# FINAL REPORT TO THE JOINT FIRE SCIENCE PROGRAM

**Project Title:** Archiving Data for the National Fire and Fire Surrogate study (FFS)

**Joint Fire Science Program ID Number:** 12-04-01-7

**Principle Investigator:** James McIver, Senior Research Associate Professor, Eastern Oregon Agricultural Research Station, Oregon State University, P.O. Box E, Union, Oregon, 97883

## ABSTRACT

This final report describes the results of the project 'Archiving Data for the National Fire and Fire Surrogate study (FFS)', which was funded by the Joint Fire Science Program ($9,982; Project 12-04-01-7) under Task Statement RFA 2012-4 (Dataset Archival Task). To complete this project, we gathered, documented, and archived the complete dataset for the National Fire and Fire Surrogate study, including pre-treatment data, and post-treatment data collected through four years after treatment. The FFS was originally funded by the JFSP in spring 2000 and was completed in spring 2006, at which time a final report was submitted. The study was designed to evaluate how alternative fuel reduction treatments, including prescribed fire and its principle mechanical surrogates, influenced a number of ecological variables at 12 seasonally dry forests nationwide. We studied the response of the fuel bed, vegetation (understory and overstory), bark beetles, soils and the forest floor, and avifauna. Data on these components of the ecosystem were originally collected, entered and cleaned under the direction of scientists working at each of the 12 sites, and were then sent to a database manager working at the network level, where they were organized into a national database in 'Oracle', and then extracted into a more user-friendly database in Microsoft Access. The current work began with the existing Access Database, and thoroughly documented its components, following general guidelines in the meta-data program 'MetaVist'. After the database was fully documented, on 26 September 2013 we submitted a draft to the Forest Service Research Data Archive (http://www.fs.usda.gov/rds/archive/), for review and ultimate publication. At the time of publication, a link to the database will be provided on the FFS project website, which is held and administered on the website of FRAMES (Fire Research and Management Exchange System; www.frames.gov).

In this final report, we will briefly introduce the FFS project, including its principle data components, and then describe the database within which it has been submitted for publication. In its current form, FFS data reside in a number of relational tables in Microsoft Access, and the data themselves are supplemented by meta-data compiled in MetaVist, contained in an FFS Study Plan, and summarized in a number of figures and tables, all of which can be accessed from within the Database itself. In addition, because many potential users may not be familiar with databases in general, or Access in particular, we have also provided the data in a set of fully-documented queries, in spreadsheet format, which can be accessed directly from the opening menu-bar within Microsoft Access. Finally, in order to provide the user with information on the analyses that have already been published with the dataset, principle FFS findings and publications are also available as supplemental information within the Access Database. We recognize that at some point in the future, as better open-source database options become more readily available and easier to use, FFS data may ultimately be transferred out of the proprietary database Access into such an open-source option, at the discretion of the Forest Service archive administrators.

## BACKGROUND AND PURPOSE

The FFS was originally funded by the JFSP in April 2000, and data collection began later that year. The study was successfully completed by April 2006, and a final report to the JFSP was submitted at that time. The FFS was designed to evaluate how alternative fuel reduction treatments influenced a multitude of ecological variables at 12 sites nationwide, and was at that time the most comprehensive experiment ever attempted in a dry forest setting (Figure 1; McIver and Weatherspoon 2010). Each of the 12 sites was a replicated experiment with a common experimental design that compared four treatments: un-manipulated control, prescribed fire, mechanical treatment, and mechanical + fire. We measured variables within several components of the ecosystem, including vegetation, the fuel bed, forest floor and soil, bark beetles, tree diseases, and wildlife in 10 ha experimental units. This design allowed us to assemble a fairly complete picture of ecosystem response to treatment at the site scale, and to compare treatment response across the wide variety of features and conditions observed among sites. Short-term results of the FFS study have been disseminated in a variety of media over the years (Youngblood et al. 2007), and have been published in more than 200 technical papers (http://frames.gov), including collections in four journals [*Forest Ecology and Management* (2008) 255:3075-3211; *Ecological Applications* (2009) 19:283-358; *Forest Science* (2010) 56:2-138; and *Open Environmental Sciences* (2010) 4:21-75]. Detailed findings for each publication can be found on the website within FRAMES, on the website of the Joint Fire Science Program (http://www.firescience.gov), and have been recently published as a US Forest Service General Technical Report (McIver et al. 2012).

Short-term findings of the FFS support the following general conclusions: 1) For most sites, treatments significantly modified stand structure and fuels, such that post-treatment stands would be predicted to be more resilient to moderate wildfire if it occurred in the immediate future; 2) For the great majority of variables within the vegetation, soils, and animal species, short-term response to treatments was subtle and transient; 3) Comparison of fire hazard reduction and ecological effects between one-year and several years post-treatment suggests that while effects tend to dampen with time, fire hazard increases in burned stands, due to fall of fire-killed small trees; 4) Each multivariate analysis conducted has demonstrated that critical components of these ecosystems are strongly linked, suggesting that managers would be prudent to conduct fuel reduction work with the entire ecosystem in mind; 5) Multi-site analyses generally show strong site-specific effects for many ecosystem components, which reduces the broad applicability of findings, and leads to the recommendation that practitioners employ adaptive management at the local or regional scale; and 6) Mechanical treatments do not serve as surrogates for fire for the great majority of measured variables, leading to the recommendation that fire be introduced and maintained as a process in these systems whenever possible. While short-term FFS results cannot directly demonstrate long-term ecosystem trajectories, certain predictions on restoration can nonetheless be made: 1) Restoration of conditions similar to those thought to have prevailed before settlement will require persistent management, featuring repeat entries of both mechanical treatment and prescribed fire; 2) Eastern forests will require much more frequent applications of both mechanical treatment and fire, due to their greater productivity, and the need to control a diverse set of competing plant species; 3) Application of mechanical treatments alone will gradually cause dry forest systems to diverge significantly from states maintained by fire alone, despite the generally subtle effects of both treatments in the short term; and 4) Long-term monitoring of key ecosystem components needs to accompany persistent management, in order to gauge whether or not projected goals are met, and to make course corrections if needed.

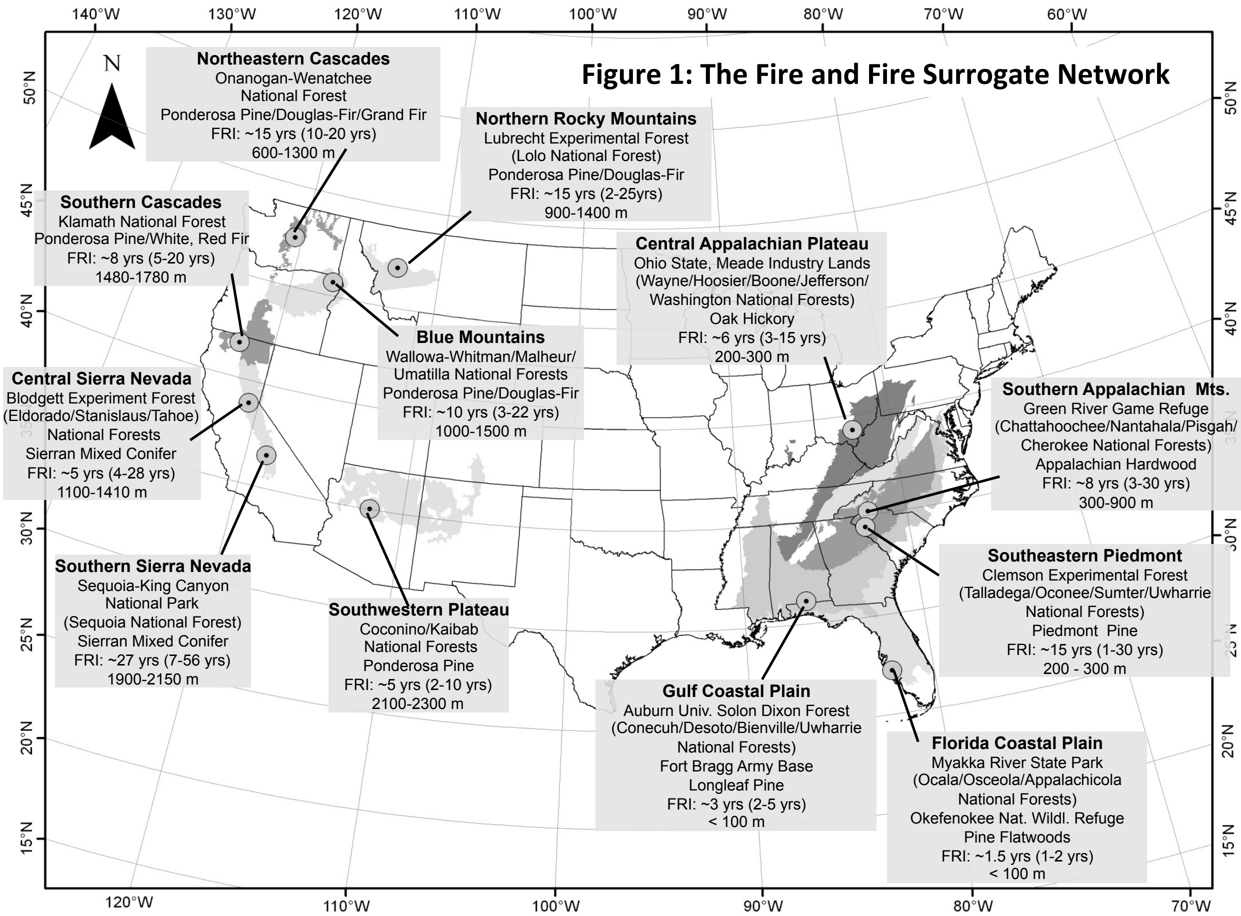


**Figure 1: The Fire and Fire Surrogate Network**

Despite the fairly complete documentation and publication of short-term results by the original team of principle investigators, numerous opportunities still remain for other investigators to capture insights on the effects of fire and fire surrogate treatments, particularly in the areas of longer-term effects, multivariate analyses, and among-site comparisons. It is therefore important to make a complete and thoroughly documented FFS dataset available for others to use.

## STUDY DESCRIPTION AND LOCATION

The Fire and Fire Surrogate Study (FFS) was a multi-site, multi-disciplinary experiment that evaluated the economics and ecological consequences of prescribed fire and its fuel reduction surrogates (mechanical treatments, e.g. thinning from below and mastication). We expected that the multi-site information would help managers understand when ecological response was general or site-specific. The multivariate information from this experiment was intended to allow managers to better assess how fuel reduction treatments influenced whole systems, and to hopefully lead to a better understanding of the tradeoffs inherent in their decisions. The original 6-year FFS study was designed to elucidate how alternative fuel reduction treatments reduced *short-term* fire risk, and to understand the magnitude of effects caused by these treatments. We thus needed to measure the fuel bed and stand structure to understand changes in fire risk, and we needed to measure a wide variety of ecological variables to cover the broad spectrum of values held dear by managers and by society. These variables can be grouped into disciplines that include vegetation (trees, shrubs, grasses, forbs), fuels (forest floor, features of the living vegetation, and dead wood of various sizes), soil properties (chemical and physical properties of the forest floor and mineral soil), wildlife (birds, small mammals, herps), and bark beetles. While the FFS study did have an economics component (Hartsough et al. 2008), the database does not contain economics data.

A typical FFS site was composed of 12 experimental units, 10 ha in size, within which was established a sampling grid for the location of at least 10 plots per unit (see Table 1). Vegetation (including trees) and soils were measured within Whitaker or circular plots. Fuels were measured with Brown's transects that began at grid points. Beetles and birds were assessed with unit-level surveys.

Table 1. The hierarchical sampling design of the FFS study, with definition of terms.

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FFS **Network** -- The entire collection of 12 separate study **sites**

- **Site** -- Autonomous, fully replicated experiment, composed of 4 FFS treatments, replicated within either three or four experimental **units**
  - **Unit** -- Contiguous land area > 10 ha, receiving one type of FFS treatment, and containing **grid points** distributed uniformly throughout
    - **Grid --** A system of systematically located **grid points** within each **unit**, each point usually separated by 50 m, onto which a system of **plots** was established, for measurement of core variables
    - **Plot** -- Circular (0.04 ha) or Whitaker (20 x 50 m - 0.1 ha) area, located in relation to **grid** points within each **unit**, within which key variables were measured
    - **Transect** -- A line beginning at or near each grid point, along which certain core variables were tallied (e.g. woody fuels)

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While all 12 sites within the FFS network had a similar experimental design, and used similar protocols for measuring variables, nonetheless each site has certain idiosyncrasies in design and protocol. For more detailed descriptions of the standard protocol for the FFS network, and the variances applied by the 12 sites, please see the FFS Study Plan, in particular Appendix B-4, the site-level study plans. In the following section, we provide a brief history of FFS data management, and then describe the contents of the FFS database, as submitted to the Forest Service Data Archive.

**BRIEF HISTORY OF FFS DATA MANAGEMENT.** The original FFS budget specified a half-time position for a network database manager, to serve for the five-year duration of the project. The project was officially funded on May 1, 2000, and the network database manager began work in August 2000, *after* pre-treatment data had been collected on most sites. At the Clemson University annual meeting in November 2000, the project's technical committee decided to build the network database so that data would be available at the grid point level of scale. Specific procedures for data collection and data entry tended to be sculpted independently for each site, and so building the network database required retrofitting each site with a standard data submission form for each discipline. These standard forms were built for each discipline under the guidance of the FFS network discipline leaders, between January 2002 and May 2004. Data submission to the network database began in June 2004. While most data were successfully submitted and validated by

December 2005, data submission continued for some disciplines until November 2006, and various changes by site-level people continued to be made through the spring of 2007.

The fact that the network database was built 'after-the-fact', after the construction of idiosyncratic site-level databases, meant that it became virtually impossible to insure the veracity of grid-point level data at the network scale (see McIver and Weatherspoon 2010). We therefore suggest that while the current network database does contain grid-point and plot-level data as planned in Clemson in November 2000, *we believe the most reliable data are the unit-level summaries*. This is because in most cases these summaries were undertaken by the site managers themselves (or their staff), who are the only people who had intimate knowledge of the idiosyncrasies in data collection and data reduction at their respective sites.

## FFS DATABASE CONTENTS (as submitted to the Forest Service Archive)

When viewed in the 'Custom Navigation' mode in Microsoft Access, the FFS Database includes the following ordered components (see Figure 2 for screen shot of contents):

•An **INTRODUCTION**, which contains much of the information about the study as provided in this final report, in an attempt to introduce the user to the key aspects of the FFS study.

•**META-DATA**, including the MetaVist file, the FFS Study Plan, project map (Figure 1), site descriptions, ecological components studied, and study chronology.

•The **DATABASE** itself, consisting of a set of 37 linked tables, that must be used in conjunction with one another to place each variable within its proper context, and to allow queries of the database to be conducted. A box and arrow diagram can be viewed in Access, showing the specific relationship among tables in the Database (see Figure 3 for screen shot of a portion of the box and arrow diagram). A brief description of the linked tables follows:

***Site.*** Four tables describing names and characteristics of the 12 sites, including locations and features of experimental units, gridpoint locations, and plots.

***Treatment.*** Four tables providing treatment name and code, desired future forest, type of treatment activity, and information on the prescribed fire activities.

***Prescribed Fire Effects.*** Two tables on first-order prescribed fire effects, for individual trees and for effects summarized to the unit level (i.e. stand level).

***Fuels***. One table containing data on mass of woody fuel, the forest floor, and understory fuel (where relevant).

The *'fuel bed'* is expressed primarily in terms of mass, and includes the forest floor (litter, duff), woody fuels in various diameter size categories, shrubs and small trees (if relevant for that site), plus other aspects of the stand relevant to potential fire behavior, such as ladder fuel and crown height. Forest floor and woody fuel mass were estimated with the use of the 'Brown's' transect method, where forest floor depth and down woody pieces were tallied along transects originating from each of the grid points (see Study Plan for details), and then converted with standard equations into mass estimates. An important variance among sites within the network is that while some sites used the standard equations with bulk densities to convert forest floor depths to mass, other sites sampled the forest floor destructively, and obtained mass directly by weighing. For those sites where shrubs and trees were an important component of the fuel bed, mass of these fuel elements was obtained by converting cover (estimated in the field) to mass, with the use of standard equations. Although the FFS Network Database contains data expressed at the plot level, we recommend that analysts use only the unit-level summaries, primarily because transect line length for a single gridpoint is generally insufficient for an accurate calculation of fuel mass.

***Vegetation***. Eight tables containing data pertaining to various aspects of the vegetation, consisting of six tables on trees, one on the understory, and one on plant diversity. The six tree tables provide basic tree characteristics, tree species, size class information, and stand-level (i.e. experimental unit level) information on tree density and basal area.

*Vegetation* included trees, shrubs, forbs, and grasses. A large number of variables were collected within these broad categories, mainly having to do with the number of individuals or cover within a plot. Two types of plots were used, each established in accordance with the grid system within each unit. Two sites (Blue Mts. and Central Sierra Nevada) used 0.04 ha circular plots (radius = 11m) for counting and measuring all vegetation variables. All other sites (10 of 12) established between 6 and 10 rectangular Whitaker plots within each unit, each 20 X 50 m (0.1 ha) in size. Trees were counted and diameters were generally measured within the whole plot, while other components of vegetation were measured in sub-plots of various sizes within each plot. All other data (e.g. understory components, biodiversity) are summarized to the plot and then to the unit level. For multi-site analyses, we recommend that analysts use vegetation data at the unit level, due to the fact that plot sizes varied among sites.

***Bark Beetles.*** Four tables on bark beetles, including one table on observed bark beetle species, one table on tree mortality attributed to bark beetles, one table linking beetle guild to tree mortality, and one table linking beetle activity to woodpecker foraging and cavity creation.

***Soils and the Forest Floor***. Nine tables on soils and the forest floor are provided, including two tables on soil type, one on methods, one on soil physical effects, one table on soil carbon dynamics, one table on nitrogen dynamics, one table on soil nutrients, and one table on soil biology.

The *forest floor and soils* component of the larger study was designed to determine the consequences of different fuel management treatments on key aspects of forest floor and soil structure, function, biogeochemistry, and biodiversity. The database contains soils and forest floor data in seven principle categories: soil physical properties, soil nutrient status, soil N-dynamics, soil C-dynamics, soil biology, soil classification, and soil coverage. Most of the sites submitted both pre- and post-treatment soils and forest floor data for all of these categories, except the Southern Rockies site. Again, we recommend that analysts use the unit-level summaries for all of these categories of soils data.

***Avifauna***. Five tables containing data on birds, including information on species observed, point count data, foraging behavior, and nesting.

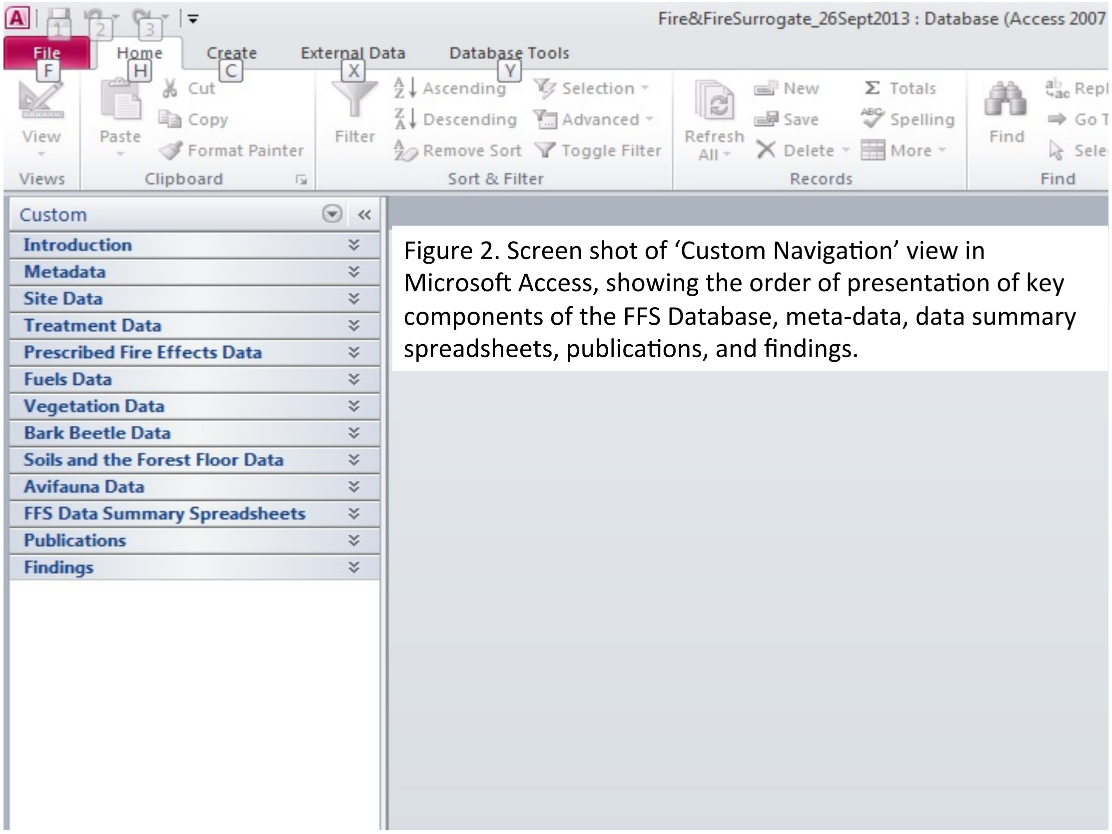


Figure 2. Screen shot of 'Custom Navigation' view in Microsoft Access, showing the order of presentation of key components of the FFS Database, meta-data, data summary spreadsheets, publications, and findings.

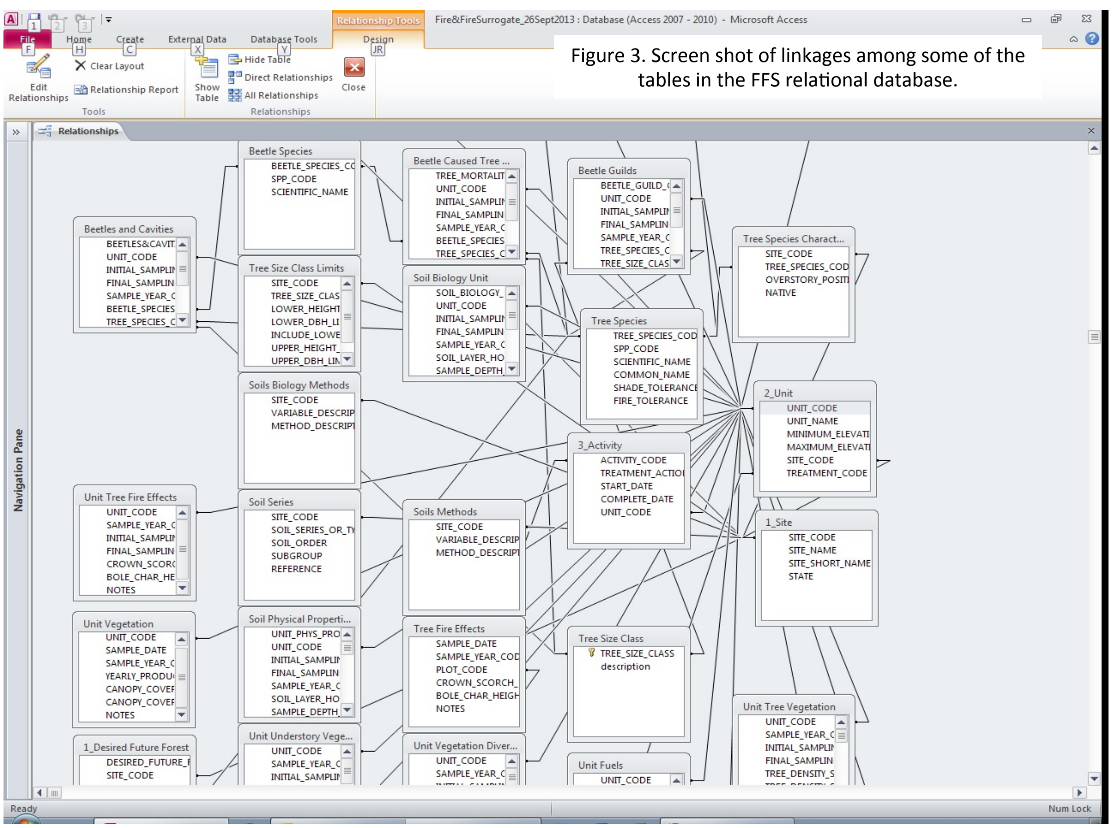


Figure 3. Screen shot of linkages among some of the tables in the FFS relational database.

•**DATA SUMMARY SPREADSHEETS**. This tab contains spreadsheets that represent queries from the Access Database, and cover all key aspects of the study. They are organized by study discipline, including site information, experimental unit summaries of vegetation, the fuel bed, prescribed fire behavior, bark beetles, avifauna, and soils and the forest floor. Each data spreadsheet is accompanied by a meta-data spreadsheet, which includes definitions of each variable in the data spreadsheet.
•**PUBLICATIONS**. This tab provides access to all of the 200+ technical papers FFS scientists produced through the duration of the study (summarized in Database Table 4). These publications are also provided in searchable format, on the FFS website in FRAMES (Fire Research and Management Exchange System; www.frame.gov/ffs).
•**KEY FFS FINDINGS.** Key short-term science findings are provided in several forms, including: 1) A searchable database of findings, the same as provided on the FFS website in FRAMES; 2) a PDF of the General Technical Report, entitled, 'Principle short-term findings of the national fire and fire surrogate study', by James McIver, Karen Erickson, and Andrew Youngblood, which provides a printed form of findings organized in various ways; 3) Database Table 5: treatment effectiveness; 4) Database Table 6: summary of findings organized by treatment type; 5) Database Table 7: summary of findings organized by management theme; 6) Database Table 8: summary of findings organized by ecological discipline; and 7) Database Table 9: summary of findings organized by site. All of these findings are also published on the FFS website within FRAMES (Fire Research Application Management System).

## MANAGEMENT IMPLICATIONS

FFS evaluated the ecological consequences of fuel reduction methods, and the research team published over 200 technical papers on short-term effects (McIver et al. 2012). Yet for any large, multivariate, multi-site study of this kind, there will always be several meaningful analyses that are yet to be undertaken. In the realm of dry forest fuel reduction and restoration work, while investigators at most sites were extremely productive, basic work comparing alternative fuel reduction treatments still remains to be done at four FFS sites, particularly with respect to understory response: Southern Cascades, Southwestern Plateau, Gulf Coastal Plain, and Florida Coastal Plain (Figure 1). As for additional work outside the scope of the original study, there are many opportunities for additional analyses using the current FFS database. For example, many papers evaluated faunal response to treatment in the context of key habitat conditions at the *site* level. Yet few studies attempted to link patterns and magnitudes of faunal response to basic life history characteristics, and then ask how these linkages varied for species occurring at many sites. Such analyses could be useful for fine-tuning management strategies aimed at providing habitat for key species. Both soil and vegetation varied markedly among sites, and these patterns of variation were documented in several multi-site papers. But significant work remains on how among-site variation in soil conditions might explain variation in the response of the vegetation. Similarly, despite nearly complete data on precipitation and temperature at all sites throughout the study period, little work has been done to understand how this variation influenced response to treatment, despite knowledge that weather varied considerably at most sites for each year we conducted the study. We know that the fuel bed changed in important ways at every site in the first four years post-treatment. Yet nobody has yet explored the patterns of change in various components of the fuel bed, in the context of basic site features such as soil, productivity, and weather. Finally, for longer term studies, the FFS database offers a unique multi-site, multivariate view of conditions before and after fuel reduction treatments, that can be used as a baseline for modeling purposes. In general, because the variables and protocols are so similar among the 12 sites, the use of FFS data to describe conditions in multiple forest layers is enhanced. Finally, the detailed documentation that we have provided in this soon-to-be-published FFS database, will allow future analysts to extend insights, more fully explore multi-site and multivariate relationships, and compare FFS results to other studies. All of this will have significant positive benefits, for scientists and managers working in seasonally dry forests of the U.S.

## RELATIONSHIP TO OTHER RECENT FINDINGS AND ONGOING WORK ON THIS TOPIC

We know of no other data on fuel reduction that has recently been published. However, we expect that in the next few years, the Forest Service Archive, and other data repositories will publish similar data on the ecological effects of fuel reduction practices, which will be important to compare with the FFS dataset.

## FUTURE WORK NEEDED

This product provides essentially all the information we have on the national fire and fire surrogate study, in terms of its history and development, data management activities, publications, and findings. We have done the best we can to provide the necessary meta-data that any future analyst might need to further analyze and interpret FFS data. Certainly, our study plans could have been written with more detail, especially on idiosyncrasies that developed at the site level. Yet we believe that in this published FFS database, we have provided the most important details of meta-data that are now available.

## THE DELIVERABLES CROSSWALK TABLE

Just one deliverable was promised: a published FFS dataset. The submission to the Forest Service Data Archive fulfills that promise. The publication of supplemental information, including data summary spreadsheets, publications to date, and findings, enhances the published dataset for any future user.

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