

Fire in the Sierra Nevada¹

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Fire has been described as both a major ecological force necessary for long-term functioning of Sierra Nevada ecosystems and as one of the greatest threats to human and natural resources (SNEP 1996a). Fire has shaped the terrestrial ecosystems of the Sierra Nevada for millennia. Before the mid-1800s, fires generally were frequent and mostly of low to moderate intensity, from lower-elevation blue oak woodlands through upper-montane red fir forests (Skinner and Chang 1996). Modern fire regimes are highly altered from their historical character because of the combined effects of fire exclusion, logging, grazing, forest clearing, urbanization, and climate change. These highly altered fire regimes have fostered changing ecosystems, including commonly discussed increases in vegetation density and accumulation of detritus (fuel for fires) that support more high-intensity fires than occurred under historical conditions (Chang 1996; McKelvey and Busse 1996; McKelvey and others 1996; Skinner and Chang 1996).

The changing fire environment, along with increasing urbanization and human use of the Sierra Nevada, have created conditions where human life and property, as well as key ecosystem components, are at increasing risk from the effects of high-intensity wildfires (Biswell 1989, California Spotted Owl Federal Advisory Committee 1997, SNEP 1996a). There is significant Congressional interest in finding a way to reverse the trend toward increasing funding necessary for fire suppression (GAO 1999, Schuster and others 1997). As a result, national emphasis has been placed on increasing fuels treatments, especially thinning of dense stands in the western United States (National Fire Plan <http://www.fireplan.gov/content/home/>). Though information exists on the effectiveness of different fuel treatments in reducing potential fire behavior in the Sierra Nevada (van Wagtendonk 1996; Stephens 1998), considerable debate surrounds nearly any strategy suggested to address forest and fuels conditions.

To help inform the debate on how to manage fire-prone ecosystems in the Sierra Nevada, five leading scientists in this field were asked to address important topics related to fire management. The topics that follow include: (1) fire history and climate interactions, (2) fire and landscape patterns and processes, (3) historic and current smoke potential, (4) evidence of the effectiveness of thinning and prescribed fire for reducing fire behavior, and (5) the National Fire and Fire Surrogates Study. Each presentation was developed independently by its author(s) with knowledge of the topics to be addressed by the other authors and the vision of the overall session theme.

T. W. Swetnam set the stage by reviewing his recently published work (Swetnam and Baisan 2003) that describes broad-scale climatic influences on both long-term and short-term fire regimes of the Sierra Nevada and southwestern United States. Because the article is not

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included in this volume and only a brief synopsis is provided here, readers are urged to peruse the complete article.

Swetnam and Baisan (2003) describe how broad, regional synchrony of fires in extensive networks of tree-ring records is related to global-scale climatic processes, such as the El Niño-Southern Oscillation. Decadal scale variations (10 to 100 years) in historical fire frequency and extent were related to trends in temperature and moisture as reconstructed from tree rings. Generally, the influence of climate on fire regimes is through temperature trends affecting fire frequency and precipitation affecting fire extent (Chang 1999, Swetnam 1993, Swetnam and Baisan 2003). Tree-ring evidence (Swetnam 1993, Swetnam and Baisan 2003) and modeling (Chang 1999) suggest that fire seasons lengthen with increasing temperature, thus increasing the probability of fire in a given year. The same evidence suggests that precipitation is related to the growth of vegetation (fuels) so that periods of higher precipitation lead to more extensive fires in the inevitable, occasional dry years.

As climate has warmed considerably since the mid-1800s (Graumlich 1993, Jacoby and D'Arrigo 1989, Stine 1996, Taylor 1995, Wiles and others 1996) and was accompanied by relatively high precipitation through much of the 20th century (Earle 1993, Graumlich 1987, Graumlich 1993, Hughes and Brown 1992), Stine (1996) speculated that in the absence of fire suppression, fire regimes of the 20th century would likely have been characterized by increased fire frequency and increased fire extent—the opposite of what actually happened. Current projections of warming climates (see papers in the climate session of these proceedings) portend a greater opportunity for fire ignitions due to longer fire seasons. A higher probability of fire starts coupled with the changes in forest fuel conditions that have occurred over the past century lead many to predict that large, generally more intense fires will become more likely than occurred historically (McKelvey and others 1996, SNEP 1996a).

Scientists have only recently begun to understand the long-term influence of fire on the dynamics of landscape patterns in forests historically characterized by frequent fires of mostly low to moderate intensity (Beaty and Taylor 2001, Heyerdahl and others 2001, Taylor and Skinner 1998, Taylor and Skinner 2003). Yet, knowledge of the long-term influence of fire in landscape dynamics is crucial to improving models of the spatial pattern of fuel treatments in efforts to help managers better achieve goals of sustainable habitat conditions while providing for the reduced likelihood of large, high-intensity fires (Skinner and Chang 1996, Taylor and Skinner 1998, Weatherspoon and Skinner 1996). Drawing on the experience of three decades of wildland fire use in Yosemite National Park, van Wagtenonk (these proceedings) furthers this knowledge by discussing the spatial and temporal interactions of ignitions, fuels, weather, and topography that are necessary for fire to influence long-term landscape patterns.

At present, the most significant contribution to detrimental air quality in the Sierra Nevada comes from air pollutants originating from outside the range (Cahill and others 1996). Yet, if fire is to be reintroduced as a major process in forest management (SNEP 1996a), there is likely to be an increased contribution of smoke to deleterious air quality (Cahill and others 1996). Little is known about how historical fire regimes and vegetation patterns influenced past air quality or indeed what “pristine” conditions would be (Skinner and Chang 1996). Ottmar and Alvarado (in these proceedings) present results of modeling work that was designed to better understand how vegetation composition and structure (fuels) under both historical fire and modern management regimes influence fire vulnerability and resultant smoke production. Their work describes the tradeoffs involved in managing forests for different structural and compositional conditions with and without the use of fire.

Omi and Martinson (in these proceedings) discuss results of several studies that assessed the effectiveness of fuels treatments (primarily thinning and prescribed fire) throughout the western United States. Reported results showed that although the level of effectiveness varied between

landscapes, areas that received fuels treatments in the decade before a wildfire generally had less damage to tree boles and crowns than did untreated areas.

A critical finding of the Sierra Nevada Ecosystem Project (SNEP 1996b) identified the need for a study of the effects of using alternative treatment methods to achieve fire hazard reduction and ecological restoration (Weatherspoon and Skinner 2002). To help fill this void in knowledge, a large study is under way—“A National Study of the Consequences of Fire and Fire Surrogate Treatments (FFS)” funded by the USDA/USDI Joint Fire Science Program (http://www.nifc.gov/joint_fire_sci). Knapp and others (these proceedings) describe the objectives of the FFS, the national network of FFS sites, and the two FFS sites in the Sierra Nevada.

Opinions differ widely over alternative approaches to fire management in the Sierra Nevada. Regardless of management strategy, fire is a fundamental, undeniable process that significantly affects ecosystems in this bioregion. This session attempts to inform the debate through a synthesis of current research on important aspects of fire ecology and fuels management.

References

- Beaty, R.M.; Taylor, A.H. 2001. **Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, southern Cascades, California, USA.** *Journal of Biogeography* 28: 955-966.
- Biswell, H.H. 1989. **Prescribed burning in California wildlands vegetation management.** Berkeley, CA: University of California Press; 255 p.
- Cahill, T.A.; Carroll, J.J.; Campbell, D.; Gill, T.E. 1996. **Air quality.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II; Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1227-1261.
- California Spotted Owl Federal Advisory Committee. 1997. **Final report of the California Spotted Owl Federal Advisory Committee.** Washington DC: U.S. Department of Agriculture, <http://www.fs.fed.us/pnw/owl/htm>.
- Chang, C. 1996. **Ecosystem responses to fire and variations in fire regimes.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1071-1099.
- Chang, C. 1999. **Understanding fire regimes.** Durham, NC: Duke University; 184 p. Ph.D. dissertation.
- Earle, C.J. 1993. **Asynchronous droughts in California streamflow as reconstructed from tree rings.** *Quaternary Research* 39: 290-299.
- GAO (General Accounting Office). 1999. **Western national forests: A cohesive strategy is needed to address catastrophic wildfire threats.** GAO/RCED-99-65. Washington, DC: General Accounting Office.
- Graumlich, L.J. 1987. **Precipitation variation in the Pacific Northwest (1675-1975) as reconstructed from tree rings.** *Annals of the Association of American Geographers* 77: 19-29.
- Graumlich, L.J. 1993. **A 1000-year record of temperature and precipitation in the Sierra Nevada.** *Quaternary Research* 39: 249-255.
- Heyerdahl, E.K.; Brubaker, L.B.; Agee, J.K. 2001. **Spatial controls of historical fire regimes: A multi-scale example from the interior West, USA.** *Ecology* 82: 660-678.
- Hughes, M.K.; Brown, P.M. 1992. **Drought frequency in central California since 101 B.C. recorded in giant sequoia tree rings.** *Climate Dynamics* 6: 161-167.
- McKelvey, K.S.; Busse, K.K. 1996. **Twentieth-century fire patterns on Forest Service lands.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1119-1138.

- McKelvey, K.S.; Skinner, C.N.; Chang, C.; Erman, D.C.; Husari, S.J.; Parsons, D.J.; van Wagtendonk, J. W.; Weatherspoon, C.P. 1996. **An overview of fire in the Sierra Nevada.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1033-1040.
- Schuster, E.G.; Cleaves, D.A.; Bell, E.F. 1997. **Analysis of USDA Forest Service fire-related expenditures 1970-1995.** Res. Paper PSW-RP-230. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 27 p.
- Skinner, C.N.; Chang, C. 1996. **Fire regimes, past and present.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1041-1069.
- SNEP. 1996a. **Fire and fuels.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. I. Assessment summaries and management strategies. Wildland Resources Center Report No. 36. Davis, CA: Centers for Water and Wildland Resources, University of California; 62-71.
- SNEP. 1996b. **Status of the Sierra Nevada:** Summary of the Sierra Nevada Ecosystem Project. Wildland Resources Center Report No. 39. Davis, CA: Centers for Water and Wildland Resources, University of California; 22 p.
- Stephens, S.L. 1998. **Effects of fuels and silvicultural treatments on potential fire behavior in mixed conifer forests of the Sierra Nevada, CA.** Forest Ecology and Management 105: 21-34.
- Swetnam, T.W. 1993. **Fire history and climate change in giant sequoia groves.** Science 262: 885-889.
- Swetnam, T.W.; Baisan, C.H. 2003. **Tree-ring reconstructions of fire and climate history in the Sierra Nevada and southwestern United States.** In: Veblen, T.T.; Baker, W.; Montenegro, G.; Swetnam, T.W., editors. Fire and climatic change in temperate ecosystems of the western Americas. New York: Springer-Verlag; 158-195.
- Stine, S. 1996. **Climate, 1650-1850.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 25-30.
- Taylor, A.H. 1995. **Forest expansion and climate change in the mountain hemlock (*Tsuga mertensiana*) zone, Lassen Volcanic National Park, California, USA.** Arctic, Antarctic, and Alpine Research 27: 207-216.
- Taylor, A.H.; Skinner, C.N. 1998. **Fire history and landscape dynamics in a late-successional reserve in the Klamath Mountains, California, USA.** Forest Ecology and Management 111: 285-301.
- Taylor, A.H.; Skinner, C.N. 2003. **Spatial patterns and controls on historical fire regimes and forest structure in the Klamath Mountains.** Ecological Applications 13: 704-719.
- van Wagtendonk, J.W. 1996. **Use of a deterministic fire growth model to test fuel treatments.** Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1155-1166.
- Weatherspoon, C.P.; Skinner, C.N. 1996. **Landscape-level strategies for forest fuel management.** In: Sierra Nevada Ecosystem Project: Final report to Congress, Vol. II. Assessments and scientific basis for management options. Water Resources Center Report No. 37. Davis, CA: Centers for Water and Wildland Resources, University of California; 1471-1492.
- Weatherspoon, C.P.; Skinner, C.N. 2002. **An ecological comparison of fire and fire surrogates for reducing wildfire hazard and improving forest health.** In: Sugihara, N.; Morales, M.; Morales, T., editors. Proceedings, Fire in California ecosystems symposium; Nov. 1997; San Diego, CA. Miscellaneous Publication No. 1.; Association for Fire Ecology; 239-245.
- Wiles, G.C.; D'Arrigo, R.D.; Jacoby, G.C. 1996. **Temperature changes along the Gulf of Alaska and the Pacific Northwest coast modeled from coastal tree rings.** Canadian Journal of Forest Research 26: 474-481.