Analysis of Santa Ynez Watershed Using HAWQS Modeling

(Photo by Natural Atlas)

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1. Introduction

Watershed analyses serve as objective foundational tools for understanding the hydrologic dynamics of natural systems and human interactions within a given geographical area. These assessments offer valuable insights into conservation strategies, irrigation management, and flood resilience. This analysis uses Hydrologic and Water Quality System (HAWQS) modeling software to make statements about potential future scenarios.

Under the authority of Santa Barbara County, the Santa Ynez watershed acts as a lifeline for a diverse range of species while also contributing to the water supply of three reservoirs. The largest reservoir, Cachuma, was constructed by the Federal Bureau of Reclamation in 1953. The manmade lake provides 85% of water to 250,000 residents and supports 12,000 acres of agricultural land in South Santa Barbara County. (Cachuma Project) The agricultural, municipal, and biological importance of the Santa Ynez watershed implies a necessity to protect its quality and health for future generations.

2. Location

The Santa Ynez watershed drains for 900 square miles. (Figure 2) Flowing 90 miles west into the Pacific Ocean, the Santa Ynez River is bounded to the east by the Santa Rosa mountains. The Cachuma Reservoir is 5 miles in length and has a maximum capacity of 193,000 acre-feet. The water diverted from the Cachuma Reservoir travels 6 miles along the Tecolote Tunnel, flowing through the Santa Ynez mountains to South Coast Conduit, which extends 24 miles from Goleta to Carpinteria. (Mills, 2013)

Santa Ynez Watershed

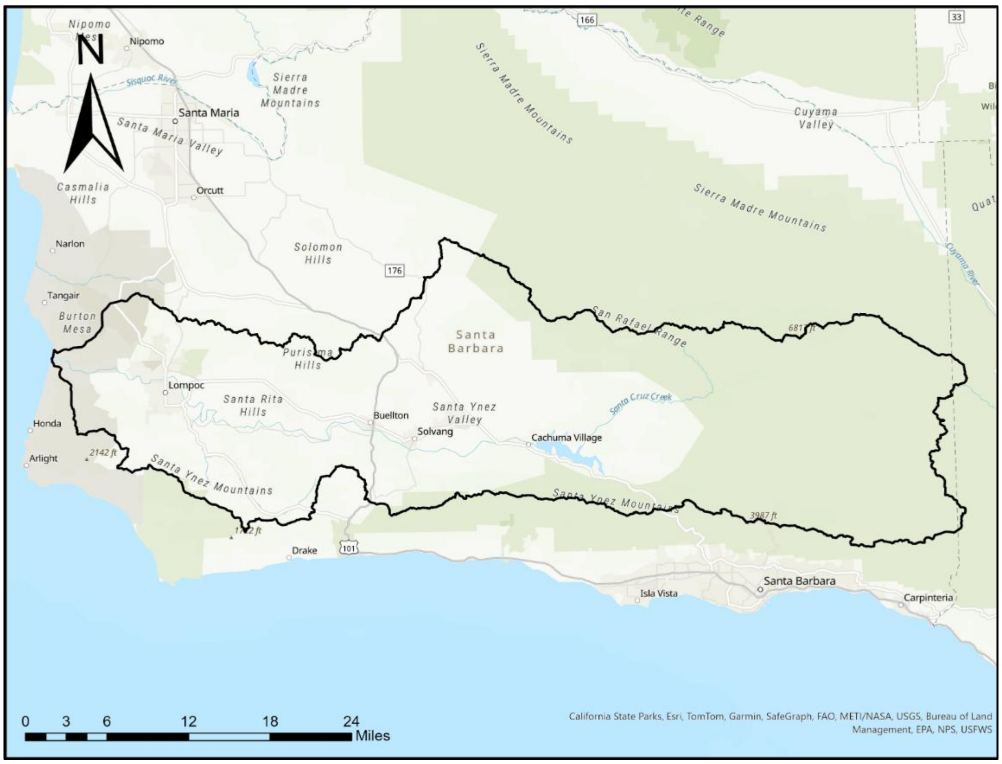

Figure 2. Santa Ynez Watershed Location Map

3. Topography

The Santa Ynez watershed flows out into the Pacific Ocean. The Santa Ynez river's main tributaries are the Santa Maria and Sisquoc River. Runoff from the Santa Rosa mountains, reaching an elevation of around 2,000 meters, contributes to the discharge of the Santa Ynez River because of its sloping characteristics. (Figure 3) Throughout the watershed, the Santa Ynez River generally has the lowest elevation.

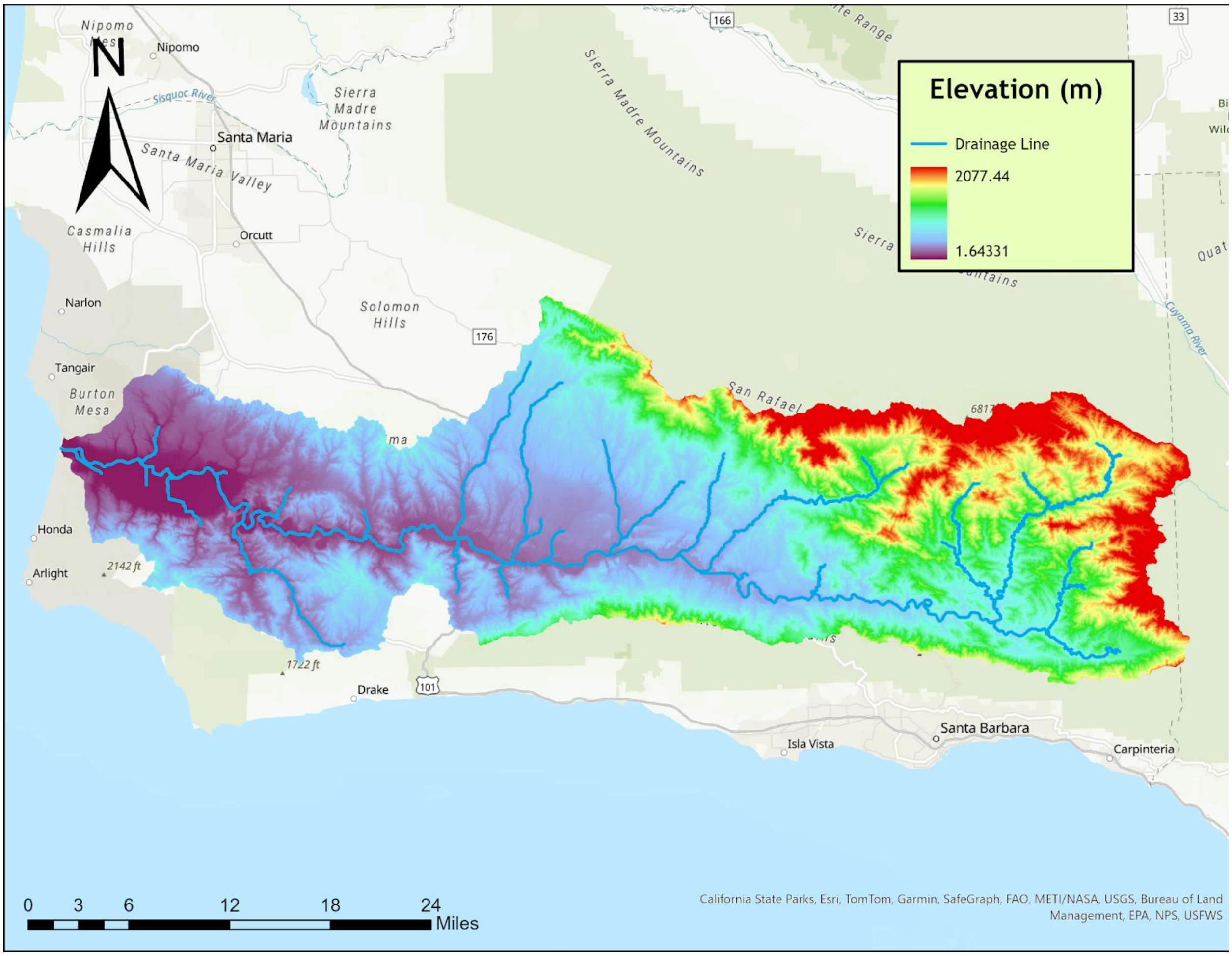

Figure 3. Topographical map (Digital elevation model) and drainage line of the Santa Ynez watershed. The watershed slopes downward from the Santa Rosa mountains to the east and the Santa Ynez mountains from the south.

4. Land Use

Agricultural Land-Row Crops contribute to 2% of the Santa Ynez watershed (Figure 4). Common riparian vegetation dominates most of the watershed; coyote brush, coastal sagescrub, purple needlegrass, and cottonwood is common within Santa Barbara County. There are few paved roads and little urban development within the part of the watershed conserved by the Los Padres National Forest. (Block, 2013)

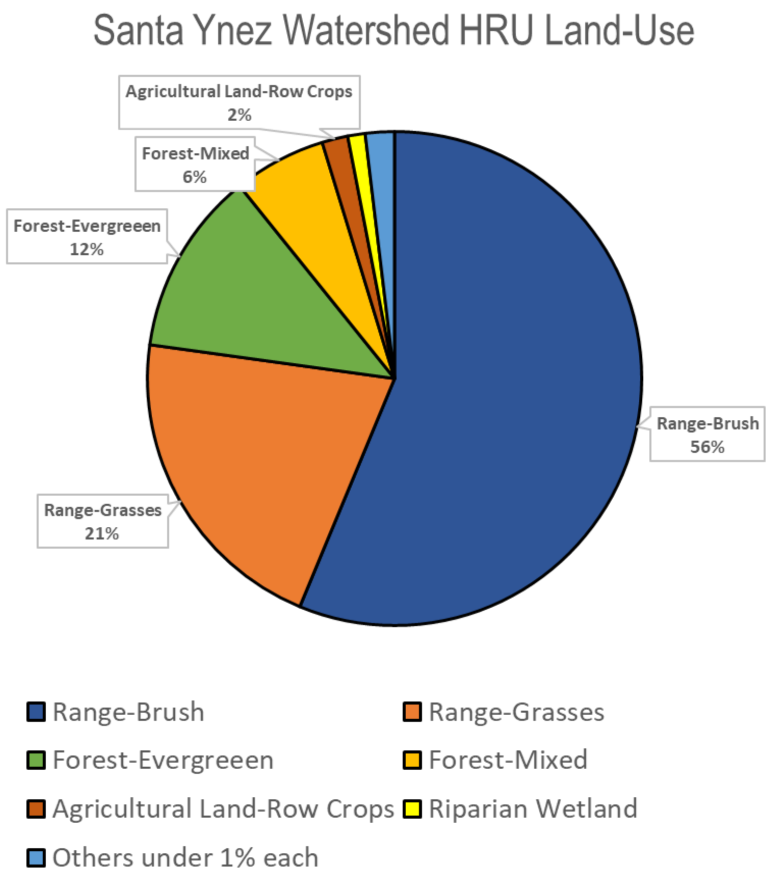

Figure 4. Modeled distribution of land use of Santa Ynez watershed. HAWQS utilizes the Soil Water Assessment Tool (SWAT) as its main modeling engine. SWAT uses hydrologic response units (HRU), which are the smallest spatial unit of the model. Each unit is lumped together based on soil class, slope, and land uses within a subbasin (Range-Brush, etc.). To maintain the accuracy of the HUC-12 model, all HRU's smaller than 0.5 km^2 were removed. HRU removal, however, has a negligible effect on flow accuracy within the model. (Her, 2015)

5. Soil Characteristics

The most common soil type along the Santa Ynez River is Type A, a sandy loam with high infiltration rates and low runoff rates. (Soil Hydrologic Groups) The further away from the Santa Ynez River, the more prevalent Type C and D become. (Figure 5) The impervious nature of Type C and D soil combined with the sloping, elevated mountains create large amounts of runoff during precipitation events. (Mills, 2013)

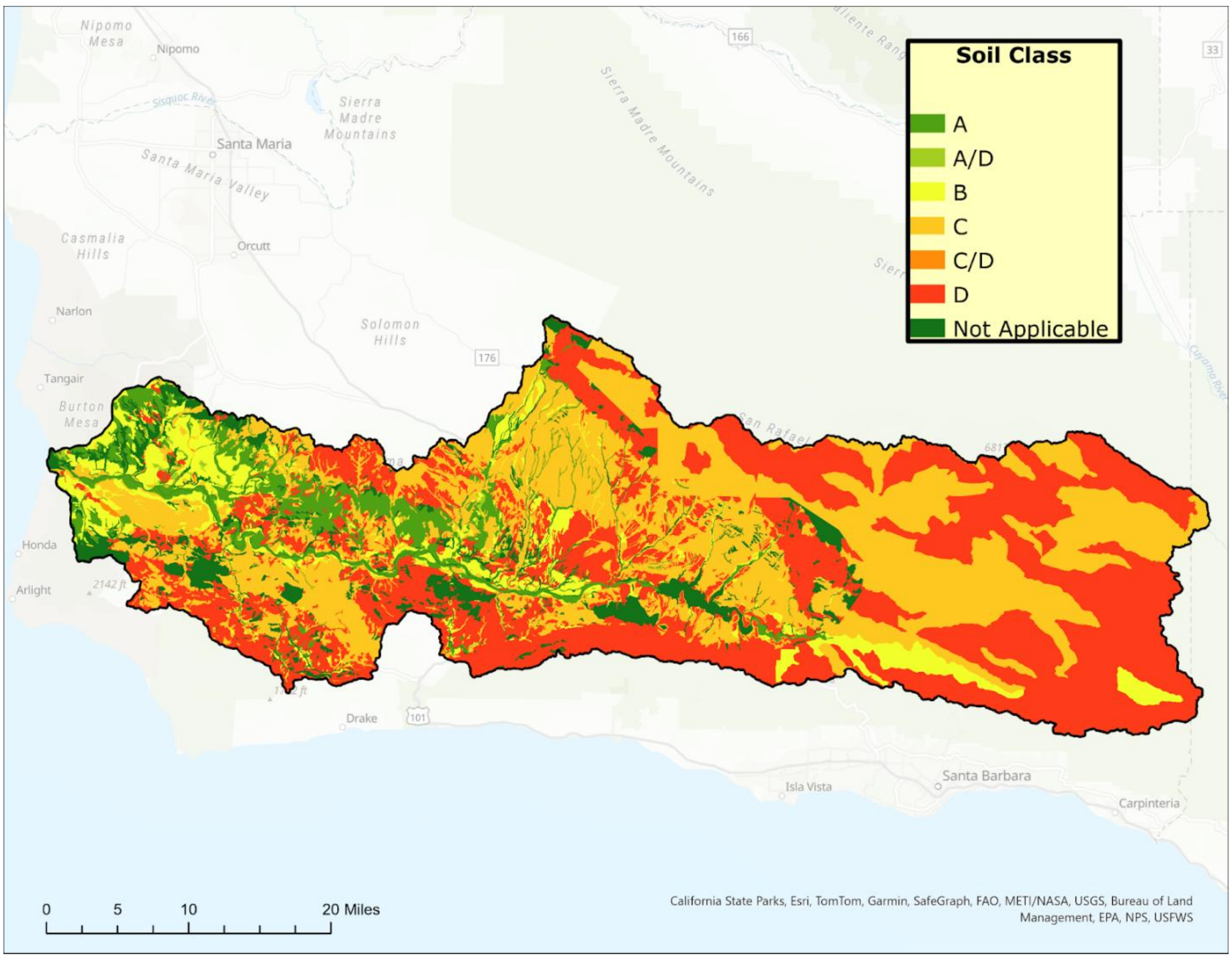

Figure 5. Distribution of hydrologic soil groups that make up Santa Ynez watershed from A (high infiltration) to D (low infiltration).

6. Discharge

According to the HAWQS model, flow increases from east to west, until the discharge to the ocean. (Figure 6a) The small jumps in cumulative flow are explained by predicted precipitation events. Santa Barbara County has a Mediterranean-type climate, which is characterized by flashy runoff caused by wet-season storms, usually during winter. (WRDC, 2019) These cause periodic increases in runoff that flows to the Santa Ynez River, increasing discharge rates.

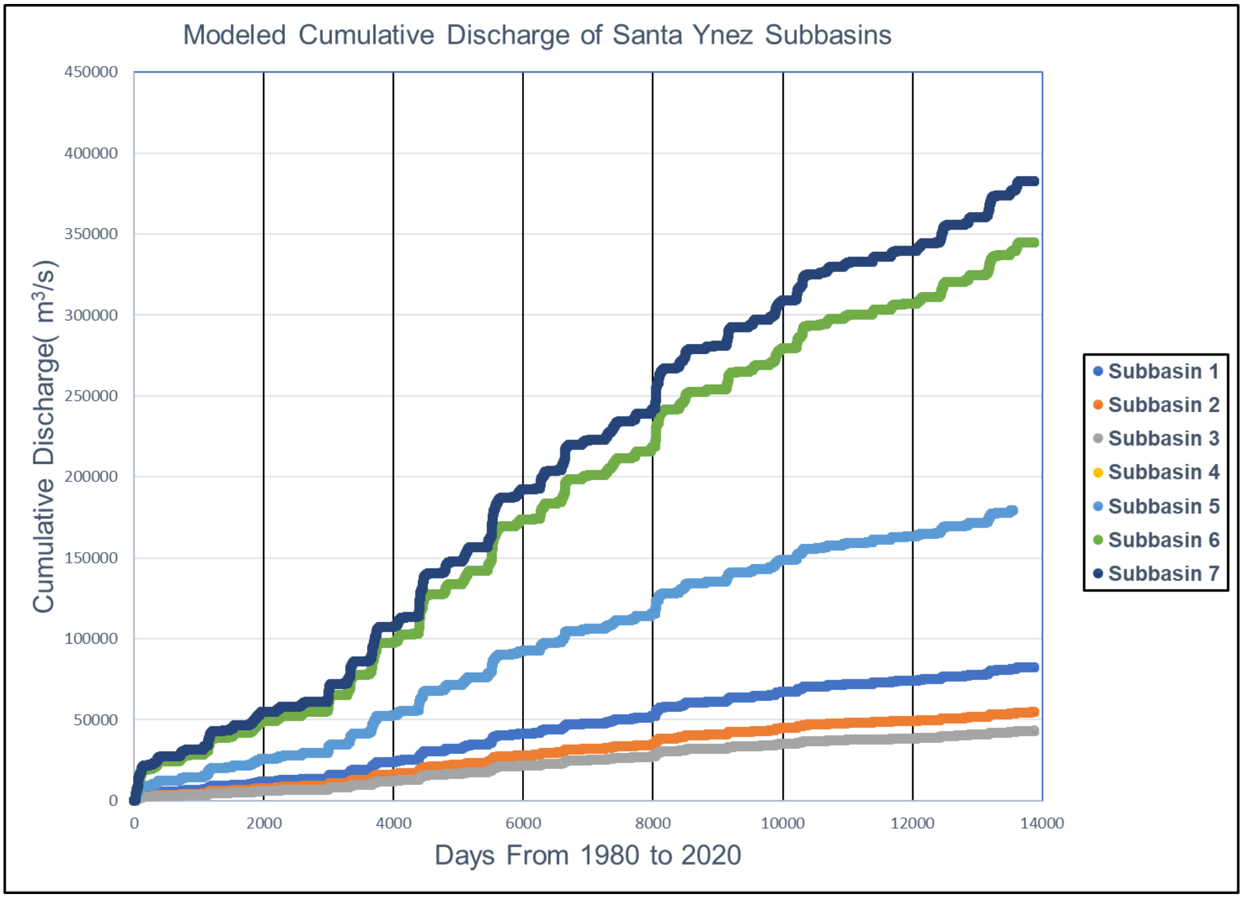

Figure 6a. Modeled 40-year cumulative discharge of seven subbasins of the Santa Ynez watershed from 1980 to 2020.

Figure 6b. Map of the Santa Ynez watershed with seven labeled subbasins delineated by the HUC-10 model.

7. Climate Scenarios

Representative concentration pathways (RPC) describe possible future greenhouse gas outcomes. RPC 4.5 is described by the Intergovernmental Panel on Climate Change (IPCC) as a moderate scenario where emissions peak and then decline around 2050. RPC 8.5 describes a scenario where emissions continue to rise. The Santa Ynez watershed is predicted to increase its discharge as emissions worsen. The melting of snow caps, more frequent extreme weather events, and increased precipitation are possible explanations of the rise in discharge in RPC 8.5 compared to RPC 4.5. (IPCC, 2016)

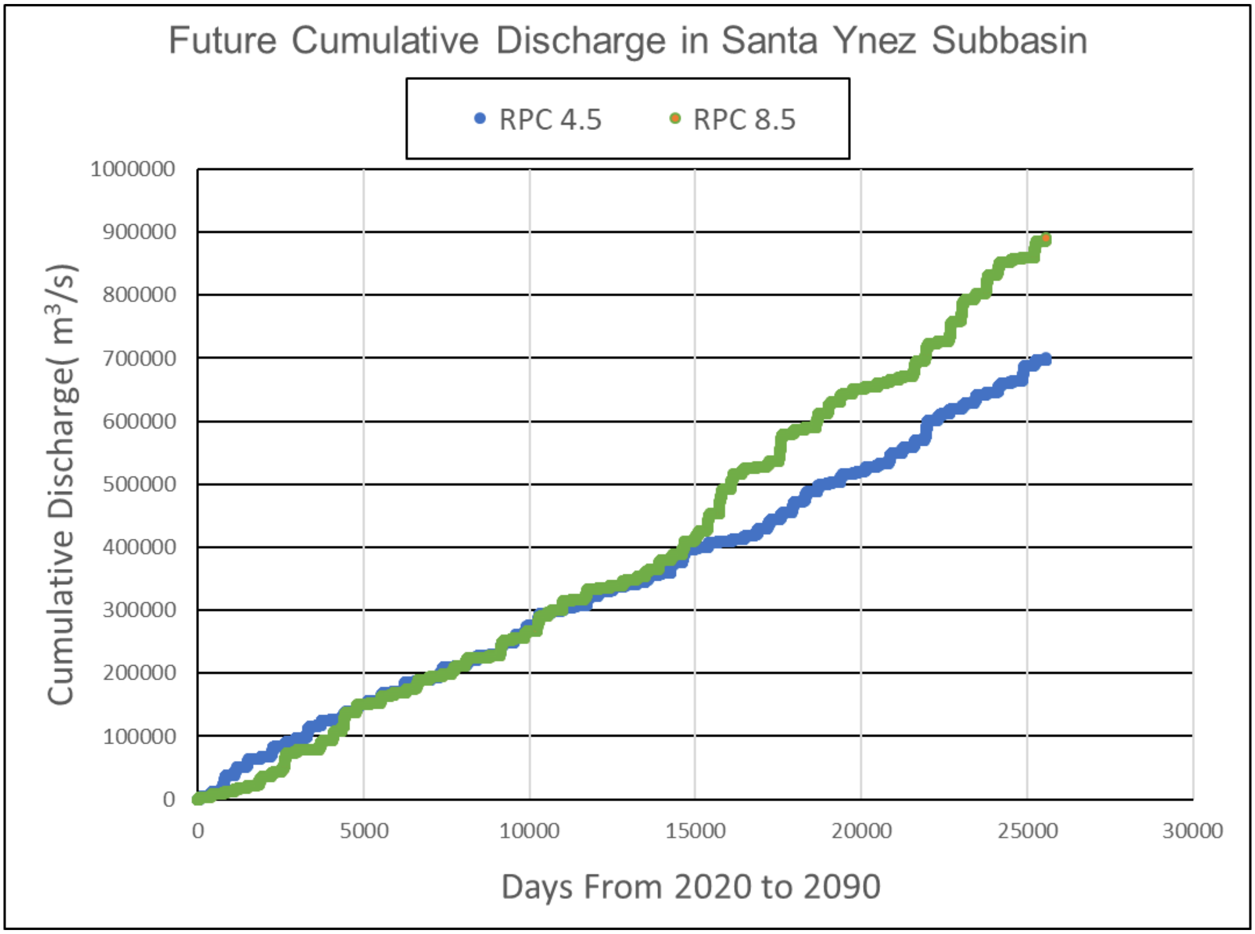

Figure 7. 70-year modeled cumulative discharge in Santa Ynez subbasin 5.

8. Biologic Interests

The Southern California steelhead trout (*Oncorhynchus mykiss)* who historically used the Santa Ynez River as a major breeding site, are listed as endangered under the Endangered Species Act. Because of their sensitivity to water quality and temperature, Steelhead trout act as an indicator species for the health of the Santa Ynez watershed. Steelhead trout return to freshwater to breed after spending most of their life in saltwater. The construction of the three dams, Gilbatrar, Jameson, and Bradbury, from 1920 to 1953 prevented flow of trout to their spawning grounds, largely diminishing their population and reducing genetic diversity. 13,000 to 25,000 individuals were estimated to have occupied the Santa Ynez River before the dams were constructed. Today, there are fewer than 100. (Block, 2013). The Bradbury dam, which maximizes municipal and agricultural water output, prevents adequate flow required for the trout to survive. By improving flow and water conservation measures in the Santa Ynez River, Steelhead trout populations may escape extinction.

Steelhead trout (*Oncorhynchus mykiss)* swimming downstream (CalTrout)

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