State of the Basin: Scott River
Background and Methods

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Prepared for and in cooperation with:
Klamath Tribal Water Quality Consortium

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A. Project Overview

To communicate to a broad audience, the Klamath Tribal Water Quality Consortium produced a two-page flyer summarizing long-term trends in water temperature and hydrologic conditions in the Scott River (Appendix A). The Scott River is located in Siskiyou County, California, USA and is a large tributary to the Klamath River. This document summarizes the data sources and methods used in the flyer.

The six parameters analyzed for this project were imported from various sources and processed using R Statistical Software (R Foundation for Statistical Computing, 2022). To assess change in each parameter over time, data were first processed into time series format. Then, each time series was modeled using linear modeling techniques from R package ggplot2 (Wickham, 2016).

This project is a follow up to the Consortium's production of water quality flyers for the Middle Klamath and Lower Klamath sub-basins of the Klamath Basin in 2018 (Genzoli et al., 2018).

B. Data Sourcing & Processing

Water Temperature

Water temperature data for the Scott River Near Fort Jones, CA (U.S. Geological Survey gage number 11519500) for 6/14/1995– 8/16/2020 were obtained from Asarian et al. (2023a, 2023b) . These data were originally collected the Quartz Valley Indian Reservation (Asarian et al., 2020; Quartz Valley Indian Reservation, 2016), the Klamath National Forest (Klamath National Forest, 2010, 2011) and U.S. Bureau of Reclamation (Smith et al., 2018) using instream probes that continuously record temperatures. QVIR use the site code SRGA for this site, but other agencies have used different names. Details on the equipment and data collection history are provided in the Supporting Information of (Asarian et al., 2023b). The QVIR Environmental Department monitors water temperatures at this site using YSI (Yellow Springs, Ohio) 6600 multi-parameter datasondes that will be used for future State of the Basin updates.

Daily maximum water temperature values for July were run through a QA process to remove months with incomplete data sets. The total number of days of data available per month were calculated, then months with less than 28 days of data available were removed from the dataset. The mean of the daily maximum temperature values for July was then calculated from the remaining months.

Air Temperature

Air temperature data were imported from the Global Historical Climatology Network daily database of climate summaries and is maintained by the National Centers for Environmental Information (NCEI) (Menne, Durre, Korzeniewski, et al., 2012; Menne, Durre, Vose, et al., 2012). Data were compiled from three KNF sites: Quartz Hill, California (USR0000CQUA), Callahan, CA (USR0000CCAL), and Oak Knoll, CA (USR0000COAK). Data import was completed using the rnoaa package (Chamberlain et al., 2023).

Maximum air temperature values were calculated using a QA process to filter flagged values. Daily air temperature data from the Quartz Hill station were cleaned and all dates with a quality flag removed. For days lacking Quartz Hill measurements, we infilled missing values by linear regression with nearby stations. We estimated missing air temperatures against one of the following stations, in decreasing order of priority: 1. Global Historical Climatology Network - Daily (GHCN-Daily) station USR0000CCAL at Callahan located 35 km from Quartz Hill, 2. GHCN-Daily station USR0000COAK at Oak Knoll located 28 km from Quartz Hill, and 3. the closest 4km-resolution cell from the gridded PRISM dataset (Daly et al., 2008)

Flow

Daily average flow data were imported from the US Geological Survey National Water Information System (USGS NWIS) (US Geological Survey, 2016). Data were imported from one site, Scott River Near Fort Jones, CA (11519500). Data import was completed using the dataRetrieval package (De Cicco et al., 2022). For each year, we calculated mean July flows from the daily values.

Snowpack

We obtained modeled April 1 (the typical annual peak) snow water equivalent (SWE) data from the University of Arizona (https://climate.arizona.edu/data/UA_SWE/) (Broxton et al., 2016; Dawson et al., 2018; Zeng et al., 2018). These 4km-resolution snowpack estimates were derived by combining ground-based measurements of SWE and snow depth with gridded PRISM precipitation and temperature data (Daly et al., 2008). We used a GIS polygon of the Scott River sub-basin to extract an annual SWE time series for the years 1982–2021. After the initial draft of the Scott River State of Basin, a new online tool became available that will make updating these data easier in future years: https://climate.arizona.edu/snowview/.

Evaporative Demand

Reference evapotranspiration, also known as evaporative demand, is the amount of water consumed by irrigated grass, assuming no water limitation (Albano et al., 2022). We used reference evapotranspiration data from the gridded gridMet dataset (Abatzoglou, 2013), calculated from solar radiation, air temperature, humidity, and wind speed. We generated a daily evapotranspiration time series for the Scott Valley using the Climate Engine website (Huntington et al., 2017) and a GIS polygon of the boundary of the Scott Valley groundwater basin. The daily evapotranspiration values for the Scott Valley were summed annually from April to September to calculate an annual evapotranspiration value for the growing season.

Tree Cover

We used an annual time series of tree canopy cover data from the University of California, generated using satellite remote sensing and machine learning (Wang, 2022; Wang et al., 2022). Data were imported from the Harvard Dataverse using the dataverse package (Kuriwaki et al., 2023). Unfortunately, it is unclear of these data will be updated for future years beyond 2021.

The original data set consisted of raster files with four vegetation bands; the tree vegetation band was isolated for analysis. A GIS file of coho-bearing streams (Haney et al., 2022) in the Scott Valley were buffered to include 30 meters on each side of the stream system in a new, expanded polygon. The buffered stream polygon was used to extract a table of annual tree cover percentage values for the coho bearing streams. The annual mean of these regions was calculated.

C. Data Source Locations

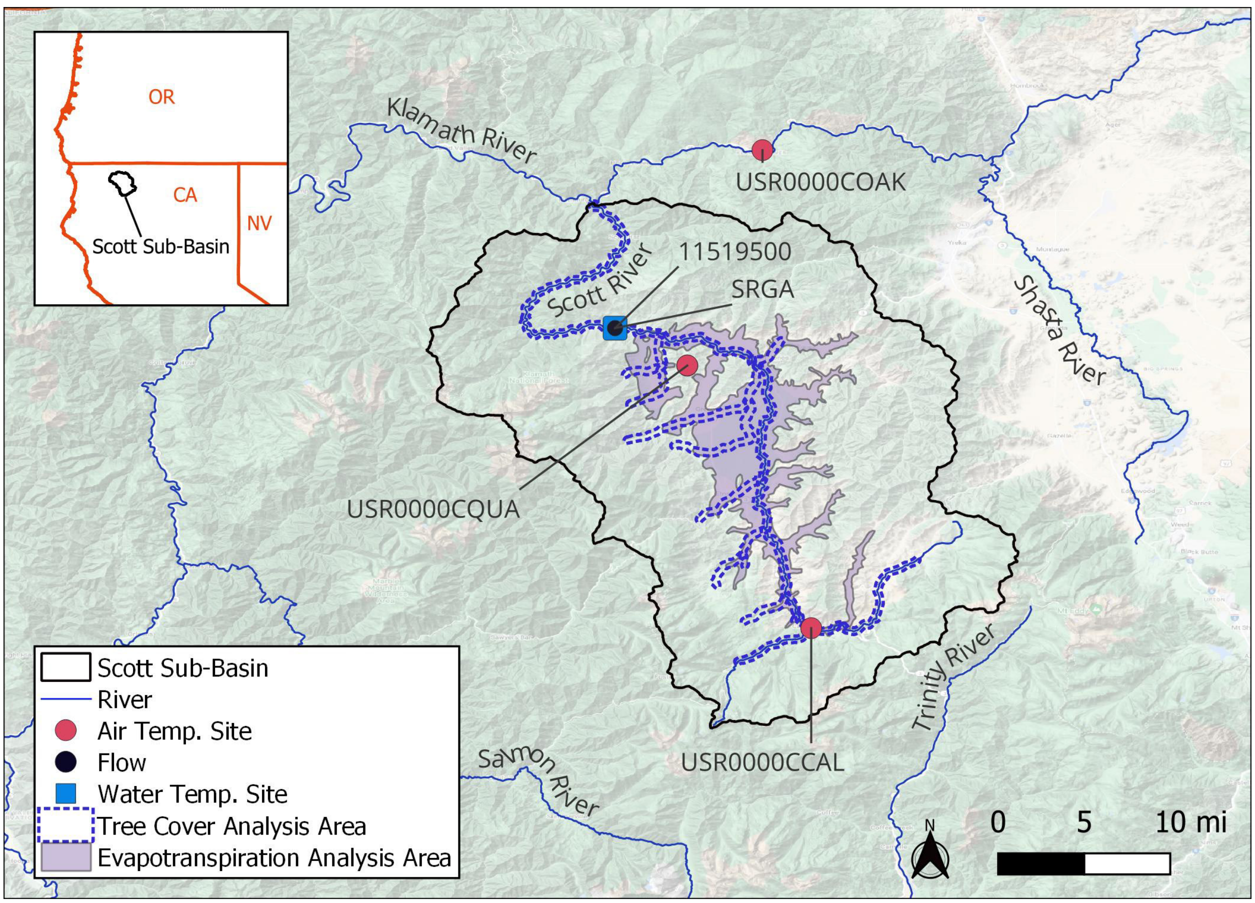

Figure 1. Map of data source stations and locations

Table 1. Data source site locations

Data Type	Site ID or Spatial Extent	Latitude	Longitude	Source
Water Temperature	SRGA	41. 6408	-123. 0139	Multiple (QVIR, KNF, USBR)
Air Temperature	USR0000CQUA	41.5992	-122.9336	GHCNd
Air Temperature	USR0000CCAL	41.3075	-122.7958	GHCNd
Air Temperature	USR0000COAK	41.8386	-122.8500	GHCNd
Air Temperature	USR0000CQUA	41.5994	-122.9336	PRISM
Flow	11519500	41.6408	- 123.0139	NWIS
Evaporative Demand	Groundwater Basin of Scott Valley Polygon			Climate Engine
Snowpack	Scott River Sub-Basin Polygon			University of Arizona
Tree Cover	Coho-Bearing Streams Polygon			Dataverse

D. Citations

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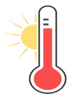
Appendix A

The following pages contain the Scott River State of the Basin flyer.

SCOTT RIVER STATE OF THE BASIN

Background The Scott River is a large tributary of the Klamath River and is listed for multiple water quality impairments. Increased water temperatures, caused in part by decreases in river flow, have contributed to declines in culturally and economically important fish like coho salmon.

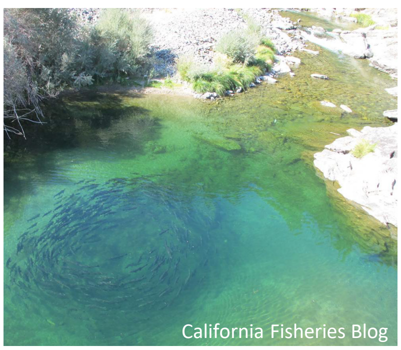
Summary of Findings Climate change and human activities have increased water temperatures and reduced flows.



Climate change continues to increase air temperatures, which increases both water temperatures and the amount of water required to grow crops.

Human activities have removed streamside vegetation, reducing stream shade. Water diversions and groundwater pumping have reduced river flows, increasing water temperatures.

Efforts to restore streamside vegetation in Scott Valley include planting trees and cattle exclusion fencing. Streamside tree cover is improving; however, water temperatures are still increasing because these improvements are not enough to offset rising air temperature and declining flows.

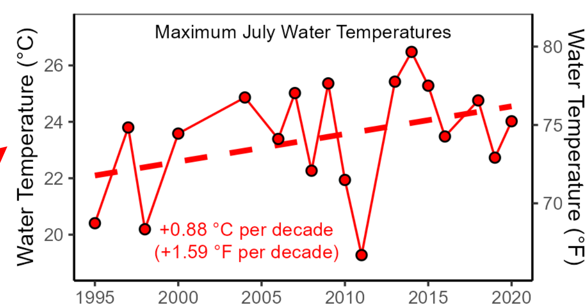


Water temperature, flow, and salmonids

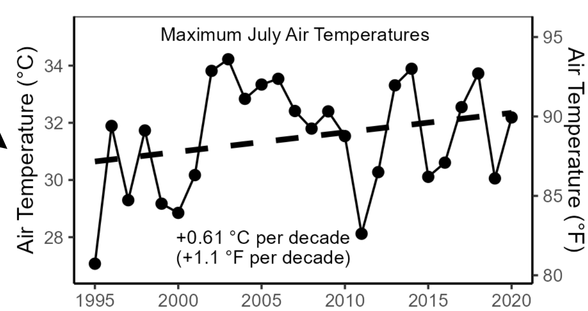
- Salmonids require sufficient in-stream flows, streamside shade, and access to cool water.
- High water temperatures can stress and kill salmonids by hindering fish growth, reducing oxygen supply, increasing susceptibility to disease, and changing migratory patterns.
- Low flows can cut off important habitat, including preventing fall-run chinook salmon from accessing prime Scott River spawning grounds (left).

While data show considerable year-to-year variability, there are clear long-term trends in water quality and quantity caused by a combination of climate change, increased water consumption, and other human activities in the Scott Valley.

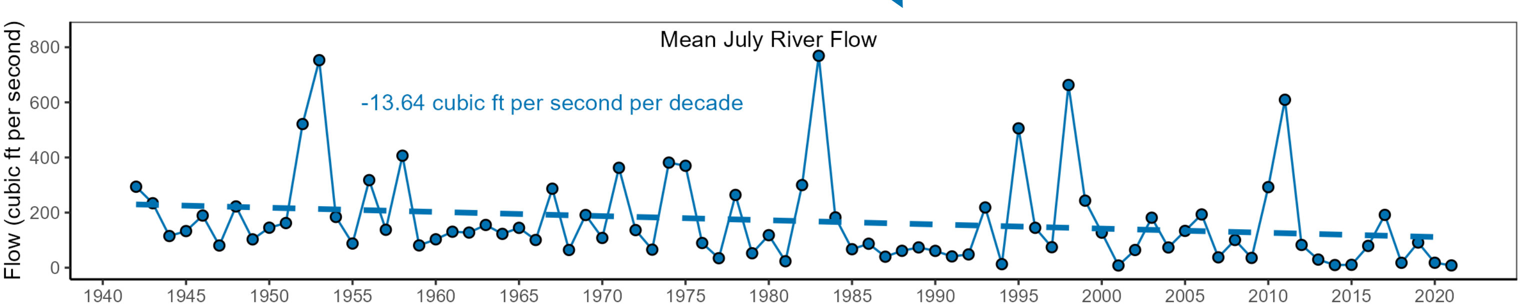
Water temperatures have risen over the past two decades at the U.S. Geological Survey gage according to measurements by the Quartz Valley Indian Reservation, Klamath National Forest, and U.S. Bureau of Reclamation. Increased water temperatures are likely caused by increasing air temperatures and declining flows.



Air temperature transfers heat from air to water. July air temperatures at Klamath National Forest's Quartz Hill weather station have increased over the past two decades, consistent with rising concentrations of greenhouse gases and air temperatures around the world.



River flow is a measure of water quantity. Average July flows have declined since the mid-1940s. The U.S. Geological Survey measures flow at the outlet of Scott Valley.



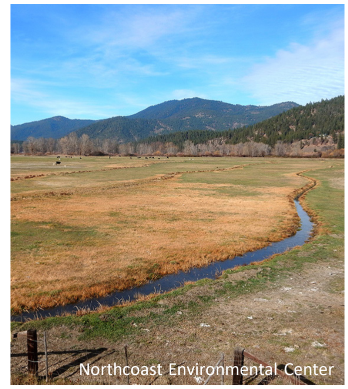
Climate change, people, and water temperature

Climate

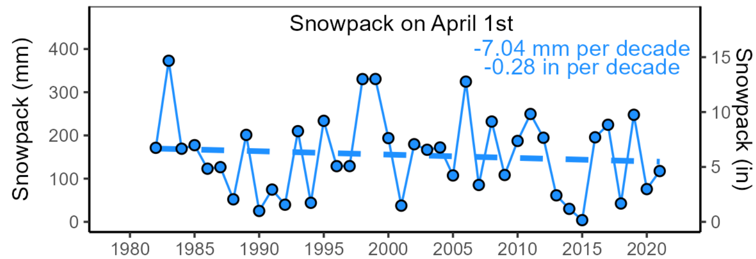
- Climate change and drought decrease snowpack, resulting in reduced flows and groundwater inputs to the river.
- Climate change increases air temperatures, resulting in increased water temperatures.
- Wildfire smoke acts like a cloud, shading the river and cooling water temperatures

People

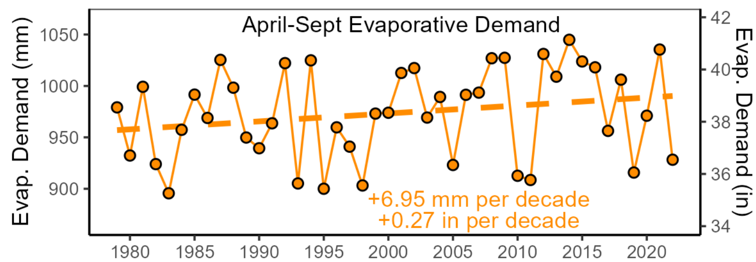
- Agricultural diversions reduce stream flows, making water more vulnerable to warming
- Alterations to the river system like the removal of streamside vegetation (reduced shade) and historic mining increase solar radiation and heat storage in streams.
- At a global scale, emissions of carbon dioxide and other greenhouse gases heat the planet



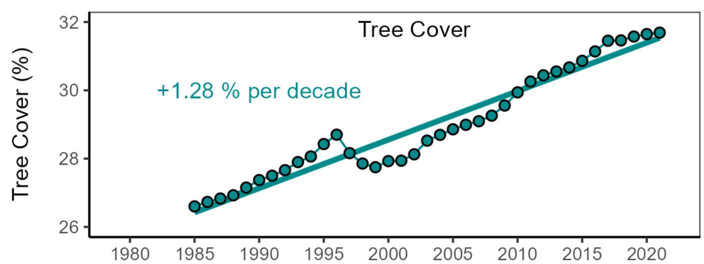
Mountain **snowpack** provides water to Scott Valley and strongly influences summer flows. University of Arizona's analysis integrating California Dept. of Water Resources' measurements at sites in the Scott River watershed shows snowpack declines over the past four decades.

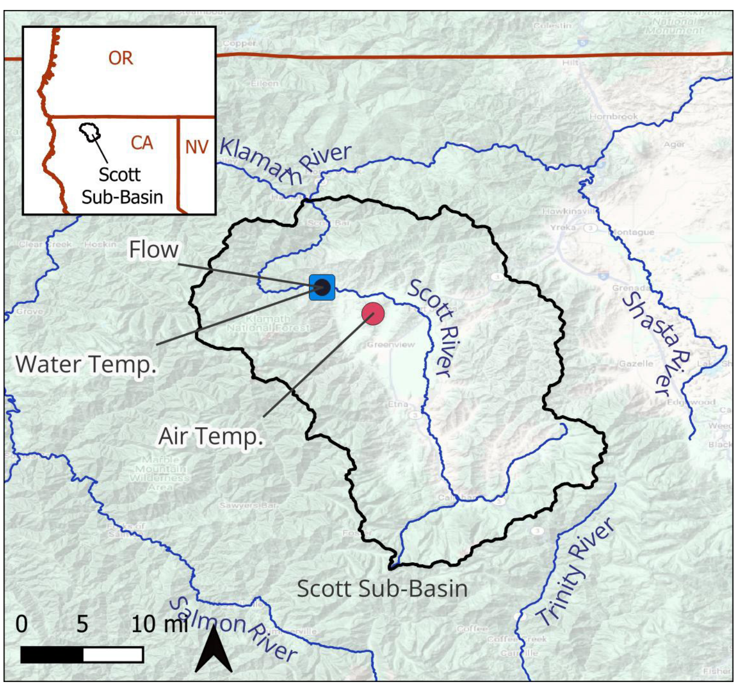


Evaporative demand is the amount of water consumed by irrigated grass, assuming no water limitation. University of California Merced calculations based on Scott Valley weather data indicate increasing evaporative demand over the past four decades, due to hotter air temperatures. As a result, irrigated lands now consume more water per acre than in previous decades.



Streamside tree cover provides shade, cooling the water. University of California data derived from NASA satellites in a 60-meter zone around the Scott River and its tributaries in Scott Valley show tree cover has increased over the past three decades.





Klamath Tribal Water Quality Consortium

Karuk Tribe
Yurok Tribe
Hoopa Valley Tribe
Quartz Valley Indian Reservation
Resighini Rancheria

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