



# FFI: A software tool for ecological monitoring

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## Abstract

A new monitoring tool called FFI (FEAT/FIREMON Integrated) has been developed to assist managers with collection, storage and analysis of ecological information. The tool was developed through the complementary integration of two fire effects monitoring systems commonly used in the United States: FIREMON (Lutes 2006) and the Fire Ecology Assessment Tool (Sexton 2003). FFI provides software components for: data entry, data storage, Geographic Information System, summary reports, analysis tools and Personal Digital Assistant use. In addition to a large set of standard FFI protocols, the Protocol Manager lets users define their own sampling protocol when custom data entry forms are needed. The standard FFI protocols and Protocol Manager allow FFI to be used for monitoring in a broad range of ecosystems. FFI is designed to help managers fulfill monitoring mandates set forth in land management policy. It supports scalable (project to landscape scale) monitoring at the field and research level, and encourages cooperative, interagency data management and information sharing. Though developed for application in the U.S., FFI can potentially be used to meet monitoring needs internationally.

## Introduction

FFI (FEAT/FIREMON Integrated) is a software tool developed in the United States and designed to assist managers with collection, storage and analysis of ecological monitoring information. This tool was developed through a complementary integration of two fire effects monitoring systems commonly used in the U.S.: FIREMON (Lutes et al. 2006) and the Fire Ecology Assessment Tool (FEAT) (Sexton 2003). The National Interagency Fuels Coordination Group sponsored development of FFI and the National Park Service (NPS) was the managing partner.

FEAT was developed from the NPS, Fire Monitoring Handbook (FMH) (USDI 1992, USDI 2003) and associated software (Sydoriak 2001). This handbook was initially developed by the Pacific West Region of the NPS to guide fire related ecological monitoring in California, Oregon and Washington. The handbook provides detailed descriptions for establishing a sampling strategy based on levels of monitoring activity relative to fire and resource management objectives. FMH had a DOS-based software package for entering data into a Microsoft® FoxPro database. Beginning in 1995 the NPS conducted a series of regional workshops to examine user needs for fire and ecological monitoring throughout the entire NPS, then in 1996 FMH was adopted by all NPS regions across the U.S. The handbook was updated first in 2001 and again in 2003 to reflect the national scope of the system. The FMH software was replaced in 2005 with a Windows-based system that became known as the Fire Ecology Assessment Tool. FEAT uses a Microsoft SQL Server database that is much more flexible than the original DOS-based program, allowing data from a greater variety of field sampling procedures to be stored in the database, greater ability to query data and export data, provided GIS tools, and supported PDA use.

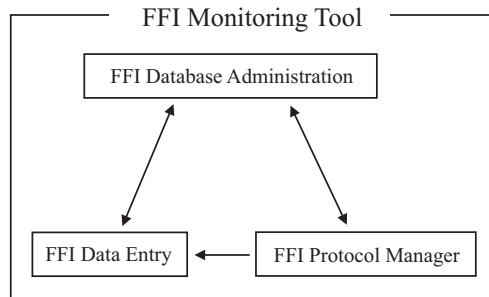
The FIREMON fire effects monitoring system was developed by the U.S. Forest Service (USFS), Missoula Fire Sciences Laboratory through a grant from the Joint Fire Science Program in 2000. Many of the protocols in FIREMON were taken from the ECODATA ecological monitoring program used in Region One of the USFS (Keane, et al 1990). ECODATA used an IINFOS data management system and FORTRAN-77 based data analysis package called ECOPAK. FIREMON uses Java™-based data entry software and Microsoft Access database. The FIREMON software package includes report and analysis software, and a handbook with sampling strategy and detailed field sampling procedures.

FEAT and FIREMON both facilitate fire ecology monitoring and have similar procedural characteristics and database architecture. Their integration results in an enhanced ecological monitoring tool. FFI includes an extensive list of sampling protocols and users are able to define their own protocols in Protocol Manager, if necessary. While the core fire ecology components are still part of FFI the new flexibility means FFI can be used more broadly for monitoring a wide variety of ecosystem attributes. FFI is now better suited to assist managers in meeting the monitoring mandates set forth in land management policy (for example, the U.S. National Environmental Policy Act). It eases data collection; supports cooperative, interagency data management and information sharing; and supports scalable (site specific to landscape level) monitoring for both field application and research needs.

FFI provides data entry and storage for a set of ‘standard’ protocols delivered with the software, summary reports, analysis tools, Geographic Information System (GIS) and Personal Digital Assistant (PDA) support. Protocol Manager – described in more detail below - is an FFI component that allows design of new sampling protocols thus making the FFI database capable of storing data in not just the standard protocols delivered with the FFI software but also any protocol designed by the user.

FFI is designed for Microsoft Windows XP operating systems. Data is stored in a Microsoft SQL Express 2005 database and accessed with SQL and Microsoft Visual Basic .NET programs. ESRI® Arc products are used for GIS functionality. The system is designed for the varying Information Technology requirements of the USFS, NPS, Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA) and the U.S. Fish and Wildlife Service (FWS).

The relationship of the three FFI software components is shown in Figure 1. The FFI Database Administration component interfaces with SQL Server Express 2005 and is used for general database management functions like creating and deleting databases. This component is also used to add users and user roles to each database. The SQL databases in FFI have either a ‘Protocol Manager’ or ‘Data Capture’ schema. Protocol Manager databases contain the design criteria for each protocol and provide the list of data fields viewed in the FFI Data Entry software. Data capture databases store field data the user enters in the FFI Data Entry software.



**Figure 1.** Relationship of the three FFI software components.

## Development and testing

Like FEAT and FIREMON before it, FFI incorporates the evolutionary improvements of the systems it was borne from. In addition, FFI has benefited from its own testing and improvement process. Many hours were spent considering use cases and system architecture, testing the user interface and checking coded procedures. This work was done in cooperation with employees from numerous U.S. land management agencies. An FFI Testing Workshop was held in August 2007 to intensively test the FFI software, again with agency cooperation. After the August workshop, nine additional versions of FFI were built and tested before it was finally released in November 2007. We continue to compile a list of suggested improvements to the system, such as new protocols, and additional summary reports and analysis that will be incorporated in future

versions. Where applicable, FFI has either been approved or is in the process of being approved by the U.S. land management agencies.

### **Species lists**

FFI incorporates the U.S. Department of Agriculture, Natural Resource Conservation Service, PLANTS database (USDA 2008). Users query the PLANTS database to populate a 'local' species list using the FFI species management utility. Species in the local list appear in species dropdown menus on the data entry screens. Species or items not available in the PLANTS database can be included in the FFI local list by adding a 'user species'. For example, if a user is interested in sampling pine cone density then 'pine cones' can be added as a user species and it will be included on the species list dropdown menus on the data entry screens. The FFI local species list will also accommodate an unlimited number of 'unknown' species. This option is useful when field crews do not have the expertise to identify all the species encountered. In that case they can record the species as an unknown on the data collection form (for example, UNK01) and collect a sample. When the sample is identified by a botanist, the FFI species management utility can be used to replace the unknown species with its appropriate species name in the FFI local species list and FFI database. The FFI species management utility can also be used to replace a species name if the species was misidentified in the field. The FFI local species list can be exported from one FFI database and imported to another.

The master species list included with FFI is the component most likely to limit the use of FFI; however, with a minimum amount of development any master species list can be incorporated in FFI allowing it to be used outside the U.S. Interested parties can build their own 'user species' list and test FFI before making the commitment of incorporating a new master species list. Further, when used in conjunction with the protocol manager, a new master species list and sampling protocols will allow FFI to be used for sampling other life forms such as terrestrial wildlife.

### **Data entry and storage**

FFI provides programmed data entry screens for entering data into the Microsoft SQL database. Entry screens are provided for plot location, surface fuels, tree data, point intercept, density, line intercept, rare species, cover/frequency, species composition, fire behavior, disturbance history, Fuel Characterization Classification System (FCCS), post burn severity and composite burn index (CBI). FFI also has a 'Biomass-Fuels' protocol for storing ocular or photographic estimates of biomass, for example those found in the U.S. Forest Service, Pacific Wildland Fire Sciences Lab, Natural Fuels Photo Series (available online at: <http://depts.washington.edu/nwfire/dps/>). Data entry screens have built-in flexibility to accommodate data from a wide variety of plot-based sampling schemes. The data entry fields represent a combination of those in the FEAT and FIREMON so data can be collected using the methods described in the FMH (USDI 2003) or FIREMON (Lutes, et al 2006) field manuals and stored in an FFI database. In many cases the FFI database will also accommodate data collected with field sampling protocols from other publications.

## Sampling protocols

The ‘standard set’ of sampling protocols delivered with the FFI software is listed in Table 1 as well as the source of the protocol, where applicable. The protocols were developed from the existing, recognized methods previously available in FEAT and FIREMON and supplemented with new protocols suggested during FFI development. Protocols that require unit data are available in metric and English unit versions. While FFI was developed from fire effects systems the wide array of protocols make the system applicable for monitoring rangeland, forest and other ecosystems regardless of the presence or absence of fire as a disturbance.

**Table 1.** Protocols delivered with FFI. Protocols not available in FIREMON or FEAT are listed as ‘New’ and, when applicable, the source of the protocol is provided.

<b>Protocol</b>	<b>Source</b>
Biomass – Fuels	New
Biomass – Plants	FEAT
Composite Burn Index	FEAT and FIREMON
Cover – Line Intercept	FEAT and FIREMON
Cover – Species Composition (Ocular Macroplot)	FEAT and FIREMON
Cover – Individual Points	FEAT
Cover – Points by Transect	FIREMON
Cover/Frequency (Daubenmire)	FEAT and FIREMON
Density – Belts	FEAT and FIREMON
Density – Quadrats	FEAT and FIREMON
Fuel Characteristic Classification System	New <sup>A</sup>
Fire Behavior	FIREMON
Plot Description (biotic, abiotic variables, fire behavior, photo links)	FIREMON
Post-Burn Severity	FEAT
Rare Plant Species	FIREMON
Surface Fuels (down woody material, duff, litter)	FEAT and FIREMON
Surface Fuels – Alaska Duff and Litter	New <sup>B</sup>
Surface Fuels – Piles	New <sup>C</sup>
Surface Fuels – Vegetation	FIREMON
Tree Data	FEAT and FIREMON

<sup>A</sup> Ottmar et al, 2007

<sup>B</sup> Alaska Interagency Fire Effects Task Group, 2007

<sup>C</sup> Hardy, 1996

## Protocol Manager

Protocol Manager is a unique extension to FFI that lets users design new protocols that can then be imported for use in FFI. A protocol is defined as a set of methods implemented separately to perform a certain task. The user defines methods and combines them in Protocol Manager to build a protocol that will facilitate a comprehensive assessment of ecosystem attributes important to the user. User defined methods can be highly varied ranging from new methods to monitor

vegetation to methods to monitor mammals, birds, amphibians, reptiles, insects or aquatic species. Protocol Manager also records metadata for each protocol (e.g., plot size, plot shape, quadrat size, etc.). The data recorded with user defined protocols is stored in the same database as data collected with the standard FFI protocols.

### **Queries, reports and analysis**

FFI includes the query features found in FEAT with added functionality to allow data to be queried from user defined protocols designed in the Protocol Manager. The Query screen lets the user retrieve method data in a flexible, ad hoc manner in which values are filtered and parameters are defined through the user interface. The data summary reports and analysis tools are an expanded set of those provided in FIREMON. The FFI summary reports provide plot-by-plot summaries or grouped summaries of measured attributes such as trees per acre, down woody material biomass, frequency, cover and density. The FFI analysis tools program can perform grouped or ungrouped summary calculations of a measured attribute, or statistical comparisons of grouped or ungrouped plot data taken at different sampling periods. For statistical comparisons the analysis tools assume data was collected in a randomized block design with each time point structured as a block. Parametric analyses are made using analysis of variance. If a significant difference in means is noted, Dunnett's multiple comparison procedure is used to compare treatment groups to a designated control group to identify which means are different. Friedman's test is provided for non-parametric analyses. A minimum of four plots per group is required for statistical analysis. Reports and graphs can be saved to a file, printed, or cut-and-paste into other documents. Statistical testing procedures were developed with guidance of station statisticians at the U.S. Forest Service, Rocky Mountain Research Station. As an additional feature, tree and fuels data can be exported to build files necessary to run the Forest Vegetation Simulator (Dixon 2002).

### **GIS**

The GIS module is an optional component users can add to FFI. It is similar to the GIS module in FEAT and is accessible in ArcMap as a tool bar. Users who desire GIS capability need to have an understanding of GIS, and must have ArcGIS 9.2 and Spatial Analyst installed on their computers. The GIS module does not deliver any data layers or attempt to manage GIS data. Users may need the help of a GIS specialist to identify the appropriate GIS data for their needs if they utilize the GIS module in FFI.

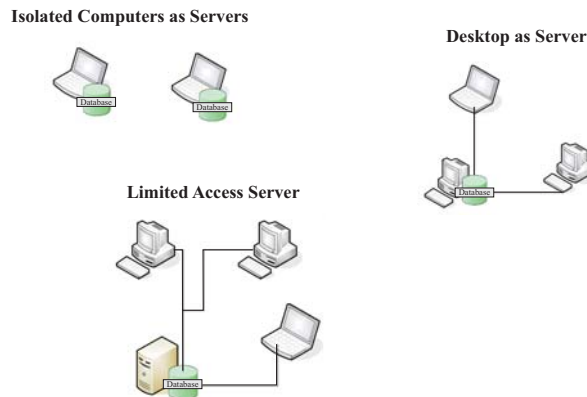
The GIS module provides support for developing geographic project areas. A custom tool allows users to overlay different types of GIS layers that identify the geographical area of their sample population. The GIS module also allows users to randomly or selectively choose sample points within polygons (e.g. burn severity classes or vegetation classes) that can then be passed to the FFI database. The module supports basic display of FFI macro plot sites and the interactive spatial queries of the collected data using the ArcMap tools. Tools that identify severity thresholds in Differenced Normalized Burn Ratio layers for Composite Burn Index (Key and Benson 2006) sampling are also included.

## Electronic field data collection

Electronic field data collection is facilitated using a PDA or data recorder equipped with the Microsoft Windows Mobile 5 operating system and requires Microsoft ActiveSync to manage the connection between the PDA and the FFI host computer. The PDA application first moves empty electronic field data collection forms to the PDA for user specified macro plots, protocols, and sampling events. When data collection is complete the application then moves data from the PDA back into the FFI database, appending the data already stored. Data entered on the PDA is editable on the PDA until it is uploaded to the host FFI database; then it may be edited in the host database if the user has the appropriate permission level.

## Computer configuration

Computers used for implementation of FFI fall into three categories: isolated computers, desktop as server and a limited access server (Figure 2). The configuration chosen by users depends upon individual needs and available computer resources. When GIS functionality is desired ArcGIS 9.2 and Spatial Analyst must be installed and run from computers that have the FFI software installed on them.



**Figure 2.** The three main computer configurations used with FFI.

### *Isolated Computer as Server*

The stand-alone computer has no other computers attached to it that share its internal databases. This configuration has both the FFI software and SQL Server installed.

### *Desktop as Server*

One computer with FFI and SQL Server installed is connected via network to other computers that have only FFI installed on them. Data entry can be accomplished on any of the computers. Database storage and management on occurs on the desktop server.

### *Limited Access Server*

A database server is a dedicated computer running a database engine that can be either accessed directly from a server or client computer with password protection or via intranet access. This configuration has SQL Server only installed on the database server and only FFI installed on the connected computers.

### **System security**

FFI supports four levels of internal data access or user permission levels. The goal of the permissions levels is to balance system accessibility with data security. For example, some users will only need to query data for summarization and analysis while other users will need access to edit data for quality analysis/quality control (QA/QC). Each user role has different permissions for the FFI program and its databases:

- The FFI Administrator can modify the database schema, create new database instances, import external data, and manage database users. Record locking will require FFI Administrator privileges. Administrators can also do any activities assigned to Managers, Users and Readers.
- FFI Managers can create protocols and methods. Managers can also do any activities assigned to Users and Readers.
- FFI Users can read and write FFI data, queries, and reports, and export FFI data. FFI Users cannot change the database schema.
- FFI Readers will have read-only access to FFI. FFI Readers can export FFI data.

### **Hardware requirements**

The FFI software requires Microsoft Windows XP Service Pack 2 or XP 2003 operating systems. Data must be stored in Microsoft SQL Server Express 2005 or SQL Server 2005 full edition database. The FFI software and SQL Server Express require 500MB combined free disk space for installation. The FFI SQL databases range from 100MB to 4GB in size (4GB is the maximum size for SQL Server Express 2005 databases. Larger databases can be stored in SQL Server full edition). Recommended minimum processor speed and random access memory are 1Ghz and 512MB, respectively. Increasing memory to 1MB enhances system performance.

### **Technology transfer**

FFI is being supported by annual training workshops and on-line presentations. User assistance is provided through the FFI Website, help desk and Web forum. Training schedules, software installation packages, documentation and technical support contacts are provided on the FFI Website: [frames.nbio.gov/ffi](http://frames.nbio.gov/ffi).



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