U.S. Department of the Interior
U.S. Geological Survey
Western Ecological Research Center

Sierra Nevada Global Change Research Program

Sierra Nevada Forest Dynamics: Pattern, Pace, and Mechanisms of Change

Annual Report for Fiscal Year 2002

Compiled by

Nathan L. Stephenson and **Phillip J. van Mantgem**
U.S. Geological Survey, Western Ecological Research Center
Sequoia and Kings Canyon Field Station
HCR 89 Box 4
Three Rivers, California 93271

Principal Investigators

Lisa J. Graumlich
Jon E. Keeley
Nathan L. Stephenson
Thomas W. Swetnam
Dean L. Urban
Jan W. van Wagtendonk

Collaborators, Contributors, and Research Staff

Christopher Baisan
Andy Bunn
Tony Caprio
Mary Ellen Colberg
Mark Fain
Malcolm Hughes
Jonathan Humphrey
Patrick Jantz
Ruth Kern
Kurt Menning
Connie Millar
Peggy Moore
William Mundy
Jennifer Nissenbaum
Anne Pfaff
Ken Pierce
Julie Proctor
Monique Rocca
Greg Seabloom
Lauren Shapiro
Phil van Mantgem

INTRODUCTION

The Sierra Nevada Global Change Research Program began in 1991 as a peer-reviewed, competitively-funded component of the National Park Service's (now USGS-BRD's) Global Change Research Program. While Sequoia, Kings Canyon, and Yosemite national parks form the core study areas of the program, the full study region encompasses adjacent public lands.

The goal of the Sierra Nevada Global Change Research Program is to understand and predict the effects of global changes on montane forests. By far the greatest limitation to understanding and predicting the effects of future global changes is the lack of a precise mechanistic understanding of how contemporary forest structure and function are controlled by the physical environment, disturbances, and biotic processes. Our research program therefore places landscape patterns within the context of the physical template (abiotic factors such as climate and soils), disturbances (such as fire), and biotic processes (demography, dispersal, growth, and competition). Our program focusses on developing a mechanistic understanding of this simple model as it applies to Sierra Nevada forests in particular, but also for the montane forests of western North America in general.

Our program consists of integrated studies organized around three themes: paleoecology, contemporary ecology, and modeling. The *paleoecological theme* takes advantage of the Sierra Nevada's rich endowment of tree-ring and palynological resources to develop an understanding of past climatic changes and the consequent responses of fire regimes and forests. The *contemporary ecology theme* takes advantage of the Sierra Nevada's substantive climatic gradients as "natural experiments," allowing us to evaluate climatic mechanisms controlling forest composition, structure, and dynamics. The *modeling theme* integrates findings from the paleoecological and contemporary studies, and is the indispensable vehicle for scaling up our mechanistic findings to regional landscapes, and predicting which parts of montane landscapes may be most sensitive to future environmental changes.

The Sierra Nevada Global Change Research Program currently focusses on addressing nine central sets of questions:

- What is the relative importance of topography and soil on site water balance in the Sierra Nevada, and how well does this compare with model predictions?
- What is the role and importance of reproduction in determining forest pattern and forest sensitivity to climatic change? By what mechanisms does climate control reproduction, and therefore forest sensitivity to climatic change?
- How do seed dispersal, seedling dynamics, and fine-scale variations in topography and soils interact with climatic change to affect forest sensitivity and change at local scales?
- How does climatic change affect the spatial extent, landscape pattern, and severity of fires?
- What are the relative importances of tree recruitment, death, and growth rates, and their interannual variabilities, in determining forest response to climatic variation in space and time?
- What portions of Sierra Nevada landscapes are most sensitive to climatic changes (temperature, precipitation, and seasonality), what are the implications of this for a greenhouse world, and what are the implications for land managers?

- Does climate synchronize fire regimes at subcontinental scales? If so, what large-scale climatic phenomena drive the synchrony?
- Can agents of pattern formation and mechanisms of forest change be generalized at subcontinental scales?
- How do the relative importances of agents of pattern formation vary among different climates? Is our understanding of mechanisms of forest change sufficient for a single model to explain forest dynamics at several different sites across the continent?

OVERVIEW OF PROGRESS AND RESULTS

During 2002 the Sierra Nevada Global Change Research Program produced or contributed to 23 scientific manuscripts (published or accepted for publication, including one Ph.D. dissertation), with another eight manuscripts currently in review, and several in progress. Examples of some of our significant findings are as follows. We continued our work that calls into question some of the basic demographic assumptions common to most forest dynamics models meant to predict the effects of climatic change, and have pointed out how those models might be improved. However, initial analyses of tree growth rates seem to corroborate other model assumptions about the way in which trade-offs in growth rates versus environmental tolerances generate patterns in species replacement along climatic gradients. We also provided the first demonstration that pre-fire growth rate, in addition to fire-induced crown scorch, influences probability of tree death following fire, suggesting that resource managers will need to consider the effects of stressors (such as climatic change) interacting with fire. We developed a conceptual model describing where and when upper treeline might be most sensitive to climatic change, with implications for interactions between forest cover, hydrology, and species habitat. Our detailed records of fire-climate interactions continue to inform projections of the severity of upcoming fire seasons for the fire management community.

Investigators of the Sierra Nevada Global Change Research Program continued to leverage funds in support of the program. Swetnam and colleagues used their Sierra Nevada work to help leverage funds for their workshop on "Fire, Climate, and Vegetation in the Americas," held March 23-28, 2002, Tucson, Arizona. This workshop furthered collaborations relevant to the Sierra Nevada and Western Mountain Initiative. Urban's NSF funding continued, leveraging his Sierra Nevada work with a cross-site comparison among forests of the Sierra Nevada, Oregon Cascades, and southern Appalachians. Keeley's Joint Fire Science Program (JFSP) funding continued, allowing us to better determine the effects of fire on forest dynamics (particularly seedling dynamics). Urban's JFSP funding also continued, supporting his student Monique Rocca in her exploration of patterns of fine-scale spatial heterogeneity in microenvironment, fire effects, and herbaceous layer seedling response (including tree seedlings). Ruth Kern (Calif. State Univ., Fresno) captured matching funds to determine how variation in tree seedling dynamics might be driven by fine-scale variations in soil moisture -- information that complements our efforts to understand climatic controls of forest dynamics.

SPECIFIC ACCOMPLISHMENTS AND RESULTS

We continued our analyses of our long-term forest demographic data, challenging some of the basic assumptions of current models of forest dynamics. A particularly important

assumption of current models is that the only way environmental changes can affect tree death rates is by altering tree growth rates. However, our data suggest that environmental changes may have some of their greatest effects not by altering growth rates, but by altering the fundamental nature of the relationship between growth rates and death rates. These results are presented in a manuscript that *Ecology* has invited us to revise and resubmit.

Our manuscript on the relationships among tree growth rate, fire severity, and probability of tree death was accepted for publication by *Canadian Journal of Forest Research*. This paper provides the first demonstration that pre-fire growth rate, in addition to fire-induced crown scorch, influences probability of tree death following fire. This finding suggests that (1) similar processes may affect tree death in both disturbed and undisturbed stands, potentially providing some conceptual unification to models of tree mortality, and (2) resource managers will need to consider the effects of stressors interacting with fire. For example, if tree growth is reduced by air pollution or climatic change, there will likely be a *de facto* increase in fire severity (trees killed) even when there is no change in fire intensity.

Analysis of data from our long-term forest demography plots showed that most populations of sugar pine (*Pinus lambertiana*) are declining, primarily due to low recruitment. The low recruitment, in turn, ultimately appears to be caused by white pine blister rust, an introduced pathogen that is particularly deadly to small sugar pines. Matrix model projections indicated that none of our measured sugar pine populations is likely to go extinct within the next 50 years. However, the prospects for long-term survival of sugar pine as an important forest component are grim, especially in the face of interacting stressors such as rapid climatic change. These results are presented in a manuscript we have submitted to *Ecological Applications*.

We now have four years of data on seedling establishment and recruitment that can be related to overstory composition and seed fall, including two mast years for white fir. We have leveraged this work with other ongoing projects, adding three new sites that allow us to follow post-fire seedling establishment and recruitment patterns and post-fire tree survivorship and growth. In addition we have had some success with regression analysis relating seedling size to age.

Collaborators Bunn, Graumlich, and Urban developed a conceptual model describing where and when upper treeline is most sensitive to climatic change with implications for interactions between forest cover, hydrology, and species habitat. Additionally, Bunn, Waggoner, and Graumlich completed analysis of topographic mediation of tree growth rate on eight long tree-ring chronologies from Sequoia National Park. Their results indicate the importance of spatial scale in working with tree-ring data. Specifically, they showed that the biophysical setting of a stand of trees affects its sensitivity to climate, its structure, and the retrievable climate signals inherent in the tree rings.

Bunn, Sharac, and Graumlich completed a tree-ring simulation model, parameterized from Sierra Nevada data, that is being used to test assumptions about tree-ring processing methods and the detectability of systematic signals in long tree-ring series under various climate situations.

Bunn and colleagues mapped the locations of all old, dead wood above current treeline at one extensive site in Sequoia National Park. These data are being analyzed to detect topographic signatures that might allow predictive modeling to locate this rare and important paleoclimatic resource.

Collaborators Swetnam and Baisan extended their richly detailed tree-ring fire chronology of the Giant Forest sequoia grove in both space and time. Their previous fire-scar

chronology extended back about 3,000 years, but only one tree spanned the earliest few centuries of this record. Additional samples have now increased their sample depth to at least nine trees extending back to 600 BC, and at least four trees back to 900 BC. Additional samples from circa AD 1 to 500 will also allow the first robust comparisons of seasonal to centennial-scale changes in fire regimes and climate variations encompassing time periods before, during, and after the warm period of the Middle Ages (circa 900 to 1300). These results will have important implications for policy makers and managers, because this warm period (sometimes referred to as the Medieval Warm Period) is a subject of considerable debate as a warming episode possibly equalling or exceeding late 20th century warming.

The detailed records of fire-climate interactions developed by Swetnam and Baisan continue to inform projections of the severity of upcoming fire seasons for the fire management community. Particularly exciting results have come from a collaboration with Tony Westerling at Scripps Oceanographic Institute. The fire history network time series from the Southwest and Sierra Nevada were used in statistical modeling with modern and paleo-reconstructions of Palmer Drought Severity Index (PDSI). This work showed that the PDSI and a statistical model can "retrodict" time series of regional area burned before 1890. The chronology of estimated area burned closely matches the fire scar records, suggesting that fire scar data are a good regional measure of area burned, and that fire-climate relations of the 20th century are similar to the previous two centuries. Results are currently being written up.

Swetnam and colleagues used their Sierra Nevada work to help leverage funds through (1) a Joint Venture Agreement with USDA Forest Service Rocky Mountain Research Station for "Development of a Permanent, Public Fire History Archive" ($20,000; PI: Swetnam), (2) the National Oceanic and Atmospheric Administration for "A Multi-Proxy Fire History Database" ($82,000; PI: Connie Woodhouse of NOAA, with Swetnam as collaborator and member of Board of Advisors), and (3) NSF (International Programs), NOAA (Office of Global Programs), U.S. Forest Service (Pacific NW Research Station), PAGES (inter-American Institute), and Joint Fire Sciences Program for a workshop on "Fire, Climate, and Vegetation in the Americas" March 23-28, 2002, Tucson, AZ ($55,000; Co-PIs: Swetnam and Cathy Whitlock).

In addition to establishing new survey and focus plots, Urban and his students finished processing their tree cores and began analyzing tree growth rates. Initial results suggested that growth rates for ponderosa pine and red fir did not vary with elevation, whereas white fir showed a weak quadratic relation, peaking at middle elevations. The smoothed growth rate curves for the three species cross at elevations roughly corresponding to the ecotones between the forest types dominated by each species. This is consistent with earlier modeling work (Urban et al. 2000), which illustrated the way in which trade-offs in growth rates versus environmental tolerances generate patterns in species replacement along gradients. These results are significant to modeling possible forest responses to changing climate and fire regimes.

Urban's related NSF funding continued, leveraging his Sierra Nevada work with a cross-site comparison among forests of the Sierra Nevada, Oregon Cascades, and southern Appalachians. Joint Fire Science Program (JFSP) funding also continued, supporting Urban's student Monique Rocca in her exploration of patterns of fine-scale spatial heterogeneity in microenvironment, fire effects, and herbaceous layer seedling response (including tree seedlings).

As usual, USGS personnel in the Sierra Nevada Global Change Research Program frequently assisted the National Park Service in such tasks as transmitting research findings to the interpretive staffs, setting research priorities, aiding in fire management decision-making,

designing inventory and monitoring, aiding vegetation mapping, and so on. Stephenson continued his service as a member of the Science Advisory Board (appointed by the Secretary of Agriculture) for the newly-created Giant Sequoia National Monument.

USGS staff were contacted frequently by the press, often for information ultimately derived from the Sierra Nevada Global Change Research Program. These contacts included interviews by ABC News, Associated Press, the Los Angeles Times, Fairness and Accuracy in Reporting (FAIR), The Grand View (a public television series featuring national parks), the Sacramento Bee, and the Fresno Bee. A half-page photo from our research, illustrating forest changes due to fire exclusion, was used in an article in *U.S. News and World Report*, and Stephenson was contacted by the White House speech-writers' office for a fact-check for President Bush's policy speech on his *Healthy Forests Initiative*.

PROGRESS TOWARD INTEGRATION WITH OTHER PROJECTS WITHIN RESEARCH THEME

Swetnam et al.'s workshop on "Fire, Climate, and Vegetation in the Americas" (March 23-28, 2002, Tucson, AZ) included representatives from all regions within the Western Mountain Initiative (WMI) (Scott Anderson, Don McKenzie, Emily Heyerdahl, Tony Caprio, Jeremy Littel, Tom Swetnam, and others). A key result of the workshop was an initiative to develop an international, permanent archive of paleo-fire history data (tree-ring and sediment-based fire history proxy records). This archive will facilitate the compilation, safe keeping, and exchange of fire history data, becoming a fundamental source of data for assembling and studying the fire climatology of the western United States. Funding for establishing this Paleo-Fire Database at the National Geophysical Data Center in Boulder Colorado has been obtained from both the U.S. Forest Service and NOAA.

In addition to the above, Swetnam conducted detailed discussions with other WMI partners regarding collaborations on fire-climate research to compare fire scar networks and climate reconstructions among the Sierra Nevada, Southwest, and Pacific Northwest. These discussions will lead to new proposals to complement and expand upon current synthetic efforts.

Urban's modeling efforts have focussed on products applicable to any montane site. He continued work on cross-site comparisons among the Sierra Nevada, Oregon Cascades, and southern Appalachians. His fire project funded by the Joint Fire Sciences Program includes a substantial emphasis on generalizing the approach and disseminating it to other western systems.

Graumlich continues to actively pursue integration related to the Western Mountain Initiative. In 2002 she continued integrative tree-ring work in Yellowstone National Park, WY (Mt. Washburn); Gallatin National Forest, MT (Absaroka - Beartooth Wilderness); and the Inyo National Forest, CA (Lee Vining). This work emphasizes the nature and drivers of climatic variability at decadal to centennial time scales.

Stephenson organized a workshop including key collaborators within the Western Mountain Initiative (WMI), aimed at setting future directions for WMI. The workshop will be held March 15-16, 2003, at Sequoia National Park.

PLANS FOR COMING YEAR

All collaborators will focus particularly on analysis, synthesis, and writing during the coming year -- the last year of this funding cycle. Specifically, Swetnam, Baisan, and colleagues

will complete their analyses and report on their fire history plot data, extended sequoia fire history (in both space and time), and fire-climate interactions within the western United States. They will work with their Western Mountain Initiative partners to develop a proposal to carry out detailed, inter-regional comparisons and analyses of fire climatology (using tree-ring reconstructions) in the western United States over the past four centuries. Bunn and Graumlich will complete analysis of fine scale drivers of tree growth at treeline, finish collecting data on seedling demography, and complete their process model of treeline dynamics. Urban will spend most of the year producing manuscripts for submission to journals. His student Monique Rocca will continue her field studies on fine-scale spatial heterogeneity in prescribed fires. Stephenson, Keeley, van Mantgem, and van Wagtendonk will continue to produce manuscripts from the long-term forest plots arrayed along an elevational gradient, particularly emphasizing climatic controls of forest demography (including seedling establishment and survival) and forest carbon dynamics. At a workshop to be held in March 2003, all collaborators will contribute toward setting future directions for the Sierra Nevada program and the broader Western Mountain Initiative.

PRODUCTS

Publications:

Bunn, A. G., L. J. Graumlich, and D. L. Urban. In review. Interpreting the climatic significance of trends in twentieth-century tree growth at high elevations. Submitted to *Arctic, Antarctic and Alpine Research.*

Bunn, A. G., R. L. Lawrence, G. J. Bellante, L. A. Waggoner, and L. J. Graumlich. In Press. Spatial variation in distribution and growth patterns of old growth strip-bark pines. *Arctic, Antarctic and Alpine Research.*

Bunn, A. G., L. A. Waggoner, and L. J. Graumlich. In review. Topographic Mediation of Growth of Subalpine Trees in the Sierra Nevada, USA. Submitted to *Landscape Ecology.*

Gardner, R. H., and D. L. Urban. In Press. Model testing and validation: past lessons and present challenges. In C. D. Canham, J. J. Cole, and W. K. Lauenroth (eds.), *The role of models in ecosystem science*. Princeton University Press, Princeton, NJ.

Graumlich, L. J., M. F. J. Pisaric, L. A. Waggoner, J. Littell, and J. King. In Press. Upper Yellowstone River flow and teleconnections with Pacific basin climate variability during the past three centuries. *Climate Change.*

Graumlich, L. J., L. A. Waggoner, and A. G. Bunn. In press. Detecting Global Change at Alpine Treeline: Coupling Paleoecology with Contemporary Studies. In Bugmann, H. (ed). *Global Change and Mountain Regions: A State of Knowledge Overview.*

Keeley, J. E. 2002. Fire management of California shrubland landscapes. *Environmental Management* 29: 395-408.

Keeley, J. E. 2002. Native American impacts on fire regimes of the California coastal ranges. *Journal of Biogeography* 29: 303-320.

Keeley, J. E. 2002. Plant diversity and invasives in blue oak savannas of the southern Sierra Nevada, pp. 693- 704. In R. B. Standiford, D. McCreary, and K. L. Purcell (eds) Proceedings of the Fifth Symposium on California's Oak Woodlands: Oaks in

California's changing landscape. US Forest Service General Technical Report, PSW-GTR-184, Pacific Southwest Research Station, Albany, CA.

Keeley, J. E. and C. J. Fotheringham. 2002. Impact of past, present, and future fire regimes on North American Mediterranean shrublands, pp. 214-258. In T. T. Veblen, W. L. Baker, G. Montenegro, and T. W. Swetnam (eds), Fire Regimes and Climatic Change in Temperate and Boreal Ecosystems of the Western Americans. Springer-Verlag, New York.

Keitt, T. H., and D. L. Urban. In Review. Scale-specific inference using wavelets. Submitted to *Ecology*.

Lookingbill, T. R., and D. L. Urban. In Press. Spatial estimation of air temperature differences for landscape-scale studies in montane environments. *Ag. Met*.

Montenegro, G., R. Ginocchio, A. Segura, and J. E. Keeley. In press. Fire regimes and vegetation responses in two mediterranean-climate regions. In G. A. Bradshaw and P. A. Marquet (eds), *How landscapes change: Human disturbance and ecosystem disruptions in the Americas.* Springer-Verlag, NY.

Peters, D. P., D. L. Urban, R. H. Gardner, D. D. Breshears, J. E. Herrick, M. B. Coughenour, and R. A. Pielke. In Review. Strategies for ecological extrapolation. Submitted to *Oikos*.

Pierce, K. B. 2002. *Reconciling forest demography with gradient analysis in montane landscapes*. Ph.D. dissertation, University Program in Ecology, Duke University.

Pierce, K. B., T. R. Lookingbill, and D. L. Urban. In Review. A simple method for estimating potential relative radiation (PRR) for landscape-scale vegetation analysis. Submitted to *Landscape Ecology*.

Shafer, S. L., T. W. Swetnam, P. J. Bartlein, and C. Whitlock. 2002. "Fire and Climate History in Western North and South America," Meeting Review of a workshop held in Tucson, Arizona, 23–28 March 2002. Bulletin of the Ecological Society of America 83(3):187-188.

Stephenson, N. 2002. Sierra Nevada global change and fire research. *People, Land, and Water* 8(10):18.

Stephenson, N. L. 2002. The Story Continues. Closing chapter (pages 72-74) in R. J. Hartesveldt, H. T. Harvey, H. S. Shellhammer, and R. E. Stecker, *Giant Sequoias.* Fourth printing with revisions. Sequoia Natural History Association, Three Rivers, CA.

Stephenson, N., M. Keifer, and J. Manley. 2002. Restoring western forests: fires, saws, or both? *People, Land, and Water* 8(10):18.

Stephenson, N. L., P. J. van Mantgem, P. E. Moore, J. F. Franklin, and D. J. Parsons. In Review. Dissecting the inverse relationship between tree growth rate and probability of death. Submitted to *Ecology*.

Swetnam, T. W. 2002. Fire and climate history in the western Americas from tree rings. PAGES News, 10(1) April 2002.

Swetnam, T. W. and C. H. Baisan. 2003. Tree-ring reconstructions of fire and climate history in the Sierra Nevada and Southwestern United States. Chapter 6, pages 158-195, In: T. T. Veblen, W. Baker, G. Montenegro, and T. W. Swetnam, editors. *Fire and Climatic Change in Temperate Ecosystems of the Western Americas*. Ecological Studies Vol. 160. Springer-Verlag, New York.

Urban, D. L. 2002. Tactical monitoring of landscapes. Pages 294-311 in J. L. Liu and W. W. Taylor (eds.), *Integrating landscape ecology into natural resource management.* Cambridge Univ. Press, Cambridge.

Urban, D. L. 2002. Classification and regression trees. Pages 222-232 in B. McCune and J. B. Grace, *Analysis of ecological communities*. MjM Software Design, Gleneden Beach, Oregon.

Urban, D. L, S. Goslee, K. B. Pierce, and T. R. Lookingbill. 2002. Extending community ecology to landscapes. Ecoscience 9:200-212.

van Mantgem, P. and M. Schwartz. In Press. Bark heat resistance of small trees in Californian mixed conifer forests: testing some model assumptions. *Forest Ecology and Management.*

van Mantgem, P. J., and M. W. Schwartz. In Review. An experimental demonstration of stem damage as a predictor of fire-caused mortality for ponderosa pine. Submitted to *Canadian Journal of Forest Research.*

van Mantgem, P. J., N. L. Stephenson, M. Keifer, and J. Keeley. In Review. Effects of an introduced pathogen and fire exclusion on long-term demographic trends of sugar pine in the Sierra Nevada. Submitted to *Ecological Applications.*

van Mantgem, P., N. L. Stephenson, L. S. Mutch, V. G. Johnson, A. M. Esperanza, and D. J. Parsons. In Press. Growth rate predicts mortality of *Abies concolor* in both burned and unburned stands. *Canadian Journal of Forest Research.*

Veblen, T. T., W. Baker, G. Montenegro, and T. W. Swetnam (editors). 2003. *Fire and Climatic Change in Temperate Ecosystems of the Western Americas*. Ecological Studies Vol. 160. Springer-Verlag, New York. 444 pp.

Selected presentations:

Bueno, M. M., N. Stephenson, J. E. Keeley, and A. Pfaff. 2002. The southern Sierra repeat photography project: vegetation changes over the past 125 years. Sierra Nevada Science Symposium, Kings Beach, California.

Bunn, A. G. 2002. Comparison of topographic correction algorithms for use with Landsat ETM+ in mountainous landscapes. ACSM- ASPRS Conference and Technology Exhibition. Washington, D.C.

Bunn, A. G., L. A. Waggoner, and L. J. Graumlich. 2002. Extreme Variability in Tree-ring Chronologies from Different Physical Settings. Sierra Nevada Science Symposium, Kings Beach, California.

Graumlich, L. J. 2002. Global Change, Globalization and Mountain Systems. Melting Mountains: Climate Change in the Asia Pacific Region. Keynote address. 2002 Mansfield Conference, Big Fork Montana.

Graumlich, L. J. 2002. Global Change, Globalization and Mountain Systems. Rocky Mountain Summit. Kalispell Montana.

Knapp, E. E., J. E. Keeley, and N. L. Stephenson. 2002. Tree mortality following reintroduction of fire to an old growth mixed conifer forest. Annual Meeting of the Ecological Society of America, Tucson, Arizona.

Knapp, E. E., J. E. Keeley, and N. L. Stephenson. 2002. Ecological impacts of season of prescribed fire in a Sierran mixed conifer forest. Sierra Nevada Science Symposium, Kings Beach, California.

Menning, K. M., J. J. Battles, T. L. Benning, and N. L. Stephenson. 2002. Forest litter densities under different dominant tree species: a factor affecting ground fire spread. Sierra Nevada Science Symposium, Kings Beach, California.

Pierce, K. B., and D. L. Urban. 2002. Predicting optimum sampling strategies to capture species-environment interactions. Annual meeting of the Ecological Society of America, Tucson, AZ.

Stephenson, N. L. 2002. Predicting the effects of global changes on vegetation: how good are our assumptions? Seminar series, Institute for the Study of Planet Earth, University of Arizona, Tucson.

Stephenson, N. L. 2002. The National Park Service mission and ecosystem impairment in an era of rapid global change. National Park Service *West by Northwest 2002* conference. Seattle, Washington.

Stephenson, N. L. 2002. Ecosystem stressors in the Sierra Nevada. Yosemite National Park Vital Signs Workshop. Mariposa, California.

Stephenson, N. L. 2002. Ecosystem stressors in the Sierra Nevada. Devil's Postpile National Monument Vital Signs Workshop. Lee Vining, California.

Stephenson, N. L., and J. E. Keeley. 2002. Fire and forest demography. First annual symposium on *Fire and Fire Surrogate Study -- Sequoia National Park*. Sequoia National Park, California.

Stephenson, N. L., J. E. Keeley, J. W. van Wagtendonk, D. L. Urban, T. W. Swetnam, and L. J. Graumlich. 2002. The Sierra Nevada Global Change Research Program. Sierra Nevada Science Symposium, Kings Beach, California.

Stephenson, N. L., P. J. van Mantgem, and P. E. Moore. 2002. Tree growth and death in the Sierra Nevada. Sierra Nevada Science Symposium, Kings Beach, California.

Swetnam, T. W. 2002. Organized and directed "Fire in the West" workshop in collaboration with CLIMAS, Tucson, AZ.

Swetnam, T. W. 2002. Organized, hosted, and presented at "Fire, Climate, and Vegetation in the Americas," Tucson, AZ.

Swetnam, T. W. 2002. Presented an invited after-dinner lecture at 6th International Dendrochronology Conference, Quebec City, Canada.

Swetnam, T. W. 2002. Presented invited lecture/seminar at Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY.

Swetnam, T. W. 2002. Invited lectures at Continuing Education in Ecosystem Management course at Northern Arizona University, Flagstaff, AZ.

Swetnam, T. W. 2002. Invited lecture at Forest Ecology Field Course, Cortina de Ampezzo, Italy.

Swetnam, T. W. 2002. Lecture to Environmental Law class at Arizona State University, on fire and climate issues in the Western US.

Swetnam, T. W. , and P. Sheppard. 2002. Taught National Science Foundation Chautauqua course on Using Tree-Rings in Environmental Education, for Science teachers in small colleges and universities. University of Arizona, Tucson, AZ.

Urban, D. L. 2002. Landscape pattern and ecological process in the Sierra Nevada. Invited plenary, Sierra Nevada Science Symposium, Lake Tahoe, CA.

Urban, D. L. 2002. Landscape pattern and forest process in the Sierra Nevada of California. Invited speaker, University of Puerto Rico, San Juan.

Urban, D. L. 2002. Landscape pattern and ecological process in the Sierra Nevada: a model-data dialogue. Invited Biology Colloquium, Colorado State University, Fort Collins.

van Mantgem, P. J., M. Keifer, and N. L. Stephenson. 2002. The sugar pine dilemma: prescription burning, naturalness, and the management of a declining species. Annual meeting of the Association for Fire Ecology, San Diego, California.
van Mantgem, P. J., and N. L. Stephenson. 2002. Searching for a general model of tree death in burned and unburned stands. Annual Meeting of the Ecological Society of America, Tucson, Arizona.
van Mantgem, P. J., and N. L. Stephenson. 2002. When life ain't so sweet: the decline of sugar pine (*Pinus lambertiana* Dougl.) in the Sierra Nevada. Sierra Nevada Science Symposium, Kings Beach, California.
Weise, D. R., J. van Wagtendonk, M. Arbaugh, J. Chew, G. J. Jones, M. Witala, J. Merzenich, M. Schaaf, S. Schilling, and R. Kimberlin. 2002. Simulation of historical fires and their impact on fuels in Yosemite National Park. Conference of Fire, Fuel Treatments and Ecological Restoration: Proper Place, Appropriate Time. April 16-18, Fort Collins, CO.

Latitude and Longitude of study sites:

The two primary study sites are at approximately 118 45' W, 36 35' N (Sequoia National Park, California) and 119 50' W, 37 50' N (Yosemite National Park, California).

WEB PAGE REVIEW

No changes are required to our web page.