CALIFORNIA FIRE SCIENCE CONSORTIUM

Joint Fire Science Program Knowledge Exchange

Research Brief for Resource Managers

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Climate change in California: vegetation, wildfire, and carbon dynamics

Lenihan JM, Bachelet D, Neilson RP, Drapek R (2008) Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. Climatic Change 87: 215–230. doi: 10.1007/s10584-007-9362-0
http://www.treesearch.fs.fed.us/pubs/34934

Management Implications

- Climate change in California is likely to lead to a decline in alpine/subalpine and conifer forest, woodland, and shrubland extent while promoting grassland dominance.
- Transitions in the distribution of plant mixtures will likely be mediated by wildfire disturbance. An increase in annual area burned is expected.

Climate change in California is projected to substantially alter the distribution of vegetation types, and is expected to impact ecosystem carbon stocks as well. These changes are likely to be mediated through wildfire disturbance.

A study by scientists from the USDA Forest Service and Oregon State University, published in *Climatic Change*, simulated vegetation, wildfire, and carbon dynamics under three scenarios of future climate change. Two climate models were run for an historical period from the 1800s to 1995 using observed greenhouse gas concentrations, and into the future (to 2100) using two different emission scenarios: a low emissions scenario, in which pre-industrial CO_2 concentrations are doubled by the end of the century, and a medium-high scenario in which CO_2 is more than tripled. Three of these climate change scenarios were then used in subsequent vegetation and fire modeling. They represented a relatively high temperature increase (>4˚C) and a dry moisture regime [1] and an intermediate temperature increase (<3˚C) with either a neutral [2] or dry moisture regime [3].

Changes in vegetation distribution were assessed by comparing percentage coverage of plant type mixtures between the periods 1961-90 and 2071-2100. All climate change scenarios predicted coverage declines for alpine/subalpine forest due to longer and warmer growing seasons. Evergreen conifer forests gave way to woodland, shrubland, and grassland, while mixed evergreen forest increased in extent. For the relatively cool and wet scenario, total forest cover increased by 23% relative to its historical extent, but declined by 3% and 25% under the warmer and drier scenarios, respectively. Mixed evergreen woodland and shrubland declined under all scenarios; for the warmer-drier scenarios, this was due to replacement by grassland as a result of lower moisture and increased wildfire activity; for the cooler-wetter scenario it was the result of both grassland increase and forest encroachment. Grassland gained in extent under all scenarios either due to reduced effective moisture or because increased moisture led to increased grass productivity, biomass, and fine fuels which in turn increased fire frequency, further favoring grasses over other vegetation types.

For the projected future period, the warmer-drier scenarios produced a decline in total ecosystem carbon (carbon stocks) by 1.3 and 2.2%, while the warmer-wetter scenario led to an accumulation of ecosystem carbon of 5.5% above historical levels.

Annual area burned in California for the future period, while quite variable from one year to the next, was greater in nearly every year than the average area burned in the historical period. By 2100, average annual area burned was 9-15% greater than was simulated for the historical period (1895-2003).

Future precipitation trends in California are still very uncertain. Though a warmer, wetter climate could increase net primary productivity, another study found that even with an increase in annual precipitation of 75%, increased area burned restricted net carbon stock increases to 5% of historic levels (Lenihan et al. 2003). In the case of drier conditions, reduced decomposition rates and the transition to dominance by grasslands, which more effectively protect belowground carbon than woody vegetation types, may limit declines in carbon storage.

Suggestions for further reading:

Bachelet D, Neilson RP, Lenihan JM, Drapek RJ, 2001. Climate change effects on vegetation distribution and carbon budget in the U.S. Ecosystems 4: 164–185.

Cayan D, Luers AL, Hanemann M, Franco G, 2006. Scenarios of climate change in California: an overview. Report from the California Climate Change Center. Sacramento, CA. CEC-500-2005-186-SF, 47 p. http://www.energy.ca.gov/2005publications/CEC-500-2005-186/CEC-500-2005-186-SF.PDF

Hayhoe K, Cayan D, Field C, Frumhoff P, Maurer E, Miller N, Moser S, Schneider S, Cahill K, Cleland E, Dale L, Drapek R, Hanemann R, Kalkstein L, Lenihan J, Lunch C, Neilson R, Sheridan S, Verville J (2004) Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences USA 101:12422–12427. http://www.pnas.org/content/101/34/12422.long

Lenihan JM, Drapek R, Bachelet D, Neilson R (2003) Climate change effects on vegetation distribution, carbon, and fire in California. Ecological Applications 13: 1667–1681 http://www.fsl.orst.edu/dgvm/Lenihan.EcolAppl.2003.pdf

Westerling AL, Bryant BP (2008) Climate change and wildfire in California. Climatic Change 87: 231–249. http://meteora.ucsd.edu/~meyer/pdffiles/Westerling_wildfire_jan2008.pdf

Figure 1. *(Right)* Percent change in mean annual area burned for the 2050–2099 future relative to the mean annual area burned for the historical period (1895–2003)