Facing Future Climate Change: A View From the Watersheds

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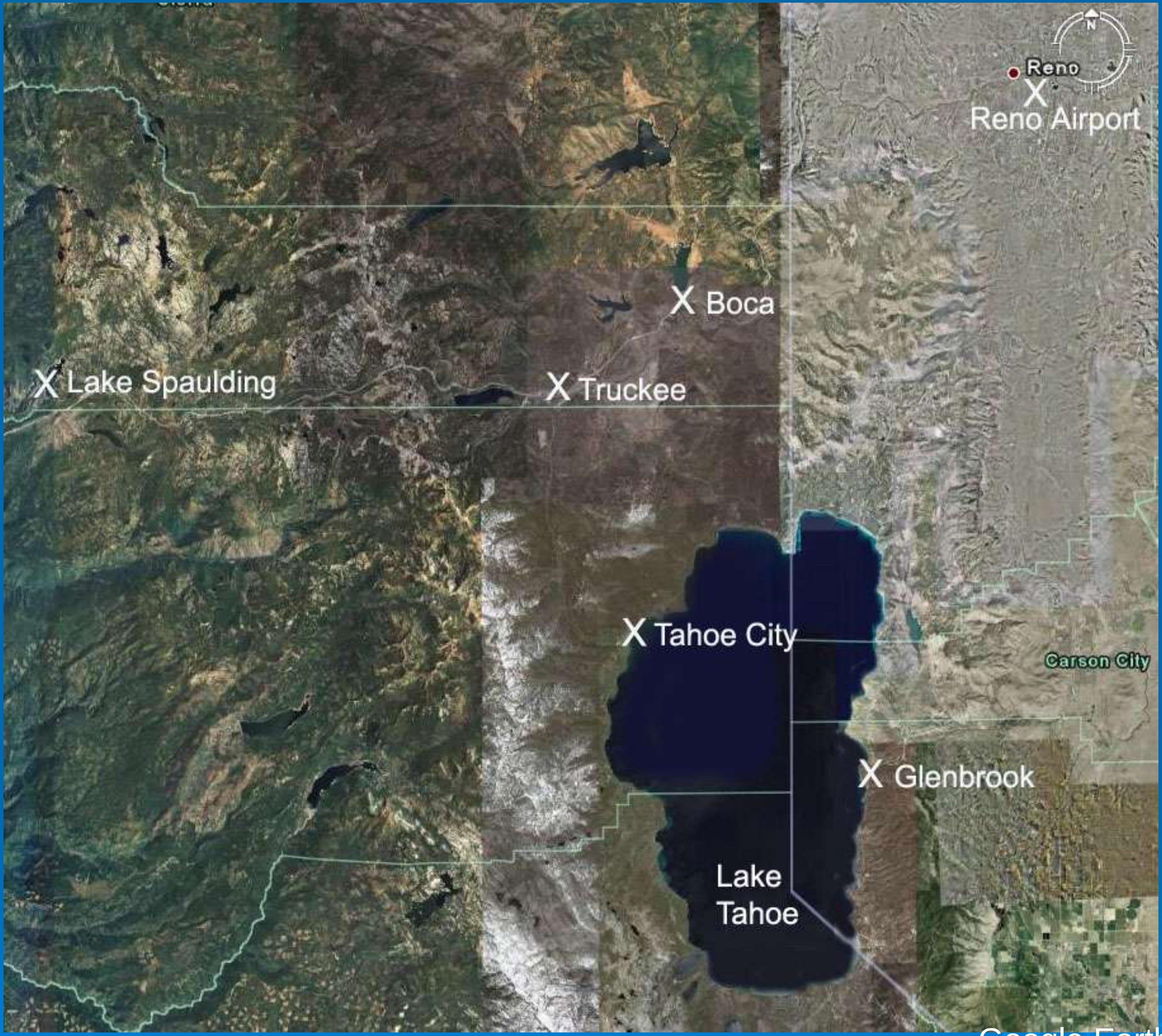
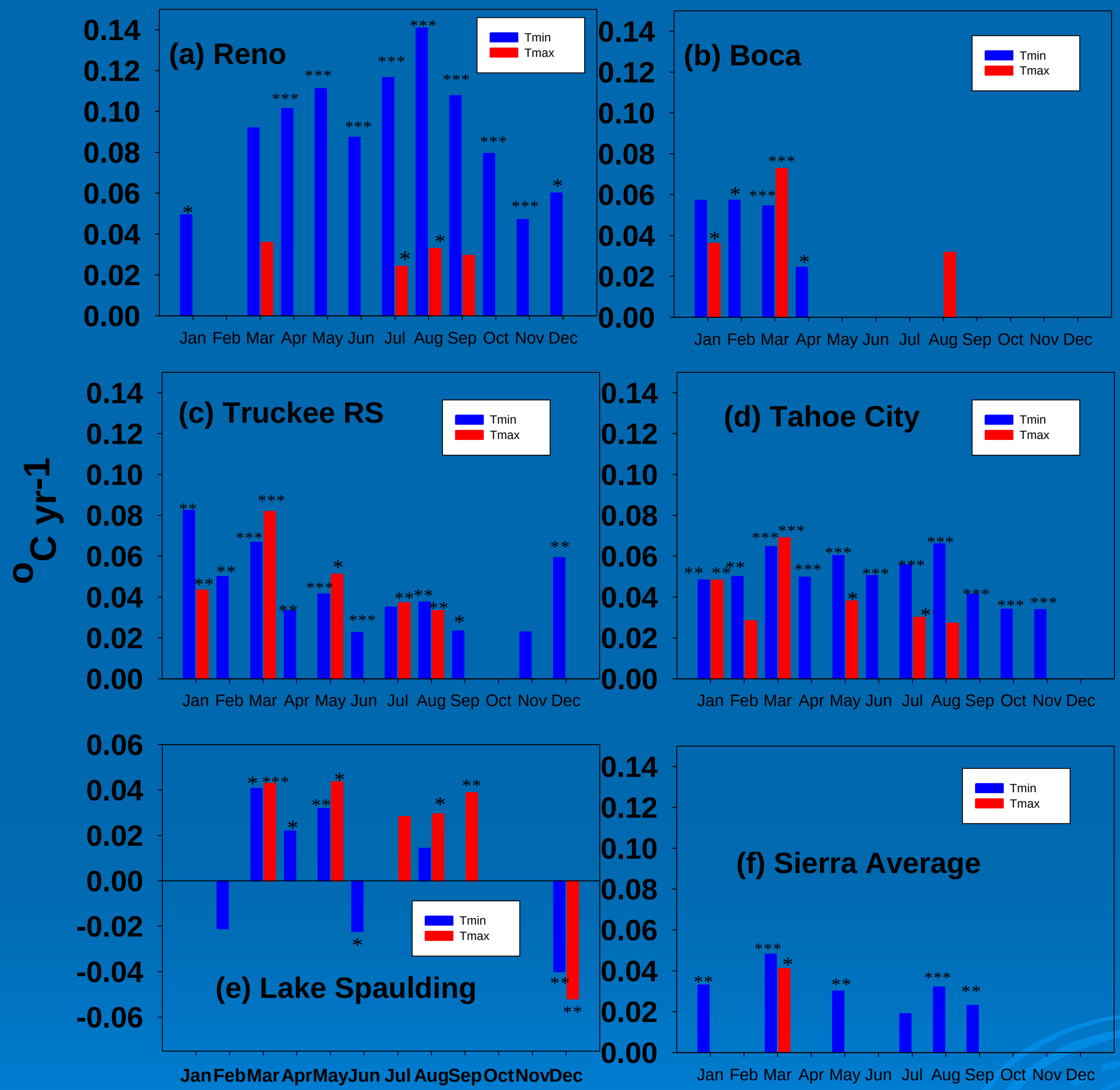


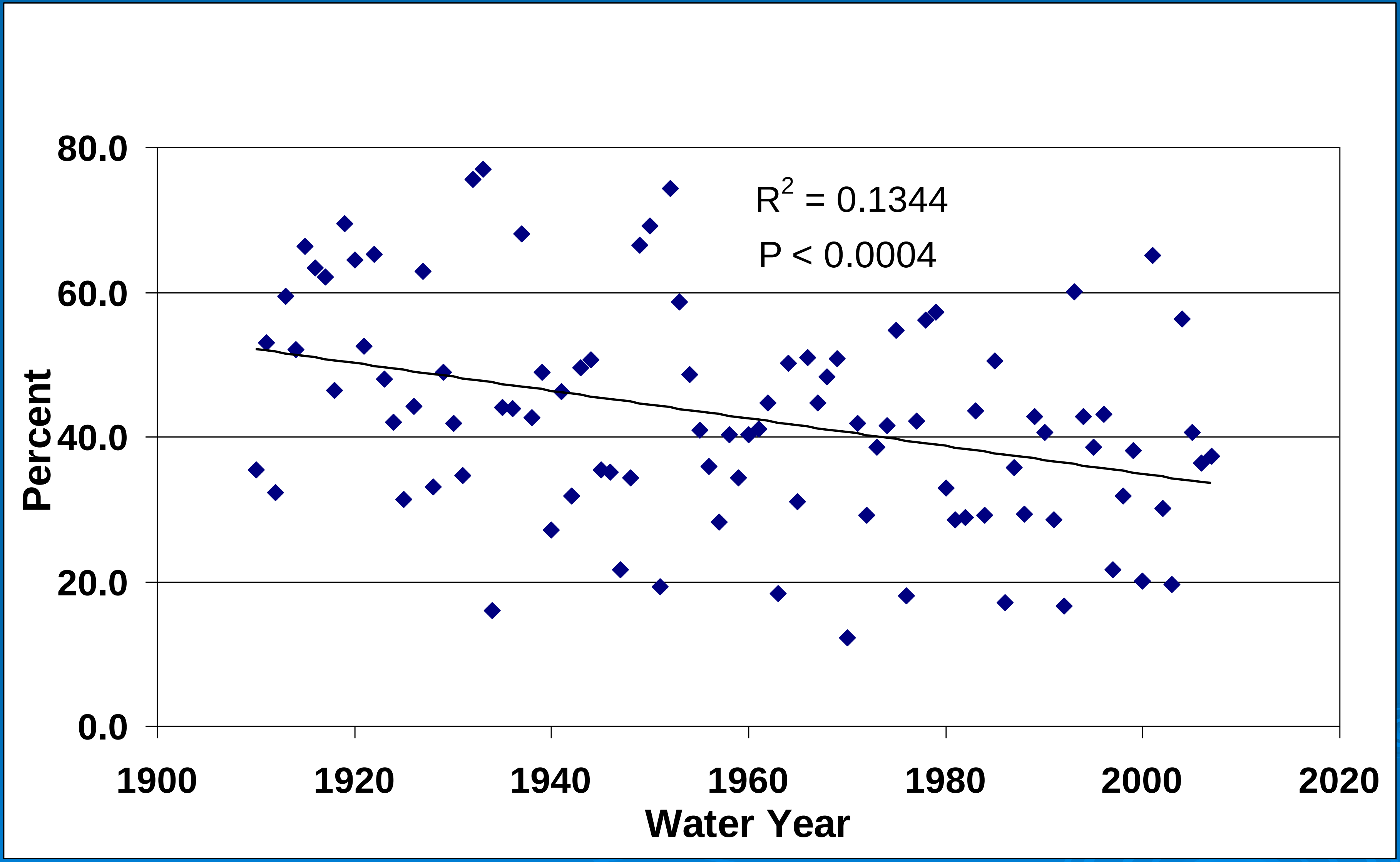
Google Earth

Coop weather stations used to examine regional temperature trends

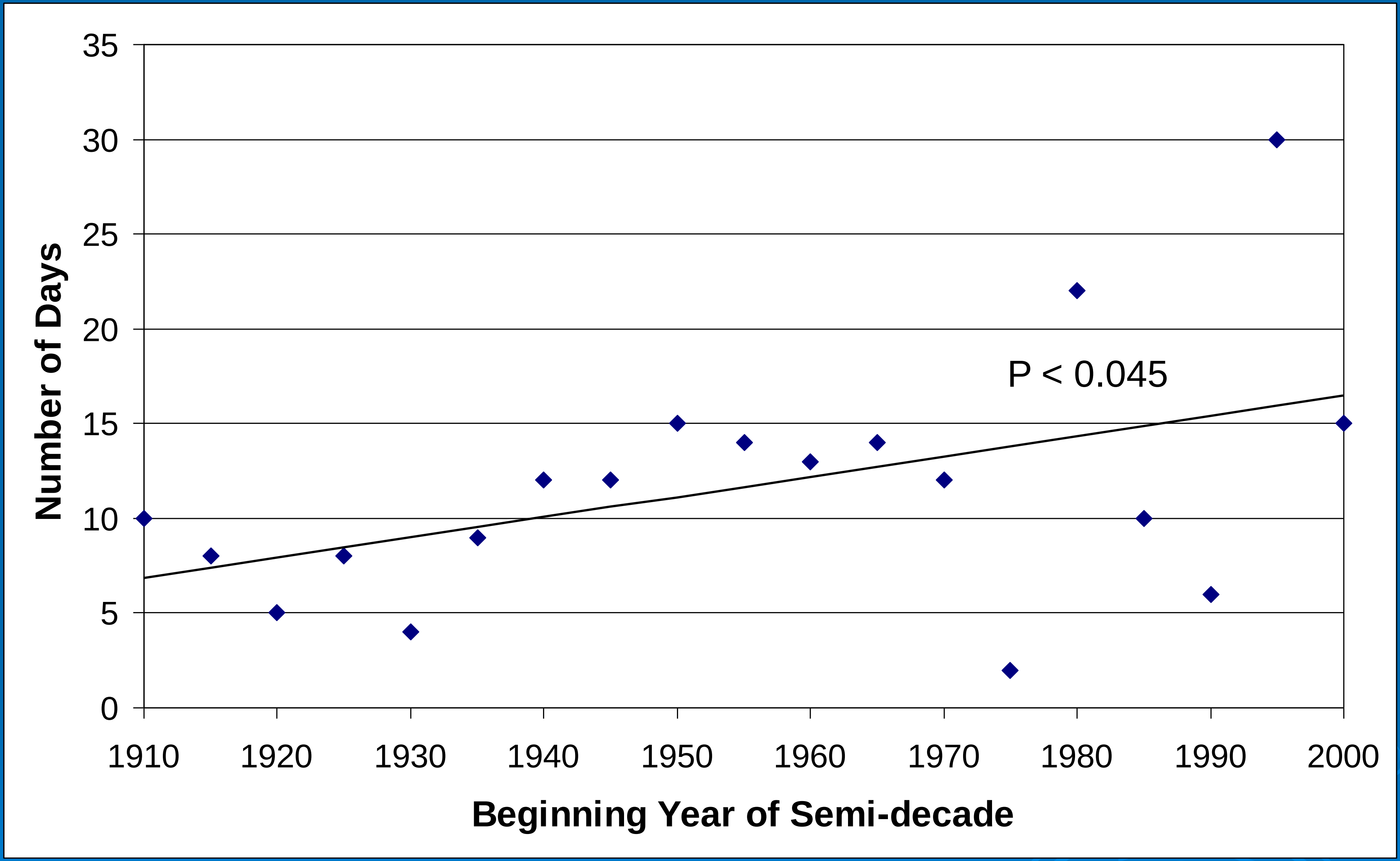


Thiel slope of trend in monthly averages of Tmax and Tmin,1956-2005.
*** indicates P< 0.01; ** P=0.01-0.05; * P =0.05-0.10; no asterisk indicates P = 0.15-0.1

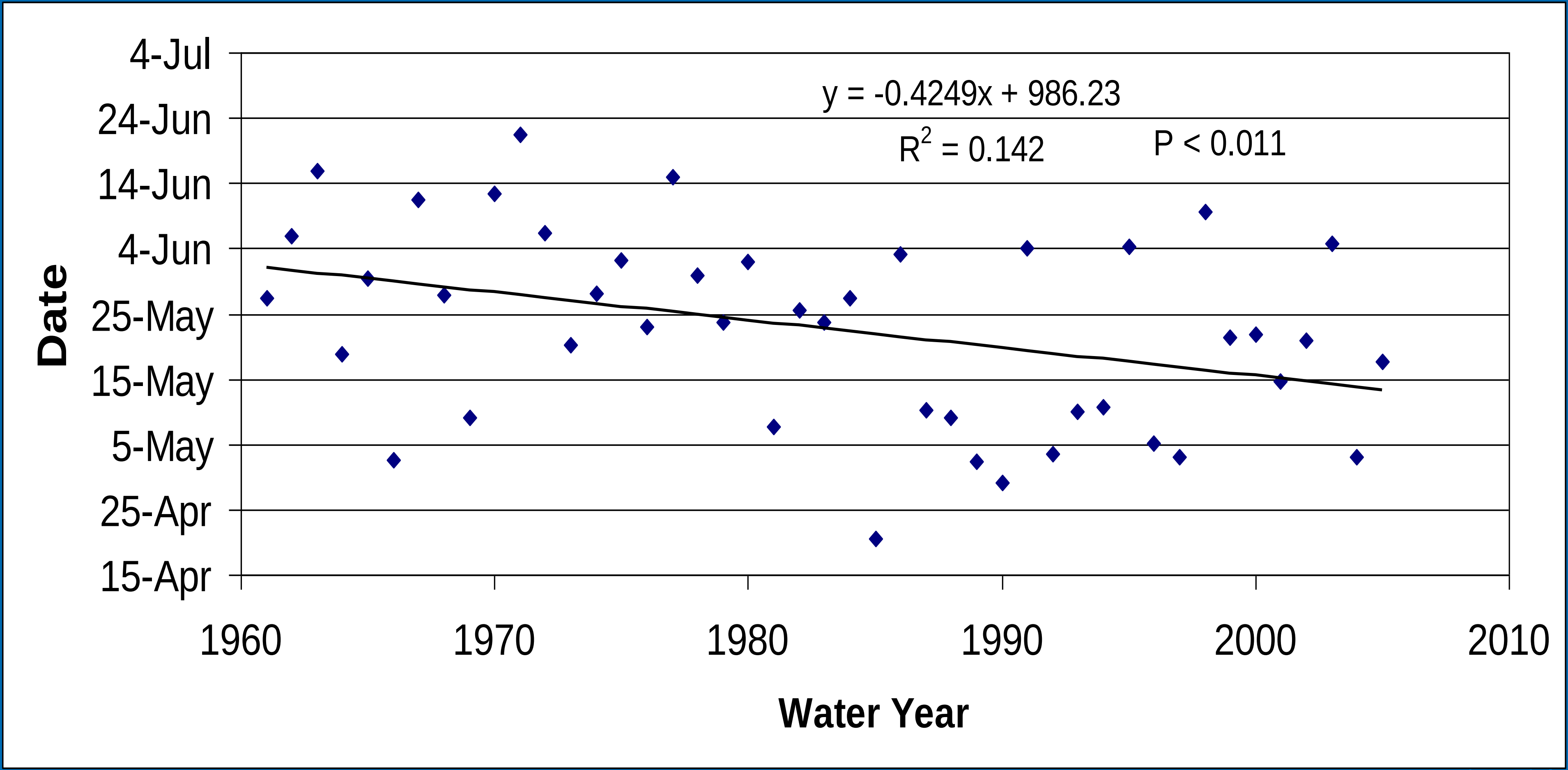
Glenbrook Fire Station, Coop ID No. 263205



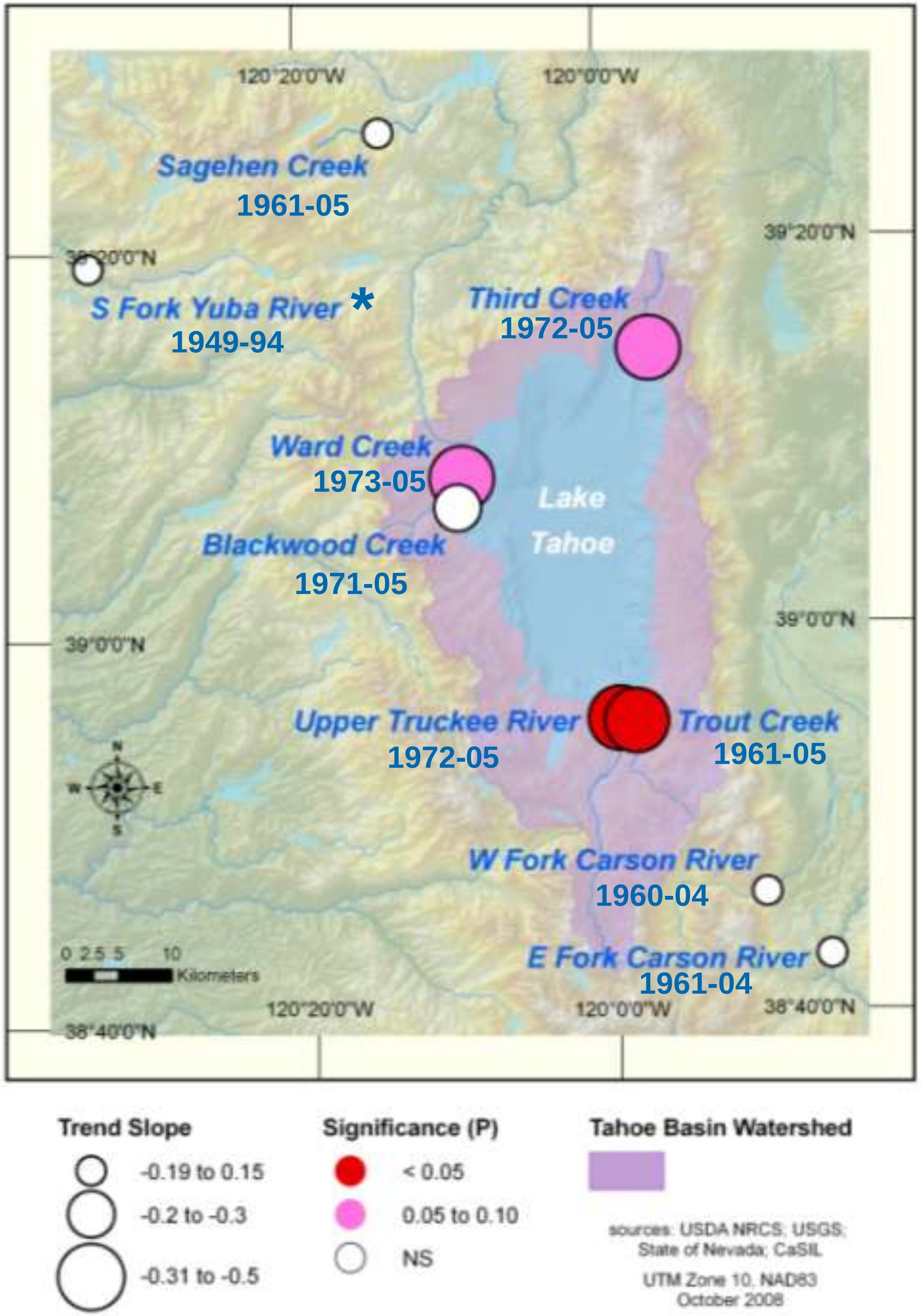
Percent of total annual precipitation as snow, based on Tahoe City precipitation and temperature data



Number of days per semi-decade that daily rainfall at Tahoe City exceeded 3.9 cm, the 95th percentile value for days with rain .



Average date of snowmelt peak discharge for 5 streams in the Tahoe Basin, (Ward, Blackwood, UTR, Trout & Third Cr.) after removal of total annual snowfall effect

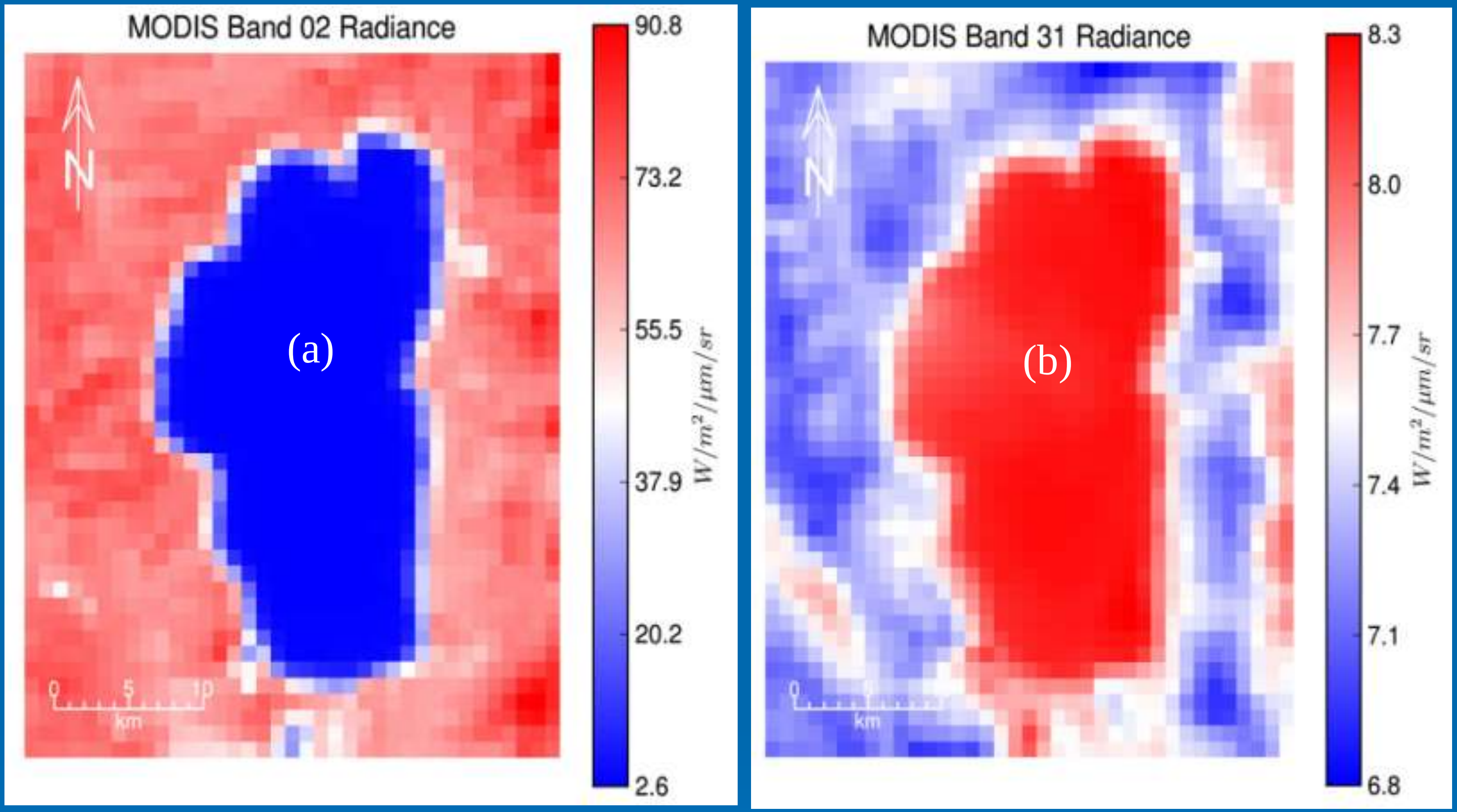


Shift in the Date of Peak Snowmelt Discharge for Streams in and Near the Tahoe Basin

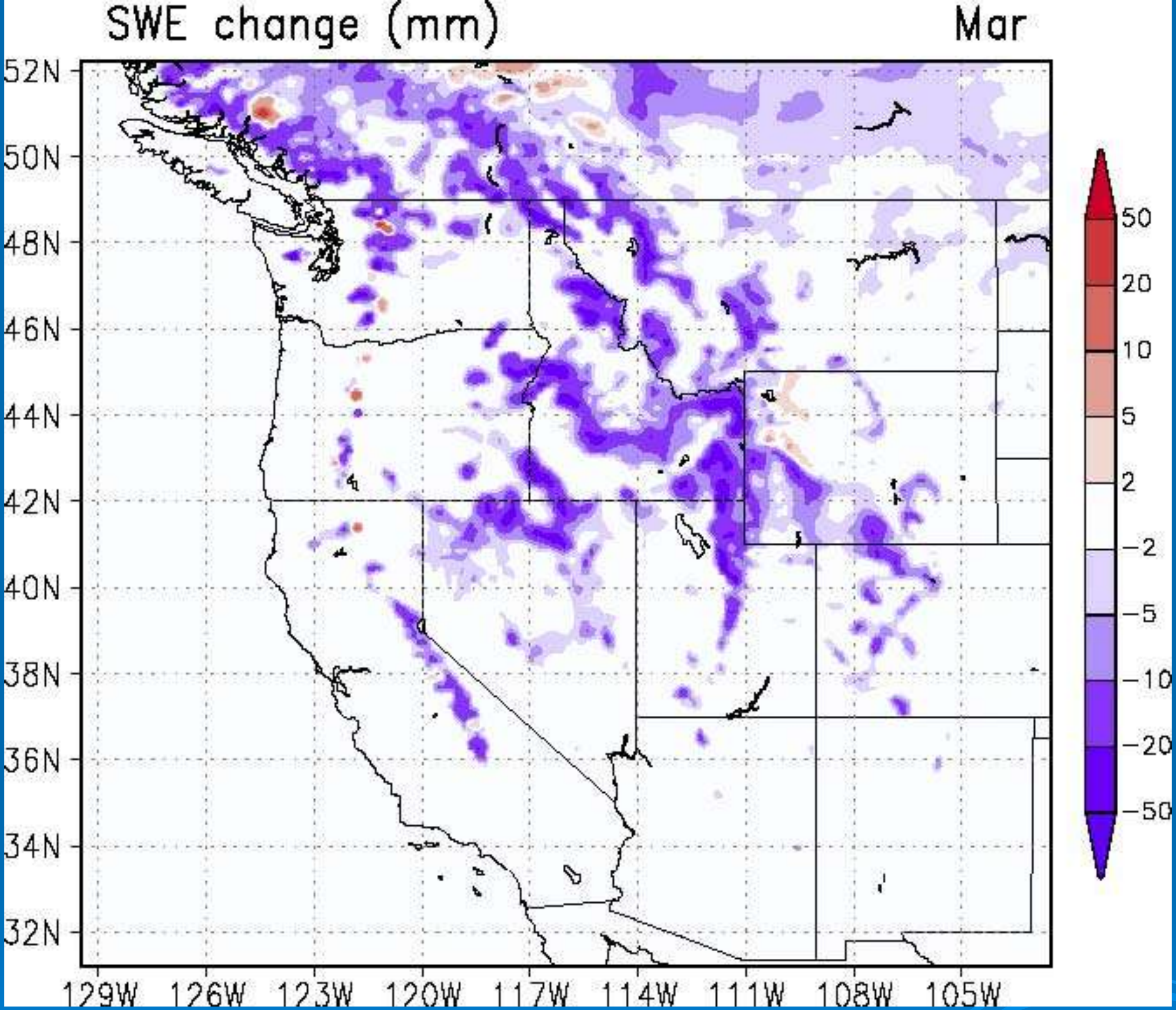
Trend Slope (days yr^{-1}) and Significance (corrected for autocorrelation) from Kendall Trend Test

Effect of Total Annual Snowfall removed by LOWESS smoothing

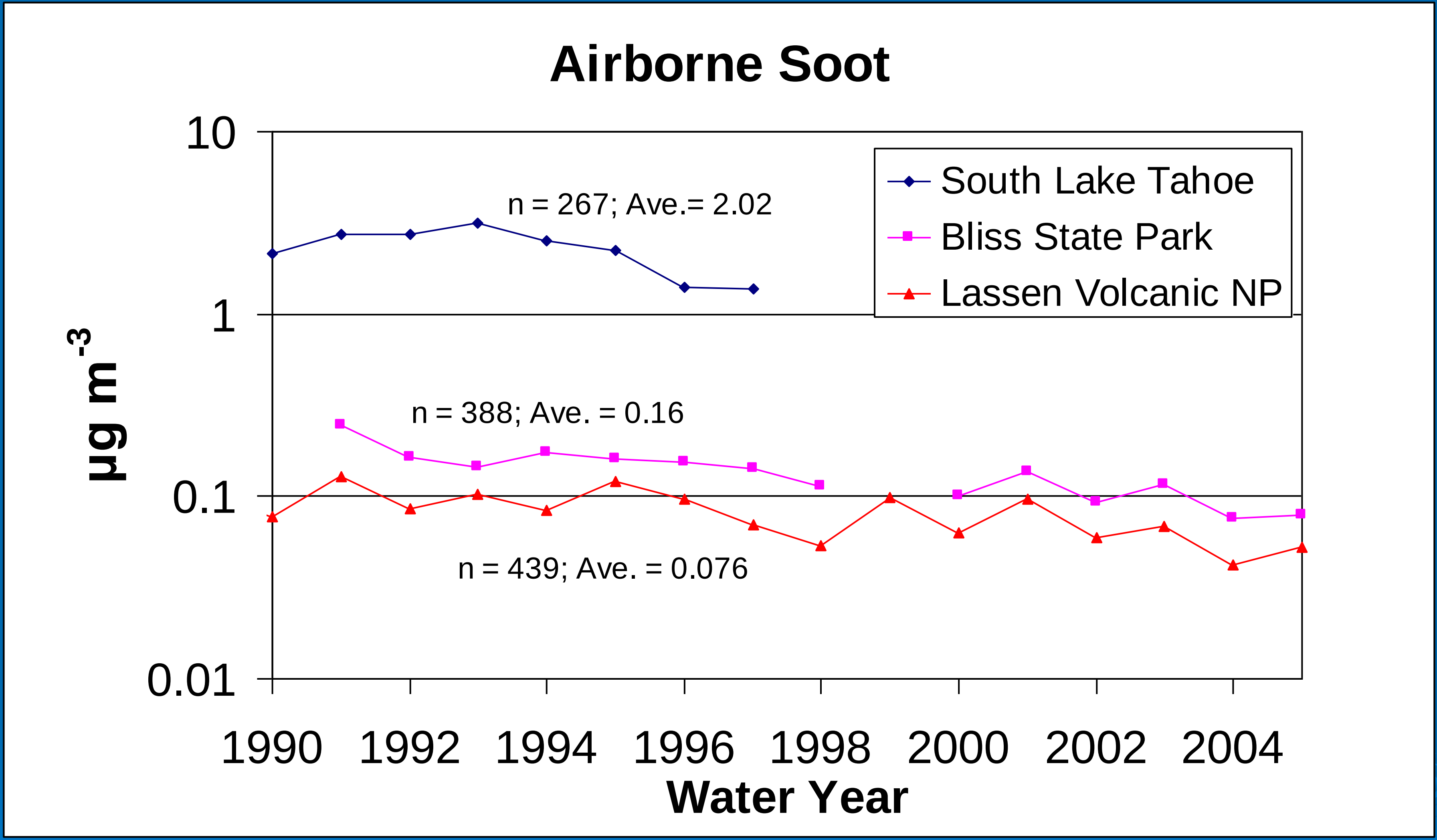
Map by Janet Brewster, CTC



MODIS satellite images of Lake Tahoe, day and night, at mid-summer. (a) Reflected Near-IR radiation, 0.84-0.85 μm , at 10:50 AM PST, 7/31/2007. (b) Outward Long wave radiation, 10.8-11.3 μm, at 10:10 PM PST, 8/5/2007. Source: Todd Steissberg, Univ. California at Davis.

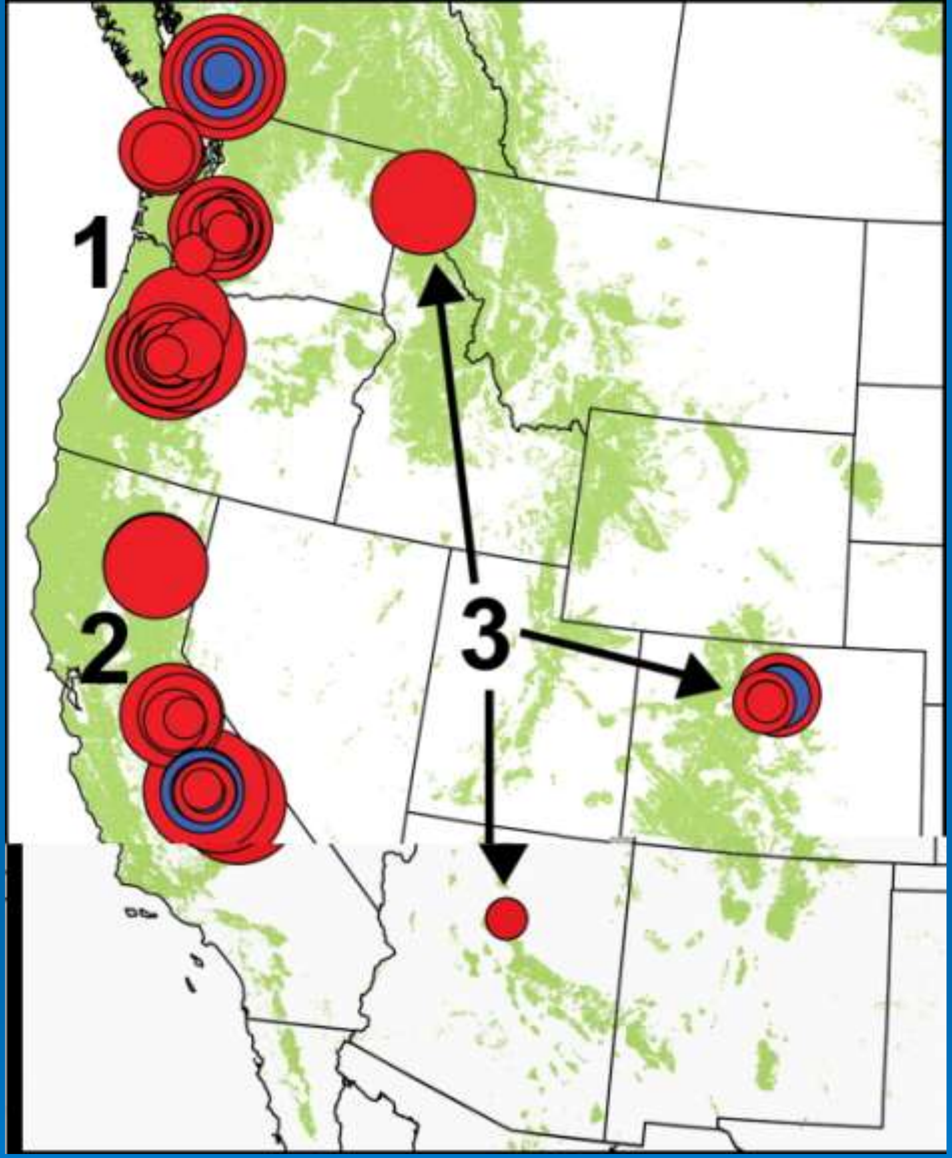


Modeled effect of soot deposition on March mean snow water equivalent (Fig. 12 from Qian et al. 2009. Jour. Geophys. Res.)

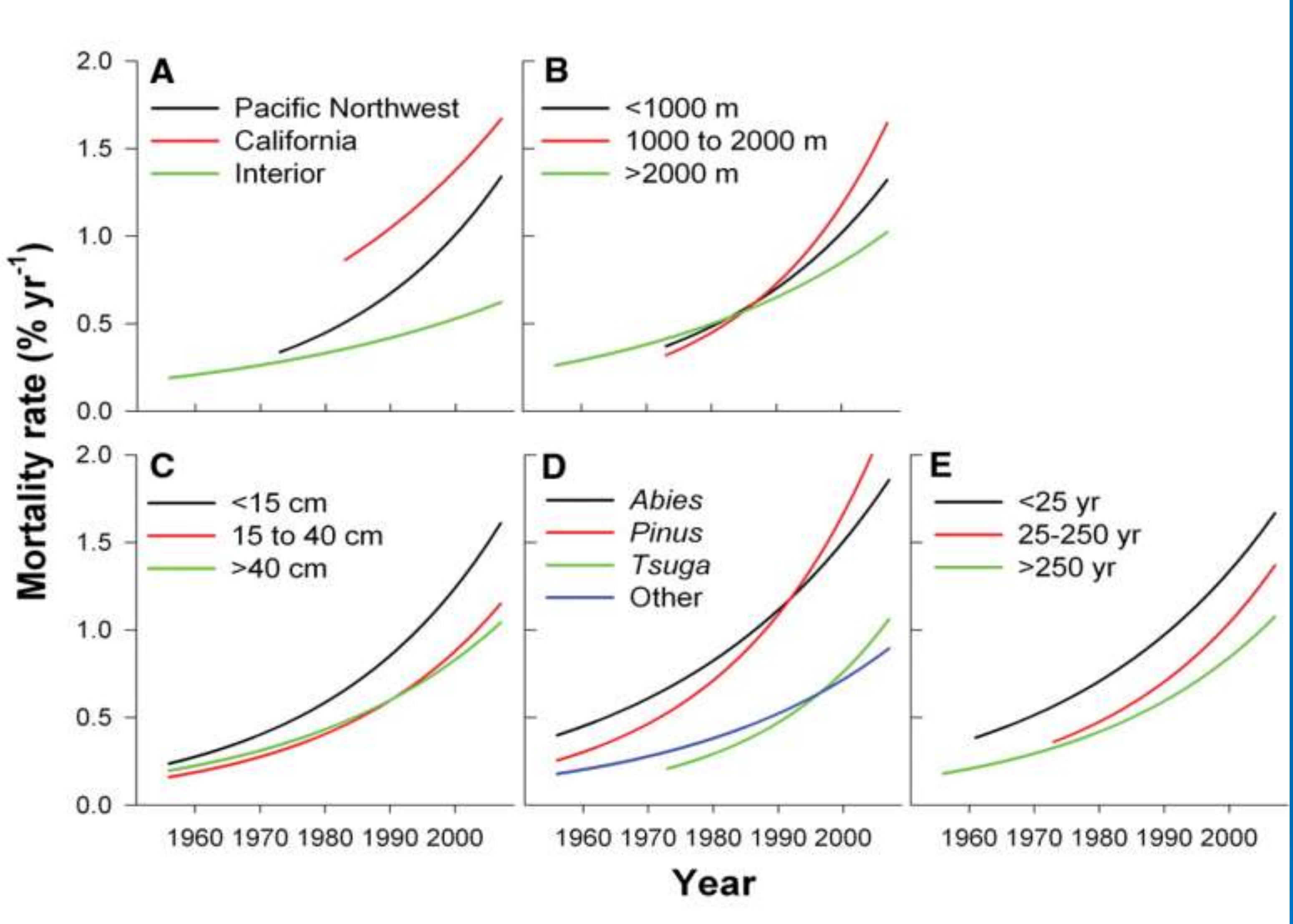


Annual averages of near-surface atmospheric fine total elemental carbon concentration (< 2.5 µm), Dec., Jan and Feb.

The California Cooperative Snow Surveys:
A Monitoring Opportunity

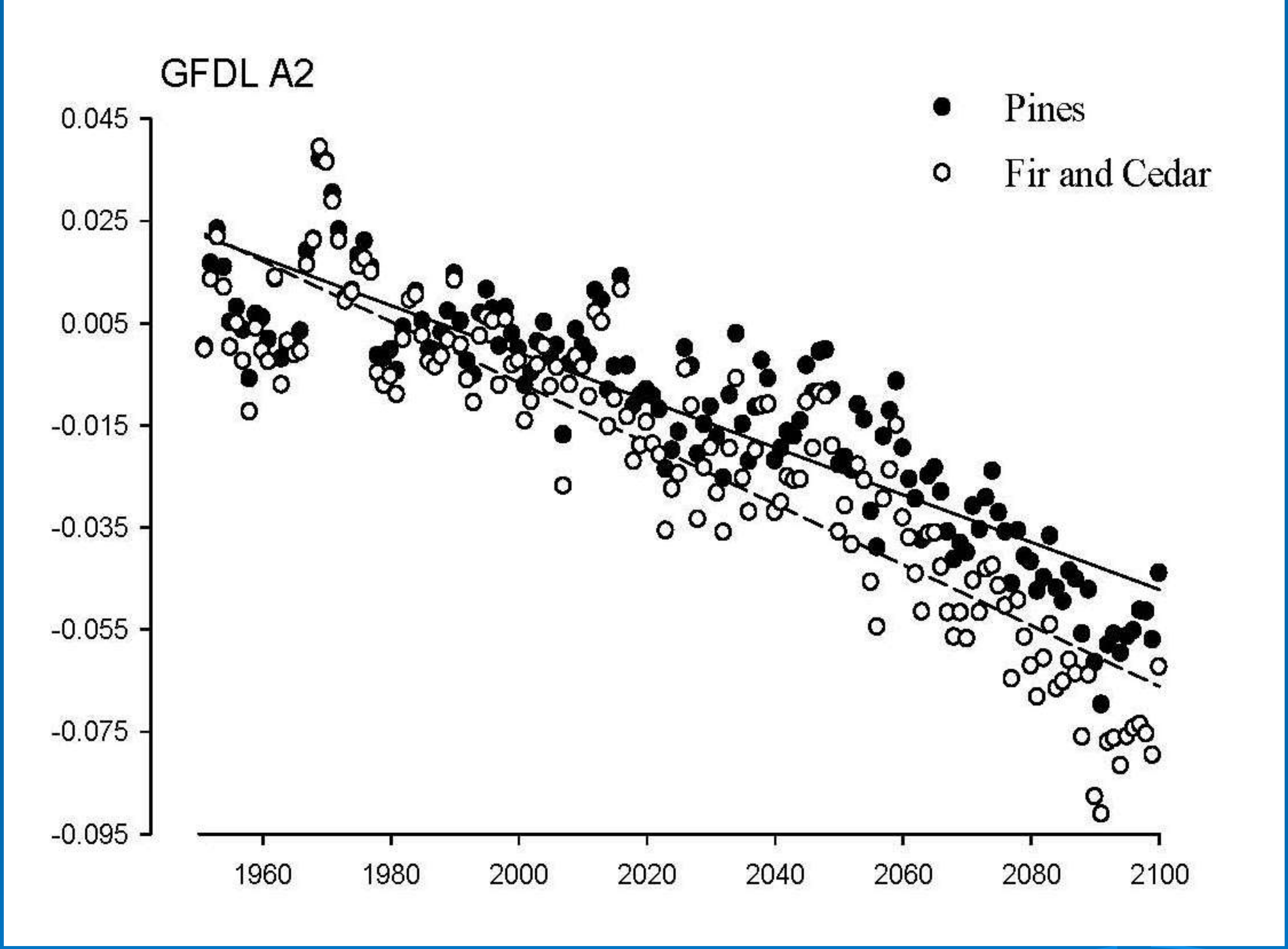


Locations of the 76 forest plots in the western United States and southwestern British Columbia P. J. van Mantgem et al., Science 323, 521 -524 (2009)



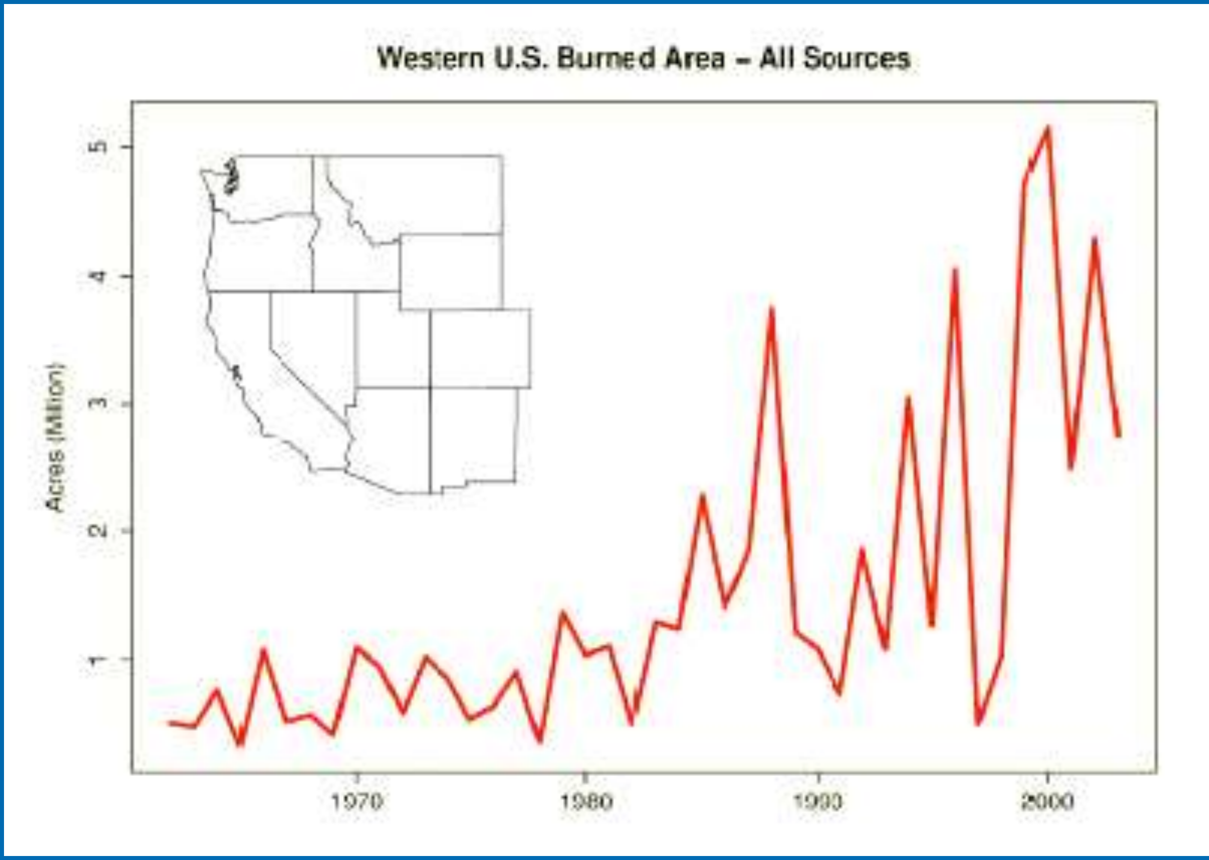
Modeled trends in tree mortality rates for (A) regions, (B) elevational class, (C) stem diameter class, (D) genus, and (E) historical fire return interval class

Climate Growth Residuals, in. dia.

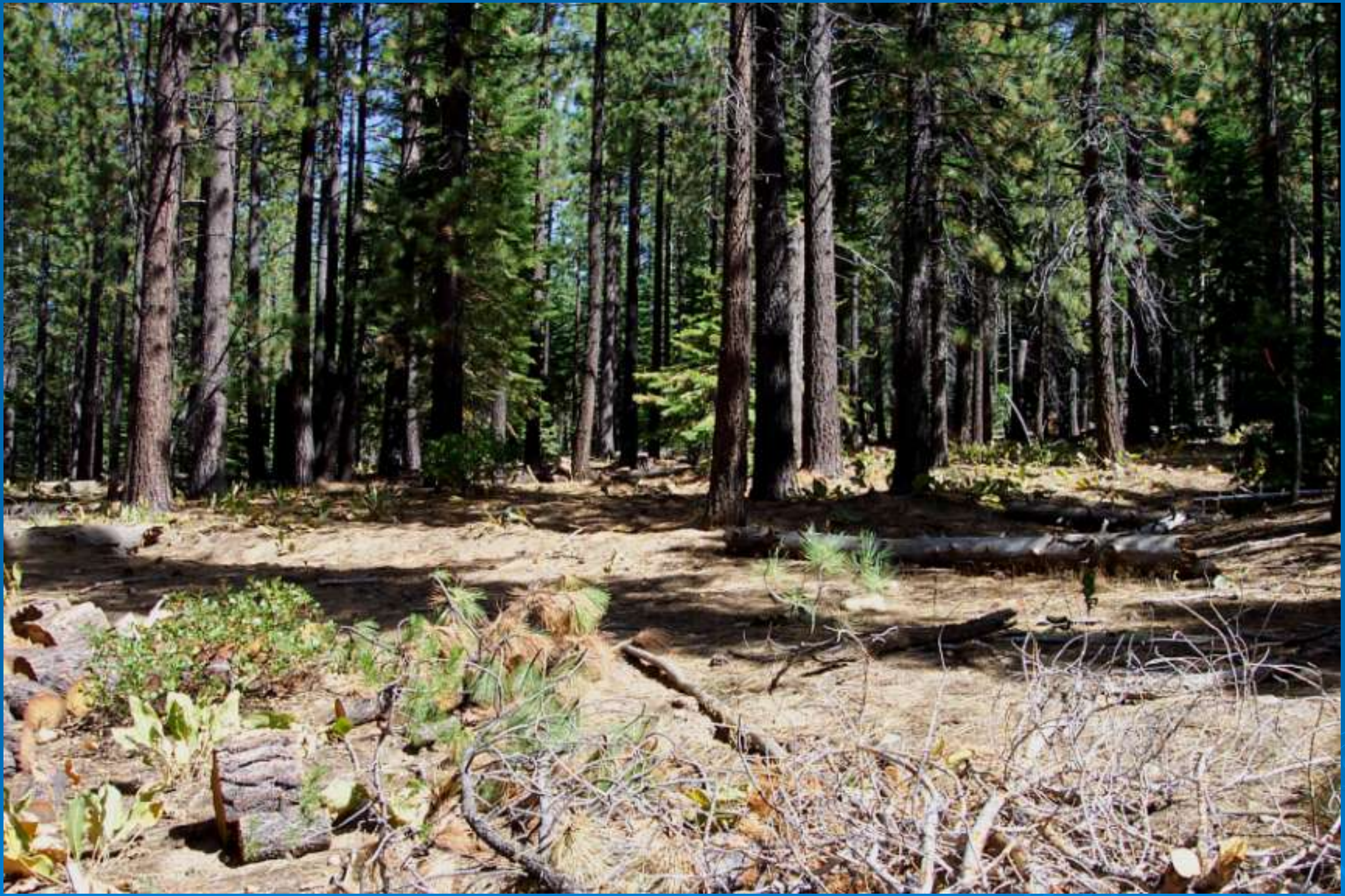


Year

Battles et al. 2006. Climate Change Impacts on Forest Resources. Calif. Climate Change Cent.



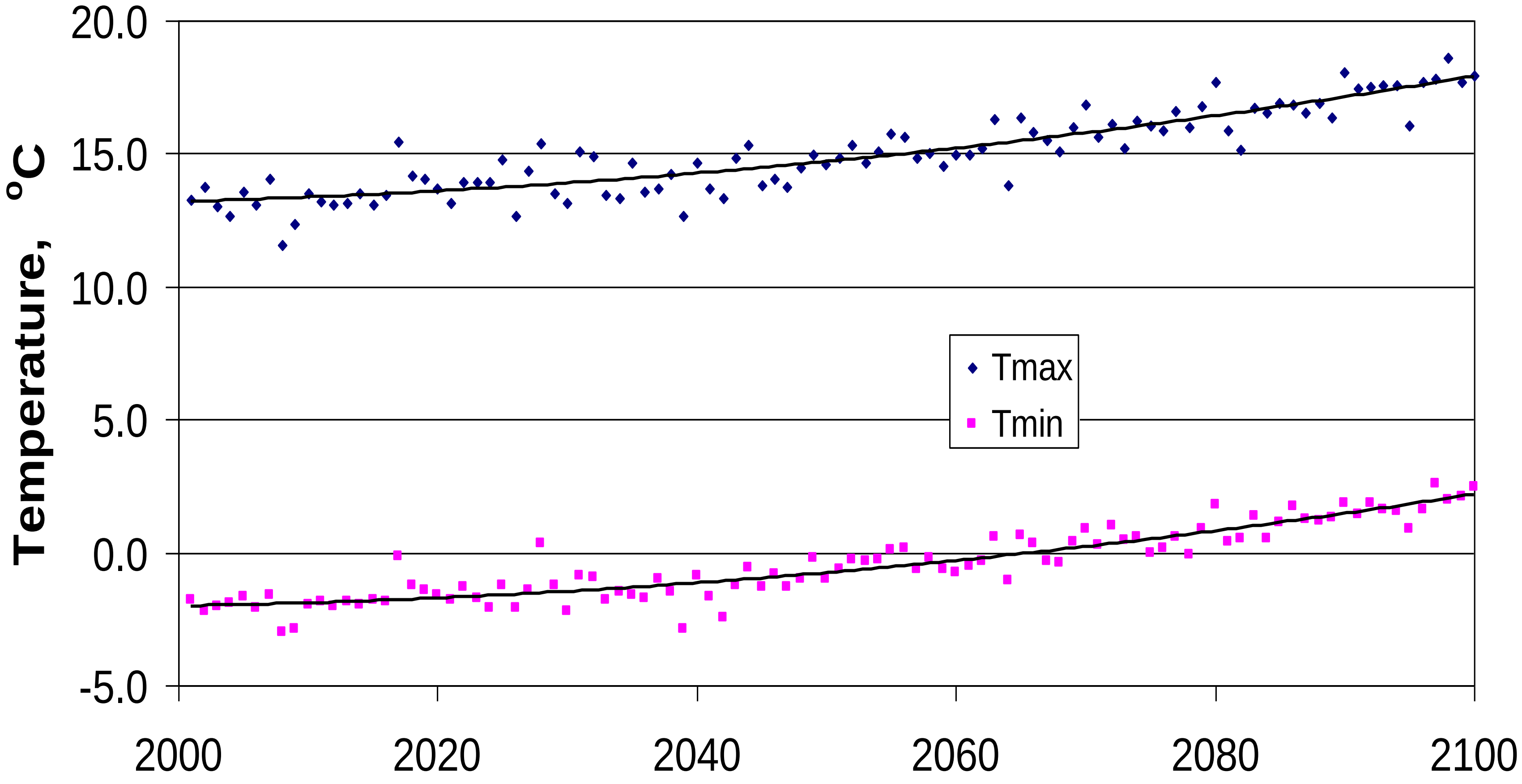
Westerling et al. 2006. Warming and early spring increases western U.S. Wildfire activity



Fuel Load Reduction, near Incline

Photo by Steve DeVries

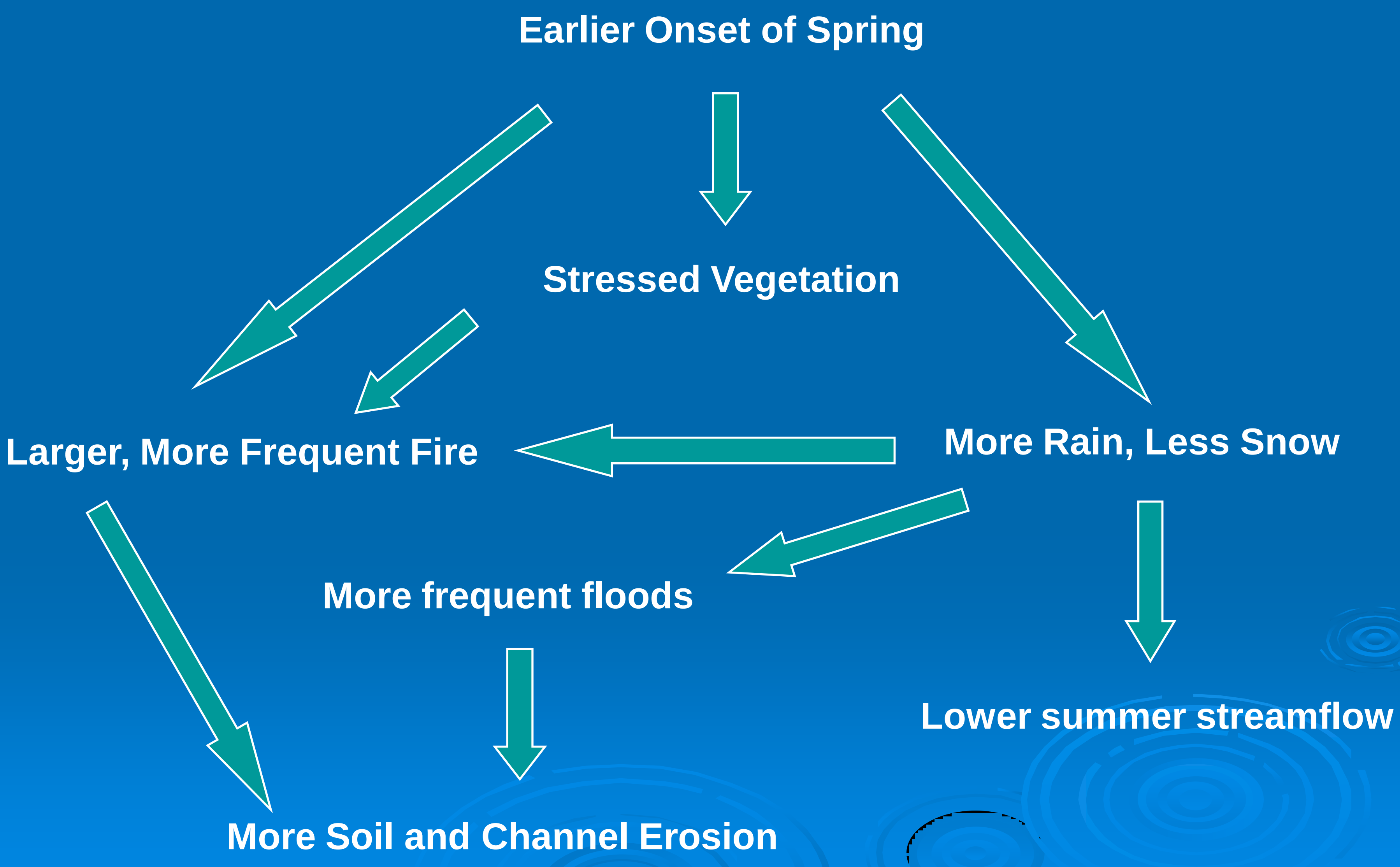
The Angora Fire, 2007

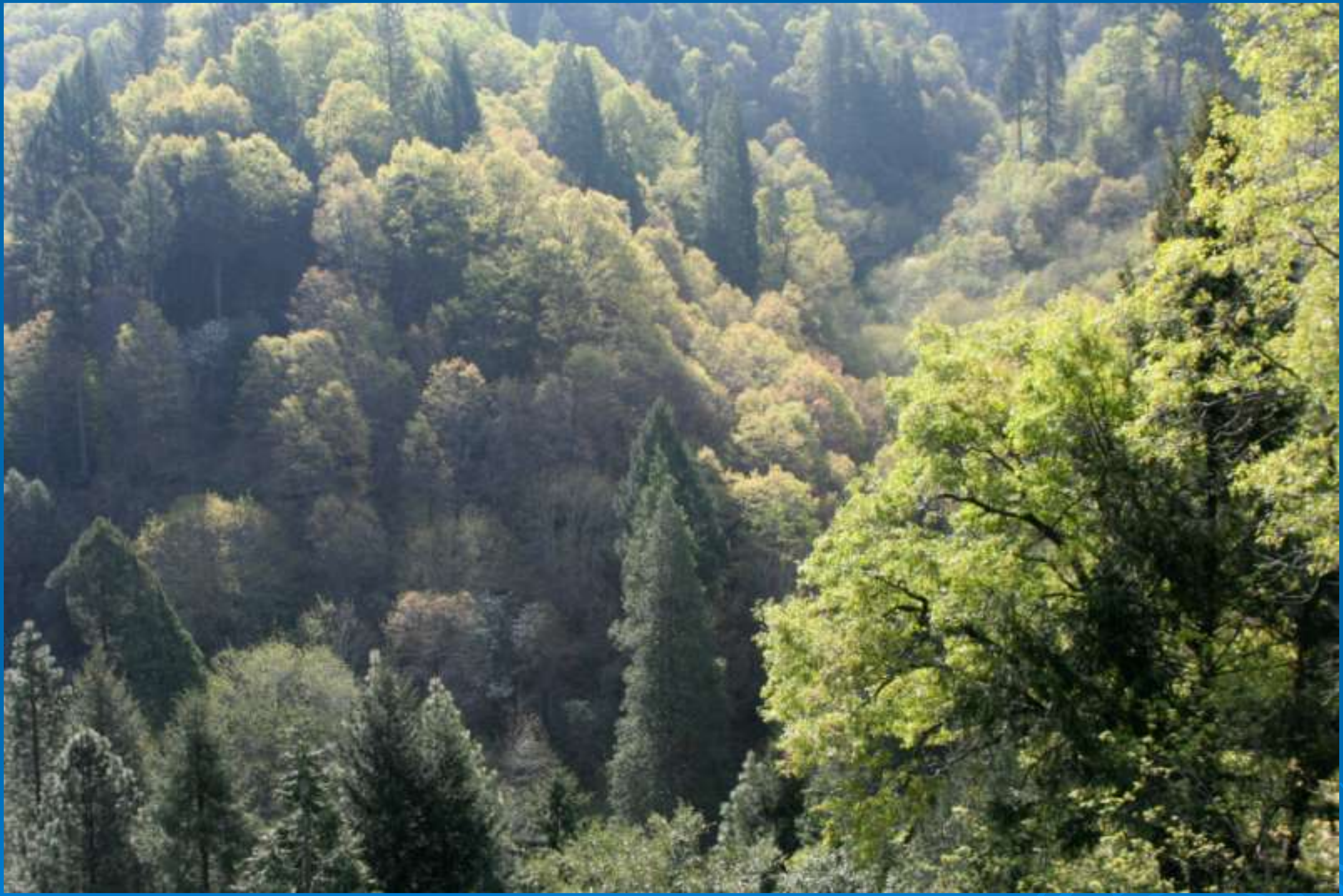


Modeled Tahoe Basin Mean Annual Temperature, GFDL A2

Source: Michael Dettinger, USGS/Scripps

Changes in the Watershed





Is This the Future Tahoe Forest??

Or this?

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have

Design criteria for detention basins and culverts will need to be modified take account of changes in precipitation phase and intensity

Flood-frequency estimates for stream restoration may need to be modified

Getting Ready for Climate Change

- Reduce fuel loads; create defensible space
- Plan for the future forest; begin experiments
- Modify BMP and stream restoration design for higher discharge
- Modify monitoring programs

Acknowledgements

- Patty Arneson, UCD
- Michelle Breckner, WRCC
- Janet Brewster, CTC
- Charles Goldman, UCD
- Scott Hackley, UCD
- John Reuter, UCD
- Geoff Schladow, UCD
- Iris Stewart-Frey, U.Santa Clara

Some Useful Resources

Hydroikos ftp site:

Host = ftp-dom.earthlink.net
(ftp://ftp-dom.earthlink.net)
User ID = ftp@hydroikos.com
password = spartina
path = /Public/Climate Change

realclimate.org
climatechoices.org
climatecrisiscoalition.org
ipcc.ch
climatechange.ca.gov/index.php
fs.fed.us/ccrc/