**Project Title:**
Fighting drought with fire: Can prescribed fire increase forest resistance to drought?

**Project Leader, Science / Contact Information:**
Phillip van Mantgem, USGS, Redwood Field Station, 1655 Heindon Road, Arcata, CA 95521. tel (707) 825-5189, email: pvanmantgem@usgs.gov

**Project Leader, Resource Management / Contact Information:**
Tony Caprio, Fire Ecologist, Sequoia and Kings Canyon National Parks, 47050 Generals Hwy., Three Rivers, CA 93271. tel (559) 565-3126, email: tony_caprio@nps.gov

**Project Duration:**
24 months

**Total Requested Funding:**
$37,431

**Partners:**
Nathan L. Stephenson, USGS, Sequoia and Kings Canyon Field Station, 47050 Generals Hwy., Three Rivers, CA 93271. tel (559) 565-3176, email: nstephenson@usgs.gov

Adrian Das, USGS, Sequoia and Kings Canyon Field Station, 47050 Generals Hwy. #4, Three Rivers, CA 93271. tel (559) 565-3179, email: adas@usgs.gov

**Amount of Funding Leveraged for this Project:**
$60,800

**Geographic Scope:**
Sierra Nevada

**Project Description:**

A century of fire exclusion across many forest types in the western U.S. has resulted in unforeseen changes, including high fuel accumulations, high densities of trees and increasing dominance of fire-intolerant species. These changes are particularly acute in forests that historically experienced high frequency and low severity fires (Noss et al. 2006). In response, the NPS Pacific-West region supports a large prescribed fire program to reduce understory fuels and forest density. Prescribed fire has been generally successful at reducing understory fuels (e.g., Stephens et al. 2009) and threats of catastrophic fire (stand replacing fires) (Hurteau and North 2009). That is, treated stands are expected to be more resistant (showing measurably less response) to future wildfire. Less well understood is how well prescribed fire confers resistance to other forest stressors, such as drought.

Drought is a major forest stress causing tree mortality directly or by making trees more vulnerable to insects (bark beetles) or other pathogens. While reduced precipitation (rain or snowfall) often defines drought, higher temperatures lead to increased evapotranspiration that also cause drought stress (Williams et al. 2015). Indeed, chronic drought caused by long-term warming trends are believed to be an underlying cause of increased 'background' (non-catastrophic) tree mortality across western North America (van Mantgem et al. 2009, Peng et al. 2011). Recent observations have shown that the co-occurrence of reduced precipitation and high temperatures can lead to massive forest die-back, where entire stands are lost (Allen et al. 2015).

The severe drought extending from 2012 to 2015 across much of California provides a remarkable natural experiment to test if prescribed fire creates conditions where forests are resistant to drought. Has prescribed fire removed enough small trees so that remaining trees have sufficient moisture to survive the extended drought? The answer to this question has profound implications for forest management over the coming decades as drought stress on our forests is expected to increase rapidly (Seager and Vecchi 2010). At Sequoia and Kings Canyon National Parks we are uniquely qualified to address this question, as we have access to several ongoing long-term forest monitoring projects that have tracked tree survivorship both with and without fire for over 30 years. Comparisons of survivorship across these sites will inform us how well prescribed burning influences drought responses and how this response varies across treatment intensity (number, size class, and basal area of trees removed) and forest type.

**Approach and Scope of Work:**

We will build on previous work to produce rapid results. We will use two primary data sources for this project: the USGS-led Sierra Forest Demography Database and the NPS FFI fire effects monitoring database for FMH data. The USGS Forest Demography Database is a globally unique and ongoing plot-based forest monitoring project that has annually tracked the birth, death and growth of nearly 30,000 individual trees across all major forest types in the western slope of the Sierra Nevada since the early 1980s. Analysis of long-term records have revealed that background rates of tree mortality are increasing, likely in response to temperature-driven increases in evapotranspiration (van Mantgem and Stephenson 2007), and is expected to continue increasing into the future (Das et al. 2013). However, most of the forests measured in this project remain unburned after over a century of fire exclusion, so that many stands have a high density of trees. These additional trees are expected to exacerbate the drought-mortality response.

The FMH forest monitoring data from the NPS fire effect sampling program (NPS 2003) is focused on measuring the effects of prescribed fire. Sequoia and Kings Canyon National Parks

(SEKI) were an early adopter of these fire-effects monitoring protocols and have maintained an active program since the 1980s. At SEKI over 80 FMH plots have been established, tracking the effects of approximately 50 fires at mid- to low-elevation forests where prescribed fire has been deployed. Stand conditions at these sites differ according to pre-fire conditions and variability in fire effects. This plot-based program also tracks individual tree birth, death and growth, but at staggered intervals (typically pre-fire, and post-fire at 0-, 1-, 2-, 5-, 10-year intervals, and then every 10 years thereafter). A small number of unburned FMH plots exist, but as a rule the NPS program does not monitor unburned 'control' areas.

We propose to conduct additional measurements at the SEKI FMH plots to better understand forest response to the 2012-2015 drought. Because we want to capture the effects of the unusually severe drought, we will measure all relevant burned FMH plots (regardless of the planned measurement schedule). For this effort we will focus on tree survivorship (rather than the full suite of potential data), allowing us to remeasure the maximum number of FMH plots for minimal costs. The continuing measurements of the unburned Forest Demography plots will occur using USGS funding that has already been secured.

An inventory of burned and unburned forest stands in the early stages of the drought (up to 2014) suggested that trees in burned stands, after accounting for individual differences in size, had lower mortality probabilities compared to trees in unburned stands (van Mantgem et al. *In press*). But the full effects of drought were not yet evident in 2014, and mortality rates were only slightly elevated above long-term background mortality. The situation changed dramatically in 2015, with record-breaking tree mortality across the southern Sierra Nevada. We seek to take advantage of the extreme drought effects of 2015 – and anticipated subsequent insect activity in 2016 and 2017 – to determine whether mortality continued to remain lower in areas that had been previously burned. Moreover, we will determine whether differences in mortality now also extend to higher-elevation forests (>2100 m).

*Analyses*

We will compare observed mortality in 2017 in burned and unburned forest for all species and for common genera (i.e., *Pinus* and *Abies*). We will also consider differences in mortality rate across forest type and stem size classes (e.g., large vs. large trees, >40 and ≤40 cm stem diameters). It will also be possible to describe the effects of previous fire-caused injuries and time since last fire, as recorded by earlier FMH plot data. These analyses can be conveniently conducted using generalized linear mixed models (GLMM). This modeling approach allows us to analyze non-normal demographic data (based on tree status, live or dead), considering both individual-level variables (characteristics of individual trees and fire-caused injury) and group-level variables (e.g., plots nested within forest type). Model selection will be done using the Akaike information criterion adjusted by sample size (*AICc*). Ultimately, these analyses will determine how stand density varies according to management history (burned or unburned) and how differences in stand conditions and management history confer (or don't confer) increased resistance to recent drought-induced tree mortality.

*Roles*

This project will benefit from collaborative efforts between the USGS and the National Park Service. This partnership allows us to leverage the diverse skill sets of participating scientists. Direct involvement of NPS scientists will help streamline access to existing databases and ensure relevance to DOI clients.

Phillip van Mantgem, USGS. van Mantgem will conduct data analysis and take a primary role in writing manuscripts and outreach materials.

Tony Caprio, Fire Ecologist, Sequoia and Kings Canyon National Parks. Caprio will oversee fieldwork, data collection, data organization and data archiving. He will also assist in developing manuscripts and outreach materials.

Adrian Das, USGS, Sequoia and Kings Canyon Field Station, 47050 Generals Hwy. #4, Three Rivers, CA 93271. Das will help in data analysis and assist in developing manuscripts.

Nathan Stephenson, USGS, Sequoia and Kings Canyon Field Station, 47050 Generals Hwy. #4, Three Rivers, CA 93271. Stephenson will provide assistance in data analysis, interpretation and manuscript preparation.

**CA LCC Priorities and Place-based Project Criteria addressed:**
This work addresses a key information gap for forest managers in the Sierra Nevada: how can we manage for forests that are resistant to the effects of climate change? Drought-induced tree mortality was identified as a key emerging threat to US forests in the recent National Climate Assessment (Joyce et al. 2014). Indeed, droughts are expected to be more frequent and severe in coming decades in the Southwest (Garfin et al. 2014), underscoring the importance for land management agencies to develop cost-effective adaptation strategies to drought (Millar et al. 2007). The effects of drought occur at intermediate time-scales (interannual to decadal) so the collection of these data is time sensitive. If these data are not collected within the next two years we will miss an important opportunity to learn from this severe drought.

From 2012 to 2015 forest managers in the southern Sierra Nevada experienced increasing tree mortality and complete diebacks linked to drought and rising temperatures, with continued mortality expected as insects attack weakened trees. Land managers, as they work to develop robust climate change adaptation strategies, are keen to buy time by enhancing forest resistance (*sensu* Walker et al. 2004) to such abrupt, severe, and widespread changes. Reductions in tree density following prescribed fire have been widely presumed to increase resistance to drought. Yet this proposition has remained largely untested, meaning land managers do not have the basic information they need for critical cost-benefit analyses. **Capitalizing on unique long-term forest monitoring datasets at Sequoia National Park, we will assess if stand conditions created by prescribed fire promotes tree survivorship in the face of the severe drought of 2012 to 2015.**

**Capacity:**
Our research team has extensive publication records in top journals in the fields of climate change impacts, fire science, forest ecology and tree-ring analysis. Much of our work has focused on understanding the patterns and processes of tree mortality in relation to disturbance and climate variability. Moreover, the USGS scientists involved in this project are all embedded within National Parks and have a long and successful history of translating their results to information relevant for managers.

**Timeline**:

- Winter 2016: Hire field crew, obtain supplies.
- Summer 2017: Data collection.
- Fall/Winter 2017 - 2018: Data entry and quality checking.
- Winter 2018: Complete final report and manuscript.

**Measuring results:**
Our primary target audience for these results is professional land managers. Specifically, this information will assist managers who wish to conduct cost-benefit analyses of prescribed fire effects on forest resistance to drought across a range of conditions in the Sierra Nevada. If current practices for modifying forest conditions through fire are found to increase drought resistance, our project could help managers apply these methods across western forests more broadly. The results of this study may change management policy to maximize resource benefit from fire.

These results will help inform fire and climate change adaptation planning among federal agencies (DOI agencies such as NPS, BLM and USFWS as well as US Forest Service). We plan to reach this audience using multiple outreach platforms, but relying heavily on in-person contacts with fire managers. We are in routine contact with managers, so it will be simple for us to provide formal and informal presentations of our findings. Upon project completion we will provide in-person presentations of the results and implications of the synthesis to park resource staff. For managers outside of our network we will present our results using web-based approaches, primarily webinars, coordinating with the California LCC. It is our intent to make the data and products freely available to managers, preferably using formats already in use by the California LCC (Climate Commons) and USGS (Science Base). In addition, we will make our results and outreach materials available via a USGS-hosted project webpage.

**Budget:** Funding will be used to support two additional field technicians (supervised by Caprio) and salary support for van Mantgem. All other funding will come from contributed sources (see attached spreadsheet).

*Requested funding*
<u>NPS</u>
GS-5 Field technician (temp) × 2, 9 pay periods each = $23,500
Estimated travel charges (camping per diem) = $2,800
Vehicle charges = $800
Field supplies = $1000

<u>USGS</u>
Phillip van Mantgem, salary: 80 hours = $5,400
Travel = 500
Publication charges = $1500
Indirect charges = $1931
*Total request: $37,431*

*Contributed funding:*
USGS Forest Demography data collection: $60,000
Vehicle charges = $800
*Total contributed*: *$60,800*
***Contributed funding represents 62% of the project total.***

**Products/Data Sharing:**
There are no known restrictions on sharing data generated as part of this project. Forthcoming Federal regulations will require full sharing of data prior to publication. We will follow USGS guidelines on data sharing prior to publishing results of this work.

**References:**
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Das, A. J., N. L. Stephenson, A. Flint, T. Das, and P. J. van Mantgem. 2013. Climatic correlates of tree mortality in water-and energy-limited forests. PLOS ONE **8**:e69917.

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Joyce, L. A., S. W. Running, D. D. Breshears, V. H. Dale, R. W. Malmsheimer, R. N. Sampson, B. Sohngen, and C. W. Woodall. 2014. Forests. Pages 175-194 *in* J. M. Melillo, T. C. Richmond, and G. W. Yohe, editors. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, Washington, DC, USA.

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Noss, R. F., J. F. Franklin, W. L. Baker, T. Schoennagel, and P. B. Moyle. 2006. Managing fire prone forests in the western United States. Frontiers in Ecology and the Environment **8**:481-487.

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Seager, R., and G. A. Vecchi. 2010. Greenhouse warming and the 21st century hydroclimate of southwestern North America. Proceedings of the National Academy of Sciences **107**:21277-21282.

Stephens, S. L., J. J. Moghaddas, C. Edminster, C. E. Fiedler, S. Haase, M. Harrington, J. E. Keeley, E. E. Knapp, J. D. McIver, K. Metlen, C. N. Skinner, and A. Youngblood. 2009.

Fire treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. Ecological Applications **19**:305-320.

van Mantgem, P. J., A. C. Caprio, N. L. Stephenson, and A. J. Das. *In press*. Does prescribed fire promote resistance to drought in low elevation forests of the Sierra Nevada, California? Fire Ecology **12**.

van Mantgem, P. J., and N. L. Stephenson. 2007. Apparent climatically-induced increase of mortality rates in a temperate forest. Ecology Letters **10**:909-916.

van Mantgem, P. J., N. L. Stephenson, J. C. Byrne, L. D. Daniels, J. F. Franklin, P. Z. Fulé, M. E. Harmon, A. J. Larson, J. M. Smith, A. H. Taylor, and T. T. Veblen. 2009. Widespread increase of tree mortality rates in the western United States. Science **323**:521-524.

Walker, B., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social-ecological systems. Ecology and Society **9 (2)**:5.

Williams, A. P., R. Seager, J. T. Abatzoglou, B. I. Cook, J. E. Smerdon, and E. R. Cook. 2015. Contribution of anthropogenic warming to California drought during 2012–2014. Geophysical Research Letters.

**NPS**

| Budget Categories | CA LCC Request | Partner(s) Contribution(s) (monetary) | Partner(s) Contribution(s) (non-monetary value/in-kind) | **Total** |
|---|---|---|---|---|
| | | | | |
| Salaries | $ 23,500.00 | $ - | $ - | $ 23,500.00 |
| Supplies | $ 1,000.00 | $ - | $ - | $ 1,000.00 |
| Overhead | $ - | $ - | $ - | $ - |
| Equipment | $ - | $ - | $ - | $ - |
| Travel | $ 3,600.00 | $ - | $ - | $ 3,600.00 |

**USGS**

| Budget Categories | CA LCC Request | Partner(s) Contribution(s) (monetary) | Partner(s) Contribution(s) (non-monetary value/in-kind) | **Total** |
|---|---|---|---|---|
| | | | | |
| Salaries | $ 5,399.80 | $ - | $ 60,000.00 | $ 65,399.80 |
| Supplies | $ - | $ - | $ - | $ - |
| Overhead | $ 1,931.13 | $ - | $ - | $ 1,931.13 |
| Equipment | $ - | $ - | $ - | $ - |
| Travel | $ 500.00 | $ - | $ 800.00 | $ 1,300.00 |
| Publication charges | $ 1,500.00 | $ - | $ - | $ 1,500.00 |

| | | | | |
|---|---|---|---|---|
| **Total** | $ 37,430.93 | $ - | $ 60,800.00 | $ 98,230.93 |

| Product Name | Product Type (select from pull-down) | Expected Delivery Date | Description | How will access to this product be provided? (See examples) | Target Audience (be as specific as possible) |
|---|---|---|---|---|---|
| Quarterly Financial and Progress Reports | Administrative | Quarterly | These are the quarterly reports required of all projects. | Quarterly Financial and Progress Reports should be emailed to CA LCC | Financial: CA LCC; Progress: CA LCC and Partners |
| Forest mortality inventory | Datasets: Tabular data | Winter 2018 | Counts of live and dead trees in burned and unburned permanent forest plots. | Data will be stored on NPS servers, CA LCC Climate Commons and on USGS Science Base. | NPS forest managers and forest science research community |
| Final project summary | Publication | Summer 2018 | Detailed project description and results of data analysis. | Emailed to CA LCC and NPS | CA LCC and NPS forest managers |
| Project presentation | Presentation or Poster | Summer 2018 | In person and/or webinar describing results. | and/or CA LCC hosted webinar | CA LCC and NPS forest managers |
| Project website | Website | Summer 2018 | Project summary and highlights of results | Hosted on USGS WERC webpage | CA LCC and NPS forest managers |
| Peer-reviewed manuscript | Publication | Summer 2018 | Primary scientific report appearing in a peer-reviewed journal. | Manuscript pdf emailed to to CA LCC and NPS | CA LCC and NPS forest managers |

**Phillip van Mantgem**
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Tel. (707) 825-5189, Email: pvanmantgem@usgs.gov

EDUCATION

| | | | |
|---|---|---|---|
| Ph.D. | 2001 | University of California, Davis, CA | Ecology |
| M.S. | 1996 | University of California, Davis, CA | Plant Biology |
| B.S. | 1991 | University of Iowa, Iowa City, IA | Botany |

PROFESSIONAL EXPERIENCE

2008 – present Research Ecologist, USGS, Redwood Field Station, Arcata, CA
2009 – present Adjunct Professor, Humboldt State University, Arcata, CA
2000 – 2008 Ecologist, USGS, Sequoia and Kings Canyon Field Station, Three Rivers, CA

SELECTED RECENT PUBLICATIONS

**van Mantgem, P. J.**, Caprio, A. C., Stephenson, N. L., and Das, A.J. *In press*. Does prescribed fire promote resistance to drought in low elevation forests of the Sierra Nevada, California, USA? *Fire Ecology*.

Schwartz, M. W., N. Butt, C. R. Dolanc, A. Holguin, M. A. Moritz, M. P. North, H. D. Safford, N. L. Stephenson, J. H. Thorne, and **P. J. van Mantgem**. 2015. Increasing elevation of fire in the Sierra Nevada and implications for forest change. *Ecosphere* 6(7):1-10.

**van Mantgem, P. J.**, and Sarr, D. A. 2015. Structure, Diversity, and Biophysical Properties of Old-Growth Forests in the Klamath Region, USA. *Northwest Science* 89: 170-181.

Stephenson, N.L. (and 37 others, including **P.J van Mantgem).** 2014. Rate of tree carbon accumulation increases continuously with tree size. *Nature 507:90-93.*

**van Mantgem, P. J.**, Nesmith, J. C., Keifer, M., Knapp, E. E., Flint, A., and Flint, L. 2013. Climatic stress increases forest fire severity across the western United States. *Ecology Letters* 16:1151-1156.

**van Mantgem, P.J.**, M.A. Madej, J. Seney and J. Deshais. 2013. Estimating ecosystem carbon stocks at Redwood National and State Parks. *Park Science* 30: 20-26.

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**van Mantgem P.J.**, Nesmith J.C.B., Keifer M. and Brooks M.L. 2013. Tree mortality patterns following prescribed fire for *Pinus* and *Abies* across the southwestern United States. *Forest Ecology and Management* 289: 463-469.

**van Mantgem P.J.** and Stuart J.D. 2012. Structure and dynamics of an upland old-growth forest at Redwood National Park, California. USDA Forest Service Gen. Tech. Rep. PSW-GTR-238. Pacific Southwest Research Station, Albany, CA, pp. 323-333.

Stephenson, N.L., **P.J van Mantgem**, A.G. Bunn, H. Brunner, M.E. Harmon, K.B. O'Connell, D.L. Urban, and J.F. Franklin. 2011. Causes and implication of the correlation between tree mortality rates and forest productivity. *Ecological Monographs* 81: 527-555.

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Das, A., Battles, J., **van Mantgem, P.J.**, and Stephenson, N.L. 2008. Spatial elements of mortality risk in old-growth forests. *Ecology* 89: 1744–1756.

**Anthony C. Caprio** - *Fire Ecologist*
Division of Resources Management & Science, Sequoia and Kings Canyon National Parks, 47050 Generals Highway, Three Rivers, CA 93271, 559-565-3126 (fax 559-565-4253), E-mail: tony_caprio@nps.gov

## EDUCATION

1994 ***M.S., Forest and Watershed Management***, School or Renewable Natural Resources, University of Arizona. **Thesis:** *Fire Effects and Vegetation Response in a Madrean Oak Woodland, Southeastern Arizona*.
1977 ***B.S., Biology***, University of Montana

## CURRENT & PREVIOUS POSITIONS

- ***Ecologist*** (1995-present), Div. Resources Mgmt. and Sci., Sequoia and Kings Canyon National Parks, Three Rivers, CA
  - Fire Ecology & Fire Research Coordinator, fire ecology/effects, fire history, and coordination of fire research activities
- ***Faculty Affiliate*** (2002-2008), Department of Earth Resources, Colorado State University, Fort Collins, CO
- ***Ecologist*** (1994-1995), Sequoia-Kings Canyon Field Station, National Biological Service, Three Rivers, CA
  - fire/forest ecology and dendrochronology research on Sierra Nevada forest communities
- ***Consultant*** (1987-1991), Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ
  - plant demography research on Sonoran Desert annuals at Desert Laboratory, Tumamoc Hill
- ***Research Specialist*** (1987-1994), Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ
  - dendrochronology, dendroecology/climatology, and fire history research on southwestern forests and giant sequoias
- ***Research Assistant*** (1984-1986), School or Renewable Natural Resources, University of Arizona, Tucson, AZ
  - fire effects and fire ecology research Madrean oak woodlands, southeastern Arizona.
- ***Biological Technician*** (1982), Resources Management, Denali National Park and NPS Alaska Regional Office, AK
  - fire ecology, fire effects/fire monitoring, and fire history of boreal forest and tundra ecosystems
- ***Biological Technician*** (1980-1982), South Florida Research Center, Everglades National Park, FL
  - fire ecology research (vegetation, small mammals, birds, and hydrology) of wet prairie and south Florida pinelands
- ***Biological Aid*** (1975-1979, seasonally), Research Office, Yellowstone National Park, WY
  - vegetation mapping, plant/fire ecology, and fire effects/fire monitoring of montane forest and grassland ecosystems

## SELECTED PUBLICATIONS

Hilimire, K., J.C.B. Nesmith, A.C. Caprio, and R. Milne. 2013 Attributes of Windthrown Trees in a Sierra Nevada Mixed-Conifer Forest. WEST.J. APPL. FOR. 28: 85-88.
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Caprio, A.C., C. Conover, M. Keifer, and P. Lineback. 2003. Fire management and GIS: a framework for identifying and prioritizing fire planning needs. Association for Fire Ecology Misc. Publ. No. 1:102-113.
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Caprio, A.C. and T.W. Swetnam. 1995. Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California. In: USDA, For. Serv. Gen. Tech. Rep. INT-GTR-320. pp. 389-398.
Caprio, A.C. and M..J. Zwolinski. 1995. Fire and vegetation in a Madrean oak woodland, Santa Catalina Mountains, southeastern Arizona. USDA, For. Serv. Gen. Tech. Rep. RM-GTR-264. pp. 389-398.
Caprio, A.C. 1994. Long tree-ring chronologies from foxtail pine in the southern Sierra Nevada, California. In: D. Meko, E. Cook, K. Briffa, and D. Graybill. *Extraction of Climate and Other Environmental Signals from Millennial-Aged Tree-Ring Chronologies.* Report to National Science Foundation on the Dec. 1-3, 1993 Long Chronology Workshop, University of Arizona, Tucson, Arizona. 60 pp.
Venable, D.L., C. Pake, and A.C. Caprio. 1993 . Diversity and coexistence of Sonoran Desert winter annuals. Plant Species Biology 8:207-216.
Caprio, A.C., and M.J. Zwolinski. 1992. Fire effects on two oak species, ***Quercus emoryi*** and ***Q. oblongifolia***, in southeastern Arizona. pp. 150-154. USDA For. Serv., Gen. Tech. Rep. RM-GTR-218, 224 pp.
Brown, P.M., M.K. Hughes, C.H. Baisan, T.W. Swetnam, and A.C. Caprio. 1992. Giant sequoia ring-width chronologies from the central Sierra Nevada, California. Tree-Ring Bulletin 52:1-14.
Caprio, A.C. and D.L. Taylor. 1984. Effects of frost on a subtropical Muhlenbergia prairie in south Florida. Flor. Sci. 47:27-32.

## OTHER PROFESSIONAL ACTIVITIES

***Professional Organizations:*** Ecological Society of America, Tree-Ring Society, Association for Fire Ecology.
***Reviewer:*** *Radiocarbon, Intl. J. Wildl. Fire*, *Tree-Ring Res.*, *Fire Ecol.*, Joint Fire Sci. Prog., *Can. J. For. Res., For. Ecol. Mgmt.*
***Current Grants/Collaboration:*** **(1)** Were Giant Sequoias Trees Impacted Differently by the Rough Wildfire in Areas Treated by Prescribed Burns Versus Areas That Were Untreated? (NPS,); **(2)** Fire and Lodgepole Pine in Southern Sierra Nevada Parks (NPS/RMTRR)