USDA

United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General Technical Report
PNW-GTR-727
July 2007

Making Fire and Fire Surrogate Science Available: A Summary of Regional Workshops With Clients

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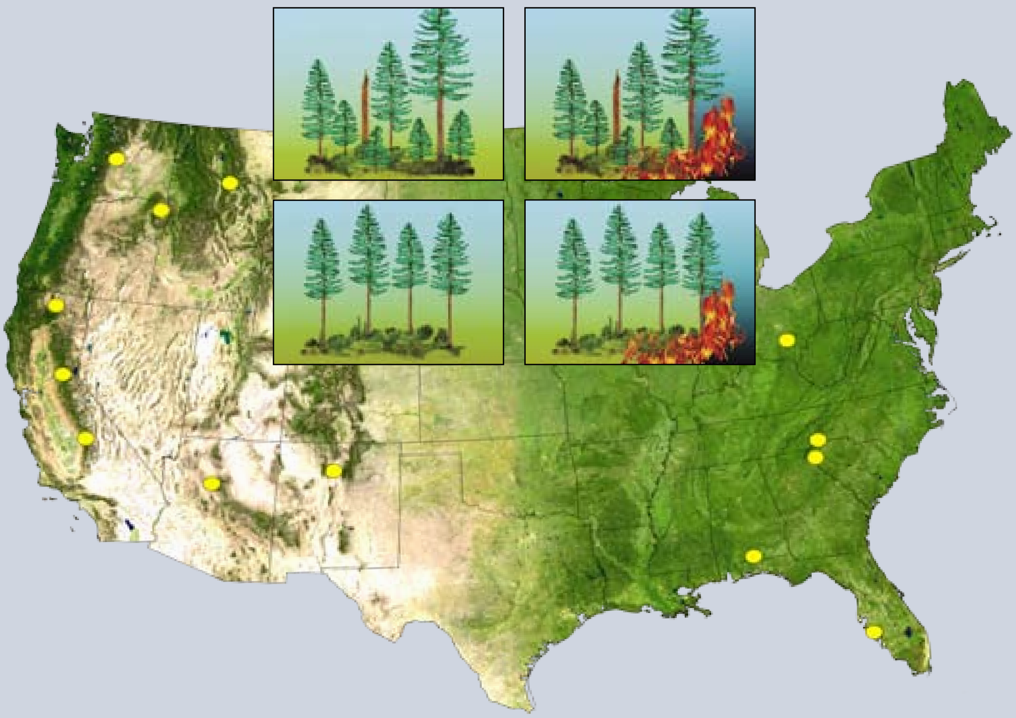

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Abstract

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.; 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.

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. The national Fire and Fire Surrogate (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. Beginning in September 2005, four regional workshops were conducted with selected clients to identify effective and efficient means of communicating FFS study findings to users. We used participatory evaluation to design the workshops, collect responses to focused questions and impressions, and summarize the results. We asked four overarching questions: (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? 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. User groups identified by workshop participants and recommendations for science delivery are then combined in a matrix to form the foundation of a strategic plan for conducting science 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.

Keywords: Fire and Fire Surrogate study, fuel reduction treatments, forest restoration treatments, science delivery, communication plans, participatory management.

Contents

Introduction

Many fire-dependent forests—especially those with historically short-interval, low- to moderate-severity fire regimes—contain more small trees and fewer large trees, have higher fuel loads, and greater fuel continuity compared to conditions under historical fire regimes (Agee 1993, Agee and Skinner 2005, Arno and others 1997, Barden 1997, Caprio and Swetnam 1995, Cowell 1998, Kilgore and Taylor 1979, Swetnam 1990, Taylor and Skinner 1998, Van Lear and Waldrop 1989, Waldrop and others 1987, Yaussy and Sutherland 1994, Youngblood and others 2004). Areas once open, such as meadow inclusions in pine forests, are now forested (Norman and Taylor 2005). These conditions resulted from fire exclusion and suppression, livestock grazing, timber harvests, tree recruitment after farm abandonment (especially in the Southern United States), and changes in climate (Arno and others 1997, Norman and Taylor 2005, Skinner and Chang 1996). Collectively, these conditions contribute to a general deterioration in forest ecosystem integrity and increase the probability of unnaturally severe wildfires (Stephens 1998).

In the past two decades, unusually large and severe wildfires across the Western United States have heightened public awareness of forest ecosystems and raised concerns for forest health. These uncharacteristic wildfires emphasize the need for well-designed treatments to change forest stands from their current structure and development trajectory to conditions that are healthier, more resilient to fire, and are safer to nearby communities (Brown and others 2004, Graham and others 2004). Recent Presidential initiatives such as the National Fire Plan and legislation such as the Healthy Forests Restoration Act of 2003 have promoted large-scale and strategically located fuel reduction and forest restoration projects to manage landscapes (USDI and USDA 2006).

Silviculturists and fuels specialists are increasingly being asked to design fuel reduction and forest restoration treatments that reduce stand basal area and the density of small trees, retain fire-resistant trees, reduce the accumulation of woody debris, and increase height to live crowns to help protect forests from severe wildfire and meet a host of other resource objectives. Strategies for managing forest fuels to reduce expensive and damaging wildfires include underburning with prescribed fire, cutting live and dead trees by hand (chainsaw felling), cutting trees and removing logs with mechanized equipment like feller-bunchers, mowing ground vegetation, chopping or grinding surface fuels (mastication), or any combination thereof. The ecological consequences of implementing these strategies remain largely unknown. Innovative operational-scale experiments that evaluate the effects of alternative management practices involving fire and mechanical/manual “surrogates” for natural disturbance events are essential to increase understanding and improve management decisions.

The National Fire and Fire Surrogate Study

The Fire and Fire Surrogate study is an integrated national network of long-term studies of using fire and other treatments for fuel reduction and forest restoration.

A team of federal, state, university, and private scientists and land managers designed the Fire and Fire Surrogate (FFS) study, an integrated national network of long-term studies established to document consequences of using fire and fire surrogate treatments for fuel reduction and forest restoration. Financial support for the FFS study came from the Joint Fire Science Program (JFSP), the National Fire Plan, the U.S. Department of Agriculture through a National Research Initiative competitive grant, and the home institutions and agencies of each participating scientist. The JFSP was established in 1997 to provide scientific information and support for wildland fuel and fire management programs. The program is a partnership of six federal agencies: the Forest Service in the U.S. Department of Agriculture, and the Bureau of Indian Affairs, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey, all in the Department of the Interior. The FFS study currently includes 13 sites on federal- and state-administered lands extending from the Cascade Range in Washington to south Florida (fig. 1). These 13 sites represent ecosystems with frequent, low-severity natural fire regimes. At each site, a common experimental design was used to facilitate broad comparisons of treatment effects (Weatherspoon 2000). The FFS study network represents the largest operational-scale experiment ever funded to test silvicultural treatments designed to balance ecological and economic objectives for sustaining healthy forests. Details of the network and links to individual study sites are available at the Web site http://frames.nbii.gov/ffs.

FFS Study Objectives

The FFS study was designed to quantify the ecological and economic consequences of fire and fire surrogate treatments across a number of forest types and conditions in the United States. Specific objectives include:

- Quantify the initial effects (first 5 years) of fuel reduction and forest restoration treatments on specific core response variables.
- Establish and maintain an integrated national network of long-term interdisciplinary studies using a common design that facilitates broad applicability of results yet allows flexibility for addressing locally important issues.
- Designate FFS study sites as demonstration areas for technology transfer.
- Develop a single integrated and spatially-referenced database that contains archived data from all network sites to facilitate interdisciplinary and multiscale analyses.

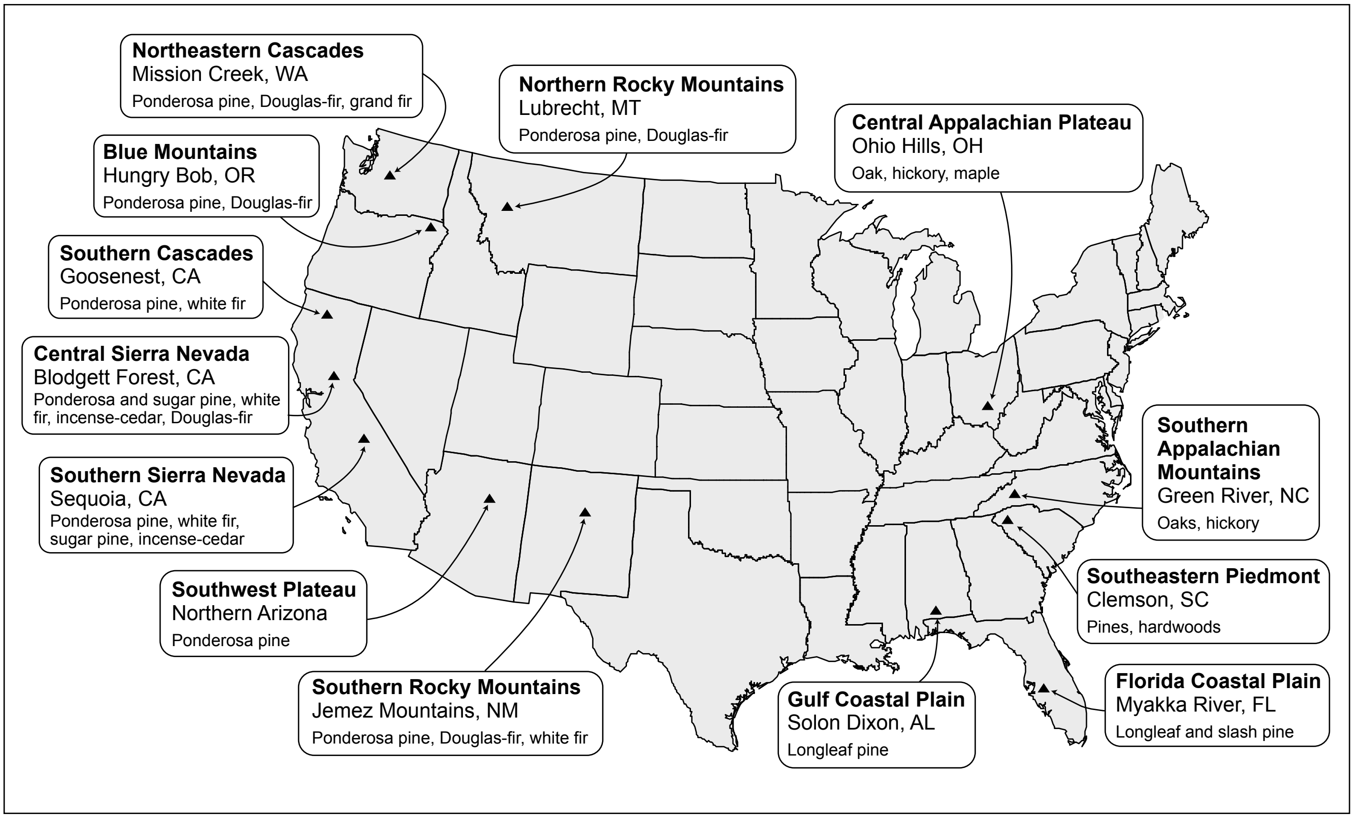

Figure 1—Distribution of Fire and Fire Surrogate study sites and associated tree species.

- Over the long term, repeat treatments where appropriate, develop and validate models of ecosystem structure and function, and refine recommendations for ecosystem management.

FFS Study Design

The FFS study was implemented on land administered by the Forest Service, National Park Service, various university experimental forests and education centers, state parks, and state forests. The core experimental design for the FFS study includes common treatments, similar treatment replication and plot sizes, and common response variables for all research sites in the network. The four treatments used at 12 of the 13 sites include (1) untreated control; (2) prescribed fire only (burn); (3) mechanical fuel reduction, including cutting and yarding with mechanical systems, hand felling, mowing, and mastication (thin); and (4) mechanical fuel reduction followed by prescribed fire (thin + burn) (table 1). For simplicity, all forms of mechanical fuel reduction used at the different FFS sites are hereafter referred to as "thin" despite the common silvicultural convention restricting usage of this term to trees. Treatments at the Sequoia National Park site consisted of

The core experimental design for the FFS study includes common treatments, similar treatment replication and plot sizes, and common response variables for all research sites in the network.

Table 1—Treatment structure at Fire and Fire Surrogate study sites represented at four regional workshops

Lubrecht	Solon Dixon	Blodgett	Green River
Blue Mountains— Hungry Bob, Oregon 1—Untreated control 2—Burn, Sept. 2000 3—Thin, July 1998 4—Thin, July 2000; burn, Sept. 2000	Gulf Coastal Plain— Solon Dixon, Alabama 1—Untreated control 2—Burn, April 2002, May 2004 3—Mow, March 2002 4—Mow, March 2002; burn, May 2002, April 2004 5—Herbicide, Sept 2002; burn April 2003	Central Sierra Nevada— Blodgett Forest, California 1—Untreated control 2—Burn, Oct. 2002 3—Thin, Sept. 2001; mastication, Aug. 2002 4—Thin, Sept. 2001; mastication, Aug. 2002; burn, Oct. 2002	Central Appalachian Plateau— Ohio Hills, Ohio 1—Untreated control 2—Burn, April 2001 3—Thin, Nov. 2000–April 2001 4—Thin, Sept. 2000–Feb. 2001; burn, March–April 2001
Northern Cascades— Mission Creek, Washington 1—Untreated control 2—Burn, June 2001 3—Thin, Feb. 2001 4—Thin, Feb. 2001; burn, June, 2002		Southern Cascades— Goosenest, California 1—Untreated control 2—Burn, Oct. 2002 3—Thin, Sept. 1999 4—Thin, Oct. 1999; burn, Oct. 2001	Southern Appalachian Mountains— Green River, North Carolina 1—Untreated control 2—Burn, March 2003 3—Shrub removal, March 2002 4—Shrub removal, March 2002; burn, March 2003
Northern Rocky Mountains— Lubrecht, Montana 1—Untreated control 2—Burn, May–June 2002 3—Thin, Jan.–March 2001 4—Thin, Jan.–March 2001; burn, May–June 2002		Southern Sierra Nevada— Sequoia, California 1—Untreated control 2—Burn, June 2002 3—Burn, Oct. 2001	Southeastern Piedmont— Clemson, South Carolina 1—Untreated control 2—Burn, April 2001, April 2004 3—Thin, April 2001 4—Thin, March 2001; burn, March 2002, May 2005

an untreated control, an early-season burn, and a late-season burn, which are the principal landscape-scale treatment options available to managers in the National Park Service. Implementation of the active (non-control) treatments at each site was guided by a desired future condition or target stand condition uniquely defined for each stand such that, if a stand were impacted by a head fire under 80^{th}-percentile weather conditions, at least 80 percent of the basal area of overstory trees would survive. Each treatment unit was at least 10 ha and was surrounded by a similarly treated buffer of 50 m along each boundary. Treatments were replicated at each of the sites at least three times in either a completely randomized or randomized complete block design, with treatments randomly assigned to each unit. Replication and randomization are key experimental design components of studies from which sound, statistically-valid inferences can be drawn, but are infrequently used in large operational studies.

Core variables represented broad disciplines, including vegetation, fuel and potential fire behavior, soils and forest floor, wildlife, entomology, pathology, and treatment and utilization economics (USDA FS 2001, Weatherspoon 2000). Some 400 response variables were monitored. The majority were spatially referenced to a 50-m square grid of permanent sample points established and maintained in each treatment unit at each site.

Science-Delivery Needs

Federal research agencies are being challenged to demonstrate that research is contributing to tangible improvements in land management. In supporting a broad array of fire and fuels research disciplines, the JFSP seeks science delivery strategies that actively involve managers in addition to more traditional means such as publishing results in peer-reviewed journals. As studies on the effects of fuel reduction and forest restoration were implemented at each of the 13 FFS study sites, lead scientists and local managers engaged in discussions on the types and kinds of research products that would most benefit managers in both the short and long terms. During the 6th annual FFS network meeting held in late 2004, the researchers agreed to conduct a set of regional workshops. These workshops were conceived as an opportunity to not only present the latest research findings but also to engage selected land managers in focused discussions about the most effective and efficient means of communicating FFS study findings to users. Workshops were designed to explore options for delivering FFS science to the right people in a usable format through appropriate communication channels. Four regional workshops were held; this document is a summary and synthesis of the lessons learned during the workshops. Although this synthesis focuses on FFS study science-delivery options, it likely will aid other fire science researchers to better identify their potential audiences and better understand similar science-delivery options.

These workshops engaged selected land managers in focused discussions about the most effective and efficient means of communicating FFS study findings to users.

Methods

Approach to Synthesis

We used the process of participatory evaluation (Greenwood and Levin 1998), a formal, reflective process of self-assessment, to design the workshops, collect responses to focused questions and impressions, and summarize the results. Participatory evaluation, in this case, was used to create a learning process that would aid FFS study researchers in identifying opportunities for communicating research results in the most effective and efficient manner. Our participatory evaluation involved self-assessment, collective knowledge development, and cooperative establishment of an action plan as a result of the findings. Our process engaged a total of 132 invited participants at the regional workshops, and looked for shared concerns and common solutions, yet recognized that differences represent potentially important regional distinctions. The large number of workshop participants provided a foundation for evaluating opportunities for communicating FFS study research results, despite differences in individual views. Acceptable solutions rarely come from one viewpoint, whereas the same idea voiced at different times and locations probably represents a more consistent and cohesive concept. Finally, our approach to participatory evaluation gave workshop participants opportunities to voice concerns with the very individuals most interested in and most likely to affect change in communicating research results.

The FFS study researchers wanted to identify specific strategies for enhancing science delivery. To this end, workshop participants were asked to describe communication opportunities rather than barriers. This approach to research, known as "appreciative inquiry," is more apt to result in outcomes that are more easily implemented than are approaches that attempt to correct communication strategies with known barriers or impediments. Appreciative inquiry in the context of the FFS study is based on a four-stage process (Whitney and Trosten-Bloom 2003): identifying communication processes that work well, envisioning communication processes that would work well for FFS study results in the future, planning and prioritizing processes that would work well in the form of an FFS study outreach plan, and finally, executing the proposed FFS study outreach plan. Specifically, we asked four overarching questions:

- Who needs fuel reduction information?
- What information do they need?
- Why do they need it?
- How can it best be delivered to them?

We used various ways of asking these questions and recording workshop participants' responses. We specifically posed questions such as "What critical fuel reduction issues occur at both the operational and policymaking levels?" at different workshops to better identify who needs what information. We asked questions such as "What key findings from this workshop will you pass on to your fuels managers, and how will you communicate these findings?" to generate discussion about science delivery processes. We asked questions such as "What kinds of monitoring variables are you using to assess fuels treatments?" to help identify how some fuel reduction information may be used. We avoided biasing potential responses to questions concerning information needs or methods of accessing information by not emphasizing what or how FFS results have been communicated to date. Designated recorders captured the responses to these questions, and to the questions asked by workshop participants and the resulting discussions. We asked FFS study researchers at each workshop to summarize their observations immediately afterward. At the Lubrecht and Blodgett workshops, we recorded electronically and later transcribed the full discussion that followed the field trip. In addition, designated recorders gathered notes of discussions that occurred external to formal group deliberations.

Lubrecht Workshop

The first FFS regional workshop for managers was held on September 7, 2005, at the University of Montana's Lubrecht Experimental Forest, site of the Northern Rocky Mountains FFS study (fig. 2). The workshop was co-hosted by site leaders from the three inland Northwest sites in the FFS network: Lubrecht, Montana (Northern Rocky Mountains), Hungry Bob, Oregon (Blue Mountains), and Mission Creek, Washington (Northeastern Cascades). Workshop participants represented a range of management entities, including federal and state agencies, tribal organizations, forestry extension programs, and nongovernmental organizations (table 2). Disciplinary interests of participants also were diverse, including forestry, wildlife, fire and fuels, operations, utilization and economics, and vegetation management.

A primary objective of the workshop was to present management-related findings on the effects of fuel reduction treatments on trees and understory vegetation, fuels and fire behavior, soil properties, insects and root disease, birds and small mammals, and treatment costs and product values. Although preliminary results of work at Lubrecht were featured, comparisons to similar work at Hungry Bob and Mission Creek were emphasized and, when appropriate, discussed in the context of other FFS sites, either in the West or across the whole network. A second objective was to ask participants what kinds of information generated by the FFS studies would be most useful for developing successful fuel reduction projects, and how we could best package and disseminate that information.

The Lubrecht workshop was designed around field visits to sites that illustrated each of the four fuel treatments evaluated in the FFS study: control, thin, burn, and thin + burn. An on-the-ground visit to one unit of each treatment provided the visual context for presentations by FFS study researchers, and for questions and discussion by participants. In each treatment unit, researchers presented interim results, by discipline, from the Lubrecht site and then followed with regional and network-level perspectives on the same issues or topics. Managers responded by identifying critical operational and policy concerns and information gaps related to the topics discussed. After the day-long field trip, participants reconvened to discuss options for presenting FFS study results to managers in their organizations.

Topics presented in the control unit included historical stand structure and disturbance regimes at Lubrecht and similar western Montana forests, current forest conditions at Lubrecht and similarities in forest structure and composition among other western FFS sites, and local and regional need for fuel reduction and forest restoration. Workshop participants questioned researchers about the

Figure 2—Small Douglas-fir saplings and low branches increase the probability of crown fires by providing fuel ladders into overstory canopies of ponderosa pine and Douglas-fir at the Northern Rocky Mountains Fire and Fire Surrogate (FFS) study site, Lubrecht, Montana.

The **Lubrecht Experimental Forest** is an 11 300-ha (28,000-acre) outdoor classroom and laboratory located 48 km (30 mi) northeast of Missoula, Montana, in the Blackfoot River Valley. The land was donated to the University of Montana by the Anaconda Company in 1937, and is owned and managed by the Montana Forest and Conservation Experiment Station. The experimental forest is dedicated to the advancement of natural resource knowledge through research and education and has a history of research and demonstration projects beginning in 1950. Numerous short- and long-term studies focus on silvicultural cutting and prescribed burning effects on timber, forage, wildlife, and water resources. In addition, undergraduate and graduate students use the forest for activities, including lab exercises, field trips, summer camp, and theses projects. The Lubrecht FFS study site is installed in second-growth ponderosa pine/Douglas-fir stands within the Lubrecht Experimental Forest.

Table 2—Affiliation of participants at Fire and Fire Surrogate study regional workshops

	Lubrecht	Solon Dixon	Blodgett	Green River
Federal	National Interagency Fire Center Forest Service, Pacific Northwest Region, Fire and Fuels Forest Service, Bitterroot, Colville, Lolo, Okanogan-Wenatchee, and Wallowa-Whitman National Forests Bureau of Indian Affairs	Department of Defense, Eglin Air Force Base U.S. Fish and Wildlife Service	Joint Fire Science Program Forest Service, Pacific Southwest Region, Fire and Fuels Forest Service, Lassen and Tahoe National Forest U.S. Geological Survey, Western Ecological Research Center	Eastern Forest Environmental Threat Assessment Center Forest Service, Northeast State and Private Forestry Forest Service, National Forest of North Carolina, Cherokee, Nantahala, Chattahoochee-Oconee, George Washington and Jefferson National Forest U.S. Fish and Wildlife Service, Prime Hook National Wildlife Refuge National Park Service, Great Smoky Mountains National Park
State	Montana State University Forestry Extension Washington State University Cooperative Extension Montana Department of Natural Resources and Conservation Washington Department of Natural Resources Montana Department of Fish, Wildlife, and Parks	Florida Division of Forestry Alabama Forestry Commission Louisiana Department of Agriculture and Forestry Georgia Forestry Commission Florida Department of Environmental Protection	University of California Cooperative Extension Watershed Research and Training Center California Fire Safe Council	Georgia Forestry Commission North Carolina Division of Parks and Recreation South Mountains State Park North Carolina Wildlife Resources Commission
Nongovernmental	Salish and Kootenai Tribal Forestry Defenders of Wildlife The Nature Conservancy	Auburn University The Nature Conservancy	California Forestry Association Sierra Nevada Forest Protection Campaign Quincy Library Group Total Forestry	National Wild Turkey Federation Southern Appalachian Forest Coalition The Nature Conservancy Buffalo-Duck River Resource Conservation and Development Council
Industry		Local forest industry Local forestry consultants	Sierra Pacific Industries Timber Products Co.	

management implications of their findings, and discussed the critical fuel reduction issues they face at the operational level. At the thin unit, local harvest prescriptions, posttreatment stand structural changes, treatment costs and product values, and soil disturbance at the Lubrecht site were presented. The regional presentation focused on the similarities and differences in these same factors among the Montana, Oregon, and Washington locations. Workshop participants described the obstacles that limit project implementation under the Healthy Forests Restoration Act of

2003 (P.L. 108-148) (HFRA), and objectives for posttreatment structural features. President Bush signed HFRA into law in December 2003. Among other things, the bill contains a variety of provisions to speed up hazardous fuel reduction and forest restoration projects on specific types of federal land that are at risk of wildland fire or large-scale insect and disease outbreaks.

Topics discussed at the burn unit included prescribed burning prescriptions, burn-day weather conditions, stand structural changes, and influences of burning on soil properties and wildlife habitat at Lubrecht. Researchers provided preliminary results of regional analyses of stand-replacement-fire risk reduction, treatment cost, postburn stand structure, soil change, and avian and small mammal dynamics as a result of treatments. Workshop participants discussed smoke, threat of fire escape, and tree mortality as factors that may limit burning under the HFRA and the practicality of burning as a sole maintenance treatment once a target fuel reduction is achieved. At the thin + burn unit, the integration of mechanical thinning and burning into a single prescription was explained, stand structural changes resulting from this treatment were described, and understory responses, particularly by nonnative invasive plant species, were presented. Regional differences in prescription implementation, costs across the three inland Northwest sites, and secondary treatment effects of delayed tree mortality, dead tree dynamics and structural attributes, bark beetle dynamics, understory plant species composition, and total nitrogen relationships were presented. Workshop participants discussed how FFS study results might be used to inform development of standards and guidelines, and aid preparation of National Environmental Policy Act (NEPA) documents with a stronger scientific basis.

The Lubrecht workshop provided several unique kinds of information for managers. The preliminary research results are likely applicable to a wide range of ponderosa pine and dry Douglas-fir forests in Montana, Oregon, and Washington. The three inland Northwest sites (northern Rocky Mountains, Blue Mountains, and northeastern Cascades) represent unique environmental conditions and past management activities, yet preliminary analyses among the three sites extended the inference to more dry forest conditions and provided a more robust interpretation of treatment responses compared to analyses of treatment effects at any single site. In addition to presentations on individual response variables such as Neotropical migratory birds, woodpeckers, or nonnative invasive plants, results were presented among and across disciplines—a systems approach that features both the specific responses to treatments and the higher level process interactions among these responses. A multipage summary of key discussions by managers during the workshop was compiled and mailed to all workshop participants to document their participation.

Solon Dixon Workshop

The Solon Dixon regional workshop was held on October 27, 2005, at the Solon Dixon Forestry and Education Center in southern Alabama, home of the Gulf Coastal Plain FFS study (fig. 3). Invited workshop participants were primarily practitioners and decisionmakers responsible for implementing fuel reduction and forest restoration treatments throughout the Gulf Coastal Plain, and included managers from state forests, managers from other state and federal agencies, large private landowners, and forestry consultants (table 2).

The primary objectives of this workshop were to provide information to user groups on how different treatments for restoring longleaf pine communities affected vegetation, soils, wildlife, insects, and fuels, and to facilitate a forum for exchanging information among practitioners who apply similar treatments. In addition, the workshop provided an opportunity to showcase to various user groups the Solon Dixon FFS site as an operational-size demonstration area that featured longleaf stands after different fuel reduction and forest restoration treatments, and to receive feedback on outreach methods. The workshop format was a traditional 1-day meeting that began and ended at the classroom facilities at the Dixon Center. Following introductory presentations on the Dixon Center and the overall design of the FFS study, participants traveled to the working forest where the majority of the day was spent touring different treatment units. The day ended with a debriefing and feedback session.

Short presentations in representative treatment units at the Solon Dixon FFS site covered the range of disciplines being studied. After each presentation there was a question and discussion period. This was followed by questions from the study site manager to the group to gather input on their reaction to the treatment, reactions by those with prior experience with the treatment, and any potential barriers they could foresee in applying the treatments.

The workshop participants first visited a burn treatment unit where the study layout and treatments were presented, followed by a description of prescribed burning operations. Effects on the overstory from thinning and burning or their combination were presented at a thin treatment unit. Understory responses to treatments, bark beetle and insect pollinator dynamics, and overstory mortality were discussed at a thin + burn treatment unit. In addition to the four core treatments, the Solon Dixon site contains a fifth treatment of local interest: a broadleaf herbicide was applied in the fall followed by burning in the spring (herbicide + burn). Herbicide was applied with backpack sprayers on understory woody vegetation. Changes in fuel accumulations were contrasted at the boundary between an untreated control

Figure 3—Longleaf pine and understory shrubs such as yaupon holly (see "Species Names of Plants") at the Gulf Coastal Plain Fire and Fire Surrogate study site, Solon Dixon, Alabama. Shrubs quickly establish after disturbance, serve as fuel ladders that increase the probability of severe wildfire, and reduce habitat suitability for endangered species such as the gopher tortoise (*Gopherus polyphemus*) and red-cockaded woodpecker (*Picoides borealis*).

Solon Dixon Forestry and Education Center is a 2100-ha (5,320-acre) school forest located about 30 km (18 mi) south of Andalusia, Alabama, and adjoins the Conecuh National Forest. It is operated by Auburn University School of Forestry and Wildlife Sciences under four objectives: (1) provide quality natural resource education to a variety of user groups, particularly students from Auburn University; (2) provide a base for and support of research efforts in natural resource fields; (3) serve as a source of information and technology transfer from the scientific community to the general public; and (4) manage its own natural resources wisely and economically to provide income for the center's programs. The center was a gift to Auburn University from Solon and Martha Dixon, residents of Andalusia, Alabama. It features upland longleaf pine forests with an understory dominated by tall shrubs typical of many longleaf areas in the middle and upper coastal plains of the South. The center was established in 1980, and since that time has served as the site of research on forest growth and yield, forest regeneration, herbicide use, and amphibian habitat.

unit and the adjacent herbicide + burn treatment unit. The tour ended with presentations on soils and wildlife at a second herbicide + burn treatment unit.

Blodgett Workshop

The third FFS study regional workshop took place on November 15, 2005, at Blodgett Experimental Forest, site of the Central Sierra Nevada FFS study (fig. 4). The workshop was co-hosted by site leaders from the three California sites in the FFS network: Blodgett Forest (central Sierra Nevada), Goosenest (southern Cascades), and Sequoia (southern Sierra Nevada). The targeted audience was managers who would recognize the importance of the FFS study and promote the transfer of information from the study within their respective spheres of influence. Invited participants included representatives of federal forest management, state fire and watershed management, local nongovernmental organizations and environmental groups, forestry consultants, and the forest products industry (table 2).

The Blodgett workshop was designed to introduce the FFS study to potentially influential forest and resource managers of California, and to present some initial management-related findings as well as examples of the types of information that will soon be made available. This was accomplished by providing examples of peer-reviewed journal papers and work in progress. In addition, attendees were asked to provide feedback on their own perception of the relevance of the FFS study to their work and how FFS study researchers might improve the delivery of FFS study results and information.

The workshop emphasized a field tour to facilitate interaction between workshop participants and FFS study researchers. A brief indoor morning session was held to provide an overview of the project and of each of the three California sites. Two examples of multisite analyses were presented. Specific components of the study were discussed at different stops on the day-long field trip. The field tour involved treatment units representing each of the four FFS study treatments. At each subsequent stop, participants briefly walked around to get a visual sense of the treatment and to contrast this with adjacent treatment units. This was followed by presentations by FFS study researchers on different aspects of the study, including effects of the treatments on tree and understory vegetation, soils, bark-beetle dynamics, birds, and small mammals. Presentations were often accompanied by handouts that presented and summarized preliminary findings.

The need for fuel treatments across a wide range of sites and the variability of treatment response as a result of differences in soil structure and productivity were discussed in a control treatment unit. Managers were asked to compare fuel accumulations and treatment priorities at the Blodgett Forest FFS study site with

Figure 4—Heavy down woody fuels and dense layers of white fir and incense-cedar develop under highly productive ponderosa pine, sugar pine, and Douglas-fir at the Central Sierra Nevada Fire and Fire Surrogate study site on the Blodgett Experimental Forest in California.

The **Blodgett Forest Research Station** is an 1800-ha (4,400-acre) forest located on the Georgetown Divide in the central Sierra Nevada and represents some of the most productive mixed-conifer forests in California. The land was donated to the University of California by the Michigan-California Lumber Company in 1933. The purpose of the gift was to provide a research site and practical demonstrations of forestry for students, forest industry, and the public. The major mission of Blodgett Forest is to evaluate response, cost, and impacts of different management activities. The scientific value of Blodgett Forest has grown correspondingly with the increased demands on natural resources. Research began more than 50 years ago at Blodgett Forest and includes studies on tree growth, forest succession, harvesting costs, forest insect and disease dynamics, forest ecology, wildlife population dynamics, range animal dynamics, control of nontree vegetation, thinning and spacing of commercial conifers, soil compaction from logging operations, effects and techniques of prescribed fire, conifer regeneration methods, harvesting methods, and nutrient cycling. Blodgett Forest is managed by staff of the University of California Berkeley campus.

similar forest types across California. Effects of burning were presented for Sequoia, Goosenest, and Blodgett Forest in a burn treatment unit. Workshop participants discussed their discomfort in using numerically quantified summaries of fuel accumulations as guides for prioritizing projects and suggested pictorial guides may be more applicable. Treatment costs and the mixture of tree sizes that were cut were explained in a thin treatment unit. Workshop participants discussed the opportunity to conduct similar fuel reduction and forest restoration treatments when cost/benefit ratios were favorable, and also the difficulty in translating stand-level treatment effects and costs to landscape-scale needs. The FFS study researchers presented initial entomological and wildlife responses in a thin + burn treatment unit, and workshop participants responded with concerns for using various treatments to achieve different short- and long-term objectives.

Although the focus of research findings was on the Blodgett Forest FFS site, FFS study researchers elaborated on the subtle but important differences in treatments and results among the three California sites: active treatments at the southern Sierra Nevada site within Sequoia National Park consisted of early- and late-season burns, the thin treatment at Blodgett Forest included a mechanical mastication of surface and ladder fuels, and the entire FFS study at Blodgett Forest was overlaid on sites where the management direction involved maintaining a diverse stand structure through group selection. Finally, an open discussion in the Blodgett Forest conference center after the field trip provided a venue for addressing the relative merits of different science-delivery options. The day concluded with a group dinner.

Green River Workshop

The fourth and final FFS regional workshop was held in Asheville, North Carolina, on January 24–25, 2006. The workshop was co-hosted by site leaders from three eastern sites in the FFS network: Green River, North Carolina (southern Appalachian Mountains), Clemson, South Carolina (southeastern Piedmont), and Ohio Hills, Ohio (central Appalachian Plateau). Invited workshop participants included land managers from federal, state, and county agencies, conservation groups, and environmental groups throughout the Southeast (table 2). Disciplinary interests included wildlife biologists, fire managers, fire and plant ecologists, park rangers, inventory specialists, and conservation planners.

Specific objectives of the workshop were to provide resource mangers with an introduction to the FFS study at both the national and local levels, to relay early results of FFS core studies to resource managers, and to begin discussions with land managers about information needs and how the FFS study can help to meet those needs.

Formal presentations were made by researchers on the first day to an audience arranged in theatre style. Researchers conducting work within each core discipline and at each of the three study sites were asked to combine their presentations into a single presentation. The day began with an overview of the national study followed by presentations covering vegetation, soils, wildlife, pathology, economics and utilization, and changes in fuel accumulation. The day ended with short presentations on studies unique to a single site: southern pine beetle dynamics at the Clemson FFS study site, and fire history and dendrochronology at the Ohio Hills FFS study site.

The second day consisted of a field visit to the Green River FFS study site on the Green River Game Land, about 25 mi south of Asheville, North Carolina (fig. 5). Because of the large number in attendance, participants were split into three groups of about 25 each. Presentations were made by FFS study researchers at a burn treatment unit, a thin + burn treatment unit, and a thin treatment unit with a second thin + burn treatment unit adjacent. In the burn unit, recent work was presented on the effects of treatments on different bat species, the relation between treatments and impacts of deer browsing, and a multisite analysis of herpetofaunal impacts. Workshop participants responded by discussing operational issues of fuel reduction and forest restoration, local and regional variation in air quality, wildland-urban interface boundaries that may influence the kinds of treatments likely to occur in nearby stands, and common means of accessing fuel reduction science results for project planning and implementation.

Effects of treatments on soils, litter decomposition, and arthropods, changes in stand structure, and public perceptions of implemented treatments were major topics in a thin + burn treatment unit. In addition, workshop participants were shown results of preliminary fire behavior analyses for the Green River FFS study site. Participants discussed both implementation and effectiveness monitoring and the appropriateness of different monitoring variables. In a thin treatment unit, presentations focused on seedling and sapling survival and delayed mortality of overstory hardwoods at both Ohio Hills and Green River FFS study sites. Participants discussed the wide variation in stand structure goals across different land ownerships throughout eastern hardwood ecosystems, opportunities to maintain acceptable fuel accumulations and stand structures through the exclusive use of burning, and opportunities to communicate the key findings of the FFS study to their network of fuel managers.

Figure 5—Forests of the Southern Appalachian Mountains are often mixtures of oaks, hickories, and pines. At the Southern Appalachian Mountains Fire and Fire Surrogate study site on the Green River Game Land, North Carolina, dense thickets of ericaceous shrubs such as mountain laurel or rhododendron can form in the understory. Without frequent disturbance, these shrubs contribute to intense ground fires or crown fires.

Located in the southwestern corner of North Carolina near Hendersonville, the **Green River Game Land** consists of more than 4000 ha (10,000 acres) along the Green River in Henderson and Polk Counties. Owned by the state of North Carolina, the land is administered by the North Carolina Wildlife Resources Commission for wildlife conservation and management. It consists of gorges, steep ravines, and coves supporting recently undisturbed oak forests with shortleaf and Virginia pines on ridgelines and eastern white pines in more protected sites (see "Species Names of Plants" for scientific names). The area is named for the Green River that has cut a rugged gorge through the Blue Ridge escarpment. A major portion of the land was purchased by The Nature Conservancy from Duke Power Company and Crescent Timber in 1994.

A common request from the workshop participants was for a compilation of all study results. Final publication of all the results will likely occur in various outlets because some presentations were based on work from a single FFS study site and others spanned the three eastern sites, and some presentations were the result of short-term work by graduate students, whereas others were initial results of long-term studies. To partially fill the request for a single compilation of study results, several FFS study researchers collaborated in producing a compact disk containing the slide presentations from the first day of the meeting. All workshop participants were mailed a copy of the disk. Additional requests for copies of the disk came from resource managers throughout the Eastern United States.

Synthesis Procedures

Each of the four regional workshops differed in design, audience, and the content and format of information presented. However, the overall objectives were similar. Analysis for this study focused on discovering the widest range of audiences, science finding topics, land management contexts (ecological and political), and communication methods. Findings that transcend geographical and professional boundaries will likely represent the greatest contribution to a single, nationwide FFS study communication strategy. At the same time, findings that appear relevant for a subset of units may be especially important to consider as regional differences in the overall communication strategy.

Across all four regional workshops, we obtained 31 unique sets of documents consisting of workshop notes, recorded transcriptions, and postworkshop summaries. These 31 sets of notes, totaling some 300 pages, were reviewed, and specific ideas, statements, and phrases were independently coded by two analysts (table 3). This review and coding resulted in 1,698 comments in a single database, each referencing the page of the source document and analyst. We then used a secondary keyword coding that was unique to each primary level to identify common ideas and themes under each primary code. We carefully examined the resulting groups of statements to ensure that those selected were identified by both readers and came from at least two sources. In this way, we ensured relevancy and unbiased support for each finding. Our findings are expressed as the number of recorded statements and discussed in the following section. The actual numbers of statements within any category do not imply relative importance, however, because unequal sampling across workshops prevented quantitative comparisons.

Table 3—Primary-level coding of participant comments at Fire and Fire Surrogate (FFS) study regional workshops

Code	Label	Definition
1	Who is the audience?	Specific ideas about what groups, professions, or individuals could benefit from FFS study findings
2	What do they want?	Specific ideas about what FFS study findings clients most need or want
3	Why do they need it?	The specific context or rationale for client needs
4	How can we deliver?	Specific communication methods for FFS study science delivery
5	Manager questions	Questions raised by workshop participants for FFS study researchers that represent broad, integrative manager perspectives on fuel reduction and forest restoration
6	FFS study benefits and limitations	Specific perspectives on how the FFS study results and information might help resolve issues
7	Researcher's questions	Questions raised by FFS study researchers for workshop participants that represent broad, integrative perspectives on fuel reduction and forest restoration
8	Study insights	Specific comments by workshop participants that reflect their definition of key study insights gained during the workshops
9	Study findings	Specific comments by FFS study researchers that seemed to generate the greatest interest by workshop participants

Workshop Results

Who Needs Fuel Reduction Information?

Workshop participants identified potential 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 forest restoration issues. Not surprisingly, a wide variety of users were identified, ranging from federal agencies to private entities (table 4).

In addition to the Forest Service and the Bureau of Land Management, federal agencies that would likely benefit from FFS science include those that administer large tracts of wildlands such as the Bonneville Power Administration, U.S. Fish and Wildlife Service, National Park Service, and parts of the Department of Defense. The Bonneville Power Administration (U.S. Department of Energy) administers dams and power line corridors across the Pacific Northwest. The U.S. Fish and Wildlife Service conserves, protects, and enhances fish, wildlife, and plants and their habitats across the Nation, largely through a system of wildlife refuges. The National Park Service administers a network of national parks, monuments, and reserves. At the Solon Dixon workshop, the Department of Defense was listed as a key manager of large tracts of wildlands such as Eglin Air Force Base

Table 4—Potential users of Fire and Fire Surrogate study results and information identified by participants at regional workshops

	Regional workshop				
Audience	**Blodgett**	**Green River**	**Lubrecht**	**Solon Dixon**	**Total**
Academia			8	1	9
Conservation groups			2	8	10
Extension specialists	1	1	2	3	7
Federal agencies			17	5	22
Local governments			4	3	7
NEPA analysts	1		3		4
Nonindustrial private foresters	1		5	2	8
Policymakers	3		13		16
Practicing foresters	1		6	2	9
Public	4		5		9
Stakeholder groups		1	3		4
State agencies			8	3	11
Timber management organizations			5	8	13
Tribal foresters			6		6
Unclassified	2	1	13	1	16
Total	13	3	104	37	157

NEPA = National Environmental Policy Act.

in northwest Florida. As a special category of federal users, the workshop participants identified those that prepare and evaluate documents under NEPA. This act requires federal agencies to integrate environmental values into their decisionmaking processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. This also would extend to the judicial system and those that develop case law.

At the state level, many states have state foresters and agencies that administer state forest lands, such as the Washington Department of Natural Resources, the Division of Forestry in the Florida Department of Agriculture and Consumer Services, the Forestry Division in the Montana Department of Natural Resources and Conservation, and the California Department of Forestry and Fire Protection.

Workshop participants at Lubrecht specifically identified the Confederated Tribes of the Colville Reservation in Washington as an example of tribal users because of the large forested land base held in federal trust and managed directly by the tribes and the Bureau of Indian Affairs (Department of the Interior). Tribal entities with similar fuel reduction and forest restoration issues are the Confederated Salish and Kootenai Tribes of the Flathead Indian Reservation in Montana, and the Confederated Tribes of the Warm Springs Reservation and the Confederated Tribes of the Umatilla Reservation in Oregon.

Participants at all workshops identified politicians, especially those in city and county governments, as local government entities with potential interest in FFS science. City and county commissioners often serve as decisionmakers for urban growth boundaries that influence the wildland-urban interface, and may serve on federal resource advisory committees that provide local input for federal managers.

Academia was considered an important user by workshop participants at Lubrecht and Solon Dixon. Faculty not only teach fuel reduction and forest restoration science in forest ecology and wildland fire courses, but develop continuing education courses for professional foresters and wildland firefighters.

An important link between university teaching and research faculty and other users is the Cooperative Extension Service, established in 1914 as a partnership between the U.S. Department of Agriculture, land-grant universities, and county administrative units. The Cooperative Extension Service links the research efforts of the U.S. Department of Agriculture and land-grant universities to make scientific knowledge more readily available (Seevers and others 1997). Extension specialists and county agents associated with land-grant universities conduct educational programs, write publications, and provide research-based information to family forest owners, professional managers, private citizens, decisionmakers, and others.

The list of FFS study partners includes the Wildlife Conservation Society, an international organization dedicated to conserving wildlife and wildlands through careful science, international conservation, education, and management of the world's largest system of urban wildlife parks. To date, however, there has been little connection between FFS study researchers and members of other national or local environmental, conservation, or professional groups such as the Sierra Club, Society of American Foresters, The Nature Conservancy, and the Wildlife Society. There are two notable exceptions. The Longleaf Alliance, a partnership of state and federal natural resource agencies, forest industry, environmental groups, natural resource consultants, nurserymen, and private forest landowners works together to restore a functional longleaf forest ecosystem in the Southeastern United States. The Sierra Nevada Forest Protection Campaign is a coalition of conservation organizations, individual activists, scientists, businesses and spiritual leaders working for the protection of old-growth forests, sensitive watersheds, and threatened wildlife in the Sierra Nevada mountain range. Across the network of FFS study sites there are similar potential user groups that focus locally on providing hunting opportunities, protecting wildlife species, and managing water resources.

A group of users identified at all workshops was the professional or industrial forester, and directly related, the nonindustrial private forest owner (fig. 6). Professional or industrial foresters may serve as consultants to, or be directly

Figure 6—Clients at regional workshops identified broad groups of users for Fire and Fire Surrogate study results and information, including professional and consulting foresters and extension specialist who work with various state, private, and family forest owners.

employed by, timber management firms, investment trusts, or timber management organizations, and may benefit from FFS study results when evaluating similar operational-scale treatments. Family foresters, forest landowners, forest landowner associations, and nonindustrial private forest owners may benefit from fuel reduction and forest restoration information but are often limited in the scale of planned treatments. A special category of user identified at the Solon Dixon workshop was burning contractors and wildfire mitigation teams, charged with fuel reduction in the wildland-urban interface.

One group of users probably new to most wildland fuels researchers is the insurance industry, identified at Lubrecht and Blodgett workshops as increasingly important because of the growing concern for structure protection particularly in the wildland-urban interface.

Finally, the general public was repeatedly listed as a user group and major audience because of the role of concerned and informed citizens in shaping management activities.

What Information Is Needed?

The most commonly expressed knowledge gap identified by workshop participants was some measure of the efficacy or overall effectiveness of fuel reduction and forest restoration treatments and their tradeoffs (table 5). They repeatedly asked for information on the extent to which alternative fuel reduction treatments result in conditions that would be predicted to change fire behavior, and for information on combinations of treatments that could be used strategically across the landscape to minimize the risk of severe wildfire. They wanted side-by-side comparisons of treatments to better understand the biological and economic considerations for applying treatments in situations similar to those used in the FFS study. In addition to a comparison of tradeoffs between active treatments, workshop participants repeatedly asked for information on the effects and consequences of the control or no-action treatment. At Blodgett and Lubrecht, it was suggested that the cost of not treating fuels needed to include the increased risk of future wildfire, and that the increased costs of future wildfire suppression for the no-action treatment needed to be included in the economic comparison of fuel reduction treatments. In addition to questions about the relative and absolute costs and revenues generated by each treatment, participants at Solon Dixon asked if treatments would increase the profitability of the land, especially through income diversification because quail habitat might be enhanced with fuel reduction. The question of economic value represented

The most commonly expressed knowledge gap identified by workshop participants was some measure of the efficacy or overall effectiveness of fuel reduction and forest restoration treatments and their tradeoffs.

Table 5—Information needs of users of Fire and Fire Surrogate study results identified by participants at regional workshops

	Regional workshop				
Information needs	Blodgett	Green River	Lubrecht	Solon Dixon	Total
Applicability and extrapolation			15		15
Burning techniques	2	2	13	20	37
Decision-support tools	4		21		25
Economics of treatments	1	2	35	16	54
Fire behavior		2	12	1	15
Forest health and restoration				9	9
Landscape-scale issues	3	1	8		12
Monitoring changes			7		7
Risks and benefits of treatments			25	4	29
Social issues		5	13	12	30
Spatial scales	3		8		11
Stand structure	6	11	5	8	30
Temporal changes	10	1	20	2	33
Treatment tradeoffs	56	5	35	1	97
Wildlife issues		3	6	16	25
Unclassified	9	5	35	12	61
Total	94	37	258	101	490

by treatment-related biomass was restricted to the two western workshops. Participants asked about the volume of potentially usable biomass retained onsite after treatment and whether this might contribute to energy cogeneration projects if the supply were sustainable.

Questions about how to best implement burning programs and the sensitivity of stand-level prescriptions arose at all four workshops. Workshop participants expressed a need for more information on not only how the actual FFS study burn treatments were implemented, but how these same treatments might differ when used elsewhere (fig. 7). There was a recognized need to use the FFS study results to better predict fire behavior associated with prescribed burns and also wildfires. More specifically, information on burn treatments is needed to assess whether similar fuel reduction treatments ultimately help managers achieve their goal of reducing crown fire occurrence and severity. As expected, there was broad consensus in the need for information on where and when FFS study results might be applicable. Workshop participants repeatedly asked for criteria to aid in deciding where and when to apply any given set of fuel reduction treatments. These criteria would equally benefit a private woodlot owner in Florida protecting their investment and a national forest supervisor in Montana strategizing across broad landscapes.

Figure 7—Clients at regional workshops asked for information to better implement specific stand-level burning prescriptions such as this burn conducted after thinning in ponderosa pine and Douglas-fir at the Northeastern Cascades Fire and Fire Surrogate study site at Mission Creek, Washington.

Site-specific information on treatment implementation, specifically on burning techniques, was requested at all but the Green River workshop. These requests indicate information gaps in understanding various methods of reintroducing fire to achieve a mix of burning effects across landscapes. The Solon Dixon workshop generated requests for better information on applying herbicide treatments and the type of equipment used for mechanical treatment of ground fuels; this was the only FFS study site where use of herbicide was included as a treatment. Similarly, the Blodgett workshop generated requests for better information on applying mastication treatments.

Better information on predicted future fire behavior as a result of fuel reduction and forest restoration treatments was listed as a need at all workshops. This need is tied to the previously noted request for information on treatment efficacy. Workshop participants asked about the role of activity fuels and the input of new fuels in future fire behavior, whether any of the treatments effectively reduced the risk of crown fire, and if any of the treatments affected firefighter safety.

Better information on the effect of fuel reduction treatments for restoring longleaf pine forest health was specifically addressed at Solon Dixon. Workshop participants indicated a need for information on the suite of potential treatments that may contribute to overall forest ecosystem restoration and how treatments might benefit or protect adjacent lands that remain untreated.

While most fuel reduction treatments are currently conducted at the scale of individual stands, the need to scale the results up to larger landscapes was listed as a need at Blodgett and Lubrecht. This included consideration of not only onsite effects of treatments but more holistic concerns for ecosystem patterns and processes that involve the entire landscape in which treatments are applied.

As expected by the workshop organizers, workshop participants indicated that they need better information on fuel reduction treatments for assessing both short- and long-term risks and benefits as a research need. Risks were considered to be the probability of wildfire given that treatments were not implemented, the risk of fire escape during treatment, as well as the hypothesized decrease in probability of wildfire or wildfire severity as a result of fuel reduction treatments.

As expected by the workshop organizers, workshop participants indicated that they need better information on fuel reduction treatments for assessing both short- and long-term risks and benefits as a research need.

Participants at all workshops expressed the need for better information on the effect of fuel reduction treatments on stand structure. Workshop participants asked how the treatments could be used to target certain tree species for retention or reduction, how initial densities might affect the predicted treatment responses, how long the initial changes in structure would persist, or if structural changes would result in new stand development trajectories. Specific knowledge gaps suggested regional differences: concerns for demonstrating sustainable replacement of snags

Workshop participants noted a need for results of changes over longer time scales.

were raised at Lubrecht; the role of past fire exclusion in fostering establishment of seral species was raised at Blodgett; workshop participants at Solon Dixon wanted to better understand the effect of treatments on understory species composition; and the role of fuel reduction treatments in fostering oak regeneration was identified at Green River.

Workshop participants recognized the temporal limits of the FFS study; only short-term (i.e., less than 5 years) results of the FFS study were presented and are currently available. Although short-term results were informative, the participants noted a greater need for results that represent changes over longer temporal scales. They stated a need for better information on how the individual treatments would respond over time and asked the researchers how they might place the studies in the context of longer term management. They expressed the need to continue monitoring the individual study sites, specifically listing the need to follow temporal changes in tree mortality, tree volume, and wildfire risk. In addition, there was a clear recognition that the current set of treatments and the short-term results need to be interpreted in the context of longer time scales that preceded the treatment; i.e., all FFS study sites have a history of past management that contributed to the pretreatment structure and the response to the treatments. Several western FFS sites (Hungry Bob, Oregon, and Lubrecht, Montana) were logged via railroad access early in the 1900s, while some southern sites (Clemson, South Carolina) previously were abandoned cotton plantations. Workshop participants asked for better information on predicting the effect of fuel reduction and forest restoration treatments given different histories of past management. They perceived the set of FFS treatments as less "heavy-handed" and more subtle or restrained compared to some common management practices applied on similar landscapes in the past, and suggested the need to display this distinction to a wider group of audiences.

A relatively large group of comments obtained from workshop participants at Green River, Lubrecht, and Solon Dixon expressed the need for information in the context of social concerns. Because there was recognition that FFS study results have applicability across a wide spectrum of potential users, there was a concern for how to communicate not only the actual FFS study results, but the underlying need for fuel reduction and forest restoration to different users. Some thought the FFS study results would aid different agencies to more effectively justify the need for certain actions and therefore avoid litigation or allow the agency to be more effective in addressing concerns raised by litigants. Two somewhat unique social issues, recreation and airsheds, surfaced at Solon Dixon, probably because the Solon Dixon study site is close to urban areas such as Andalusia, Alabama, and Eglin Air Force Base. Workshop participants identified the need for information on the effect of fuel reduction and forest restoration treatments on homes in the wildland-urban interface and on recreation values such as bird hunting, and smoke production and downwind dispersal within military lands that include air strips. Participants at the Blodgett workshop were interested in ongoing work ancillary to the FFS study that addresses visitor reaction and social acceptability of fuel reduction and forest restoration treatments.

Discussions at the Lubrecht workshop highlighted participants' concerns for specific tools such as models that might be developed or improved based on the FFS study results. Workshop participants were divided on the issues of need and value of new models; some suggested that an adequate number already exist, whereas others saw the utility for more. There was broad agreement, however, that any new model needed to have clear predictive capability, to be user friendly, and to have all limitations in applicability clearly stated.

Wildlife issues were raised as research needs at the Green River, Lubrecht, and Solon Dixon workshops. Although no specific wildlife species of concern was identified at Lubrecht, participants warned that generalizations about the effects of FFS study treatments on "wildlife" species and habitat were of little value, and what were needed were species-specific guides. Workshop participants at Green River and Solon Dixon reinforced this concept by asking for FFS study results that specifically addressed foraging habitat of game birds such as turkey and quail. They also indicated that Neotropical migrant species as a group held high value and indicated that there was a need to predict the effect of fuel reduction and forest restoration treatments on their spring foraging and nesting habitat.

Why Is Information From the FFS Study Needed?

The national FFS study was established in 1999 because scientists and managers recognized that ecological consequences of the different strategies for reducing fuels and restoring forest structure were largely unknown. We asked workshop participants why they thought the information generated by the FFS study was needed (table 6). Not surprisingly, workshop participants recognized that use of research results differed depending on the user. Managers of adjacent parcels of land may have contrasting information needs because their agencies have different management objectives. Workshop participants at Blodgett, Green River, and Lubrecht elaborated on this point by stating that the study was needed to address concerns of agency managers, nonprofit managers, and the general public for the widespread use of fuel reduction and forest restoration treatments across various landscapes. In some cases, application of treatments was restricted because workshop participants recognized they lacked sufficient information to make informed decisions. In other

Workshop participants recognized that use of research results differed depending on the user.

Table 6—Reasons why information is needed from the Fire and Fire Surrogate study identified by participants at regional workshops

	Regional workshop				
Reasons for information needs	Blodgett	Green River	Lubrecht	Solon Dixon	Total
Biomass removal	1	1	1	1	4
Cause and effect of relationships	4		2		6
Costs of treatments			14	1	15
Legal issues	2		2		4
Liability of landowners			2	1	3
Multiple or competing issues	1	4	4	1	10
Science-based decisions	2	4	7	2	15
Social issues	1	1	2		4
Stand structure		9	2		11
Treatment tradeoffs	3		9	3	15
Unclassified	2	3	8	11	24
Total	16	22	53	20	111

cases, participants indicated they desired the information to counter agency claims. There was, however, consistency in recognizing that science is often driven by issues. By far the most recognized issue responsible for science priority-setting with respect to the FFS study is the increase in cost of wildland fire suppression, and the hope that some set of fuel reduction treatments will help reduce these suppression costs (fig. 8). It is easy to understand the sentiment behind these comments from workshop participants at Blodgett and Lubrecht, who come from states where uncharacteristically severe wildfires are becoming all too common (USDA and USDI 2006). Interestingly, the same perception was voiced at the Green River and Solon Dixon workshops, located in regions where the role of fire under natural regimes is perhaps less clear and the occurrence of large and uncharacteristically severe wildfire has been less frequent. This concept was variously restated as an accountability measure or performance standard. Congress expects that better information on fuel reduction and forest restoration treatments will translate into more effective treatments that reduce the number and size of wildfires and associated suppression costs.

Workshop participants at Green River and Solon Dixon indicated that key issues surrounding their need for information resulting from the FFS study might best be summarized around the concept of restoration of forest structure and processes. As such, they desired information on forest restoration incorporating knowledge that some forests may contain tree species and structures that are no longer well represented on the landscape and that some forests may contain compositions and structures that are more resilient to arson fires.

Figure 8—Clients at regional workshops recognized that a primary benefit of the Fire and Fire Surrogate study was information about specific fuel treatments that would help reduce wildland fire suppression costs.

Biomass removal was identified at each of the regional workshops as an issue that was driving the need for FFS study information. In some cases, biomass removal was perceived to be an issue because thinning treatments may increase the amount of down woody material on the forest floor and thus increase the amount of fuel available for combustion during a wildfire. In other cases, biomass removal as some form of forest product was recognized as a means to increase the potential public benefits of fuel reduction.

Information resulting from the FFS study was considered important by Blodgett and Lubrecht workshop participants for preventing or addressing legal issues of when, where, and what treatments might occur across the landscape. Litigation of agency projects and the costs associated with lawsuits may decline if all parties have more complete scientific information on the short- and long-term effects of the proposed treatments. Yet there remains at least one ownership group that FFS study information is not likely to influence: private landowners will resist using any fuel reduction treatment that involves burning because of a strong risk aversion to fire. Private landowners are not interested in the potential benefits of fuel reduction treatments that involve prescribed burning when they are liable for escaped fire and smoke dispersal.

Workshop participants at Green River, Lubrecht, and Solon Dixon indicated that FFS study information is important because it crosses multiple disciplines and thus may contribute to land management agency goals of managing for multiple benefits. Some benefits that were specifically addressed include air quality, expansion of the wildland-urban interface, production of forest products, and wildlife habitat.

Green River workshop participants indicated that a key issue for which FFS study information is especially needed is the desire to restore stand structures to those more commonly occurring under natural disturbance regimes. In some cases, this structure may include open woodlands composed of specific oaks and related mast-producing hardwood species, and low shrubs and forbs in the understory that provide valued turkey and quail habitat. This management goal apparently crosses federal and state land management boundaries and appears to have wide acceptance, yet attainment of the goal is limited by knowledge gaps.

Finally, workshop participants at all but Green River indicated that FFS study information is essential for helping to identify treatment tradeoffs, or the relative merits of one set of treatments compared to another. This concept sometimes included both a spatial and temporal component because workshop participants indicated there was a need to better understand the answer to “Why here and why now?”

How Can FFS Study Results and Information Be Delivered to Users?

For decades, the standard means of communicating or disseminating research results and scientific information from studies such as ours has been through papers published in peer-reviewed journals such as *Forest Science*, *Forest Ecology and Management*, and the *Soil Science Society of America Journal*. Peer review is a process used to ensure that the quality of published information meets the standards of the scientific community. The process is a deliberation involving an exchange of judgment about the appropriateness of methods, the reliability of results, and the robustness of inferences as presented in a review draft. Peer review occurs when a draft is reviewed by specialists who are knowledgeable in the field of study yet have no direct connection or involvement in producing the draft. “Double-blind review” occurs when the identities of authors and reviewers are not known to each other. When conducted in an open, rigorous manner, the review helps improve and ensure the quality of scientific information and gives the end user more confidence in the integrity of the science behind the journal paper. Publication of scientific information in peer-reviewed journals is a slow process, however. It also limits scientific information to journals that are not readily accessible to many users. Only recently have the majority of peer-reviewed journals been available other than by library or personal subscription, as many journals now offer electronic access through the Internet. Peer-reviewed journals, however, remain the customary outlet for work by most government and university researchers and graduate students. Regional journals such as the Southern Journal of Applied Forestry or the Western Journal of Applied Forestry meet the standards of peer-review, yet are somewhat more readily accessible to managers and practitioners.

Workshop participants were asked to help identify opportunities for communicating FFS study results (table 7). Workshop participants first provided suggestions on improving the presentation of FFS study results and then followed with more specific ideas on various methods of communication. They suggested that qualitative comparisons made with charts were often more informative for both managers and the public than were empirical data, and that a synthesis of the results would be more beneficial to most user groups compared to some compilation of the data. They asked for the display of trends or changes over time instead of results that represent some undefined point in time. Participants asked for all the results to be presented in common units of measurement that are easily understood. And they

Table 7—Means of communicating information from the Fire and Fire Surrogate study identified by participants at regional workshops

	Regional workshop				
Communication methods	Blodgett	Green River	Lubrecht	Solon Dixon	Total
Accessible information			6	1	7
Communication strategies	19	1	2		22
Conference or workshop	6	5	10	1	22
Decision-support tool			8		8
Demonstration area			2	4	6
Email		2	8	1	11
Extension specialists		4	10		14
Information characteristics	3	4	9		16
Journal paper		2	6	2	10
Levels of detail			15		15
Networks	1	7	11	7	26
Photo series	6		10		16
Professional societies		2	3	1	6
Science/management interaction	13	5	16	6	40
Summaries of papers	15	6	17		38
Syntheses	1		8		9
Target audiences			84	1	85
Training			9		9
Web site	10	7	13	1	31
Unclassified	14	14	32	11	71
Total	88	59	279	36	462

There are multiple audiences for scientific information from the FFS study who require different kinds of information or levels of detail.

suggested that the "hook" that would cause users to want more information would be the information itself and not the statistics or methods of collecting the data. Finally, there was broad agreement that written results include clearly identifiable "sidebars" where management implications for future decisions are stated.

Workshop participants at Lubrecht repeatedly stressed that there were multiple audiences for scientific information resulting from the FFS study and that these different audiences required different kinds or levels of detail in the information that would be most beneficial. Lubrecht participants acknowledged that the challenge for FFS study researchers was to recognize that different audiences exist and then develop methods for delivering the scientific information in forms that were more readily available and could be more simply applied. These participants then engaged in focused discussions on how best to target or identify different audiences and their needs. For example, policymakers may use findings that are often broad generalizations or "big picture" concepts, yet they often need the opportunity to ask detailed questions of specialists. Agency decisionmakers and managers rarely have time to delve into published scientific literature and may appreciate short and concise syntheses without the complexity of findings of detailed journal papers, yet they expect their staff specialists to be knowledgeable about the details. Extension specialists and county agents of the Cooperative Extension System conduct education programs based on local or state needs and respond to information requests from family forest owners, professional managers, decisionmakers, and private citizens, thus they often interact with groups who may have vastly different needs.

Workshop participants identified science/management interactions as an important and underused means of conveying scientific information (fig. 9). These interactions were variously described as on-the-ground consultations with researchers, one-on-one interactions, or general management reviews. Participants suggested that the most fruitful interactions were those that involved the sharing of advice and information rather than critique or criticism. Another desirable feature is for researchers to meet with local managers in person, preferably in the field rather than in an office setting, to ensure that the latest scientific information can be readily implemented. A working example of these interactions was described at the Solon Dixon workshop: natural resource managers at Eglin Air Force Base in northwest Florida regularly solicit advice and consultation from researchers not affiliated with the base.

Similarly, workshop participants stressed the importance of a network of FFS study researchers and managers who serve as recognized champions and speakers for the entire study. This network of authorities could more easily influence wider

Figure 9—Clients at regional workshops identified science/management interactions, especially those that are one-on-one and in the field, as especially important in ensuring that the latest Fire and Fire Surrogate study information can be readily implemented.

audiences because of their knowledge and because of the trust held in them by others. At another level, all of the workshop participants form a network of individuals that could serve as an information conduit. One suggestion was for FFS study researchers to develop stronger partnerships with state foresters to aid in technical assistance, and partnerships with extension specialists and county agents in the Cooperative Extension System to aid in education programs. Another suggestion surfaced at Blodgett: FFS study researchers should be a primary source of scientific information on fuel reduction and forest restoration for policymakers. This form of networking differs from advocacy, a restricted action for federal researchers. In the suggested networking, FFS study results and information would be provided directly to policymakers who might not normally acquire the information in an efficient manner. Federal researchers thus avoid participation in resource management decisions.

There was broad agreement that printed summaries of FFS study results were highly beneficial and desirable. These summaries of research papers were described as fact sheets or one- to four-page extended abstracts that put the research questions into context, and emphasize management implications rather than the methods and actual results. One example of this approach currently used by the U.S. Geological Survey is the distribution of a single-page "Publication

Brief for Resource Managers" timed for release by various research centers when a peer-reviewed paper is published. These briefs provide managers with an easy means of capturing the importance of a study, the key results and inferences, and contact information of the authors.

Publication of syntheses addressing the four FFS study treatments and perhaps others was perceived as being key to the overall communication of FFS study findings

Also included in the discussion of summarizing FFS study results was the suggestion to emphasize syntheses of FFS study results across multiple disciplines and sites, and across fuel reduction and forest restoration research in general. Participants expressed the need for a complete bibliography of research designed to reduce fuels and modify fire behavior. A synthesis of available information would pull together results from various studies. Some of this information is not easily obtained by resource managers, and other information may not be in a coherent form. Publication of syntheses addressing the four FFS study treatments and perhaps others was perceived as being key to the overall communication of FFS study findings. This effort would identify information gaps and increase the scientific credibility of the work.

The Internet has become a common means of accessing information, and workshop participants indicated that FFS study results and information should be accessible from Web sites. Web sites were perceived as a primary means of communicating FFS study results to the general public. Key features of these Web sites included: (1) information is available at different levels of complexity, (2) all peer-reviewed journal papers and their accompanying summaries are readily available, (3) the site contains glossary and keyword links, (4) the site is searchable by keyword, and (5) a system exists for frequent users to register and be notified of new postings.

The Internet affords the opportunity to use email systems and listservers to rapidly transmit common messages to large numbers of potential users of new information. Emails to entire topical groups can alert users to new FFS study results, and provide links to more detailed information in peer-reviewed journals, other documents, Web site postings, summaries of conferences or technical workshop presentations, short courses or workshops that feature FFS study results, or other products based on FFS study findings.

Conferences and technical workshops were considered highly functional venues for disseminating FFS study results and information. In addition to conferences and workshops that focus exclusively on FFS study results, workshop participants listed a number of more general conferences and workshops that would also serve as outlets. These include local, state, and national meetings of professional societies such as the Society of American Foresters; forest vegetation management conferences; regional multiagency workshops such as the Biennial Southern Silvicultural

Research Conference; and private sector stewardship conferences such as those conducted by the Longleaf Alliance. These conferences and workshops provide an opportunity to communicate through relatively formal procedures such as prepared talks, slide presentations, and panel discussions, in addition to less formal one-on-one discussions and ad hoc gatherings. Finally, workshop participants suggested that summaries of workshops and conferences be made available in hardcopy and online.

Several participants at Lubrecht commented on models and decision-support tools. Although these tools may help interpret the science as an aid in decision-making, their limitations must be clearly defined. More emphasis should be placed on refining and improving existing models to make them more effective, extensive, and user-friendly rather than building new models. The participants noted that the existence of multiple models designed and maintained for the same purpose is not beneficial and leads to questions of credibility.

Demonstration areas were considered especially beneficial (fig. 10). These sites provide a means of displaying the various fuel reduction and forest restoration treatments in real time and can be broadly used to showcase FFS study results that are easily understood and repeated. Demonstration areas open to the public are

Figure 10—Field trips to study sites and demonstration areas, such as this portion of the treated stand at the Gulf Coastal Plain Fire and Fire Surrogate study site at Solon Dixon, Alabama, provide an effective means of communicating treatment responses.

effective for communicating with neighborhoods and forest landowner associations in the wildland-urban interface because visitors can drive to and walk through the various stands and see side-by-side treatment differences.

Extension specialists and county agents of the Cooperative Extension System are trained professionals who communicate scientific information to a wide variety of audiences and levels of users. Workshop participants noted that FFS study results could easily be transferred by extension specialists and county agents. This may require closer ties than currently exist between FFS study researchers and extension specialists or county agents. In addition, extension specialists and county agents are not currently tasked with working directly with federal agencies outside the U.S. Department of Agriculture. They often focus their efforts on the private, nonindustrial forest or family forest owner, and private citizens. And they often have access to staffs with extensive technology transfer skills and resources.

Workshop participants at Blodgett and Lubrecht suggested that one unique method of sharing results from the FFS study may be a photo series consisting of various stands involved in the FFS study at different treatment levels or stages of development. It would aid managers because it would provide a strong visual guide to what has already happened within the FFS study treatments and what might be expected to occur on similar sites. It could also provide a strong tool for communicating with the public because many people respond more readily to pictures or visual images. Images of FFS study sites before and after treatment would provide the public a greater appreciation of expected results of planned treatments. Such images would provide fuels specialists a common image to use in reports detailing expected treatment responses, and may help span communication gaps between different disciplines.

Lubrecht workshop participants identified formal agency training, continuing education, and formal university education programs as additional opportunities to communicate FFS study results.

Client Reactions to FFS Study Results

We asked workshop participants to identify new and potentially important findings, conclusions, or insights gained from the presentations of preliminary FFS study results. These ideas may represent take-home messages, revelations, or a greater understanding as a direct consequence of our work. We also asked workshop participants to help us better understand opportunities for communicating results of the FFS study by identifying key questions for FFS study researchers, describing their perception of the study limitations, and critiquing information presented by FFS study researchers. Workshop organizers and FFS study researchers rarely had time to address the questions or comments directly because they often were beyond the scope of preliminary study results. In most cases, these questions or reactions suggest broad, integrated perspectives on fuel reduction and forest restoration.

Workshop participants indicated that the results of FFS study treatments were consistent with managers' expectations because the FFS study treatments were consistent with current management practices (table 8); the FFS study was designed to evaluate existing treatments instead of developing new practices. Participants at the Blodgett workshop indicated that the FFS study treatments were either the same or closely similar to those described in planning documents for national forests of the central Sierra Nevada, and that preliminary results of the FFS study were consistent with the assumptions on which the planned treatments on these national forests were based. In addition, the preliminary results were consistent with work in progress on private lands in California. Other workshop participants pointed out that one key message was that fuel reduction and forest restoration treatments being applied in fire-dependent forests were done in a sound, scientifically-based manner, and that managers now had a scientific basis for backing their decisions (fig. 11).

Another relevant take-home message for many workshop participants was the direct effect of some treatments. For many, the workshop and field trip was their first opportunity to observe the results of an operational prescribed fire in their local forest type. The participants, especially at Blodgett and Green River, seemed to anticipate more substantive changes in stand structure because of greater tree mortality,

Table 8—Benefits, insights, and messages from the Fire and Fire Surrogate study identified by participants at regional workshops

	Regional workshop				
Key findings and insights	Blodgett	Green River	Lubrecht	Solon Dixon	Total
Communication tools differed by user		4	2		6
Economics of treatments	2			3	5
Fire effects	4				4
Metrics to establish goals	4				4
New views on treatment responses	3				3
Scientist insights		1	3		4
Study design attributes	2		2		4
Topics of workshop were relevant		5	1	1	7
Tradeoffs among treatments	9		2		11
Treatment implementation	2	1		2	5
Treatment effects	5	7	2	4	18
Treatment feasibility	1	2	1		4
Validation of existing practices	10		1	1	12
Workshop applicability		1	1	1	3
Unclassified	6				6
Total	48	21	15	12	96

Figure 11—Participants at regional workshops believed that the Fire and Fire Surrogate study provided the scientific basis to support decisions by resource managers to conduct fuel reduction and restoration treatments in many fire-prone forests, such as oak-hickory forests at the Southern Appalachian Mountain Fire and Fire Surrogate study site on the Green River Game Land in North Carolina.

and commented that seeing the burn-only treatments was a valuable lesson. Others commented that seeing the treated stands convinced them that a single application of any one treatment would not be sufficient to either produce the desired structure or to significantly reduce fuels, and that continued or repeated active manipulation was required. This concept closely relates to observations made at Green River and Solon Dixon that changes occurring after treatment, such as reestablishment of understory layers and increases in plant biodiversity, were faster than expected; hence future treatments will likely need to be repeated sooner than anticipated. Finally, it was noted at Lubrecht that the changes associated with the active FFS study treatments are likely to be relatively subtle compared to changes associated with historical disturbance regimes.

A final take-home message for workshop participants was the increased knowledge of treatment effects to allow better understanding of tradeoffs among treatments. Workshop participants commented that because the three active treatments resulted in similar short-term ecological effects, and that as these effects were usually subtle in nature, then the decision to treat or to select among treatments could be based on concerns that were beyond the scope of the FFS study, such as smoke production and distribution, and opportunities to recover some or all of the treatment costs through biomass removal.

The most common set of questions or reactions raised by the workshop participants dealt specifically with fuel reduction and forest restoration treatments (table 9). Those at Blodgett, Green River, and Lubrecht expressed support for the active treatments, yet questioned whether management agencies were treating sufficient portions of the landscape necessary to reduce wildfire severity. Use of burning as a single, stand-alone treatment was viewed with concern at Green River, Lubrecht, and Solon Dixon, in part because ownerships are juxtaposed, and in part because of competing resource objectives. For example, burning has special liability issues on private lands, and may not be an option near heavily-used road corridors such as the interstate highway system where smoke dispersal patterns could impede traffic, may become increasingly difficult as the wildland-urban interface expands, and may be counter-productive on some industry lands where tree growth rates are maintained through fertilization. Participants at Blodgett and Lubrecht recognized that the FFS study was designed with controls and replicates, experimental design components often lacking in large-scale fire ecology research, and indicated that this study strength was important for establishing the study's credibility and increasing trust in the resulting information. Finally, there were questions about treatment costs that surfaced at each workshop. Workshop participants recognized that a manager's decision to implement one or more treatments was likely to involve

Table 9—Key questions for Fire and Fire Surrogate study researchers asked by participants at regional workshops

	Regional workshop				
Manager questions	Blodgett	Green River	Lubrecht	Solon Dixon	Total
Communication	2	2	9		13
Competing goals	1		4	4	9
Economics of treatments		4	22	5	31
Efficacy of treatments	4		14	3	21
Fire behavior	3				3
Forest restoration treatments	3		9		12
Fuel reduction treatments	13	6	17	8	44
Future work	3				3
Liability of landowners	1		10	1	12
Limitations of existing knowledge		1	14	4	19
Models and decision-support tools	1		14	4	19
Monitoring of effects			5		5
Policy differences			4		4
Scale effects to larger landscapes	10			13	23
Social issues of treatment acceptance	8		12		20
Validation of decisions	2	1	1	1	4
Wildlife species concerns	7		3	3	13
Unclassified	5	1	3	3	12
Total	63	15	151	31	260

consideration of more than just the FFS study results; direct and indirect costs often are as influential as are predicted outcomes or expected results. There was broad recognition that fuels treatments in the wildland-urban interface were increasing in priority and that these treatments had higher costs because of greater risks. This may be especially relevant in the Southeast, where longleaf pine restoration efforts may lead to higher real estate values.

More specific questions and concerns about costs of fuel reduction treatments were raised at each of the workshops. Workshop participants at Lubrecht questioned the economic analyses of FFS study treatments and suggested that a more complete assessment would likely include the related costs of wildfire suppression after each treatment was implemented, and that any future costs should also incorporate the value of timber or other wood products potentially produced, thus including future tree growth. They pointed out that treatment costs may be offset by removal of wood products either at the time of treatment or in the future, assuming viable markets exist (fig. 12). Workshop participants at Lubrecht suggested that private landowners were more likely to thin stands because of economic opportunities than for fuel reduction objectives. Workshop participants at both Green River and Lubrecht questioned how best to assign costs of treatments when public lands join private lands because the resource values and available funds may not be similar;

Figure 12—Workshop participants in the West pointed out opportunities to incorporate current and future values of wood products and that treatments costs often can be balanced by product value when viable markets exist for the wood products. Treatment cost may include specialized equipment such as this forwarder used at the Blue Mountains Fire and Fire Surrogate study site at Hungry Bob, Oregon.

one individual pointed out that in some Eastern States the time needed to complete required paperwork exceeded the time needed to actually conduct the treatment. In addition, sufficient labor, including certified crews, may not be available to implement treatments on private lands.

Workshop participants at Blodgett, Lubrecht, and Solon Dixon expressed concern that despite the preliminary FFS study results highlighting fuel reduction benefits, there remain unanswered questions about treatment efficacy. For example, managers lack an understanding of how the FFS study treatments may mimic natural fire effects, an understanding of how best to use treatments effectively across landscapes when faced with limited funding, and an understanding of how best to measure and communicate treatment performance to the public and those responsible for funding the treatments.

Workshop participants expressed concerns that issues outside the bounds of fuel reduction would potentially limit the use of FFS study treatments. The most common limitation listed was smoke production (fig. 13). Not only is the public increasingly concerned about burning treatments when smoke dispersal is limited, but federal and state regulations often limit the use of burning to relatively few "windows" of opportunity. Other examples of limitations include government regulations and the necessary paperwork that precedes any fuel reduction

Figure 13—Workshop participants identified smoke production during underburning, such as in the southern Sierra Nevada Fire and Fire Surrogate study site at Sequoia, California, as an issue that would limit the use of fuel reduction treatments.

treatment, the lack of sufficient infrastructure designed to use forest products that result from fuel reduction treatments, patchwork ownerships that increase concerns for landscape-scale effects, and the probability of litigation.

Social concerns not addressed by FFS study protocols were raised as questions by workshop participants at Blodgett and Lubrecht. Despite attempts by FFS study researchers to clarify that social aspects of treatments were intentionally not addressed because of funding priorities, workshop participants repeatedly pointed out that social acceptance of similar fuel reduction and forest restoration treatments will be essential for widespread implementation by government agencies. Participants pointed out current low public acceptance of stumps or blackened tree boles, so considerable work may be necessary in different regions to increase acceptance. Although FFS study researchers were careful to refrain from advocating any one treatment, some workshop participants expressed concerns that the public was unprepared to accept the levels of burning or thinning ostensibly or implicitly recommended. As previously noted, ancillary work at the Blodgett FFS study site is exploring public perceptions of stand structure and fuel composition after treatments.

Workshop participants recognized that refereed research papers may not represent the most important or effective means of transferring information to the end user,

Similar concern for communicating FFS study results was raised at Blodgett, Green River, and Lubrecht: workshop participants recognized that refereed research papers may not represent the most important or effective means of transferring information to the end user, yet researchers often lack the institutional motivation or support to engage in more extensive technology transfer to ensure the information is fully communicated. In addition, when taken out of context, research results can be misapplied. The challenge for FFS study researchers is to minimize these opportunities for mistakes by ensuring the level of detail is compatible with each user group.

Questions about FFS study results in the context of restoration goals were raised at Blodgett and Lubrecht. Workshop participants acknowledged that FFS study treatments could likely reduce the risk of uncharacteristically severe wildfire, yet were unconvinced that the same treatments were effective in meeting forest restoration goals. In most cases, treatments had subtle effects on tree size distributions, and managers are seeking treatments that accelerate the development of late-successional structures that include large trees and large snags (fig. 14). Workshop participants asked for help in projecting treatment scenarios into the future to better illustrate the long-term effects of the initial entries. In addition, it was pointed out that the public might be more receptive to the FFS study treatments if the current treatments were placed within the context of historical disturbance regimes and processes.

Figure 14—Clients at regional workshops indicated that Fire and Fire Surrogate study treatments could likely reduce the short-term risk of severe fire but were not as effective in meeting long-term restoration goals of developing late-successional structure and processes.

Liability issues were stressed at Lubrecht even though the preponderance of low-elevation dry forest in the region is in either federal or state ownership. Federal and state agencies are not exempt from liability, however, and liability concerns may restrict or limit implementation of some fuel reduction projects. Burning may be unappealing to private landowners because they also may be legally responsible for all the effects if burns are not confined to prescribed boundaries.

Workshop participants at Lubrecht expressed concern that simulation and decision-support models would become a direct means of communicating FFS study results, or that FFS study information would be indirectly incorporated into models. They indicated that many resource managers have a distrust of most models, often lack the computer skills to refine model inputs and adjust parameters to adequately tailor the output to local conditions, are concerned about making inappropriate use of models, and recognize that models provide little support when the decisions by managers are the basis of litigation.

Workshop participants at Blodgett and Lubrecht asked questions about the potential extrapolation of FFS study results and information beyond the actual stands used for comparative study. They suggested that FFS study results and information needs to be interpreted within the context of larger spatial and temporal scales. For example, the FFS study focuses on specific treatments to stands, yet fuel reduction and forest restoration treatments need to address larger landscapes and may need to involve timeframes longer than 5 years. Workshop participants asked how FFS study results and information might apply at the landscape scale and how risks and benefits found at the stand level might translate to broader scales. They also acknowledged that the initial timeframe of the FFS study was likely insufficient to provide conclusive ecological results and indicated that the fire effects would require longer timeframes to be fully manifested. In contradicting earlier concerns for simulation and decision-support models, they asked if some of the short-term findings could be incorporated into models to predict more long-term effects. Finally, workshop participants at Lubrecht suggested that logical extensions of the FFS study incorporate consideration of how to prioritize treatments across larger landscapes and how to begin assessing the cumulative effects of treatments over time.

The FFS study design and protocols limited wildlife considerations to only a few groups such as avian species, small mammals, and amphibians (eastern sites only). In most cases, home range sizes of many mammals and birds exceeded the FFS study plot size. Workshop participants at Blodgett, however, were concerned that some wildlife considerations within the FFS study did not extend to certain high-interest species and their prey. Cited as examples were the northern and California spotted owls (*Strix occidentalis caurina* and *S. o. occidentalis*) and wood rats (*Neotoma fuscipes*). At the same workshop, participants countered that managers have little basis for understanding population dynamics and distributions under historical disturbance regimes, and suggested that there is little context for attempting to manage individual species.

Finally, workshop participants raised questions about the relevancy of FFS study results and information when resource management goals differ from fuel reduction and forest restoration. For example, state forests in many Western States may have forest management goals of producing diverse forest products based on stumpage values, some Eastern States manage their lands to preserve threatened and endangered species habitat, and industry lands are managed to produce economic gains. It apparently was unclear to some that the objectives of fuel reduction and forest restoration and the FFS study results and information represent only one component of the larger matrix of competing management goals.

Client Considerations for Improving Science Delivery

During the four FFS study regional workshops, invited participants offered many recommendations for improving overall science delivery and specific ideas for improving delivery of FFS study results and information (table 10). Many recognized that organizational constraints of the research agencies represented within the FFS study, such as Forest Service Research and Development and U.S. Geological Survey, emphasize and favor science delivery through traditional peer-reviewed journals and place less emphasis on ensuring the science is more directly delivered into the hands of users. Although workshop participants acknowledged that active science delivery, such as occurred during the workshop field tours, was an effective means of communicating, they also recognized that science delivery in forms other than peer-reviewed journals would require increased effort by researchers and that organizational constraints provide little support for such activities. One proposition for going beyond the current paradigm of emphasizing science delivery by relying on peer-reviewed journals would involve greater researcher and manager interaction before any study is implemented, with managers helping to define science delivery processes as part of the formal study planning. A potential advantage of this collaboration is recognition of science-delivery methods beyond the expertise of researchers, with sufficient time to identify and include specialists before the research has been concluded. Perhaps the most common theme for improving delivery of FFS study results and information was that specific study results were not as important as answers to managers' questions and information generated from the FFS study that would aid managers in making decisions. For example, knowing that fuels can be reduced in the short term by a particular strategy may be more important than specifics on how much fuel was reduced.

Table 10—Recommendations for improving delivery of Fire and Fire Surrogate study science offered by participants at regional workshops

Recommendations for improving science delivery	Regional workshop: Blodgett	Green River	Lubrecht	Solon Dixon	Total
Different levels of information		4	17		21
Extension specialists			4		4
Goals for delivery	1		20		21
Models and decision-support tools			7		7
Papers in scientific journals	2	1	7		10
Presentations		2	2	1	5
Study results or information	2	3	29	1	35
Syntheses of existing knowledge	2		8		10
Tours and field trips	4		1		5
Unclassified			3	1	4
Total	11	10	98	3	122

Workshop participants repeatedly stressed that different levels of information were needed from the FFS study: some kinds of managers needed relatively general kinds of information, whereas others needed more detailed information. Although we made no attempt to quantify these differences in the levels of information needed, it is apparent that the closer the user of information is to actual implementation of fuel reduction and forest restoration treatments, the more detailed the information desired. For example, city and county commissioners, leaders of local or national environmental, conservation, or professional groups, and the insurance industry most likely would benefit from relatively general information derived from the FFS study or broad project overviews, whereas family foresters and private, nonindustrial forest owners, consulting foresters, extension specialists and county agents, and agency staff specialists responsible for developing treatment plans would most likely need more detailed information.

Workshop participants followed discussion of the need for information (rather than results) and information with different levels of detail by suggesting the FFS study researchers clarify science delivery by identifying a single, unified message of how FFS study results and information support and facilitate the use of similar fuel reduction and forest restoration treatments at similar sites.

More definitive recommendations were made for specific forms of science delivery. Workshop participants again pointed out that papers in peer-reviewed journals were more beneficial when they contained clearly identifiable management implications or suggestions on how to apply the results. In addition, participants recommended that more effort be devoted to multisite and multistudy syntheses based on the widest possible range of published fuel reduction and forest restoration studies, instead of just the FFS study. These syntheses should bring together the large number of divergent and contradictory study results, indicate where commonality exists and where knowledge gaps occur, and consolidate the different results in a coherent manner. Specific kinds of research products, such as path diagrams and structural equation models, were considered overly complicated for the majority of end users. Tours or field trips that provided opportunities for group dialog and discussion were considered beneficial. Finally, the workshop participants at Lubrecht recommended that FFS study researchers devote more effort to establishing collaborative relations with the network of extension specialists who may have greater skills in science delivery with some user groups.

Recommendations for Fire and Fire Surrogate Study Science Delivery

Communication Strategies

Successful communication plans contain four common processes: research, planning, implementation, and evaluation. Research, in the context of developing a communication plan, involves probing the attitudes of various groups to determine the appropriate kinds of tools, messages, and key audiences around which to focus the communication plan. We will use our prior experience in communicating FFS study results and information, and the four regional workshops and combined input of participants, as the research step in developing a new communication plan for the FFS study.

Planning includes defining the challenge or goal, setting objectives, defining audiences, and listing what needs to occur. The challenge can be identified as overcoming negative perception, creating awareness, or expanding an existing situation. Objectives provide meaningful and measurable metrics for achieving the stated goals. Defining audiences implies that different groups of users will have different needs for FFS study results and information and there will be different methods of science delivery. Next, a detailed communication plan will outline how the relevant science will be delivered to each of the groups. Finally, the communication plan needs to include projected costs and timeframes.

Implementation is the third process in completing a successful communication plan. Successful communication strategies involve using science delivery methods and materials targeted to specific user groups, using multiple communication tools to deliver messages in different forms to the same user group, and ensuring consistency of messages across the various science delivery tools and products.

Evaluation is the final step in a successful communication strategy; specifically evaluating the ongoing results of the communication effort against the objectives set during the planning stage. Questions that might be asked include:

- Were all identified user groups actually reached?
- Did the different user groups understand the messages?
- How are different groups using the science?
- Did the science delivery remain on schedule and within the projected costs?

2001 Fire and Fire Surrogate Study Communication Plan

National FFS study researchers developed and released a network-wide communication plan in 2001. This plan addressed nine specific venues for communicating FFS study results and information: a network Web site, an identifiable series of publications, a set of brochures, a standard set of electronic presentations, a full-color poster, a collection of study plans from all FFS study sites, a single FFS study-wide corporate database, and a national conference.

The FFS study Web site was originally developed and managed wholly within the FFS network. It was designed to be informational for many audiences, including the general public. It contained a variety of messages, focusing on a general description of the overall FFS study, contact information for the principal investigators, a listing of science-delivery products, and links to individual FFS study site Web sites. Early in 2005, the Web site was revised to provide more information, and electronic copies of all publications were posted. Late in 2006, the entire FFS Web site was fully migrated into FRAMES (Fire Research and Management Exchange System) (http://frames.nbii.gov/ffs), an outlet for exchanging information and transferring technology between wildland fire researchers, managers, and other stakeholders. In partnership with the U.S. Geological Survey's National Biological Information Infrastructure (NBII) Program, FRAMES is implementing Web-based technologies to help bridge the gap between fire science and management.

The brochures, electronic presentation, poster, and study plans described efforts planned within the context of study implementation rather than serving as a means of conveying information to managers. Peer-reviewed and non-peer-reviewed papers continue to be a common means of communicating FFS study results and information, and the combined efforts of FFS study researchers through 2006 have led to nearly 80 citable papers (table 11). A majority of these are not in peer-reviewed publications; however, the number of peer-reviewed publications is expected to increase as the study matures. All FFS study data have been archived and structured in a national database available to all principal investigators. This common database, essential for cross-site and multisite comparisons, will soon be moved into FRAMES. Finally, the FFS study principal investigators organized and convened a full-day symposium at the Third International Fire Ecology and Management Congress, 16 November 2006, in San Diego, California. National perspectives of the FFS study were presented through multidisciplinary, interdisciplinary, and multisite results.

While the 2001 communication plan did not specifically call for tours and field trips (a responsibility left to each FFS study site), these events provided a unique opportunity for FFS study researchers to showcase actual treatment sites and engage participants in more detailed discussions than are usually possible during more formal conferences and symposia. Between 2001 and 2005, there were 74 field tours and field trips hosted by FFS study researchers (table 11).

Table 11—Fire and Fire Surrogate (FFS) study science outputs by year

	Fiscal year produced								
Deliverable type	1999	2000	2001	2002	2003	2004	2005	2006	Total
Poster			5	13	17	9	5		49
Master's thesis	1			9	3	5	1		19
Doctoral dissertation							3		3
Non-peer-reviewed publication	1	5	2		3	20	1		32
Peer-reviewed publication					1	3	10	9	23
Invited paper or presentation	4	5	18	35	20	11	22	6	121
Conference or workshop		1	9	28	37	40	14	5	134
Tour or field trip			3	9	38	12	12		74
Total	6	11	37	94	119	100	68	20	455

Fire and Fire Surrogate Science Delivery

In the following section, we provide our recommendations for conducting science delivery of FFS study results and information. This section is not a full and complete communication or science delivery plan, yet it provides the foundation for later development of such a plan. Organization of this section is based on a matrix of user groups identified by workshop participants arrayed with potential communication tools appropriate for each user group (table 12). Opportunities to communicate FFS study results and information are not limited to the methods indicated in this matrix. The matrix indicates those opportunities that are likely to be most effective. The order of their discussion begins with those opportunities with the potential to reach the widest audience, and proceeds to those opportunities that focus on more narrowly defined user groups.

As noted in a previous section, the full-featured FFS study Web site is now hosted by the FRAMES portal (http://frames.nbii.gov/ffs). This portal appears to meet the needs of a wide variety of potential FFS study user groups because (1) information is available at different levels of complexity; (2) all peer-reviewed journal papers are currently available, and the Web site provides accompanying summaries; (3) glossaries and keyword links exist for many FFS pages; (4) the entire FRAMES site is searchable by keyword; and (5) FRAMES provides a system for frequent users to register and be notified of new postings. We recommend the FRAMES site continue to host our FFS Web site because FRAMES will likely provide information to all user groups.

Email systems and listservers can be used to rapidly transmit common messages to large numbers of potential users of new FFS study results and information. This use is likely best limited to existing systems outside the FFS study organization. For example, Forest Service Research Stations commonly use

Table 12—Potential Fire and Fire Surrogate (FFS) study user groups and science delivery tools

	Fire and Fire Surrogate study science-delivery user groups													
FFS science-delivery tools	**Academia**	**Conservation groups**	**Extension specialists**	**Federal agencies**	**Local governments**	**NEPA analysts**	**Nonindustrial private foresters**	**Policymakers**	**Practicing foresters**	**Public**	**Stakeholder groups**	**State agencies**	**Timber management organizations**	**Tribal foresters**
Conference or workshop	X	X	X	X		X			X		X	X	X	X
Decision-support tool			X	X			X		X		X	X	X	X
Demonstration area	X	X	X		X					X	X			
Email	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Extension specialists		X		X	X		X		X	X	X	X		X
Journal paper	X					X			X			X	X	X
Network		X			X	X		X			X			
Photo series		X	X	X			X		X	X	X	X	X	X
Professional society	X	X	X	X					X	X		X	X	X
Science/management interaction				X		X	X	X	X			X	X	X
Summaries		X	X	X	X		X	X	X	X	X	X	X	X
Syntheses	X	X	X	X		X	X	X	X	X	X	X	X	X
Web site	X	X	X	X	X	X	X	X	X	X	X	X	X	X

NEPA = National Environmental Policy Act.

email to distribute press releases notifying those that have previously requested such information that a new publication is released and available. Professional organizations such as the Society of American Foresters routinely announce similar research products. Users of the FRAMES portal may also request notification of new postings. We recommend use of these existing systems rather than the development of new email or listserver systems unique to the FFS study.

We recommend that FFS study researchers dedicate resources to summarize or synthesize FFS study results across multiple disciplines, across multiple sites, and across fuel reduction and forest restoration research in addition to the FFS study. There is an overwhelming need to summarize all existing work conducted to date at each of the 13 FFS study sites. In addition, there is a need to synthesize available information addressing the four FFS study fuel reduction and forest restoration treatments and other treatments designed to reduce fuels or modify fire behavior. This synthesis of available information, although not conceived as a part of the FFS study, would pull together results from various studies, identify information gaps, and increase the scientific credibility of the overall FFS study. We recommend researchers who prepare syntheses establish and use systematic review guidelines to minimize bias. Such guidelines include (1) a clear definition of questions of interest, (2) documented search strategies and explicit criteria for identifying relevant evidence, (3) appraisal of internal validity of included studies, (4) use of formal statistical techniques that ensure the synthesis is undertaken in a repeatable manner, and (5) presentation of conclusions with clear indicators of the strength of evidence and applicability of results (Roberts and others 2006). With these guidelines, syntheses are likely to inform most user groups.

We agree with the majority of workshop participants that time demands on many agency managers prevent them from reading papers in peer-reviewed journals and that printed summaries of FFS study results would be highly beneficial and desirable. These summaries should put the research questions into context with resource management issues and emphasize management implications rather than methods and actual results. These briefing pages should provide managers the distilled version of a study or piece of research, key results and inferences through bulleted statements, and contact information if managers wish to address questions to the lead researchers. We recommend that FFS study researchers take advantage of the opportunity to have research summaries produced and distributed by the Joint Fire Science Program.

Conferences and technical workshops serve as valuable science delivery venues for FFS study results and information because they provide opportunities for researchers to present new information and for researchers and individuals from almost any user group to network and interact. Through both formal and informal question and answer sessions, researchers and users establish connections that often extend beyond the conference setting. In most cases, information presented at conferences and technical workshops has yet to be published in more formal peer-reviewed journals, and the information usually should be considered tentative and subject to change. The level of detail in the material delivered is likely a function of the user group, and for some user groups such as federal agencies, state agencies, and stakeholder groups, the communication plan should account for these differences.

The concept of a photo series was described and endorsed during two workshops. This suggested photo series could consist of various stands involved in the FFS study at different treatment levels or stages of development. It would potentially aid managers because it would provide a strong visual guide to what has already happened within the FFS study treatments and what might be expected to occur on similar sites. It could also provide a strong tool for communicating with the public because many people respond more readily to pictures or visual images. We do not recommend developing a unique, stand-alone photo series as a primary science delivery tool. Instead, we recommend FFS study sites be incorporated into the national database of photos and fuel descriptions of the Fuel Characteristic Classification System (FCCS) (Ottmar and others, in press; Sandberg and others 2001; Sandberg and others, in press). This system is used to construct fuelbeds with quantitative fuel characteristics (physical, chemical, and structural properties) and probable fire parameters from inventoried data in six horizontal strata: (1) ground fuels (duff); (2) litter, lichen, and moss; (3) woody fuels (consisting of sound and rotten wood, piles, and stumps); (4) herbaceous (nonwoody) vegetation; (5) shrubs; and (6) tree canopies (consisting of both live and dead trees [snags] and ladder fuels associated with them). The description of fuelbeds within the FCCS allows the user to calculate three measures of fire hazard: surface fire behavior potential, crown fire potential, and the fuels available for consumption. These potentials provide managers a means of comparing and communicating the fire hazard associated with any unique fuelbed to evaluate the effectiveness of fuel treatments. The potentials also provide the public and various stakeholder groups easily interpretable indices of treatment response.

Presentations before professional societies, such as the International Association of Wildland Fire, Society of American Foresters, Wildlife Society, Soil Science Society of America, and the Ecological Society of America, represent a more focused form of conferences because the attendees are normally members of the professional society and share a common interest and understanding of the general topic around which the professional society is centered. Like more general conferences and workshops, presentations by FFS study researchers at professional society annual meetings, conferences, and workshops provide opportunities for researchers to present new information and for researchers and society members to network and interact. Through both formal and informal question and answer sessions, researchers and society members establish connections that often extend beyond the conference setting. Information presented at society conferences and technical workshops may have previously been published in peer-reviewed journals or may be published in the conference proceedings. The material delivered may be relatively detailed, and is likely to be accessed and used by scientists, conservation groups, extension specialists, federal and state agencies, policymakers, practicing foresters, timber management organizations, and tribal foresters.

We recommend greater collaboration between FFS study researchers and extension specialists and county agents of the Cooperative Extension System. These specialists and agents serve as educators for family forest owners, professional managers, decisionmakers, and private citizens. Their science-delivery programs could also benefit conservation groups, local governments, stakeholder groups, state agencies, tribal foresters, and federal agencies other than those in USDA. Most extension specialists and county agents have more experience than federal and university researchers in accessing detailed scientific information and transferring it to various user groups with appropriate levels of detail.

Decision-support tools and models that incorporate FFS study results are most appropriately designed specifically for those who make (or advise on) resource management decisions. This includes support foresters, fuels specialists, and decisionmakers in federal and state agencies, extension specialists, and field foresters and fuels specialists with tribes, industrial, and nonindustrial private forests. When decision-support tools and models are considered for use in science delivery, careful consideration should be given to refining and improving existing models to make them more effective, extensive, and user-friendly, rather than building new tools and models.

Direct interactions between FFS study researchers and local or regional managers were described as on-the-ground consultations with researchers, one-on-one interactions, or general management reviews, ensuring that the latest scientific information can be readily implemented. Opportunities to initiate these direct interactions are likely to occur as a result of conference or workshop presentations, field trips to demonstration sites, publication of journal papers, invitations to speak directly to managers, and information posted on FFS Web pages. We recommend FFS study researchers continue to meet directly with managers of federal and state agencies, those serving as NEPA analysts, practicing and nonindustrial private foresters, policymakers, timber management organizations, and tribal foresters.

Demonstration areas are likely to be a highly efficient and cost-effective means of communicating FFS study results and information to potential users who are more comfortable with qualitative rather than quantitative information. Demonstration areas can be developed at each of the FFS study sites by selecting portions of the actual treatment units that best represent the overall treatment response and provide the easiest access. Much of how user groups perceive treatment alternatives is visual. Because forests, including treated portions, are heterogeneous, it is important to showcase this heterogeneity. Careful consideration should be given to the selection of demonstration areas that encompass variation in both pretreatment and posttreatment conditions. Demonstration areas can be developed with common signage, consistent themes, and uniform messages to help communicate key results. The areas may be an effective means of communicating with students, conservation groups, private landowners, extension specialists, local governments, the general public, and stakeholder groups. Effective demonstration areas ideally will be near population centers or the wildland-urban interface so that visitors can drive to and walk through the various stands and see side-by-side treatment differences.

Papers in peer-reviewed journals will continue to be a standard means of FFS study science delivery for at least three key reasons: (1) the peer-review process is a fundamental component of the scientific process that validates the quality, integrity, and credibility of the work; (2) only high-quality peer-reviewed journals provide the abstracting and indexing that enables electronic searches and retrieval of entire papers; and (3) the research organizations represented by the FFS study researchers continue to use peer-reviewed papers as the most important measure of scientific output. We recommend that FFS study results and information first be published in peer-reviewed journals that offer electronic access through the Internet, and subsequently be redistributed and transferred through a variety of science delivery tools to various end users.

We recommend that the network of FFS study researchers embrace the concept of becoming champions and speakers for the entire study. This network could become a primary source of scientific information on fuel reduction and forest restoration treatments for many end users. Individual FFS study researchers, especially lead researchers at each study site, should explore opportunities to provide clear, concise, and timely FFS study results directly to end users who do not normally acquire such information from more traditional sources such as scientific journals. End users that could most benefit from direct interactions with FFS study researchers include conservation groups, local governments, NEPA analysts, policymakers, and stakeholder groups.

Our workshops were not the first effort to identify information needs and communication styles. Previous Wildland Fire Workshops initiated by the Joint Fire Science Program were designed to prioritize recommendations for wildland fire research, identify effective partnerships, and identify types of effective information, tools, and processes (White 2004). Although these Wildland Fire Workshops, held in Oregon, Arizona, and Colorado, were in response to especially large and severe wildfires, they failed to incorporate the perspectives of managers of Eastern and Southern United States forest ecosystems. Forest restoration issues in these regions may not parallel those of their western counterparts, who place more emphasis on reducing the risk of wildfire.

Given the broad array of user groups represented by participants at the four workshops and the expansive listing of fuel reduction and forest restoration information needs, what are the implications for delivery of FFS study science information and technology? Our four regional workshops identified distinct groups as potential users of FFS study results and information, including academia, conservation groups, extension specialists, federal agencies, local governments, NEPA analysts, nonindustrial private foresters, policymakers, practicing foresters, the general public, stakeholder groups, state agencies, timber management organizations, and tribal foresters. These various users desire not just the immediate results of any subset of FFS study treatments, but more importantly, they want to better understand the implications of the FFS study results with respect to numerous management issues. These issues include burning techniques; economics associated with different treatments; wildfire behavior; forest health and forest restoration efforts; scaling of effects from stand to landscape; monitoring of important responses; social issues that cross multiple spatial scales; relationships between past, present, and future stand structures; integration of these results into decision-support tools; implications of different treatments; and effects of the FFS study treatments on wildlife.

Workshop participants identified numerous areas where FFS information may have an immediate impact.

At a broader scale, the workshop participants identified numerous areas where FFS information may have an immediate impact, including management of forest biomass, determining costs for similar fuel reduction treatments, linkages between specific treatments and effects over multiple temporal scales, legal issues, differences in liability across ownership patterns, underlying scientific basis for resource management activities, social concerns across spatial scales, identifying how treatments can be used to target specific tree species for retention or reduction, and the extent to which alternative fuel reduction treatments result in conditions that would be predicted to change fire behavior. Similarly, participants identified some immediate benefits or new and potentially important findings gained from the workshops. Managers now have a scientific basis backing their decisions to implement fuel reduction and restoration treatments, the FFS study provided opportunities for many to see the immediate effects of fuel reduction and forest restoration treatments, and, in many cases, results indicate that multiple or repeated treatments are needed to restore forest health.

The workshops met the objective of identifying opportunities for communicating FFS study results and information. Workshop participants provided insight into various science-delivery venues and tools. Collectively, their comments indicate that delivery of FFS study science information and technology has the potential for wider and more multifaceted societal impact than likely originally perceived by

FFS study researchers or the Joint Fire Science Program. The FFS study researchers are now prepared to develop and implement an enhanced communication plan and science delivery effort. Finally, we believe these same questions— Who needs fuel reduction information? What information do they need? Why do they need it? and How can it best be delivered? —are equally applicable to other Joint Fire Science Program research efforts.

Acknowledgments

The authors acknowledge the thoughtful review of an earlier draft of the manuscript by D. Baumgartner, S. Charnley, and J. McIver. This is contribution number 145 of the national Fire and Fire Surrogate study, funded in part by the U.S. Joint Fire Science Program.

English Equivalents

When you know:	Multiply by:	To find:
Meters (m)	3.28	Feet
Kilometers (km)	.6215	Miles (mi)
Hectares (ha)	2.47	Acres

Species Names of Plants

Douglas-fir	*Pseudotsuga menziesii* (Mirbel) Franco
Eastern white pine	*Pinus strobus* L.
Grand fir	*Abies grandis* (Dougl. ex D. Don) Lindl.
Hickory	*Carya* Nutt.
Incense-cedar	*Calocedrus decurrens* (Torr.) Florin
Longleaf pine	*Pinus palustris* P. Mill.
Maple	*Acer* L.
Mountain laurel	*Kalmia latifolia* L.
Oak	*Quercus* L.
Ponderosa pine	*Pinus ponderosa* P. & C. Lawson
Rhododendrons	*Rhododendron* L.
Shortleaf pine	*Pinus echinata* P. Mill.
Slash pine	*Pinus elliottii* Engelm.
Sugar pine	*Pinus lambertiana* Dougl.
Virginia pine	*Pinus virginiana* P. Mill.
White fir	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.
Yaupon holly	*Ilex vomitoria* Ait.

Literature Cited

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 493 p.

Agee, J.K.; Skinner, C.N. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management. 211: 83–96.

Arno, S.F.; Smith, H.Y.; Krebs, M.A. 1997. Old growth ponderosa pine and western larch stand structures: influences of pre-1900 fires and fire exclusion. Res. Pap. INT-RP-495. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 20 p.

Barden, L.S. 1997. Historic prairies in the Piedmont of North and South Carolina, USA. Natural Areas Journal. 17: 149–152.

Brown, R.T.; Agee, J.K.; Franklin, J.F. 2004. Forest restoration and fire: principles in the context of place. Conservation Biology. 18: 903–912.

Caprio, A.C.; Swetnam, T.W. 1995. Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California. In: Fire in wilderness and park management: Proceedings of the symposium. Gen. Tech. Rep. INT-320. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 173–179.

Cowell, C.M. 1998. Historical changes in vegetation and disturbance on the Georgia Piedmont. American Midland Naturalist. 140: 78–89.

Graham, R.T.; McCaffrey, S.; Jain, T.B. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p.

Greenwood, D.J.; Levin, M. 1998. Introduction to action research: social research for social change. Thousand Oaks, CA: Sage.

Kilgore, B.M.; Taylor, D. 1979. Fire history of a sequoia mixed conifer forest. Ecology. 60(1): 129–142.

Norman, S.P.; Taylor, A.H. 2005. Pine forest expansion along a forest-meadow ecotone in northeastern California. Forest Ecology and Management. 215: 51–68.

Ottmar, R.D.; Sandberg, D.V.; Riccardi, C.L.; Prichard, S.J. [In press]. An overview of the fuel characteristic classification system—quantifying, classifying, and creating fuelbeds for resource planners. Canadian Journal of Forest Research.

Roberts, P.D.; Stewart, G.B.; Pullin, A.S. 2006. Are review articles a reliable source of evidence to support conservation and environmental management? A comparison with medicine. Biological Conservation. 132: 409–423.

Sandberg, D.V.; Ottmar, R.D.; Cushon, G.H. 2001. Characterizing fuels in the 21st century. International Journal of Wildland Fire. 10: 381–387.

Sandberg, D.V.; Riccardi, C.L.; Schaaf, M.D. [In press]. Fire potential rating for wildland fuelbeds using the fuel characteristic classification system. Canadian Journal of Forest Research.

Seevers, B.; Graham, D.; Gamon, J.; Conklin, N. 1997. Education through cooperative extension. Albany, NY: Delmar Publishers. 336 p.

Skinner, C.N.; Chang, C. 1996. Fire regimes, past and present. In: Sierra Nevada Ecosystem Project: final report to Congress. Vol. II. Assessments and scientific basis for management options. Wildland Resources Center Rep. 37. Davis, CA: Centers for Water and Wildland Resources, University of California: 1041–1069.

Stephens, S.L. 1998. Effects of fuels and silvicultural treatments on potential fire behavior in mixed conifer forests of the Sierra Nevada, CA. Forest Ecology and Management. 105: 21–34.

Swetnam, T.W. 1990. Fire history and climate in the Southwestern United States. In: Krammes, J.S., tech. coord. Effects of fire management of southwestern natural resources. Proceedings of the symposium. Gen. Tech. Rep. RM-191. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 6–17.

Taylor, A.H.; Skinner, C.N. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management. 111: 285-301.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2001. Fire and fire surrogate study plan. On file with: Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850.

U.S. Department of the Interior; U.S. Department of Agriculture, Forest Service [USDI and USDA]. 2006. Protecting people and natural resources; a cohesive fuels treatment strategy. Washington, DC. [Irregular pagination].

Van Lear, D.H.; Waldrop, T.A. 1989. History, use, and effects of fire in the Appalachians. Gen. Tech. Rep. SE-54. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 20 p.

Waldrop, T.A.; Van Lear, D.H.; Thomas, F.T.; Harms, W.R. 1987. Long-term studies of prescribed burning in loblolly pine forests of the Southeastern Coastal Plain. Gen. Tech. Rep. SE-45. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 23 p.

Weatherspoon, C.P. 2000. A proposed long-term national study of the consequences of fire and fire surrogate treatments. In: Neuenschwander, L.F.; Ryan, K.C.; Goldberg, G.E., eds. Proceedings of the Joint Fire Science conference and workshop. Moscow, ID: University of Idaho: 117–126.

White, S.M. 2004. Bridging the worlds of fire managers and researchers: lessons and opportunities from the wildland fire workshops. Gen. Tech. Rep. PNW-GTR-599. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 41 p.

Whitney, D.; Trosten-Bloom, A. 2003. The power of appreciative inquiry: a practical guide to positive change. San Francisco, CA: Berrett-Koehler. 265 p.

Yaussy, D.A.; Sutherland, E.K. 1994. Fire history in the Ohio River valley and its relation to climate. 12th Conference on fire and meteorology: fire, meteorology, and the landscape. Bethesda, MD: Society of American Foresters: 777–786.

Youngblood, A.; Max, T.; Coe, K. 2004. Stand structure in eastside old-growth ponderosa pine forests of Oregon and northern California. Forest Ecology and Management. 199: 191–217.

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