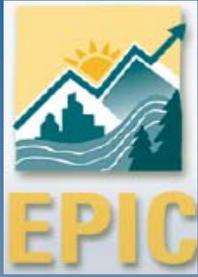




Indicators of Climate Change in California

Presented to the
California Air Resources Board
October 23, 2008

by
Carmen Milanes, M.P.H.
Office of Environmental Health Hazard Assessment



Cal/EPA Directive:

OEHHA to develop indicators of climate change in California.

- Indicator identification based on process developed by EPIC Project
- Collaborators
 - California Energy Commission
 - Air Resources Board
 - Other State and federal agencies
 - Universities and research institutions
- Report: 25 indicators



The global evidence

- **Climate change and its drivers**
 - Warming is unequivocal
 - Mostly due to anthropogenic greenhouse gases

- **Impacts on physical systems**
 - Warming of lakes and rivers
 - Increases in sea level
 - Decreases in snow and ice extent
 - Increased runoff and earlier spring peak discharge

- **Impacts on biological systems**
 - Earlier timing of spring events
 - Shifts in plant and animal ranges

Indicators of California climate change

Synthesize scientific data to characterize:



Drivers of change



Changes in climate

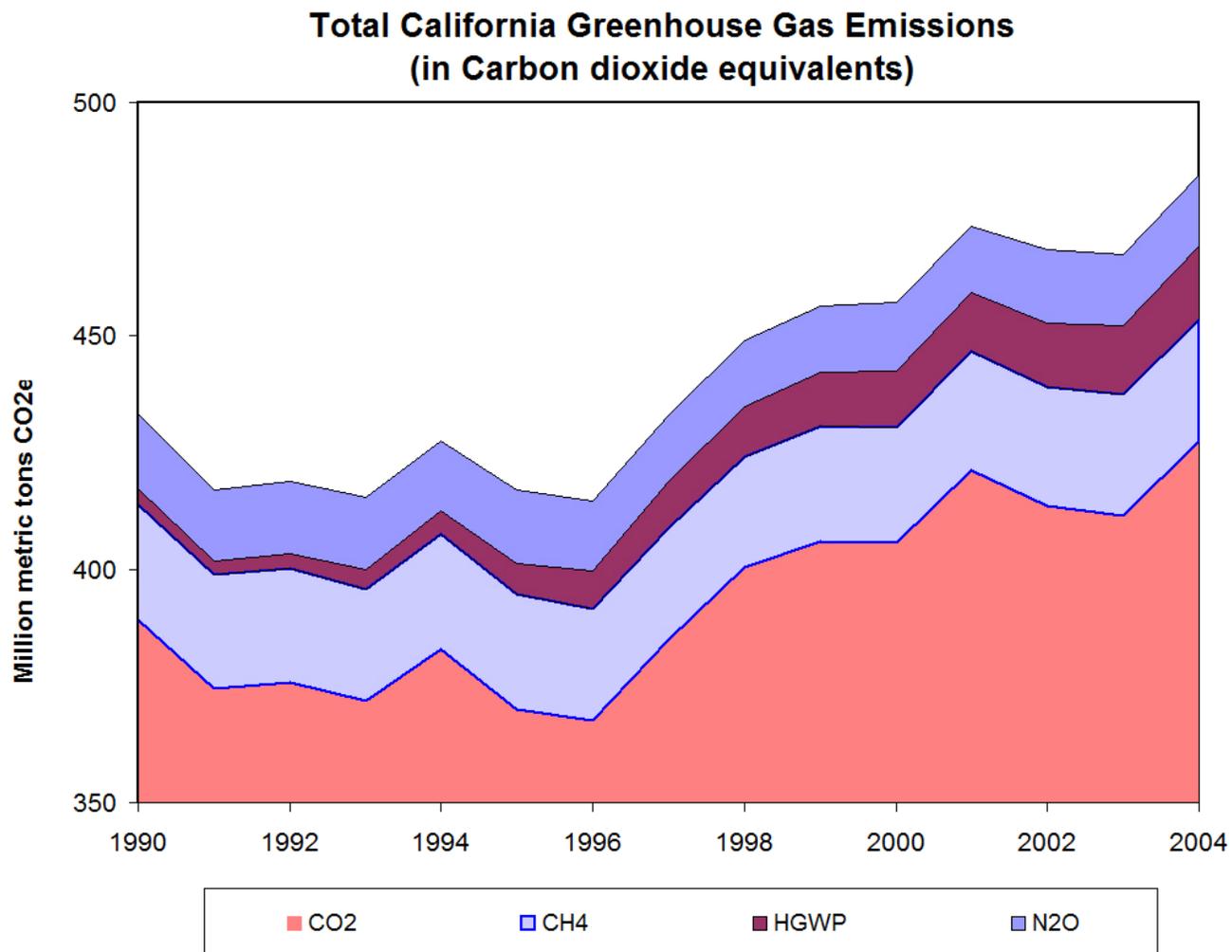


Impacts of climate change

Drivers of change



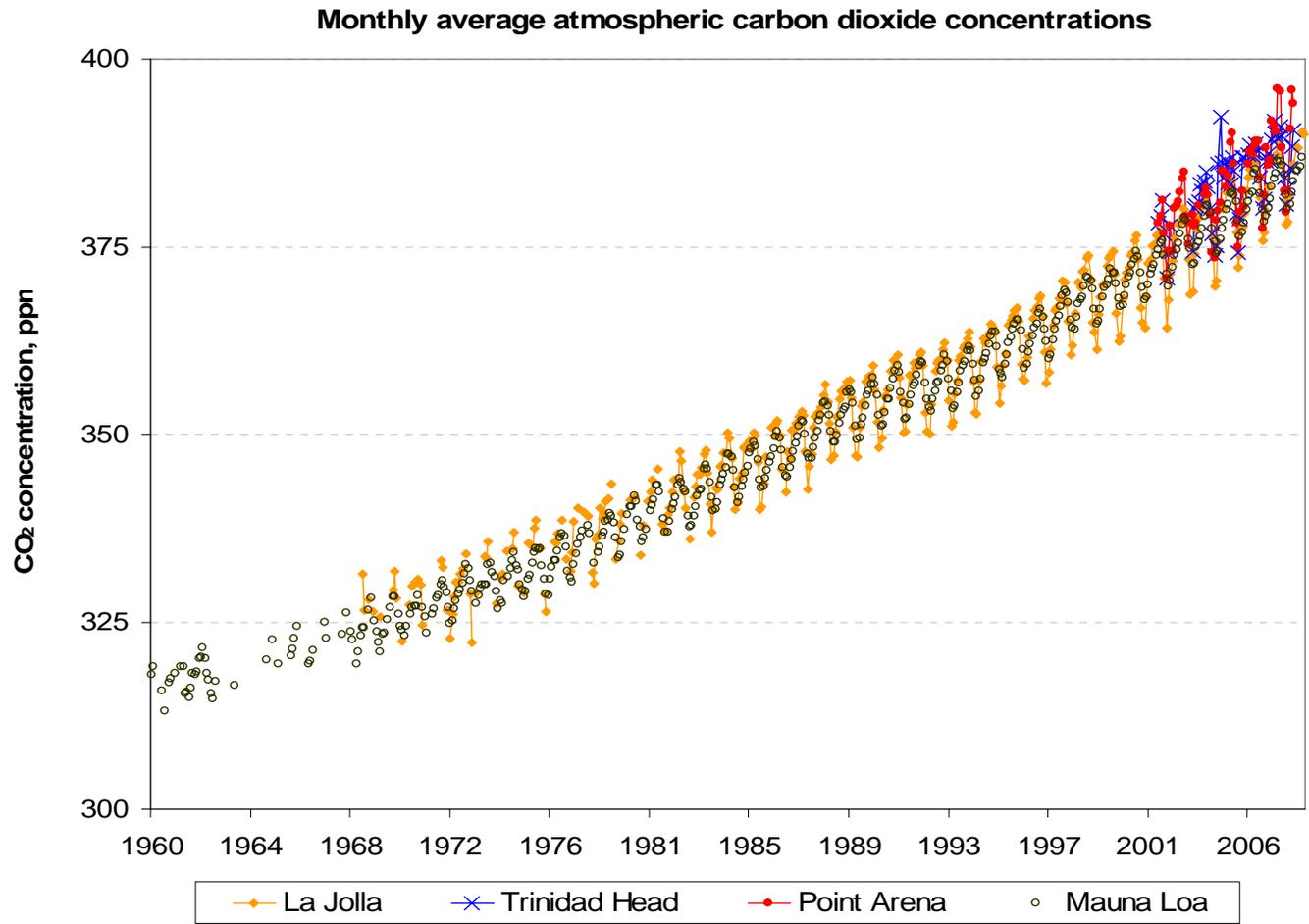
Emissions of greenhouse gases have increased...



Source: ARB, 2008

Emissions of greenhouse gases
have increased...

..as have atmospheric
CO₂ levels, consistent
with global trends.

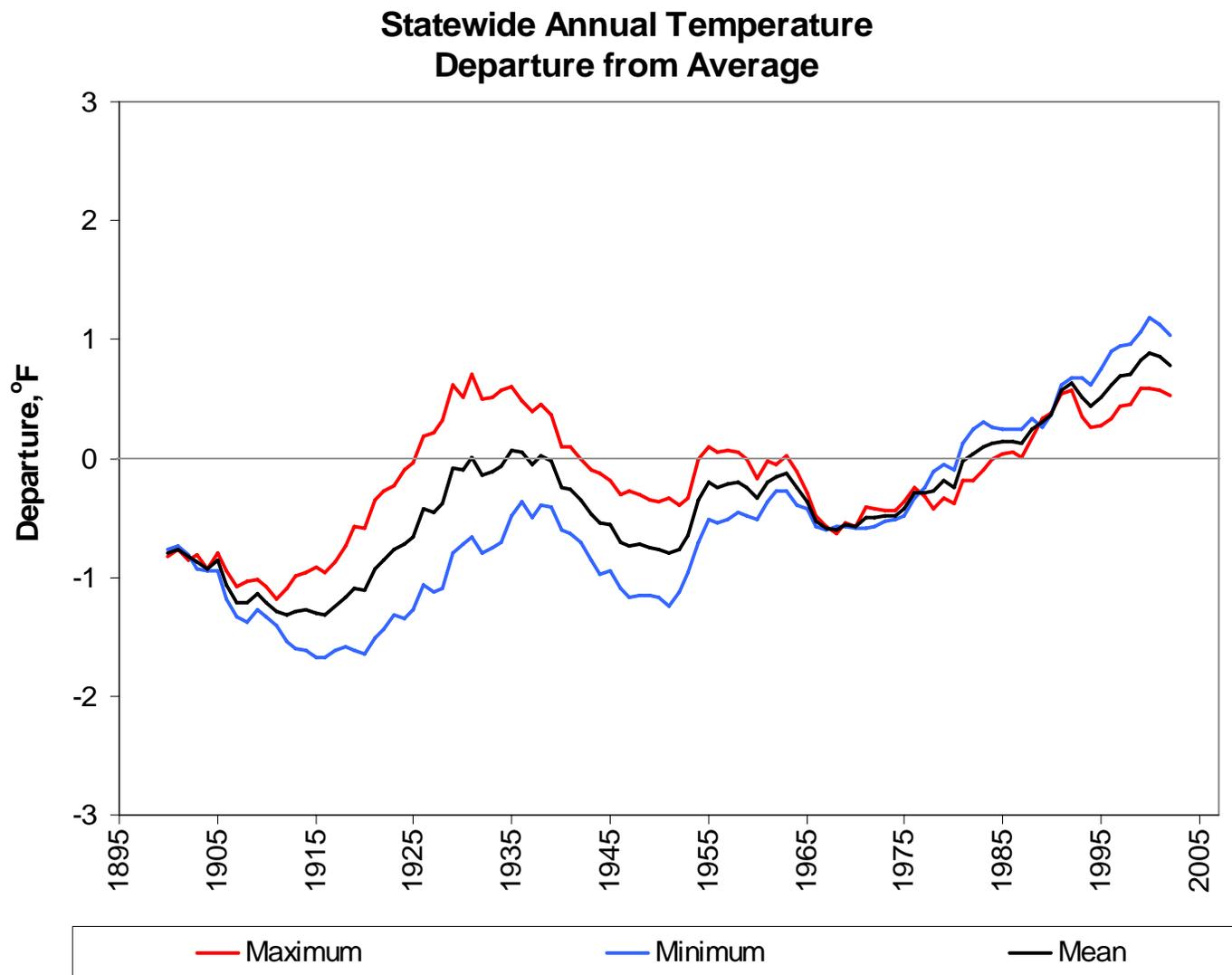


Sources: Keeling, et al., 2008a and b (La Jolla and Mauna Loa data);
NOAA, 2008a (Point Arena and Trinidad Head data)

Changes in climate



California's temperatures have increased, with minimum temperatures rising faster.

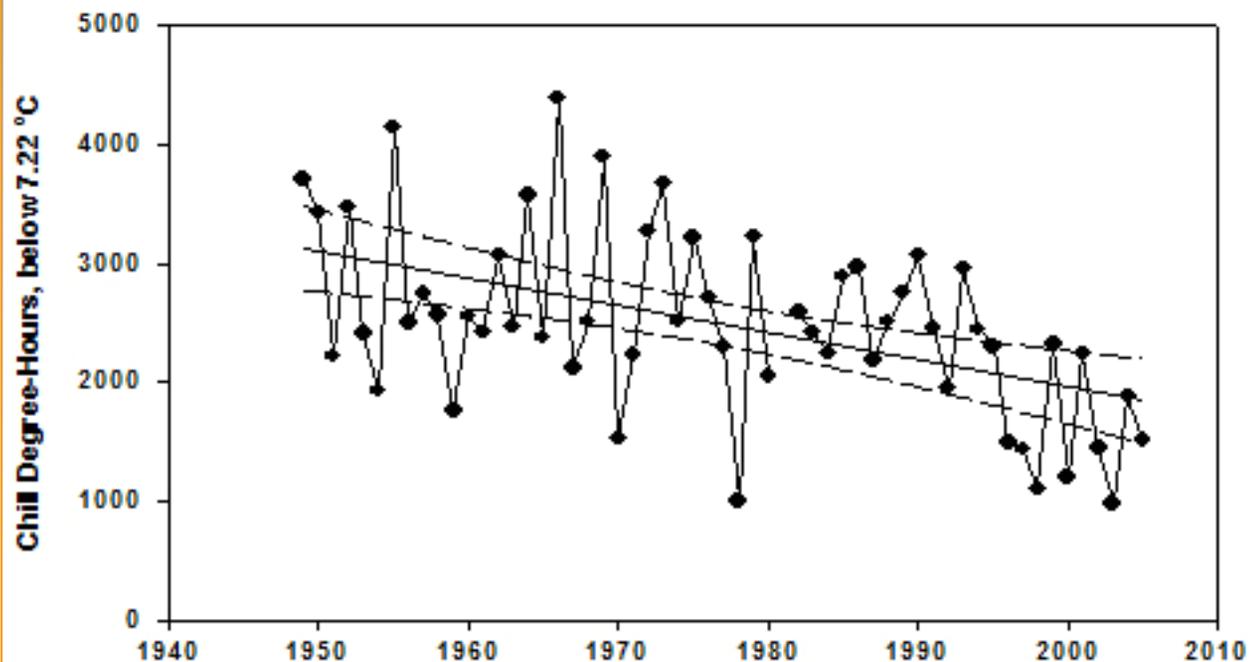


Source: WRCC, 2008

California's temperatures have increased,
with minimum temperatures rising faster.

Chill hours
have also
declined.

Winter chill in Orland, CA



Source: Baldocchi and Wong, 2007

Impacts of climate change



Sierra Nevada glaciers have decreased in size.

Lyell Glacier

1903

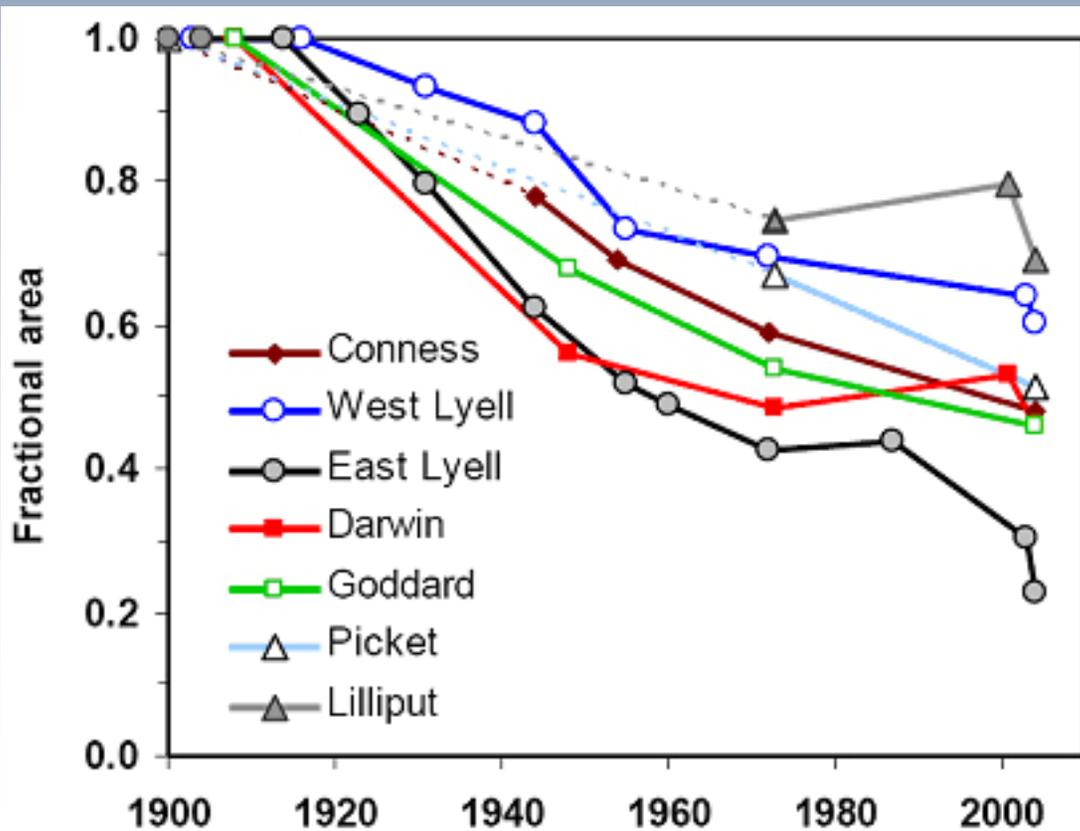


G. K. Gilbert

2004



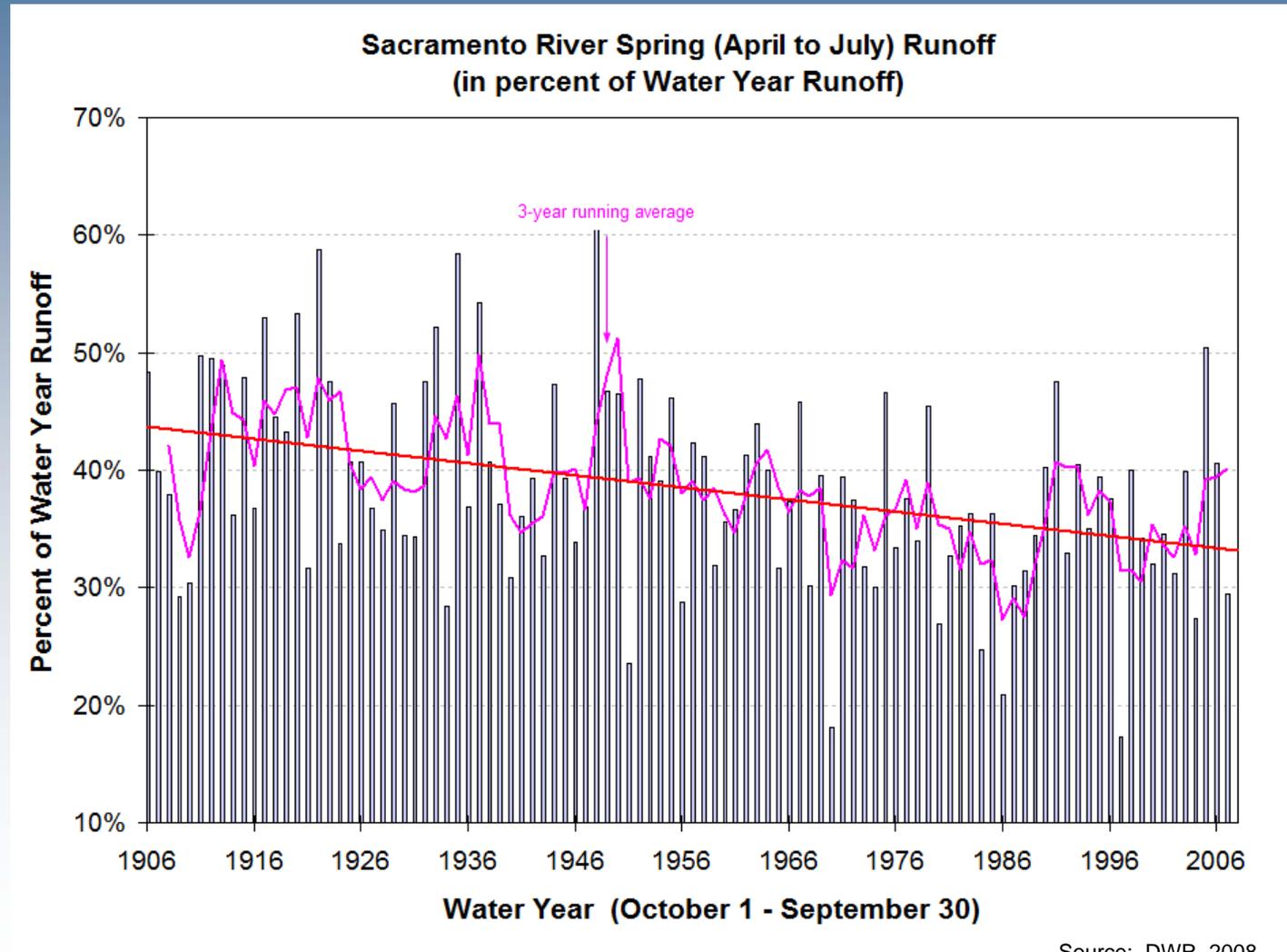
H. Basagic



Source: Basagic, 2008

Sierra Nevada glaciers have decreased in size.

Spring snowmelt runoff
has been declining.



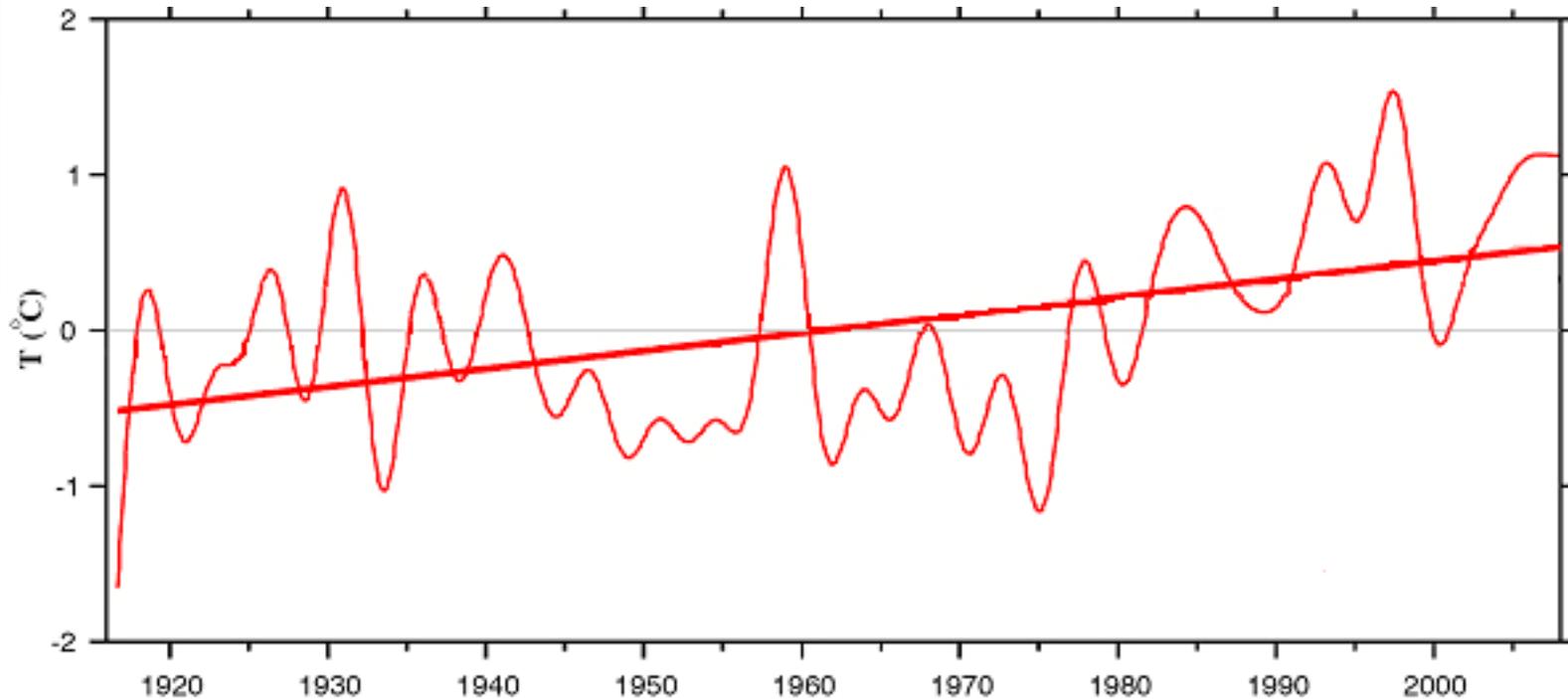
Source: DWR, 2008

Sierra Nevada glaciers have decreased in size.

**Spring snowmelt runoff
has been declining.**

And oceans are warming.

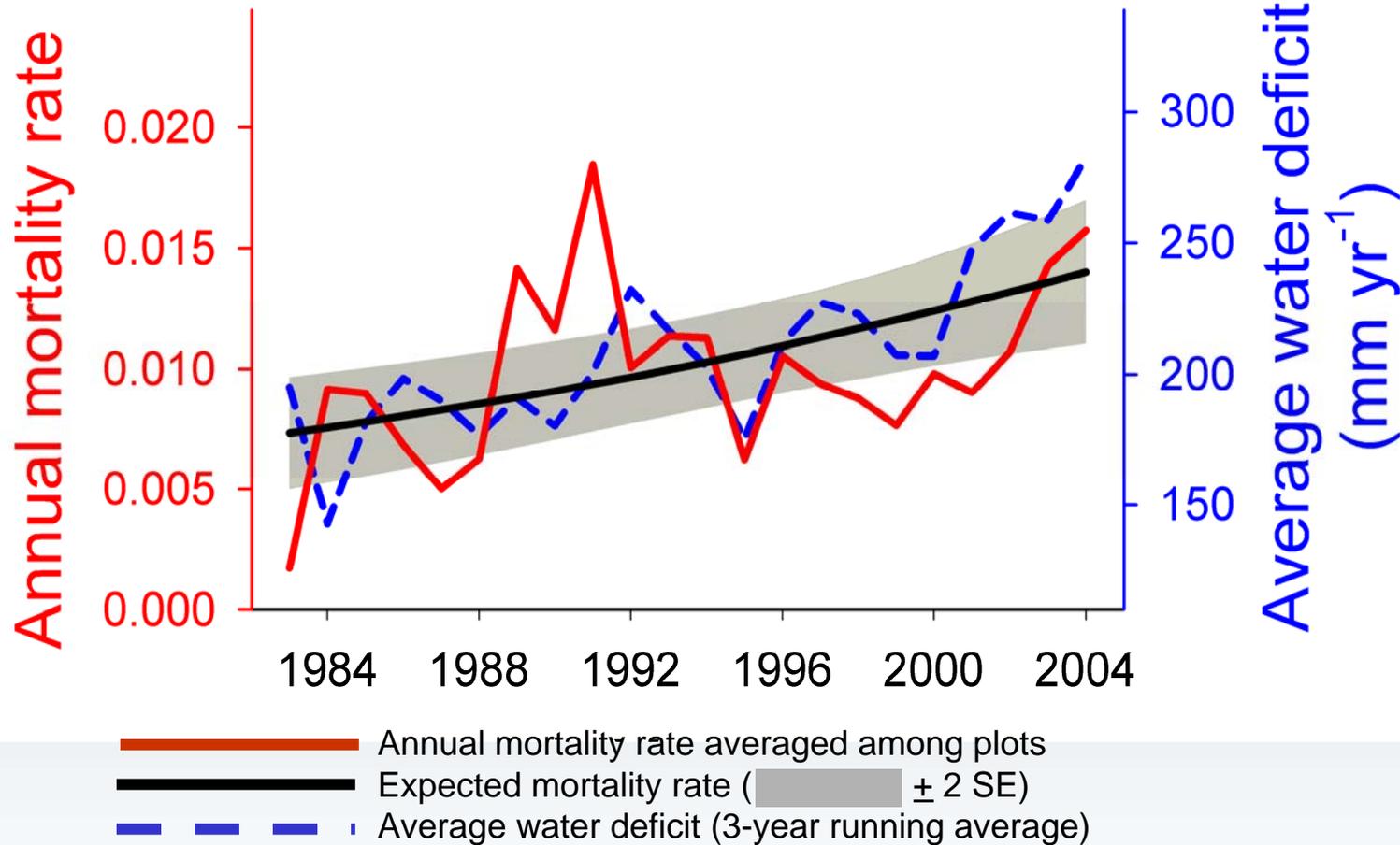
Sea Surface Temperature Anomalies (La Jolla)



Source: Schwing, 2008

Tree deaths in the Sierra Nevada have increased.

Tree mortality in the Sierra Nevada

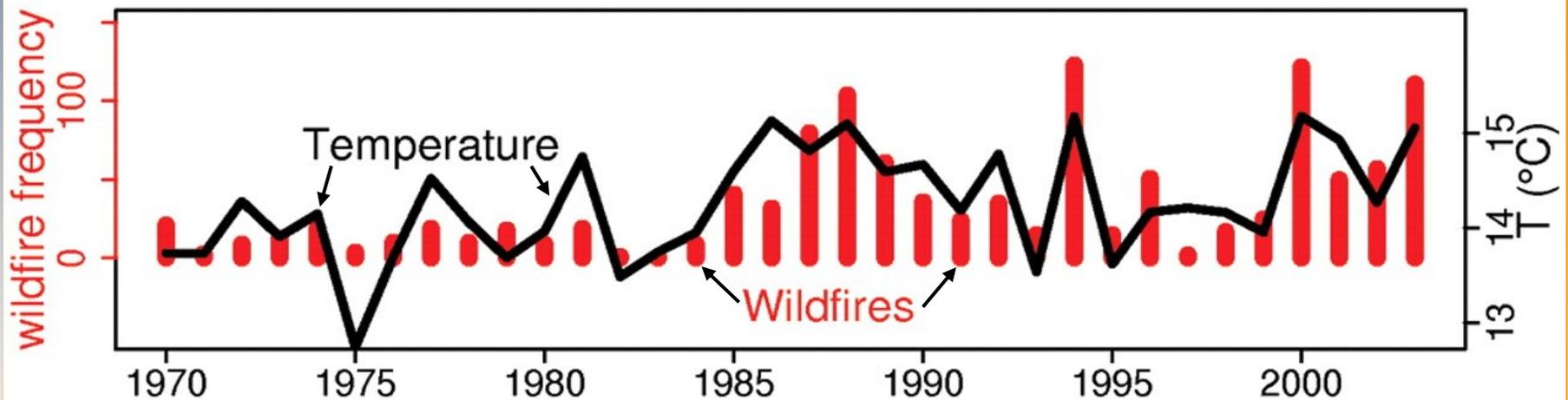


Source: van Mantgem and Stephenson, 2007

Tree deaths in the Sierra Nevada have increased.

And large wildfires are becoming more frequent.

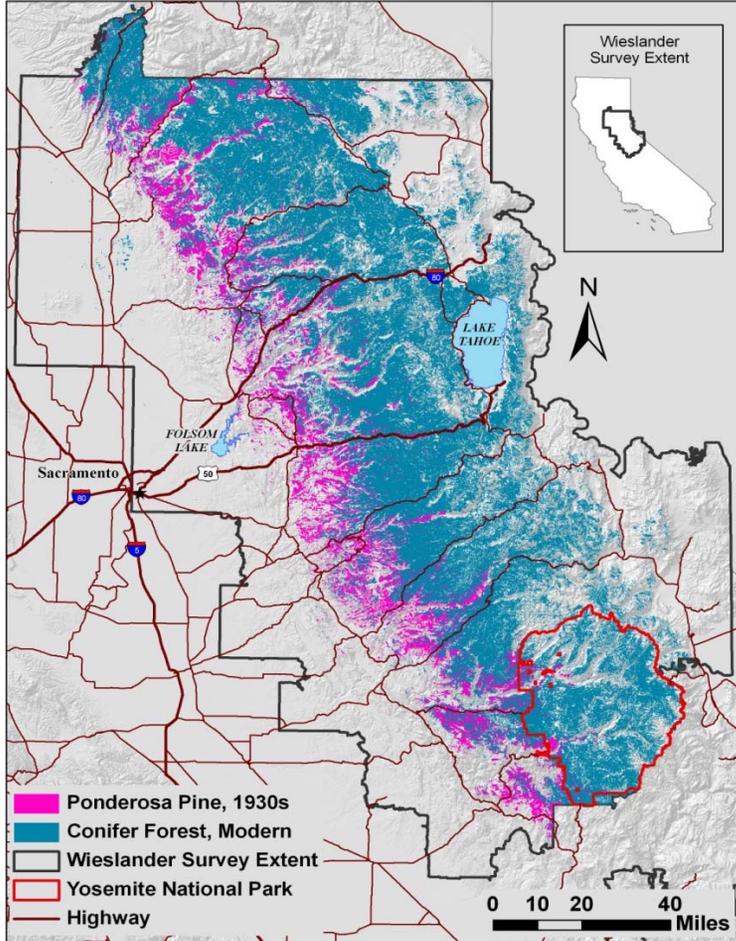
Large wildfire frequency and mean March-August temperature



Source: Westerling, et al., 2007

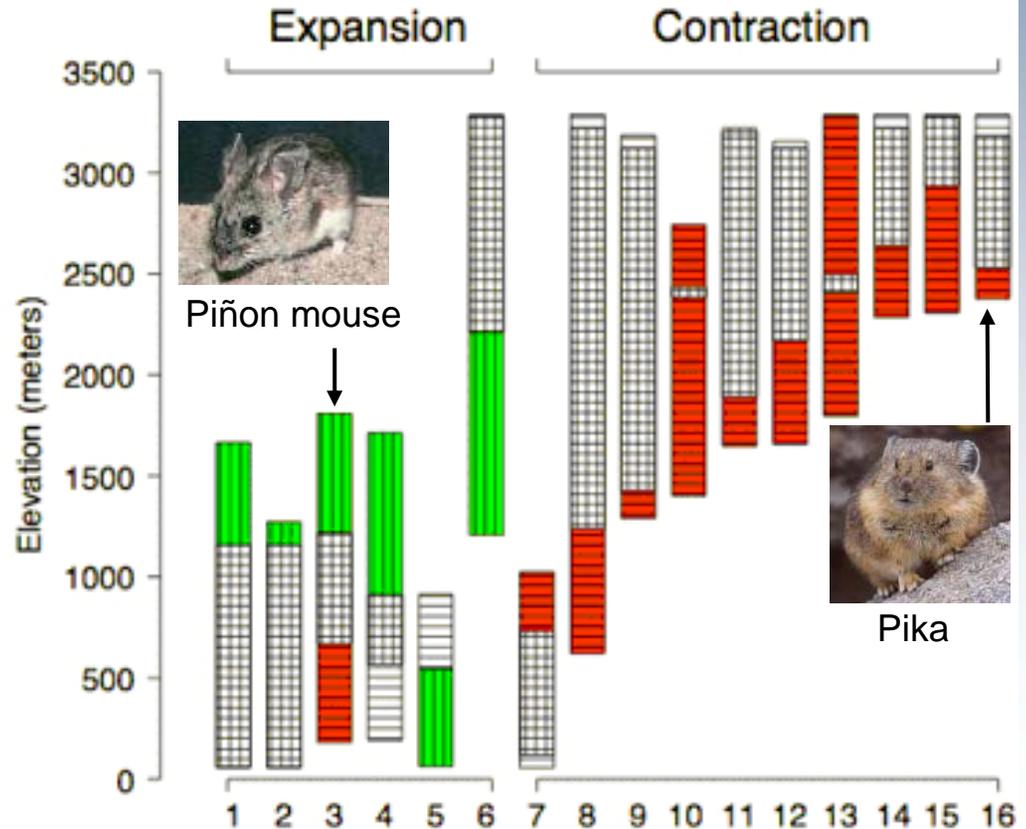
Certain plant and animal species are now found at higher elevations.

Ponderosa Pine Transition



Source: Thorne, 2008

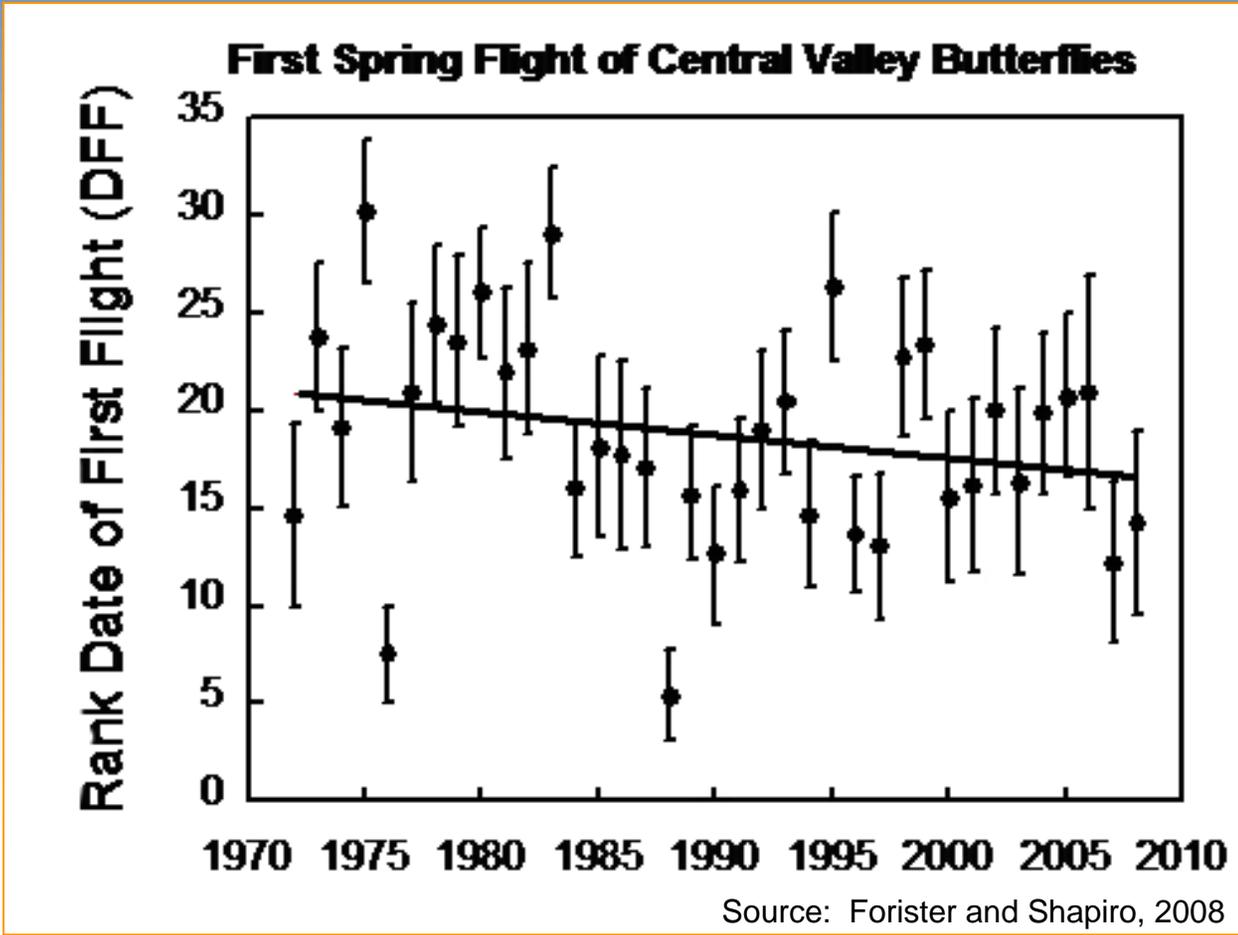
Shifts in small mammal elevational range
Yosemite National Park



Source: Moritz, 2008

Certain plant and animal species are now found at higher elevations.

Central Valley butterflies have been appearing earlier in the spring.



Heat-related mortality and morbidity

- OEHHA studies have found an association between ambient temperature and mortality.
 - Elderly, infants, young children, African Americans, and persons with cardiovascular disease are particularly vulnerable.
- Trend data will help in planning and implementing strategies to prevent heat-related illnesses and deaths.

Indicators of California climate change



- Increased greenhouse gas emissions
- Increased atmospheric CO₂ levels



- Warmer temperatures



- Receding glaciers
- Decreasing spring snowmelt runoff
- Warmer ocean waters
- Increased tree mortality, wildfire frequency
- Shifts in plant and animal ranges
- Earlier spring butterfly appearance

➤ **Changes in California are consistent with global trends.**

Next Steps

- Internal Review Draft to be released within the next few weeks.
 - Input/comments will be solicited from all investigators, Agency, ARB, CEC.
 - Revisions will be made, as appropriate, and Public Review Draft released.
- Pending future funding:
 - Develop indicators that address the implications of climate change on environmental justice .
 - Update indicators and/or develop new indicators.



For more information: Carmen Milanes, cmilanes@oehha.ca.gov
Linda Mazur, lmazur@oehha.ca.gov