Final Report, Joint Fire Science Program Project 03-1-4-11

Project Title: Effects of grass seeding and salvage logging on fuel loads, potential fire behavior, and biological diversity of severely burned low elevation southern Oregon forests

Project Location: Siskiyou National Forest, southwestern Oregon

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This final report summarizes findings to date. Deliverables, accomplishments, and expected additional products are summarized in the cross-walk table following the summary of findings.

SUMMARY OF FINDINGS TO DATE

We studied how post fire salvage logging and seeding affected fuel loads and the potential for reburns and potential fire behavior with fire/fuels modeling.

Salvage logging effects:

- Field data collection was completed on a set of four fires dating from 1987 to 2002--Galice, Longwood, Silver, Biscuit. Sampled fires provide convenient combinations of burn with and without salvage at two different time scales (chronosequence approach), and reburn with and without salvage of initial fire (advantage of measuring salvage effects on reburn empirically rather than only modeling it). Information gained by these comparisons will provide insight into important questions on postfire ecology and management, including fuels, fire and vegetation treatments.

- Initial effects of salvage on fuel loads two and three years after the 2002 fire and the potential for reburns (Donato et al. 2006 *Science*) showed that:
    - Salvage logging can produce large quantities of fine and coarse slash fuel from unmerchantable materials—equal to

[fine] or 3.5 times [coarse] that present in mature forests on comparable sites. Inherent felling/handling/grading practices result in levels that may decouple with prescribed levels.
    - Relative to unsalvaged burn areas, this slash may result in higher fire potentials in the event of reburn over short time scales (e.g. several years); effects over longer time scales due to removal of larger material warrant further study.
    - These results are consistent with those of other ongoing studies on these and other fires (Thompson et al. 2007; McIver and Ottmar 2007); together these studies are substantially broadening and deepening our understanding of postfire fuels management.

- An in-depth analysis of changes in fuel loads with stand-replacement fire, subsequent salvage logging, and 17-18 years of succession is ongoing (including fire modeling component). We expect these analyses to address some of the most important knowledge gaps regarding post-fire fuel dynamics.

- To assess effects of salvage on reburn empirically, it is essential to first quantify effects of reburns in unmanaged areas compared to those of a single fire, to provide baseline information currently lacking in the scientific literature. To this end, we analyzed fire effects on forest vegetation structure/composition in the Silver-Biscuit reburn, a double stand-replacement event with a 15-year interval.
    - A unique vegetation community was observed following the reburn compared to that following a single fire. The uniqueness of the reburn community was driven by additions or increases in several disturbance-adapted species co-occurring with the set of species occurring in mature forests and after a single fire. This resulted in higher species richness and greater total plant cover 2 years after the reburn relative to single burn areas.
    - Regeneration of major structural components—conifers and hardwoods—was similar to that following a single fire (with slightly lower initial hardwood sprouting response), suggesting that the reburn retained the potential to develop toward late-successional forest condition.

Grass seeding:

- Field data collection has been completed for grass seeding on a set of 18 study plots on the Biscuit Fire. The paucity of seeding operations at large enough spatial scales, or at cover levels greater than 15%, limited availability for fire behavior analysis. Analysis is instead focused on fine-scale effects on plant communities (see below).

We measured the effects of salvage logging and seeding on plant species composition, forest succession, and forest development.

Salvage logging:

- Field data collection was completed on a set of four fires dating from 1987 to 2002--Galice, Longwood, Silver, Biscuit. Sampled fires provide convenient combinations of burn with and without salvage at two different time scales (chronosequence approach), and reburn with and without salvage of initial fire (advantage of measuring salvage effects on reburn empirically).

- Two and three years after the 2002 fire, the initial effects of salvage on postfire conifer regeneration showed that (Donato et al. 2006 *Science*) salvage can reduce early conifer regeneration densities. The implications of this reduction to forest succession/development depend on several factors including subsequent planting, survival, and species composition. Although logging-induced reductions in seedling densities are fairly intuitive from a mechanistic standpoint, in this particular case it was somewhat unexpected since it was on an extremely large fire in which natural regeneration was not anticipated to occur in most areas.

- The above result garnered broad public and scientific attention to postfire conifer regeneration on landscape-scale wildfires, which prompted agreement between JFSP and this project to extend sampling of conifer regeneration on the Biscuit Fire to 2006 (four years post-fire). A review of fire-regeneration literature made it clearer still that the conifer component of our dataset was of high importance: There have only been two other studies of conifer regeneration following landscape fires in temperate forests of North America—the 1988 Yellowstone Fires (Turner et al. 1994, 1999) and the 1933 Tillamook Burn (Isaac and Meagher 1936). We took advantage of a rare opportunity to add

to the body of knowledge on early patterns of regeneration in a fire >100,000 hectares. Research questions and pertinent data are:

- What are overall trends and variability in densities and distribution of regeneration, and how do these compare to stem densities in mature forests? We are applying spatial statistics, frequency (stocking) quantification, and nested sampling designs to assess patterns at multiple scales.
- In what year(s) following the fire did regeneration establish? We are applying age structure analysis based on annual whorl counts to answer this question, which will be important knowledge for land managers faced with identifying planting priorities, limited resources to conduct stocking surveys, and uncertainties as to when natural regeneration might be expected to occur.
- What are early patterns of survival four years after the fire? Multiple years of data will provide insight to this question.
- Across a large mixed-severity fire, what is landscape level availability of seed sources for stand-replacement patches? We are analyzing agency vegetation and fire GIS data to quantify the proportions of the landscape that are at various distances from surviving trees that might provide a seed source.
- How do regeneration levels on the Biscuit compare to those on older fires in the area? Is the Biscuit unique in time and space or is it a larger version of small fires? We have data collected in 2004 and 2005 on two 1987 fires (17-18 years postfire) to assess this question.
- What are the strongest environmental correlates with seedling density and growth? Are top-down (seed availability) or bottom-up (site factors) more important? We are applying model selection tools, correlations, and confidence interval comparisons to explore this question. Examples of environmental correlates are substrate cover (litter, soil, rock, etc.), soil type, prefire stand composition, forb/shrub cover and canopy volume, distance to nearest green edge, topographical variables such as elevation and aspect, etc.
- We also have a unique angle due to our multi-disciplinary project: We have small mammal abundance data on a subset of plots. We can assess whether small mammals are associated with reduced seedling densities, or greater rates of seedling damage, due to herbivory.

- Salvage effects on structure of whole vegetation community, both short- and longer-term, is ongoing (including empirical data and FVS modeling; see Table below).

Grass seeding:

- Field data collection has been completed for grass seeding, on the Biscuit Fire. Because of the paucity of seeding operations at large spatial scales, or with any regularity/replication, we necessarily resorted to sampling seeded areas opportunistically in conjunction with the salvage portion of the study. Eighteen plots had at least one subplot with seeded grass or mulch.

- While grass seeding effects have been studied much more extensively than salvage logging, there are two novelties in our dataset. 1) Oat grass/mulch was seeded on this fire, whereas most previous papers have looked at annual ryegrass [the former species is hypothesized to be less competitive], and 2) Our observations cover two growing seasons after the fire/seeding event, while most studies have focused on the first year; thus we can ask whether sites in which grass persisted into the second growing season appear to be having a lingering effect. In a review of grass-seeding studies, Robichaud et al. (2000) identified these two points as needed directions for future research.

- We are using a linear mixed effects model to assess the effects of grass seeding on native forb/shrub richness and cover. Preliminary results are that the variability in the responses is quite high and exceeds any signal of grass seeding effects. The one exception is species richness, for which there is a statistically significant but biologically minor reduction in species richness with increasing grass/mulch cover.

- Levels of grass/mulch cover on the Biscuit Fire typically did not exceed 15% in 2004; such low levels may have limited effect on erosion control (Robichaud et al. 2000). This is pertinent because if grass/mulch cover were high enough to substantially curtail erosion, effects on native vegetation may be greater than we observed (e.g. threshold effects).

We measured effects of salvage logging on vertebrate species composition for the short term (1-3 years following fire) as well as the longer term (4-18 years following fire).

- We detected minimal effects of salvage logging on small mammal abundance and richness, but Peromyscus (deer mice) responded positively and strongly to recent fires. Numbers declined with time after fire. Overall richness of small mammals was highest in older burns and unburned forest.
- Bird community composition shifted conspicuously with time since fire as well as after repeat burns. Fire shifted bird communities to a composition dominated by early seral species, which persisted, in part, for up to 17 years after fire (the maximum time we were able to document). However, as time since fire advanced, shrubs dominated the recovering vegetation community and birds attracted to shrubby landscapes increased. Species richness was similar across sites spanning the chronosequence, but species composition varied strongly. Responses to salvage logging will be included in Fontaine's thesis in late 2007.
- Responses of amphibians to salvage and fire were unclear because too few animals were detected. We used sampling of amphibians as an educational tool by introducing OSU undergraduates to fire science (see table below). Students read literature on amphibians, designed and carried out sampling in the Biscuit Fire, analyzed data, and presented information to their peers and faculty at OSU.
- No reptile data were gathered because too few organisms were detected in the study sites.
- Too few sites were treated with grass seeding to allow investigation of vertebrate responses to that treatment. Where grass seeding did occur, the area affected was too small to allow meaningful measurement of vertebrate responses.

DELIVERABLES

Proposed	*Accomplished/Status*
Annual progress reports	Annual progress reports completed
Determine how post fire salvage logging and seeding affects fuel loads and the potential for reburns, and potential	Fuel load and salvage data were published: Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2006. Post-wildfire logging hinders regeneration and increases fire risk. *Science* 311:352 plus supplementary on-line materials.

fire behavior with fire/fuels modeling.	Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2006. Response to comments on "Post-wildfire logging hinders regeneration and increases fire risk." *Science* 313:615c including supplementary on-line materials. Grass seeding data and fire behavior models will be published separately. The grass seeding information (see below) will be submitted for publication by Feb, 2008. The fire behavior models will be included in graduate student Donato's thesis, which will be finished in Mar, 2008. A manuscript currently in review contains data addressing ecological effects of repeated fire, which provides important context for our forthcoming assessment of salvage effects on reburn: Donato, D.C., J.B. Fontaine, W. D. Robinson, J.B. Kauffman, B.E. Law. In review. Early response of forest vegetationto repeated high-severity fire in the Klamath-Siskiyou mountains, Oregon, USA.
Measure the effects of salvage logging and seeding on plant species composition, forest succession, and forest development.	Salvage effects on forest regeneration were published: Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2006. Post-wildfire logging hinders regeneration and increases fire risk. *Science* 311:352 plus supplementary on-line materials. Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2006. Response to comments on "Post-wildfire logging hinders regeneration and increases fire risk." *Science* 313:615c including supplementary on-line materials. Additional data, including patterns from longer term data, will be included in Donato's thesis in Mar, 2008.
Measure effects of salvage logging and seeding on vertebrate species composition for the short term (1-3 years	A manuscript currently in review contains data on bird community response to fire: Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, J.B. Kauffman. In review. Avian communities at short and intermediate time scales following high severity fire and

following fire) as well as the longer term (4-18 years following fire).	reburn in the Klamath-Siskiyou Mountains, Oregon, USA. Data on bird responses to salvage will be included in graduate student Fontaine's thesis in Dec, 2007. Too few plots were seeded (see summary above) to allow robust investigation of effects on vertebrates. Effects of salvage on small mammals are included in a manuscript to be submitted in Oct, 2007. Amphibians were studied as part of the OSU course on Vertebrate Responses to Fire (see below). Sampling limitations (too few animals encountered) caused us to focus on mammals and birds and shift effort away from amphibians and reptiles.
Produce two graduate dissertations	Doctoral student Joe Fontaine will defend his thesis by Dec, 2007, and Dan Donato will defend his thesis by Mar, 2008.
Present study results at scientific meetings and to the public	We have given 19 presentations so far: Donato, D.C., J.B. Fontaine, B.E. Law, W.D. Robinson, J.B. Kauffman. Early response of forest vegetation to a reburn in the Siskiyou mountains, Oregon, USA. Annual meeting of the Ecological Society of America. August 2007. Fontaine, J.B., D.C. Donato, B.E. Law, J.B. Kauffman, W.D. Robinson. Bird community structure following multiple high severity fires and post-fire logging in the Klamath-Siskiyou region. Annual meeting of the Ecological Society of America. August 2007. Donato, D.C., J.B. Fontaine, B.E. Law, D.W. Robinson, J.B. Kauffman. Early response of forest vegetation to a reburn in the Siskiyou mountains, Oregon, USA. North American Forest Ecology Workshop. June 2007. Fontaine, J.B., D.C. Donato, W.D.

	Robinson, B.E. Law, J.B. Kauffman. Small mammals following severe fire, reburn, and salvage logging in the Siskiyou mountains, Oregon, USA. North American Forest Ecology Workshop. June 2007. Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, J.B. Kauffman. Avian community change following high severity fire in southwestern Oregon. Oregon State University workshop on post-fire ecology. March 2007. Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, J.B. Kauffman. Wildlife and vegetation community response to disturbance in southwestern Oregon. Annual Fire Ecology Research and Management workshop, Rogue-Siskiyou National Forest, Gold Beach, OR. February 2007. Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, J.B. Kauffman. Birds, fire, and salvage logging in southwestern Oregon. AVES research group meeting. Corvallis, OR. November, 2006. Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, J.B. Kauffman. Changes in avian communities following high severity fire and salvage logging in southwestern Oregon. Partners in Flight Western Working Group Conference, Corvallis, OR. November, 2006. Fontaine, J.B. and D.C. Donato. Birds and the Biscuit Fire: How do birds respond to fire? Annual convention of the Oregon Field Ornithologists, Gold Beach, OR. May, 2006. Donato, D.C., J.B. Fontaine, J.L. Campbell,

	B.E. Law. Invited presentation: Early influences of salvage logging after the Biscuit Fire. State University of New York, Environmental Science & Forestry Program (SUNY-ESF), Annual Shifting Paradigms/Standing on the Shoulders of Giants Symposium, Syracuse, NY. April 2006. Donato, D.C., J.B. Fontaine, B.E. Law, D.W. Robinson, J.B. Kauffman. Invited presentation: Vegetation and fuels following the Biscuit Fire and post-fire logging. National Commission on Science for Sustainable Forestry (NCSSF), Forest Disturbance, Management and Biodiversity Workshop, Denver, CO. April 2006. Donato, D.C., J.B. Fontaine, J.L. Campbell, W.D. Robinson, J.B. Kauffman, B.E. Law. Oral & written testimony: Research on post-fire intervention. United States Congressional Oversight Hearing: Scientific Research and the Knowledge-base concerning Forest Management Following Wildfires and Other Major Disturbances. Medford, OR. February 2006. Fontaine, J.B., D.C. Donato, W.D. Robinson. Changes in small mammal communities following high severity fire and postfire management in southwestern Oregon. The Wildlife Society, Annual Conference, Newport, OR. February, 2006. Fontaine, J.B., D.C. Donato, W.D. Robinson, J.B. Kauffman, B.E. Law. Response of small mammal communities to high severity fire and salvage logging in southwestern Oregon. Annual Fire Ecology Research and Management

	workshop, Rogue-Siskiyou National Forest, Gold Beach, OR. February 2006. Donato, D.C., J.B. Fontaine, W.D. Robinson, J.B. Kauffman, B.E. Law. Conifer regeneration and fuel loads following the Biscuit Fire and post-fire logging. Annual Fire Ecology Research and Management workshop, Rogue-Siskiyou National Forest, Gold Beach, OR. February 2006. Donato, D.C., J.B. Fontaine, J.L. Campbell, W.D. Robinson, J.B. Kauffman, B.E. Law. Post-wildfire logging hinders regeneration and increases fire risk. Special Seminar, College of Forestry, Oregon State University, Corvallis, OR. January, 2006. Law, B.E. It's not just about carbon. College of Forestry Dept of Forest Science Seminar Series, Oregon State University, Corvallis, OR. November, 2005. Donato, D.C., J.B. Fontaine, W.D. Robinson, J.B. Kauffman, B.E. Law. Salvage Logging & Post-fire Dynamics of Fuel Profiles, Wildlife and Vegetation Communities on the Biscuit Fire, SW Oregon. USDA/USDI Joint Fire Science Program Annual PI Workshop, San Diego, CA. November 2005. Fontaine, J.B. and D.C. Donato. Avian responses to fire in mixed conifer forests of Southwestern Oregon. Partners In Flight Western Working Group Conference, Ashland, OR. April 2005.
Offer field tours of study sites and technology transfer to managers	We offered and/or participated in 3 field tours and in 2 management workshops

	June 2006. Joint Fire Sciences Program/BLM. Project Inspection. Toured study sites on the Biscuit fire and conveyed project objectives and status. August 2006. Rogue River-Siskiyou National Forest. Toured Biscuit fire, shared results, information needs, and means of effective communication between research scientists and management agency. September 2006. Joint Fire Science Program Board, Rogue River-Siskiyou National Forest, Medford BLM, USFS Pacific Northwest Research Station. Post-fire regeneration tour of Biscuit and Longwood fires. Focus on recent science addressing post-fire conifer regeneration and its application to post-fire management. February 2007. Annual Research and Management Workshop. Two day meeting with Rogue River-Siskiyou National Forest, Medford BLM, Coos Bay BLM, Roseburg BLM, and Umpqua National Forest to share science and its application to on-the-ground management in southwestern Oregon. Gold Beach, OR. February 2006. Annual Research and Management Workshop. Two day meeting with Rogue River-Siskiyou National Forest, Medford BLM, Coos Bay BLM, Roseburg BLM, and Umpqua National Forest to share science and its application to on-the-ground management in southwestern Oregon. Gold Beach, OR.
Publish results in peer-reviewed journals	We have two publications in print, two in review, and several others to be submitted

	in the next 8-12 months as student theses are completed. In print: Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2006. Post-wildfire logging hinders regeneration and increases fire risk. *Science* 311:352 plus supplementary on-line materials. Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2006. Response to comments on "Post-wildfire logging hinders regeneration and increases fire risk." *Science* 313:615c including supplementary on-line materials. In review: Donato, D.C., J.B. Fontaine, W. D. Robinson, J.B. Kauffman, B.E. Law. In review. Early response of forest vegetationto repeated high-severity fire in the Klamath-Siskiyou mountains, Oregon, USA. Fontaine, J.B., D.C. Donato, W.D. Robinson, B.E. Law, J.B. Kauffman. In review. Avian communities at short and intermediate time scales following high severity fire and reburn in the Klamath-Siskiyou Mountains, Oregon, USA.
Communicate results in classroom settings at the university level	We designed a special senior-level group problem solving class (Vertebrate Responses to Fire) at Oregon State University and offered it for 3 quarters in 2004-2005. Ten students participated. Our study was also discussed in several other classes on campus after publication of the Science paper. Two undergraduate interns served as field technicians for the project in 2004 and 2005. Interns received extensive training in forest mensuration and wildlife survey methods.
Communicate results by web site	Project information is at: http://wwwdata.forestry.oregonstate.edu/terra/biscuit.htm

	We will continue to update the site as data are analyzed and published.

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