Indicators of Climate Change in California

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by
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California Environmental Protection Agency
In collaboration with CalEPA, the California Energy Commission, state and federal agencies and universities and research institutions
Purpose

• To provide an overview of the indicator report and summarize the indicators

• To examine the indicator relationships and present the trends and status of climate change in California based on observational data
Greenhouse gas emissions have increased

Source: Karen Lutter, Air Resources Board 2008
...as have ambient CO$_2$ levels
California’s temperatures have increased, with minimum temperatures rising faster.
California’s extreme heat temperatures have increased

\[\text{SUMMERTIME* MAXIMUM TEMPERATURE} \]
(averaged over 95 stations)

\[\text{SUMMERTIME* MINIMUM TEMPERATURE} \]
(averaged over 95 stations)

...with nighttime temps rising faster

Source: NCDC, 2007 (data); Gershunov, 2008 (analysis)
Annual precipitation has stayed the same

Source: Laura Edwards, John Abatzoglou, Desert Research Institute 2008
Climate Change: Sierra Nevada
Lake Tahoe’s waters are warming

Source: Robert Coats, UC Davis TERC 2008
Sierra Nevada glaciers have decreased in size.

Lyell Glacier

1903

2004

G. K. Gilbert

H. Basagic

Source: Andrew Fountain, Hassan Basagic, Portland State University 2008
Spring snowmelt runoff has been declining

Snowpack water content has stayed the same

Source: Maurice Roos, Department of Water Resources 2008

Source: Michael Dettinger, Scripps Institute of Oceanography 2008
Large wildfires are becoming more frequent

Wildfire frequency and mean March-August temperature

Source: Tony Westerling, et al., University of California Merced 2007
Tree deaths in the Sierra Nevada have increased

![Graph showing tree mortality in the Sierra Nevada](image)

**Tree mortality in the Sierra Nevada**

- **Annual mortality rate averaged among plots**
- **Expected mortality rate (± 2 SE)**
- **Average water deficit (3-year running average)**

Source: Phil van Mantgem and Stephenson, United States Geological Survey 2007
Certain plant and animal species are changing elevations

- Small mammal populations are found at different elevations today compared with earlier in the century.
  
  Resurvey of the Grinnell study

- Alpine and subalpine plant changes are being tracked.
  
  Global observation research initiative in alpine environments (GLORIA)

Source: Moritz, University of California Berkeley 2008

Source: Constance Millar, USDA Forest Service 2008
Climate Change: Central Valley
Chill hours have declined

Source: Baldocchi and Wong 2007
Delta water temperature has stayed the same

Source: Michael Dettinger (SIO)
based on data from Department of Water Resources 2008
Central Valley butterflies have been appearing earlier in the spring and bird migration arrival times are changing.

Source: Forister, University of Nevada Reno and Shapiro, University of California Davis 2008

Source: PRBO Conservation Science 2008
Evidence suggests that wine grapes are blooming earlier

Forest vegetation is contracting upslope

Source: James Thorne, University of California Davis  2008
Source: Kim Nichols Cahill, Stanford  2008
Climate Change: Pacific Ocean and Coast
Sea levels and surface temperatures have increased

Source: Maurice Roos, Binta Coleman, Department of Water Resources 2008

Source: Frank Schwing, National Oceanic and Atmospheric Administration 2008
Dissolved oxygen levels in the Southern California Current are declining

Source: Steven Bograd et al., National Oceanic and Atmospheric Administration 2008

Note: The unconnected points denote a period of limited sampling during 1968 to 1983; the connected points denote regular scheduled surveys.
Copepods populations are changing

increased variability year to year

Cassin’s Auklet breeding success has become more variable

Source: William Sydeman and Jaime Jahncke, based on data from Point Reyes Bird Observatory 2008
Human health impacts are harder to discern

OEHHA has studied heat-related mortality and found an association between ambient temperature and mortality

Source: Rupa Basu and Bart Ostro, Office of Environmental Health Hazard Assessment 2008

Mosquito-borne diseases are under investigation and the results are unclear

Source: William Reisen, University of California Davis 2008
California’s Story

Indicators based on observational data reveal climate change impacts in California are consistent with global trends and that.....
Indicator evidence of climate change impacts date back to:

**Early 1900’s**
- glaciers
- minimum air temperatures
- sea level rise
- ocean temperature warming
- forest vegetation patterns

**Mid 1900’s**
- snowmelt runoff
- winter chill hours
- extreme heat events
- Lake Tahoe water warming
- butterfly flight

**Late 1900’s to 2000’s**
- ocean oxygen concentrations
- tree mortality
- large wildfires
- Cassin’s Auklet
- bird migration
Contributors

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www.oehha.ca.gov
www.oehha.ca.gov/multimedia/epic/climateindicators.html

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