

Final Report for the Joint Fire Sciences Program

Project # 01-3-2-02

Tree Regeneration Response to Fire Restoration in Mixed-Conifer Forests

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Principal Investigator:

Andrew N. Gray
USDA Forest Service PNW Research Station
3200 SW Jefferson Way
Corvallis, OR 97333
agray01@fs.fed.us

Cooperators:

Harold S.J. Zald
USDA Forest Service PNW Research Station
3200 SW Jefferson Way
Corvallis, OR 97333

Malcolm North
USDA Forest Service PSW Research Station
2121 2nd Ave., Suite A-101
Davis, CA 95616

Ruth A. Kern
Department of Biology
California State University at Fresno
Fresno, CA 93740

Executive Summary

Forest managers in the Sierra Nevada have been applying a variety of prescribed fire and mechanical thinning prescriptions in mixed conifer forests to meet different objectives. Some of these objective includes reducing fuel amounts, changing fuel vertical structure, restoring pre-settlement composition and structure, and maintaining late-successional wildlife habitat. The character and severity of prescribed fire and thinning treatments varies with the mix of objectives. Given the expense of implementing prescribed burns, and the difficulty in meeting regional air-quality restrictions, managers want to know to what extent mechanical thinning can replace the need for burning to reduce fuels and risk of catastrophic wildfire. We established a series of complementary experimental and survey studies in a long-term factorial experiment to determine the effect of burning and thinning intensity on understory tree survival and growth in order to estimate future impacts on stand composition and fuel structure. Measurements of soil moisture, light, ground cover, and shrub density were related to the tree responses.

Several important findings have resulted from this study:

1. Traditional cool-season burning treatments do not greatly reduce understory tree density, but do accomplish greater mortality, particularly of incense-cedar, than mechanical damage from thinning alone.
2. Moderate-severity thinning treatments designed to maintain late-successional forest habitat promote high densities of shade-tolerant white fir and incense-cedar seedlings and relatively few Jeffrey and sugar pine seedlings.
3. High-severity shelterwood/seed-tree treatments designed to promote new stand establishment tend to result in fewer seedlings, with more representation by pines, but can also stimulate vigorous shrub growth.
4. Multiple management entries over time, or re-establishment of frequent understory fire, may be necessary in treated stands to preclude development of dense ladder fuels.
5. It may be difficult to design treatments that maintain late-successional habitat and reduce understory tree density at the same locations in the short term. Treatments that combine selected attributes of the prescribed fire, moderate-severity, and high-severity treatments may be successful at reducing understory live fuels and moving stands towards pre-settlement structure and composition.

Project objectives and deliverables

The overall objective of this study was to determine local biological and physical effects of alternative fuel treatments. Specific objectives included:

1. Determine the effects of alternative fire re-introduction and fire surrogate techniques on understory tree mortality and regeneration in order to understand treatment

effectiveness at reducing live understory fuels, and potential future development of understory fuels.

2. Determine the response of soil moisture to treatments, and the importance of soil moisture and depth in understanding forest structure and tree establishment response to treatments.
3. Engage in technology transfer with local managers to discuss findings in relation to treatment effects and potential future management approaches.

The project objectives were achieved without modification, although the products and deliverables were compiled and produced somewhat differently than originally envisioned. The project got a bit of a late start as a result of delays in hiring a research assistant, but this, in combination with some additional support from the PNW Research Station, allowed us to collect an additional season of field data and complete our intended analyses. The establishment of the factorial treatments of burning and thinning severity, and sharing of data and experimental designs with other principal investigators on the Teakettle Experiment (JFSP Project # 01-3-1-05) were instrumental in accomplishing our goals.

Several presentations (led by Gray or Zald) and two publications (Gray et al. 2005, Zald et al. *submitted*) contain the principal results of the project, examining pre-treatment and post-treatment patterns of tree regeneration in relation to stand structure and microsite environments. Instead of a stand-alone paper on soil moisture responses to treatments (as originally envisioned), those results have been melded with the regeneration papers and presentations, and used in several additional papers co-authored with Teakettle collaborators (presentations and papers led by North and Innes).

Citations for these products are provided below. Those marked with an asterisk are including in the enclosed CD. Products and additional links for information are also provided on the website: <http://teakettle.ucdavis.edu/>.

I originally envisioned a presentation and General Technical Report summarizing study results and management implications. Instead, I have met with several individuals from the Sierra National Forest at the Teakettle site to discuss results, and have provided interviews and demonstrations in support of a film and interactive DVD designed to share Teakettle results with a broader audience (JFSP Project # 05-4-1-10). In addition, Malcolm North and I will be collaborating on a paper synthesizing the management implications of the various Teakettle studies, for possible publication in *Journal of Forestry*. Resulting from our discussions with local managers, we are also greatly interested in taking promising results of the current study to collaboratively develop a new fuel-reduction/forest-restoration prescription as a demonstration project in the area.

Publications

- * Gray, Andrew N., Harold S. J. Zald, Ruth A. Kern, and Malcolm North. 2005. Stand conditions associated with tree regeneration in Sierran mixed-conifer forests. *Forest Science* 51(3): 198-210.
- North, Malcolm, Brian Oakley, Rob Fiegenger, Andrew Gray, and Michael Barbour. 2005. Influence of light and soil moisture on Sierran mixed-conifer understory communities. *Plant Ecology* 177:13-24.
- North, Malcolm, Jiquan Chen, Brian Oakley, Bo Song, Mark Rudnicki, Andrew Gray, and Jim Innes. 2004. Forest stand structure and pattern of old-growth western hemlock/Douglas-fir and mixed-conifer forests. *Forest Science*, 50(3): 299-311.
- North, M., B. Oakley, J. Chen, H. Erickson, A. Gray, A. Izzo, D. Johnson, S. Ma, J. Marra, M. Meyer, K. Purcell, B. Roath, T. Rambo, D. Rizzo, T. Schowalter. 2002. Vegetation and ecological characteristics of mixed-conifer and red-fir forests at the Teakettle Experimental Forest. Albany, CA: USDA Forest Service General Technical Report, PSW-GTR-183.
- * Zald, Harold S.J., Andrew N. Gray, Ruth A. Kern, and Malcolm North. *submitted*. Fuel Reduction and Forest Restoration Effects on Tree Regeneration in a Sierran Mixed Conifer Forest. *to Canadian Journal of Forest Research*.

Presentations

- Gray, Andrew, Harold Zald, and Malcolm North. 2002. Soil Moisture and Tree Sapling Distributions in a Mature Mixed-Conifer Forest. Poster presentation at the Sierra Nevada Science Symposium 2002: Science for Management and Conservation in North Lake Tahoe, CA, October 8-11, 2002.
- Innes, James C., Malcolm P. North, Andrew Gray, and Harold Zald. 2003. Effect of local topography and disturbance on snag and log distribution in an old-growth Sierra- Nevada mixed-conifer forest. Poster presented at the 4th North American Forest Ecology Workshop: Ecosystems in Transition, Corvallis, OR, June 17-19, 2003.
- North, Malcolm, Brian Oakley, and Andrew Gray. 2003. Influence of light and soil moisture on the Sierran mixed-conifer understory community. Poster presented at the 4th North American Forest Ecology Workshop: Ecosystems in Transition, Corvallis, OR, June 17-19, 2003.
- North, Malcolm, Brian Oakley, Jiquan Chen, Heather Erickson, Andrew Gray, Antonio Izzo, Dale Johnson, Siyan Ma, Jim Marra, Marc Meyer, Brent Roath, Tom Rambo, Dave Rizzo, Tim Schowalter, and Tom Smith. 2002. The Teakettle Experiment. Poster presentation at the Sierra Nevada Science Symposium 2002: Science for Management and Conservation in North Lake Tahoe, CA, October 8-11, 2002.
- North, Malcolm, Brian Oakley, Rob Figener, Andrew Gray, and Michael Barbour. 2002. Influence of Light and Soil Moisture on Sierra Mixed-Conifer Understory

Community. Poster presentation at the Sierra Nevada Science Symposium 2002: Science for Management and Conservation in North Lake Tahoe, CA, October 8-11, 2002.

* Zald, Harold, Andrew Gray, and Malcolm North. 2005. Tree regeneration response to prescribed fire, thinning, and microsites in a sierran mixed conifer forest. Poster presented at the meeting of the Northwest Scientific Association, March 24-25, 2005, Corvallis, OR.

Zald, Harold S. and Andrew N. Gray. 2004. Tree regeneration strategies in response to burning and thinning restoration treatments in Sierran mixed-conifer forest. Talk presented at the 89th annual meeting of the Ecological Society of America, Aug 2, 2004.