FINAL REPORT – SUPPLEMENT TO THE FIRE AND FIRE SURROGATE STUDY: INTERDISCIPLINARY AND MULTI-SITE ANALYSIS

A Project Funded By The Joint Fire Sciences Program (JFSP)

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Introduction

The national Fire and Fire Surrogate Study (FFS) was designed to develop and provide managers with better information on the consequences of alternative fuel reduction treatments in forest ecosystems. The study was initiated in early March 2000 with support by the USDA/USDI Joint Fire Science Program, and is a series of experiments that evaluate the consequences of prescribed fire and fuel reduction surrogates (cutting and mechanical treatments) for fuel reduction and forest restoration. The FFS study includes 13 separate sites nationwide (11 funded by the JFSP, 2 by the National Fire Plan, and 1 started with funding from the USDA NRI program) (fig. 1). All sites have a nearly identical study design, featuring at least three replications of four treatments: unmanipulated control, prescribed fire, thinning or some mechanical fuel treatment, and the combination of thin + fire. A total of 82 key variables was measured both pre- and post-treatment within large plots (~10 ha) at each of these sites in an effort to capture an interdisciplinary whole system response to treatment. At each FFS study site, stand structure and the fuel bed were measured to understand how treatments influenced prospective fire behavior. Biological, chemical, and physical components of the soil and forest floor were measured to understand how fuel reduction affected site productivity. Tree-killing bark beetles and disease were monitored to better understand the relationship between treatments and other disturbance agents. Whole unit and plot censuses of plant species and passerine birds were conducted to assess the impact of fuel reduction treatments on variables of value to society. The FFS study is thus a novel, highly organized, closely integrated multivariate, multi-site experiment. The multivariate information from this experiment provides managers better assess to knowledge of how fuel reduction treatments influence whole systems, leading to better understanding of the tradeoffs inherent in their decisions. The multi-site nature of the experiment allows identification of patterns of response, and will allow managers to understand how site-specific conditions influence response to treatment. The information from this study adds greatly to the body of knowledge about how fuel reduction and restoration management affect forests nationwide. A full Final Report listing outputs and products, and describing findings from single-disciplinary, multi-disciplinary, single site, and multi-site studies was submitted JFSP at the end of the first funding period in May 2006. In this Final Report, additional effort in multi-disciplinary and multi-site findings is emphasized.

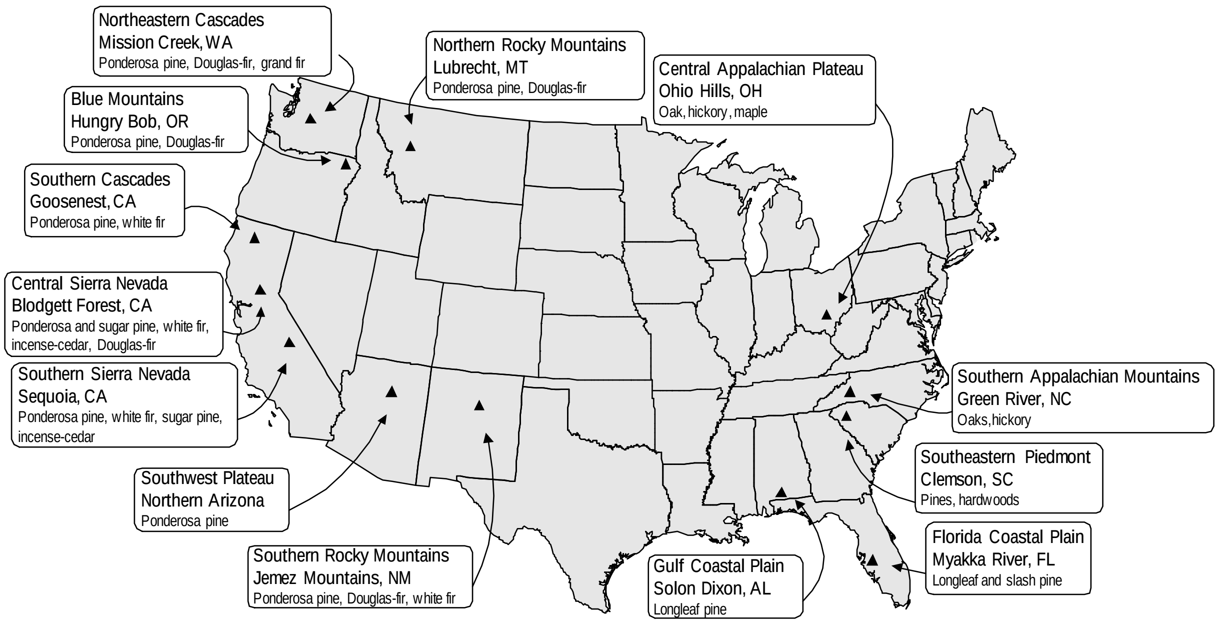

Figure 1 - Distribution of Fire and Fire Surrogate (FFS) study sites and associated tree species.

Project Overview

In an earlier report, the types of products provided by the FFS study were discussed. These include site-level/ single-discipline, site-level interdisciplinary, network-level single discipline, and network-level interdisciplinary products. Site-level, single-discipline products are the easiest to produce and usually involve no more than a few scientists. At the site level, since experimental units are replicated and treatments assigned randomly, and the analyses generally have featured models using analysis of variance and regression techniques. The FFS study already has generate dozens of these kinds of products, and the information contained in them has added greatly to a knowledge base useful to managers near the FFS study site. At the site level, interaction among scientists working in different disciplines was facilitated by a highly integrated experimental design, in which all variables were measured in relation to a common grid point system within each experimental unit. By design, each FFS study site was a multivariate experiment, and with funding under this JFSP project efforts to capture whole-system responses to fire and fire surrogate treatments were expanded. The interactive collaboration among FFS scientists and partners essential for interdisciplinary, multivariate analyses that better describe whole system responds to fire and fire surrogate treatments were emphasized. This design has great value from a management perspective, because the information we generated allows managers to assess tradeoffs in response to treatment for different key variables. Resulting products provide a better understand not only how multiple components of the system respond, but also how relationships among components change when treatments are applied. At the network level, the Science Management and Integration committee (SMIC) emphasized creation and completion of the national database containing multi-year response variable data from all FFS study sites, providing an opportunity to conduct among-site analyses. The FFS study has three design features that make it uniquely suitable for network-wide meta-analytic techniques: 1) each of the 13 sites can be regarded as a separate study; 2) each site has a robust 'stand-alone' experiment design; and 3) experimental designs are categorically identical among sites. With meta-analysis, one can ask not only to what extent does forest type influence key response variables given different fuel reduction treatments, but also how a number of other variables affect this response. Information on 'conditional' response to treatment will allow managers to better predict how a given treatment will perform given their unique set of circumstances.

Deliverables
Two major objectives were identified for this portion of the overall FFS study:

1. Accomplish site-level interdisciplinary analyses.
2. Accomplish among-site analyses.

Only a few changes were made to the Communications Plan submitted to the JFSP in May 2001. First, in addition to holding a symposium at a major national conference early in fiscal year 2006, SMIC intended to compile and submit a series of related papers to a national or international journal for a special issue devoted entirely to the FFS study. Second, SMIC intended to incorporate information from the FFS study into existing web and computer applications, such as FEIS (Fire Effects Information System), and FOFEM (First Order Fire Effects Model). Finally, SMIC conducted four regional workshops with selected clients to better identify effective and efficient means of communicating FFS study findings to users.

Summary of Findings

- **Vegetation dynamics after fuel reduction and forest restoration treatments in fire-adapted ecosystems represented by FFS study sites generally are subtle and often fail to achieve historical structures.**

After two fires and one mechanical treatment in the southern and central Appalachian regions, no treatment or treatment combination restored structure to historical levels. Burning alone had little initial effect on overstory composition and structure but mortality continued up to 5 years after treatment thus opening canopies. Mechanical treatments altered midstory structure temporarily but promoted abundant regeneration. These forests support woody species that are characterized by rapid sprouting and growth, compositions may include undesirable woody species, and thus similar treatments may need to be frequently repeated for successful restoration of historical forest structure. At the Ohio Hills site, changes in forest structure were observed for all treatments, but areas treated with fire showed the greatest increase in herbaceous cover and species richness. Burning represents a unique form of disturbance that is not mimicked by alterations of the forest structure alone. At the Southern Appalachian site, fire alone did not produce a response in the herbaceous layer. The combination of mechanical treatment and burning was necessary to increase cover and species richness. In the Piedmont region, sapling density and shrub and graminoid abundance increased after the thin + burn treatment while cover of grasses and forbs increased in the burn treatment. Treatments that included a burn component led to more rapid changes in understory composition compared to the thin treatment. Similarly, treatments had no effect on total plant cover and no effects on forb, grass, or shrub cover in the Northeastern Cascades region. Understory richness increased after the thin + burn treatments. Forbs were the most responsive group, with cover and species richness increasing in response to thinning. Shrub species richness increased with thinning, while grass species richness did not respond to treatments. Overall, understory plant communities were relatively insensitive to treatments, with environmental and inter-annual variability influencing composition more than treatments. This work suggests that fuel reduction treatments similar to those used as FFS study treatments are likely insufficient to cause major changes in plant community composition.

- **Eastern deciduous, coniferous, and mixed fire-adapted ecosystems represented by FFS study sites have greater C loss balanced against greater C sequestration compared to western coniferous fire-adapted ecosystems represented by FFS study sites**

The soils underlying twelve FFS study sites include six soil orders and >50 named soil series. Across this network, pre-treatment soils varied from 3.7 to 7.1 in pH, and ranged two fold in bulk density, four fold in soil organic C (SOC) content, ten fold in total inorganic N (TIN), and 200-1,000 fold in extractable Ca, K, and Al. At the network scale, mineral soil exposure was greater in burn and thin + burn treatments compared to controls during the first post-treatment year, and this effect persisted through the later sampling year (2nd-4th year, depending on site) in the burn treatment. A short-term increase in TIN concentrations occurred after active treatment. First-year net nitrification rates were greater after thin + burn treatments Bulk density, net N mineralization rates, SOC content, and soil C:N ratio were not affected by treatment. At the individual site scale, the combined thin + burn treatment produced approximately twice as many significant site-by-treatment-by-year effects than did the other treatments. NMS ordination of first year standardized effect sizes separated the five site-treatment combinations with the greatest fire intensity from the bulk of the network sites, with changes in pH, TIN, SOC content, and soil C:N ratio correlating most strongly with this separation. NMS ordination of the effect sizes from the later sampling year produced a clearer separation of treatment types than did the first-year ordination, suggesting that soil responses to these treatments continue to develop after the first year.

Total C storage across the network averaged 185 $Mgha^{-1}$ C, of which 45% was in vegetation, 38% in soil organic matter, 10% in the forest floor and 7% in dead wood. C stored in vegetation was not affected by burning, but decreased about 30 Mg ha^{-1} after thin or thin + burn treatments. In contrast, forest floor C storage declined about 7 Mg ha^{-1} after burn or thin + burn treatments, but was unaffected by thin treatments. Dead wood C and soil organic C was not affected by treatments. At the network scale, total ecosystem C was not affected by fire, yet four individual sites had C losses to fire. Thinning, with or without burning, reduced total ecosystem C by 16 to 32 $Mgha^{-1}$ during the first post-treatment year. This decline was partially balanced by enhanced net C uptake of about 12 $Mgha^{-1}$ during the subsequent 1 to 3 years.

- **Avian nest survival in fire-adapted ecosystems represented by FFS study sites is poorly related to fuel reduction and forest restoration treatments.**

Short-term response of avian nest success to FFS study fuel reduction and restoration treatments varied among major taxa. At the network level (across 11 FFS study sites), analysis focused on sparrows (Family Emberizidae), woodpeckers (Family Piciae) nuthatches (Family Sittidae), flycatchers (Family Tyrannidae), and vireos (Family Vireonidae). Total number of individual avian species within these five groups ranged from 5 at the Southern Cascades and southern Appalachian Mountains FFS study sites to 138 at the Central Sierra Nevada FFS study site. Ground-nesting sparrows had lower nest survival after fuel reduction treatments. Nest survival of other avian taxa varied across the network, and was partly related to intensity of treatments or resultant changes in key habitat characteristics. Changes toward more historical stand structure, reflected by increased quadratic mean diameter of live trees, resulted in increased nest survival for woodpeckers and flycatcher.

- **Small mammal density and biomass in fire-adapted ecosystems represented by FFS study sites are poorly related to fuel reduction and forest restoration treatments.**

Short-term patterns in small-mammal changes in density and biomass after FFS study fuel reduction and restoration treatments varied with individual species and taxa and with specific treatment. At the network level (across eight FFS study sites), analysis focused on small-mammal taxa including deer mice (*Peromyscus* species), yellow-pine chipmunks (*Tamias* species), and golden-mantled ground squirrels (*Spermophilus* species). Total small mammal biomass appeared generally to increase with any type of fuel reduction. Variability in taxa-specific response to treatments suggests that adaptive management policies may be necessary when applying fuel reduction treatments in areas where management of small mammal-populations is of interest.

- **Fuel reduction and forest restoration treatments in fire-adapted ecosystems represented by FFS study sites have direct and indirect effects that impact tree mortality.**

Complex hypotheses relating to the cascade of effects that influenced individual tree mortality were explored at the Blue Mountains FFS site using structural equation modeling (SEM). Burn and thin + burn treatments increased the proportion of dead trees while the proportion of dead trees declined or remained constant in thin and control units, although the density of dead trees was essentially unchanged with treatment. Most of the new mortality (96%) occurred within two years of treatment and was attributed to bark beetles. Bark beetle-caused tree mortality, while low overall, was greatest in thin + burn treatments. The probability of mortality of large ponderosa pine from bark beetles and wood borers was directly related to surface fire severity and bole charring, which in turn depended on fire intensity, which was greater in units where thinning increased large woody fuels.

- **Fuel reduction and restoration treatments in fire-adapted ecosystems represented by FFS study sites may be effective at reducing potential fire severity under severe fire weather conditions.**

The effects of FFS study fuel reduction and restoration treatments on fuel load profiles and potential fire behavior and severity under three weather scenarios was examined for six western FFS study sites. At the network level, this analysis for conifer-dominated study sites focused on effectiveness of treatments for reducing surface fuel loads, modifying forest structure, and reducing potential fire severity. Thinning increased the combined 1-, 10-, and 100-hour surface fuel loads and lowered the canopy cover at three of five FFS sites. Thin + burn treatments lowered canopy cover at all five FFS sites where applied, and resulted in forest structure that would likely provide lower probabilities for passive crown fire compared to other treatments, based on high torching indices. FFS study sites where the combined 1-, 10-, and 100-hour surface fuel loads increased because harvest systems left all activity fuels within experimental units, and thinning treatments were followed by burning, resulted in the greatest reduction in crown fire potential and predicted tree mortality. This treatment may be the most effective for fuel reduction because it results in low surface fuel loads and increased vertical and horizontal canopy separation. In general, the three active treatments (thin, burn, thin + burn) reduced potential fire severity under severe fire weather conditions. Using data on initial fuelbed conditions and changes immediately and four to six years after fuel reduction treatments at the Blue Mountains FFS study site, a representative fuelbed for each unit from inventoried data was constructed using the Fuel Characteristic Classification System (FCCS). Three indices of fire potential (or measures of the change in fire hazard resulting from treatments): surface fire behavior, crown fire behavior, and fuels available for consumption, suggested that fuel treatments provided little lasting fire hazard reduction.

- **Operational-scale experiments that evaluate the consequences of fire and mechanical "surrogates" for natural disturbance events are essential to better understand strategies for reducing the incidence and severity of wildfire in fire-adapted ecosystems represented by FFS study sites.**

The national FFS study was initiated in 1999 to establish an integrated network of long-term studies designed to evaluate the consequences of using fire and fire surrogate treatments for fuel reduction and forest restoration. A series of regional workshops were conducted with selected clients to identify effective and efficient means of communicating FFS study findings to users. Four over-arching questions were asked: 1) Who needs fuel reduction information? 2) What information do they need? 3) Why do they need it? 4) How can it best be delivered to them? Workshop notes, recorded transcriptions, and post-workshop summaries were examined for common themes. Participants identified key users of FFS science and technology, specific pieces of information that users most desired, and how this information might be applied to resolve fuel reduction and restoration issues. They offered recommendations for improving overall science delivery and specific ideas for improving delivery of FFS study results and information. These potential users, their information needs, and preferred science delivery processes likely have wide applicability to other fire science research.

Deliverables

Proposed	**Accomplished/Status**
Symposium at a national fire meeting	FY2007. 3rd International Fire Ecology and Management Conference, San Diego, CA, November 13-17, 2006. Track 5, Thursday, November 16, 2006 Effects on Fire and Fire Surrogate Treatment for Ecological Restoration: A National Perspective Invited oral presentations: Jim McIver, Eastern Oregon Agriculture Research Center, Union, UT: *Introduction to the national fire and fire surrogate study.* Dylan A. Schwilk and J. E. Keeley, US Geological Survey, Three Rivers, CA: *Multi-site vegetation responses to fuels treatments.* Tom Waldrop, USDA FS, Southern Research Station, Clemson, SC; Dan Yaussy, USDA FS, Northern Research Station, Delaware, OH.; Ralph Boerner, Ohio State University, Columbus, OH: *Delayed mortality of eastern hardwoods – a function of*

	fire behavior, site, or pathology? Andrew Youngblood, USDA FS Pacific Northwest Research Station, LaGrande OR; James Grace US Geological Survey, Lafayette LA; Jim McIver, Eastern Oregon Agriculture Research Center, Union, OR: *Ponderosa pine and Douglas-fir mortality after fuel reduction and restoration treatments in northeastern Oregon.* Leda Kobziar, University of Florida, Gainesville, FL; Jason Moghaddas, Plumas National Forest, Quincy, CA; Dan Stark, David Wood, Andrew Storer, and Scott L. Stephens, University of California-Berkeley, Berkeley, CA: *Tree mortality patterns following replicated prescribed fires in a mixed conifer forest.* Bruce Hartsough, University of California-Davis, Davis, CA: *Cost and productivity analysis of mechanical and burn treatments to remove biomass on FFS sites.* Sarah McCaffrey, USDA FS Northern Research Station, Evanston, IL.; Jason Moghaddas, Plumas National Forest, Quincy, CA; and Scott Stephens, University of California-Berkeley, Berkeley, CA: *Social responses to fire and fire surrogate treatments in the central Sierra Nevada, California.* Dylan W. Schwilk, US Geological Survey, Three Rivers, CA; Eric E. Knapp, USDA FS, Pacific Southwest Research Station, Redding, CA; Scott M. Ferrenberg, US Geological Survey, Three Rivers, CA; J.E. Keeley, US Geological Survey, Three Rivers, CA; Anthony C. Caprio, USDI NPS, Sequoia-Kings Canyon National Park: *Interactions of bark beetles and tree mortality in mixed conifer forests at Sequoia National Park.* John Bailey, Oregon State University, Corvallis, OR; Carl Edminster, USDA FS, Rocky Mountain Research Station, Flagstaff, AZ: *Fire and Fire Surrogate fuels treatments in ponderosa pine forests and their effectiveness across the West.* Carl Fiedler, Kerry Metlen, Tom DeLuca, Scott Mills, Diane Six, University of Montana, Missoula, MT; Michael Harrington, USDA FS, Rocky Mountain Research Station, Missoula, MT: *Multi-disciplinary effects of fire and fire surrogate treatments in ponderosa pine forests in Montana.* Scott Stephens, University of California-Berkeley, Berkeley, CA; UC Berkeley; Jason Moghaddas, Plumas National Forest, Quincy, CA; Carl Fiedler, University of Montana, Missoula, MT; Erik E. Knapp, USDA FS, Pacific Southwest Research Station, Redding, CA; Carl Skinner, USDA FS, Pacific Southwest Research Station, Redding, CA; Andrew Youngblood, USDA FS Pacific Northwest Research Station, LaGrande OR; Kerry Metlen, University of Montana, Missoula, MT: *Simulated wildfire performance of the western US fire and fire surrogate treatments.* Ralph Boerner, Ohio State University, Columbus, OH; Stephen Hart, Northern Arizona University, Flagstaff, AZ; J. Huang, Ohio State University, Columbus, OH: *Network stratification, meta-analytical methods, and soil microbial community responses.* Stephen Hart, Northern Arizona University, Flagstaff, AZ; J. Huang, Ohio State University, Columbus, OH; Ralph Boerner, Ohio State University, Columbus, OH: *Soil physical and chemical responses to fire and fire surrogate treatments.* Stephen Hart, Northern Arizona University, Flagstaff, AZ; Ralph Boerner, Ohio State University, Columbus, OH; J. Huang, Ohio State University, Columbus, OH: *Carbon and nitrogen dynamics of soils, forest floor, and woody debris following fire and fire*

	surrogate treatments. Sarah Converse, US Fish and Wildlife Service, Laurel, MD; Gary C. White, Colorado State University, Fort Collins, CO; Kerry Farris, Steve Zack, Wildlife Conservation Society Wildlife, Portland, OR: *Small mammal responses to forest fuel reduction: national-scale results from the Fire and Fire Surrogate study.* Kerry Farris, Wildlife Conservation Society Wildlife, Klamath Falls, OR; Sarah Converse, US Fish and Wildlife Service, Laurel, MD; Steve Zack, Wildlife Conservation Society Wildlife, Portland, OR; Andy J. Amacher, University of California-Berkeley, Berkeley, CA; Thomas Contreras, Washington and Jefferson College, Washington, PA; William Gaines, USDA FS, Okanogan and Wenatchee National Forests, Wenatchee, WA: *The effects of fire and fire surrogate treatments on avian nest survival.* Christopher Fettig, USDA FS, Pacific Southwest Research Station, Davis, CA: *Bark beetle responses to burning and thinning treatments of the fire and fire surrogate study, a multi-site approach*.
Regional workshops and field tours:	FY2005 September 7, 2005, at the University of Montana’s Lubrecht Experimental Forest, site of the Northern Rocky Mountains FFS study. FY2006 October 27, 2005, at the Solon Dixon Forestry and Education Center in southern Alabama, home of the Gulf Coastal Plain FFS study. FY2006 November 15, 2005, at Blodgett Experimental Forest in central California, site of the Central Sierra Nevada FFS study. FY2006 January 24-25, 2006, at Asheville, North Carolina, site of the Green River FFS study in the Southern Appalachian Mountains.
Non-refereed publication	Youngblood, Andrew; Bigler-Cole, Heidi; Fettig, Christopher J.; Fiedler, Carl; Knapp, Eric E.; Lehmkuhl, John F.; Outcalt, Kenneth W.; Skinner, Carl N.; Stephens, Scott L.; and Waldrop, Thomas A. 2007. *Making fire and fire surrogate science available: a summary of regional workshops with clients.* Gen. Tech. Rep. PNW-GTR-727. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 59 p. Summarizes the findings from the four regional workshops
Non-refereed publication	Ross Phillips, Todd Hutchinson, Lucy Brudnak, and Thomas Waldrop. 2007. Fire and fire surrogate treatments in mixed-oak forests: effects on herbaceous layer vegetation. In: Butler, Bret W., and Cook, Wayne, comps. 2007. The fire environment—innovations, management, and policy; conference proceedings. 26-30 March 2007; Destin, FL. Proceedings RMRS-P-46. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
Non-refereed publication	Moghaddas, Jason J., and Scott L. Stephens. 2007. *Fire performance in traditional silvicultural and fire and fire surrogate treatments in Sierran mixed-conifer forests: a brief summary*. Pages 251-260 In: Powers, Robert f., tech. ed. Restoring fire-adapted ecosystems: proceeds of the 2005 national silviculture workshop. Gen. Tech. Rep. PSW-GTR-203. Albany, CA: Pacific Southwest Res. Stn.
Refereed publication	Converse, Sarah J., Gary C. White, Kerry L. Farris, and Steve Zack. 2006. *Small mammals and forest fuel reduction: national-scale responses to fire and fire*

	surrogates. Ecological Applications 16: 1717-1729.
Refereed publication	Special Issue, Ecological Applications (published by the Ecological Society of America) Final list of paper to be submitted as a single package, Oct. 15, 2007: James McIver, Scott Stephens, and Andrew Youngblood. *The national fire and fire surrogate study: ecological consequences of alternative fuel reduction methods in seasonally dry forests.* (FFS contribution #151) Dylan W. Schwilk, Jon. E Keeley, Jim Agee, Chris Fettig, Carl Fiedler, Erik. Knapp, James McIver, Jason J. Moghaddas, Kenneth Outcalt, Carl Skinner, Scott L. Stephens, Danial Yaussey, and Andrew Youngblood. *Effects of fire and fire surrogate treatments on forest vegetation structure and fuels*. (FFS contribution #152) Scott L. Stephens, Jason J. Moghaddas, Carl Edminster, Sally Haas, Eric Knapp, James McIver, Kerry Metlen, Carl Skinner, Andrew Youngblood. *Fire and fire surrogate treatment effects on vegetation structure, fuels, and potential fire behavior and severity from six western United States coniferous forests.* (FFS contribution #130) Andrew Youngblood, James Grace and James McIver. *Delayed conifer mortality after fuel reduction treatments: interactive effects of fuels, fire intensity, and bark beetles*. (FFS contribution #153) Ralph E. Boerner, Jianjun Huang, and Steve C. Hart. *Impacts of fire and fire surrogate treatments on forest soil properties: a meta-analytical approach*. (FFS contribution #154) Kerry Farris, Sarah J. Converse, Steve Zack, Andy J. Amacher, Thomas Contreras, William Gaines, Eran Kilpatrick, J. Drew Lanham, Donald Miles, Douglas Robinson, Ghislain Rompré, Kathryn E. Sieving, and Jenny Woolf. *Short-term effects of fire and fire surrogate treatments on avian nest survival: a national-scale, interdisciplinary analysis*. (FFS contribution #155)
Refereed publications	Special Issue, Forest Ecology and Management (published by Elsevier). All papers are in review, with publication planned for November 2007. Final list of paper submitted as a single package, June 15, 2007: Ralph Boerner, Jianjun Huang, and Stephen Hart. *Fire, thinning, and the carbon economy: effects of FFS treatments on carbon storage and sequestration rate*. (FFS contribution #157) Jason Moghaddas, Robert A. York, and Scott L. Stephens. *Initial response of conifer and California black oak seedlings following fuel reduction activities in a Sierra Nevada mixed conifer forest*. (FFS contribution #142) Andrew J. Amacher, Reginald H. Barrett, Jason J. Moghaddas, Scott L. Stephens. *The effects of fire and mechanical fuel treatments on the abundance of small mammals in the mixed-conifer region of the Sierra Nevada*. (FFS contribution #158) Andrew Youngblood, Clinton Wright, Roger Ottmar, and James McIver. *Changes in fuelbed characteristics and resulting fire potentials after fuel reduction treatments in dry forests of the Blue Mountains, northeastern Oregon.* (FFS contribution #159)

	David A. Schmidt, Alan H. Taylor, and Carl N. Skinner. *The influence of fuels treatment and landscape arrangement on simulated fire behavior, southern Cascade Range, California*. (FFS contribution #160) Ross J. Phillips, and Thomas A Waldrop. *Changes in vegetation structure and composition in response to fuel reduction treatments in the South Carolina Piedmont*. (FFS contribution #161) S.C. Loeb, and Thomas A Waldrop. *Bat activity in relation to fire and fire surrogate treatments in southern pine stands*. (FFS contribution #133) A.L. Lyons, William L. Gaines, John F. Lehmkuhl, and Richy J. Harrod. *Short-term effects of fire and fire surrogate treatments on forage tree selection by cavity nesting birds in the dry forests of central Washington*. (FFS contribution #162) Erich K. Dodson, David W. Peterson, and Richy J. Harrod. *Understory vegetation response to thinning and burning restoration treatments in dry conifer forests of the eastern Cascades*. (FFS contribution #163) Richy J. Harrod, Nicholas A. Povak, and David W. Peterson. *Using thinning and prescribed fire to modify stand structure and restore forest health in dry coniferous forests.* (FFS contribution #164) Emily E.Y. Moghaddas, Scott L. Stephens. *Mechanized fuel treatment effects on soil compaction in mixed-conifer forest stands*. (FFS contribution #141) Thomas A. Waldrop, Daniel A. Yaussy, Ross J. Phillips, Todd A. Hutchinson, Lucy Brudnak, and Ralph E.J. Boerner. *Prescribed fire and mechanical fuel reduction treatments affect vegetation structure of hardwood Forests in western North Carolina and southern Ohio.* (FFS contribution #165)
FEIS Integration	Metlen, Kerry L.; Dodson, Erich K.; Fiedler, Carl E. 2006. Vegetation response to restoration treatments in ponderosa pine-Douglas-fir forests of western Montana. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ Full integration of results from the Northern Rocky Mountain FFS study.
Webpage	FFS website fully migrated and now hosted by the Fire Research And Management Exchange System (FRAMES) portal at http://frames.nbii.gov/portal/server.pt