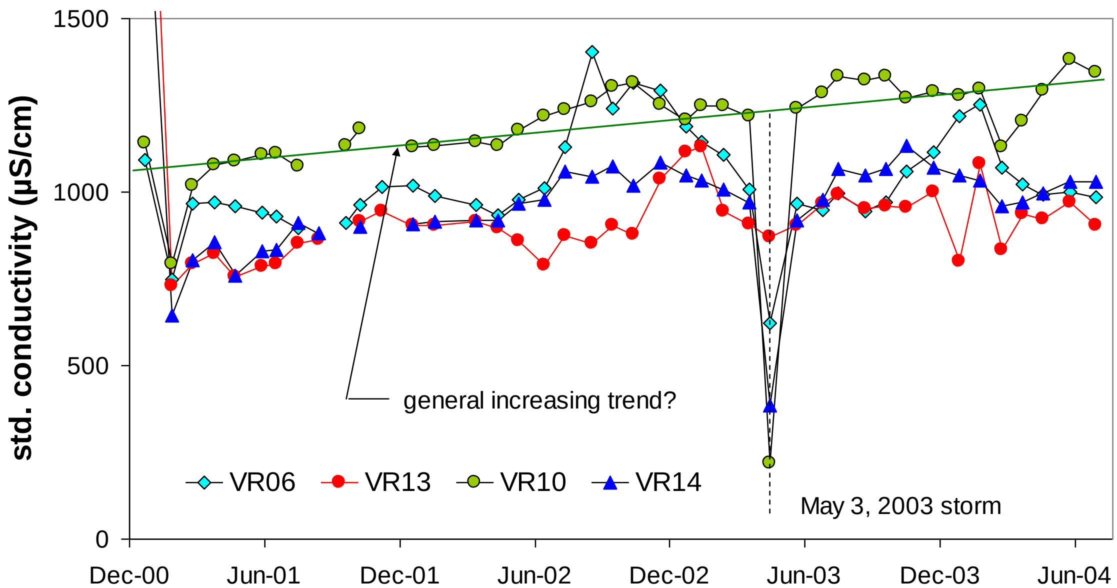
A Story About Conductivity, Climate and Change on the Ventura River

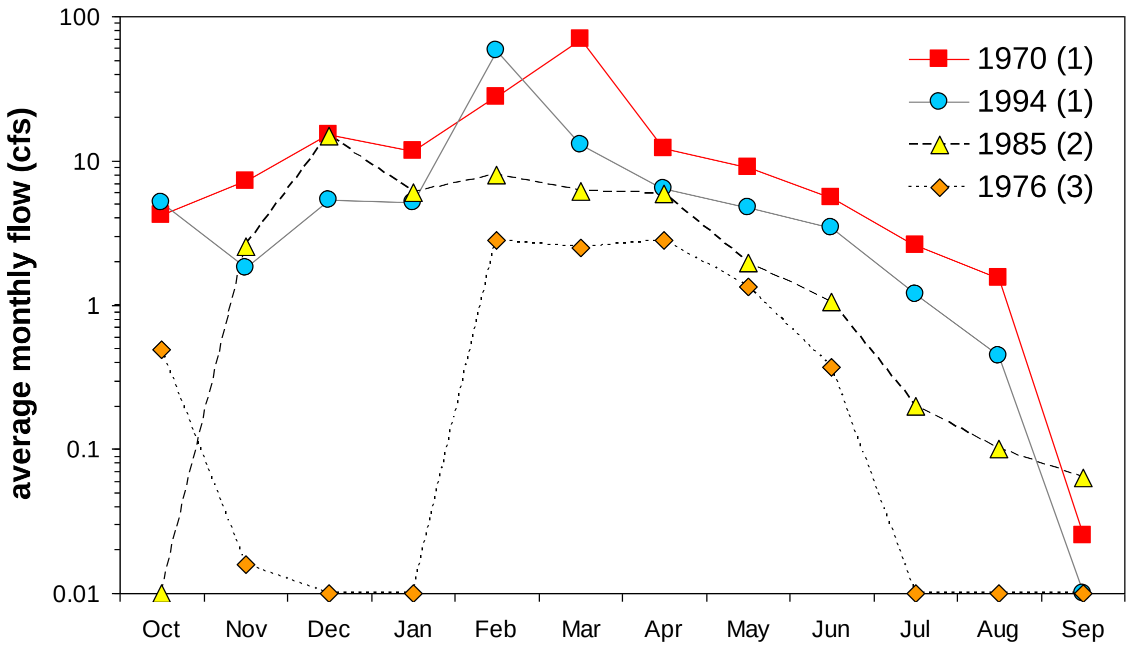
I've plotted (below) a time series of conductivity measurements at 4 Ventura River sampling locations since the beginning of Stream Team. Conductivity measures the amount of dissolved minerals in water, and it varies from creek to creek, and region to region, depending upon the geologic strata source waters traverse and the time required for passage – which is why we see different conductivities on San Antonio Creek (VR10), at Foster Park (VR06) and on the Matilija (VR13 and VR14). The longer water is in contact with soil and rock, the higher its conductivity – rainwater has very low conductivity; water draining from soil has higher values; and groundwater, which spends years or even decades in contact with geologic strata, the highest of all. The biggest cause of a change in conductivity on the river is rain, and the chart shows the drastic drop in values measured during the storm of May 3.



However, the most intriguing thing about the Ventura data is a general trend towards increasing conductivity with time (shown by the solid line drawn on the graph). It's really quite astounding: roughly a 23 percent increase since the Spring of 2001, an increase of about 7 % or nearly 80 µS/cm per year. If I were to hazard a guess, I'd suggest it represents a trend towards older groundwater in the absence of a good runoff year – we haven't had a good storm since March 2001, and the last real big storm occurred in 1998.

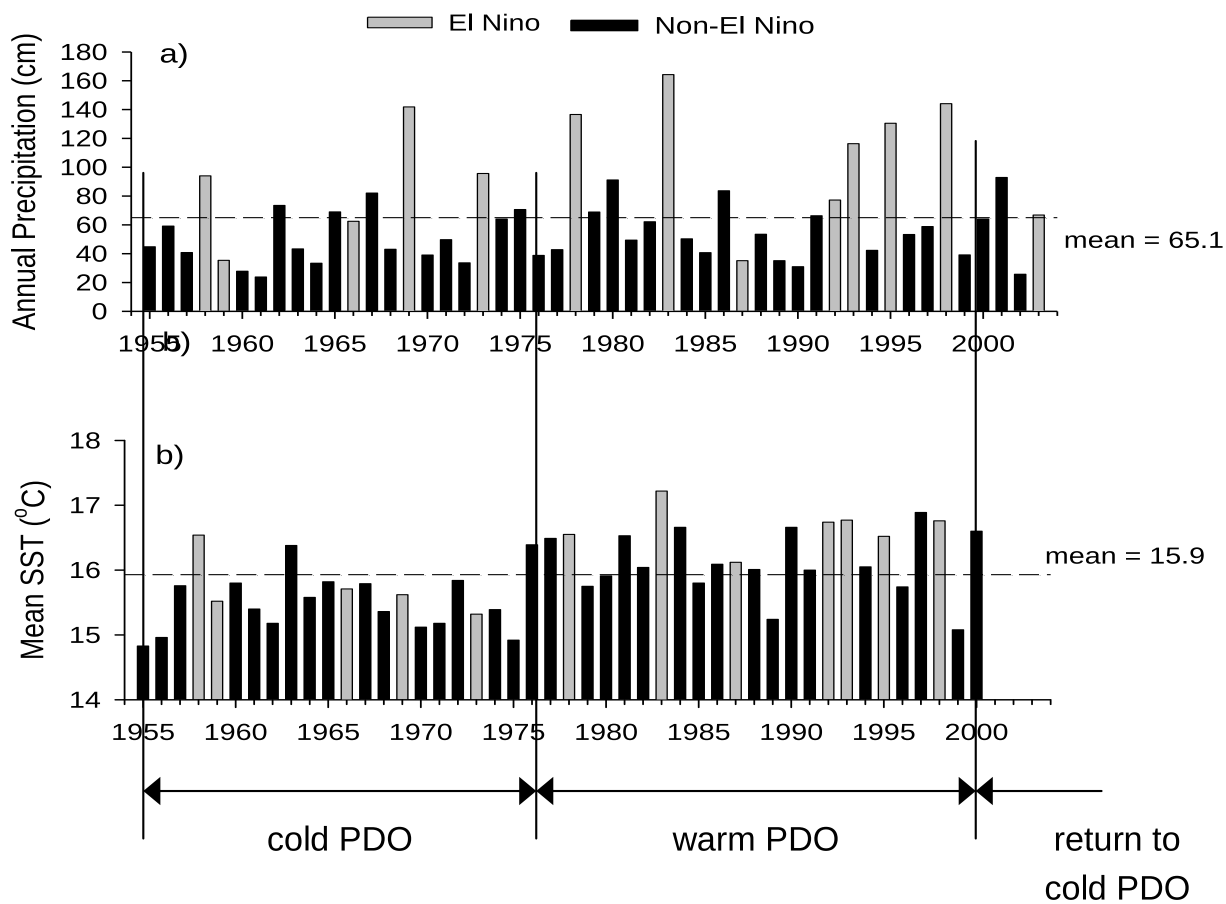
Winter storms dictate the river's flow. Most obviously during the wintertime, but they also govern low-water flows during our long dry season. Summer flows are determined mainly by groundwater levels (inflows from irrigation and urban wastewater and treated sewage also help): with higher groundwater, more water seeps into the river; with lower levels not only does less water enter, but flow is lost – leaking out of the river bottom to replenish the water table below. We have a remarkable annual variation in rainfall: it's either boom or bust, either a lot of winter rain or surprisingly little. We can blame El Nino for most of this: approximately once every 6 years El Nino brings abnormally high rainfall to Southern California, and once every 8 to 10 years the rainfall is huge.

Most other years the rains are, almost by definition, below average. During these below average years the river starts to change: aquatic plants replace algae over much of the summer, fast-growing trees and thick brush take over the river edge, and flows seem to decrease as the years go by. In years with less rainfall the groundwater table also falls; with less recharge – "new" water – entering the system the average age of groundwaters flowing into streams and rivers is growing older. And older means higher conductivity. So every year that passes without an El Nino, or without abnormally high rainfall, will be a year with decreasing flows and increasing conductivity since it needs an El Nino to bring us back to "average" conditions.



The above figure, which shows monthly average flow for 4 years at Foster Park (VR06), demonstrates what happens in the years following a wet El Nino. I've picked 4 years with approximately the same rainfall (these are "water" years, beginning in Oct. – the start of the rainy season – and ending the following Sept.). The average monthly flow is measured in cubic feet per sec (it's a logarithmic scale so little differences mean a lot) and the numbers in the legend (in parentheses following the date) indicate the number of years since the last wet El Nino. The further we get from the last El Nino the greater the decrease in monthly flows – remember, all these years had approximately 16 inches of rainfall (in Santa Barbara). 1985 (2 years after the 1983 El Nino) had lower flows than 1970, and in 1976 (3 years after the 1973 El Nino) flows were lower still. The difference between 1970 and 1994 is the difference between a big El Nino (in 1995) and a really, really big El Nino (1969).

The same situation is currently taking place on the Ventura, and in all other South Coast creeks. Flows this year are lower than during the 2002 drought year, even though we've had almost double the 2002 rainfall; and flows are lower this year than last, even though the 2003 rainfall was approximately the same as this year's. If an wet El Nino is the party, we're now suffering from an extended hangover – unfortunately, the hangover will get worse instead of better as time passes.



Actually, if you think, as I do, that creeks and rivers should be things filled with water, there is more bad news. It's called the Pacific Decadal Oscillation (PDO). The comings and goings of El Nino are not the only cyclical pattern that affects our rainfall, there is an 50-year (roughly) pattern of alternately cold and warm waters that abruptly shifts location in the Pacific Ocean. Without getting into details, the "cold" PDO phase moves the jet stream (and a lot of winter rain) northwards, while the "warm" phase shoves it, and the rainfall, southwards – giving us wetter winters. My last figure shows average annual rainfall in Santa Barbara (with past El Nino years separately identified) in the upper panel, and sea-surface temperatures at Stearns Wharf (Santa Barbara) in the lower. During the cold PDO phase (1955-1975) sea temperatures were noticeably lower and El Nino years fewer and less wet; during the warm phase (1976-2000) ocean temperatures were warmer and wet years more common, and much wetter. Think of the El Nino pattern as lying atop of the longer term Pacific Oscillation: with the PDO determining the severity and frequency of our wet El Nino years.

Unfortunately for our local streams, we appear to have entered a new cold phase in 2000. With less rainfall, we can expect to see even lower flows in our local streams, and increased vegetation growth along the banks – and higher conductivities. We might also expect more wildfires, increased summer fog and intended drought conditions. And you thought the coming election, gas prices and global warming was all you had to worry about.