITY	166/sq mi
ANNUAL INCR	-0.88%
10-YR INCR	-3.04%
AVG RAIN+SNOW (in./yr.)	16+74
AVG ANNUAL PRECIP DAYS	103





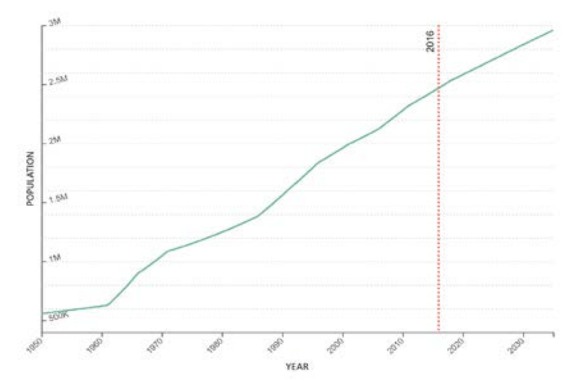
https://worldpopulationreview.com/us-cities/anchorage-ak-population
https://www.usclimatedata.com/climate/anchorage/alaska/united-states/usak0012

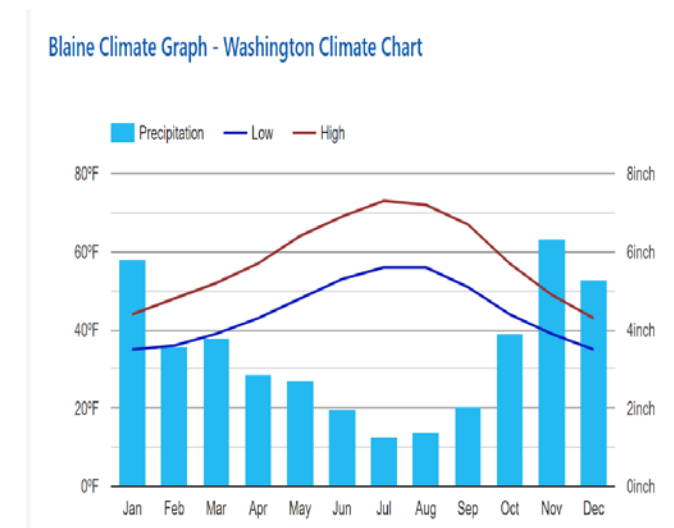
https://www.usclimatedata.com/climate/anchorage/alaska/united-states/usak0012

NOTE: This chart seems to exclude snow, which is over 70 inches per year.

CITY (V5K0A1)	**Vancouver, BC**
POP	631,486 (2016)
SQ MI	46
DENSITY	*13,590/sq mi
10-YR INCR EST (5-yr 4.4%)	8.80%
AVG RAIN+SNOW (in./yr.)	N/A
AVG ANNUAL PRECIP DAYS	N/A

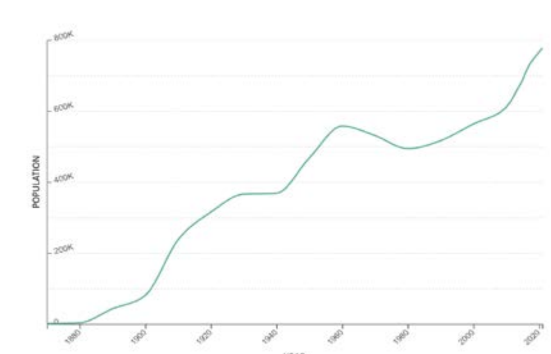
*4th most dense in N America
https://worldpopulationreview.com/canadian-cities/vancouver-population

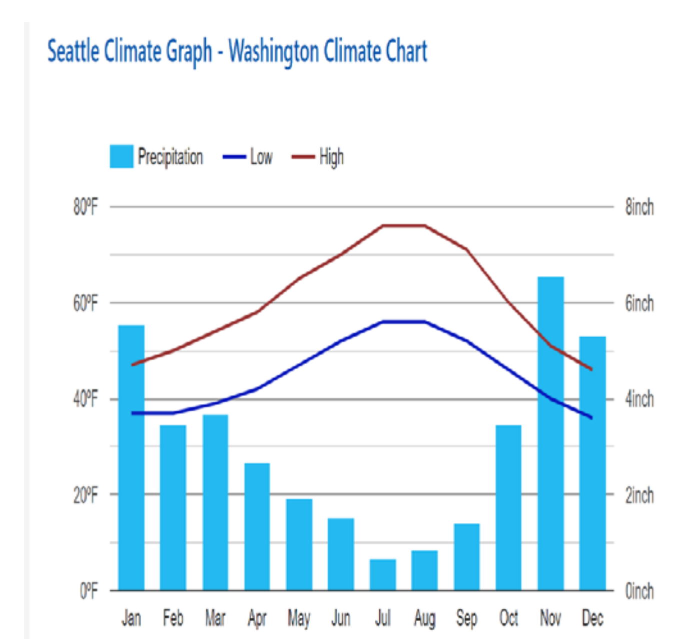




https://www.usclimatedata.com/climate/blaine/washington/united-states/uswa0036 (Proxy Blaine, WA)

CITY (98101)	**Seattle, WA**
POP	776,555 (2020)
SQ MI	84
DENSITY	9,260/sq mi
10-YR INCR	27.58%
AVG RAIN+SNOW (in./yr.)	37
AVG ANNUAL PRECIP DAYS	147

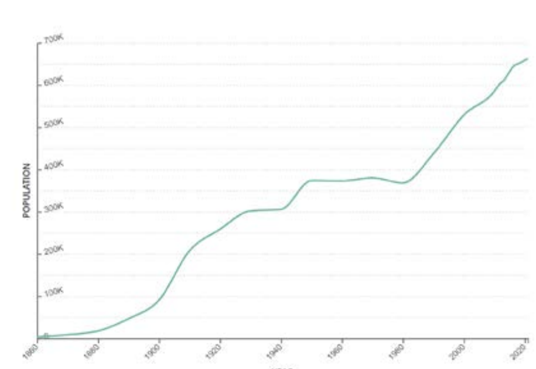


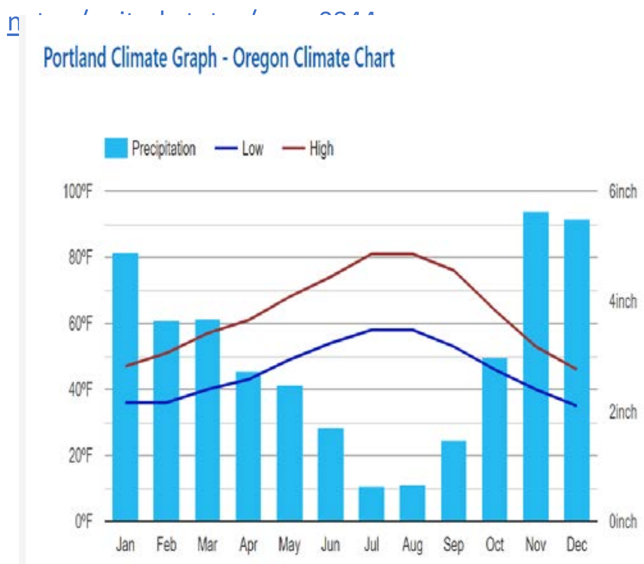


https://worldpopulationreview.com/us-cities/seattle-wa-population
https://www.usclimatedata.com/climate/seattle/washington/united-states/uswa0844

https://www.usclimatedata.com/climate/seattle/washi

CITY (97201)	**Portland, OR**
POP	662,549 (2020)
SQ MI	133
DENSITY	4,966/sq mi
10-YR INCR	13.49%
AVG RAIN+SNOW (in./yr.)	40
AVG ANNUAL PRECIP DAYS	153

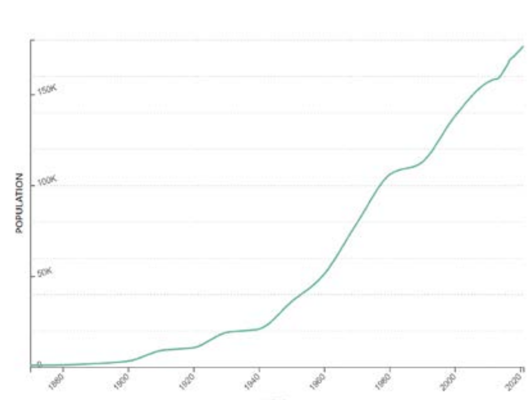


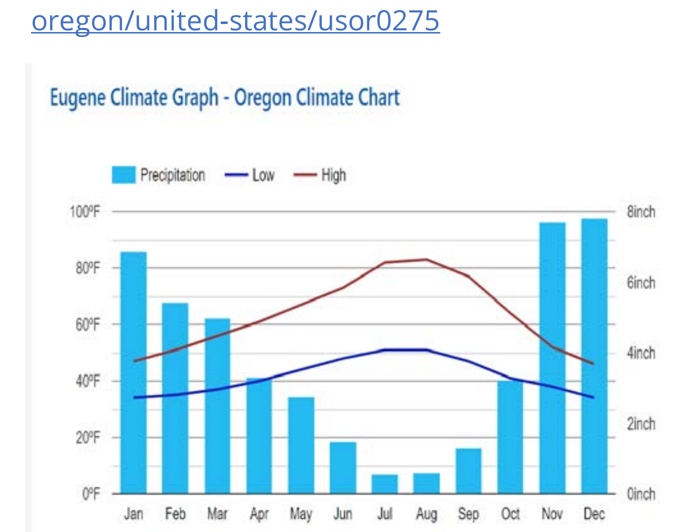


https://worldpopulationreview.com/us-cities/portland-or-population
https://www.usclimatedata.com/climate/portland/oregon/united-states/usor0275

https://www.usclimatedata.com/climate/portland/oregon/united-states/usor0275

CITY (97401)	**Eugene, OR**
POP	176,464 (2020)
SQ MI	44
DENSITY	3,998/sq mi
10-YR INCR	12.98%
AVG RAIN+SNOW (in./yr.)	46.1+5
PRECIP (in./yr)	51.1



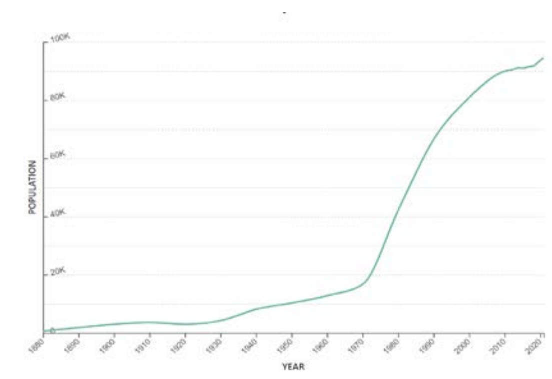


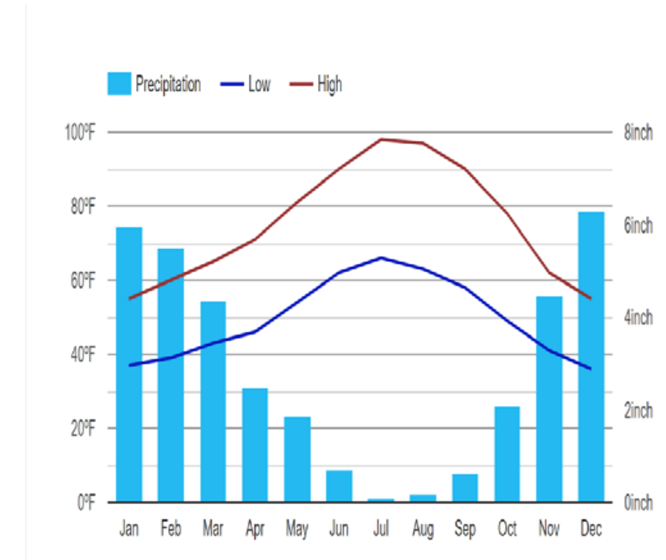
https://worldpopulationreview.com/us-cities/eugene-or-population
https://www.usclimatedata.com/climate/eugene/oregon/united-states/usor0118

https://www.usclimatedata.com/climate/eugene/oregon/united-states/usor0118

Redding Climate Graph - California Climate Chart

CITY (96001)	**Redding, CA**
POP	94,558 (2020)
SQ MI	60
DENSITY	1,585/sq mi
10-YR INCR	5.23%
AVG RAIN+SNOW (in./yr.)	
AVG ANNUAL PRECIP DAYS	

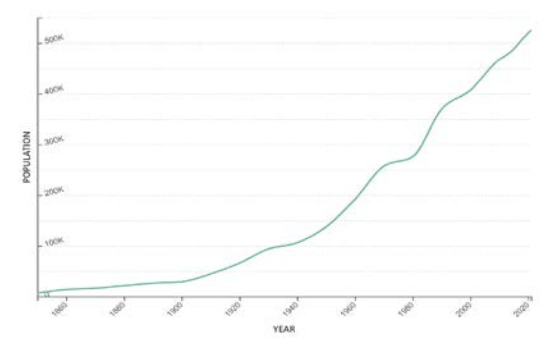


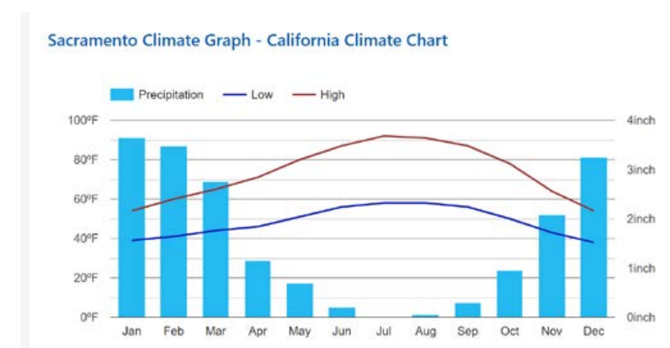


https://worldpopulationreview.com/us-cities/redding-ca-population

https://www.usclimatedata.com/climate/redding/california/united-states/usca0922

CITY (95660)	**Sacramento, CA**
POP	525,398 (2020)
SQ MI	98
DENSITY	5,376/sq mi
10-YR INCR	12.63%
AVG RAIN (in./yr.)	
AVG ANNUAL PRECIP DAYS	

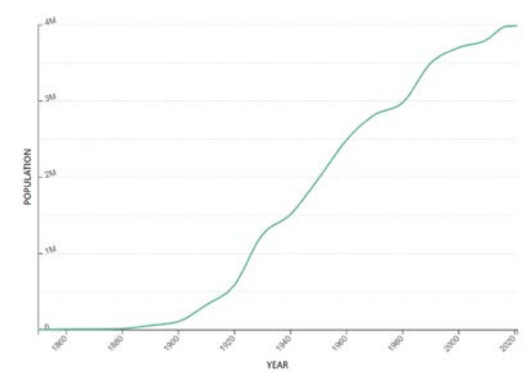


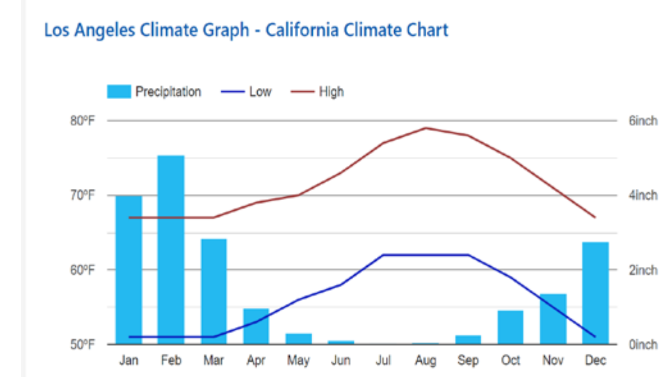


https://worldpopulationreview.com/us-cities/sacramento-ca-population

https://www.usclimatedata.com/climate/sacramento/california/united-states/usca0967

CITY (90001)	**Los Angeles.CA**
POP	3,983,540 (2020)
SQ MI	469
DENSITY	8,495/sq mi
10-YR INCR	5.03%
AVG RAIN (in./yr.)	13.5
AVG ANNUAL PRECIP DAYS	35

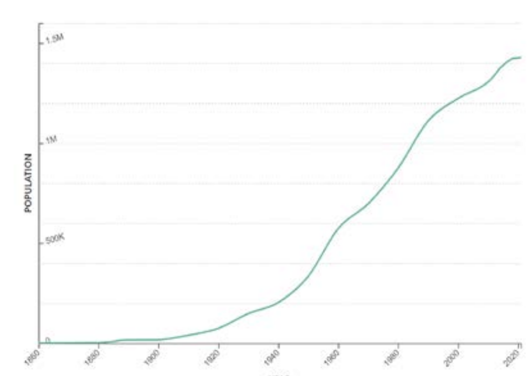


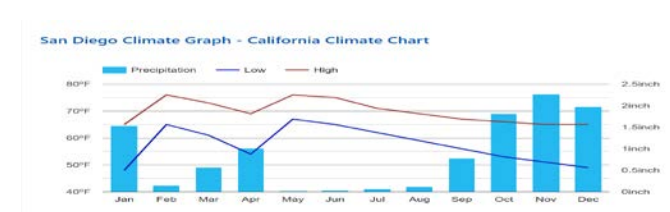


https://worldpopulationreview.com/us-cities/los-angeles-ca-population

https://www.usclimatedata.com/climate/los-angeles/california/united-states/usca1339

CITY (92101)	**San Diego, CA**
POP	1,427,720 (2020)
SQ MI	326
DENSITY	4,381/sq mi
10-YR INCR	9.20%
AVG RAIN (in./yr.)	10.77
AVG ANNUAL PRECIP DAYS	41





https://worldpopulationreview.com/us-cities/san-diego-ca-population

https://www.usclimatedata.com/climate/san-diego/california/united-states/usca0982