CSIRO PUBLISHING

International Journal of Wildland Fire **2009**, *18*, 310–314 www.publish.csiro.au/journals/ijwf

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* and the *Fire Ecology Assessment Tool*. *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 fulfil 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 USA, *FFI* can potentially be used to meet monitoring needs internationally.

Additional keywords: data management, fire effects, monitoring system, Protocol Manager.

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 US: *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, 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 US. 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 Geographic Information System (GIS) tools, and supported Personal Digital Assistant (PDA) use.

The *FIREMON* fire effects monitoring system was developed by the USDA 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 a *Microsoft Access* database. The *FIREMON* software package includes report and analysis software, and a

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 10.1071/WF08083 1049-8001/09/030310

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. Although 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 US 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, GIS and 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 are 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 US Fish and Wildlife Service (FWS).

The relationship of the three *FFI* software components is shown in Fig. 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.

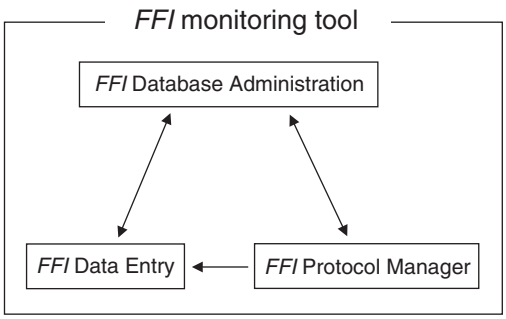

Fig. 1. Relationship of the three *FFI* software components.

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. The present work was done in cooperation with employees from numerous US 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 US land management agencies.

Species lists

FFI incorporates the US Department of Agriculture Natural Resource Conservation Service PLANTS database (USDA and Natural Resources Conservation Service 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 US. 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

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

Protocol	Source
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[A]
Fire behavior	*FIREMON*
Plot description (biotic, abiotic variables, fire behavior, photo links)	*FIREMON*
Post-burn severity	*FEAT*
Rare plant species	*FIREMON*
Surface fuels (downed woody material, duff, litter)	*FEAT* and *FIREMON*
Surface fuels – Alaska duff and litter	New[B]
Surface fuels – Piles	New[C]
Surface fuels – Vegetation	*FIREMON*
Tree data	*FEAT* and *FIREMON*

[A]Ottmar *et al*. 2007.
[B]Alaska Interagency Fire Effects Task Group 2007.
[C]Hardy 1996.

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 USFS Pacific Wildland Fire Sciences Laboratory Natural Fuels photo series. 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 the *FIREMON* manual (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 imperial unit versions. Although *FFI* was developed from fire effects systems, the wide array of protocols makes the system applicable for monitoring rangeland, forest and other ecosystems regardless of the presence or absence of fire as a disturbance.

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). The data recorded with user-defined protocols are 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, downed 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 were 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 with 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-pasted into other documents. Statistical testing procedures were developed with guidance of station statisticians at the USFS 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* (*FVS*) (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 *FFI* GIS module.

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 CBI (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 are editable on the PDA until they are uploaded to the host *FFI* database; then they 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 (Fig. 2). The configuration chosen by users depends on 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.

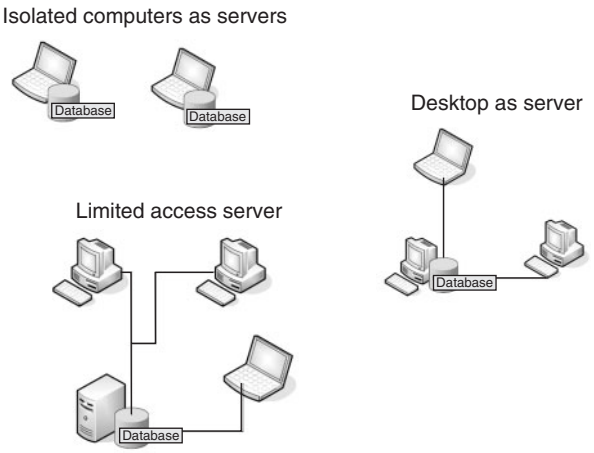

Fig. 2. The three main computer configurations used with *FFI*.

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 a network to other computers that have *FFI* and *SQL Server* components installed on them. Data entry can be accomplished on any of the computers. Database storage and management 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 *FFI* and *SQL Server* components installed on the connected computers.

System security

FFI supports four levels of internal data access or user permission levels. The goal of the permission levels is to balance system accessibility with data security. For example, some users will only need to query data for summarization and analysis whereas other users will need access to edit data for quality analysis and 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* summary reports, analysis reports and query results.

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 500 MB combined free disk space for installation. The *FFI SQL* databases range from 100 MB to 4 GB in size (4 GB 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 1 GHz and 512 MB, respectively. Increasing memory to 1 MB enhances system performance.

Technology transfer

FFI is 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 (http://frames.nbii.gov/ffi, accessed 28 April 2009).

Acknowledgements

Funding for *FFI* was provided by the National Interagency Fuels Coordination Group. Additional support was provided by the NPS, USFS, Systems for Environmental Management and Spatial Dynamics. We specifically thank Melissa Forder and Dan Swanson (NPS), Clint Isbell (USFS), Charley Martin, Chamise Kramer and Jena Dejuilio (BLM), Bil Graul (San Carlos Apache Tribe), Ben Butler (Student Conservation Association), Kristin Swoboda (Bureau of Reclamation) and Jacque Schei (US Geological Survey) for β testing *FFI* in August 2007. Jennifer Allen (NPS), Karen Murphy (US FWS), and Randi Jandt (BLM) helped us develop the Alaska Surface Fuels protocol; Roger Ottmar (USFS, Pacific Northwest Research Station) and Susan Pritchard (University of Washington) assisted with development of the FCCS protocol; and Colin Hardy (USFS, Rocky Mountain Research Station) helped us incorporate the Surface Fuels – Piles protocol. Additionally, numerous helpful comments were provided by employees at each of the agencies and organizations already recognized and also the BIA, US Department of the Army and The Nature Conservancy. Chad Keyser (USDA Forest Service, Forest Management Service Center) helped us update the *FVS* file-building utility in *FFI*. We thank Rudy King and David Turner of the USFS, Rocky Mountain Research Station, for their assistance in developing the statistical analysis tools available in *FFI*. Finally, we acknowledge the helpful comments of the anonymous reviewers.

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Manuscript received 29 May 2007, accepted 16 May 2008