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ArcFuels10 System Overview

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Cover photo: fuels treatment in Oregon ponderosa stand, by Scott Roberts, Mississippi State University, courtesy of Bugwood.org.

Abstract

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Fire behavior modeling and geospatial analyses can provide tremendous insight for land managers as they grapple with the complex problems frequently encountered in wildfire risk assessments and fire and fuels management planning. Fuel management often is a particularly complicated process in which the benefits and potential impacts of fuel treatments need to be demonstrated in the context of land management goals and public expectations. The fuel treatment planning process is complicated by the lack of data assimilation among fire behavior models and weak linkages to geographic information systems (GIS), corporate data, and desktop office software. ArcFuels10 is a streamlined fuel management planning and wildfire risk assessment system that creates a trans-scale (stand to large landscape) interface to apply various forest growth and fire behavior models within an ArcGIS platform to design and test fuel treatment alternatives. The new version of ArcFuels has been implemented on Citrix at the Forest Service Enterprise Production Data Center, eliminating the need for desktop GIS, improving connectivity to the corporate geospatial databases housed at the data centers, and enabling sharing of information among Forest Service employees. This overview introduces ArcFuels10 and the tools available within the system. Further information, including download information, demonstration data, and a tutorial, can be found at <http://www.fs.fed.us/wwetac/arcfuels/index.html>.

Keywords: ArcGIS, fire behavior models, forest growth models, fuel treatment planning, wildfire hazard, wildfire risk.

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Introduction

ArcFuels was developed to meet the growing need in federal land management agencies for tools to facilitate landscape planning and wildfire risk assessments (Calkin et al. 2011, Omnibus Public Land Management Act of 2009). For example, the Collaborative Forest Landscape Restoration Program (CFLRP), established by Title IV of the Omnibus Public Land Management Act of 2009 and the 2010 Cohesive Strategy (Calkin et al. 2011) call for wider use of landscape planning for fuel management and the use of risk assessment methods to analyze treatment strategies. The CFLRP, in particular, outlines an analysis framework that includes an “all lands” approach for forest restoration, and encourages planners to leverage local, national, and private entities to develop landscape fuel management strategies. The CFLRP process includes the Wildland Fire Management Risk and Cost Analysis Tools Package (R-CAT) that was developed to help measure the cost savings from fuel management activities and which requires wildfire risk modeling of management alternatives. The 2010 Cohesive Strategy Scientific Report outlines the need for a risk-based approach to fire and fuels management at all scales, from national budget allocation to project-level planning (Calkin et al. 2011).

ArcFuels addresses these needs by creating a geospatial analysis and modeling environment that can be leveraged to design and test fuel treatments at the stand to landscape scales. Linkages to forest vegetation, visualization models, stand-level fire behavior models, landscape-level fire behavior models, and fire effects models within a geospatial interface facilitate these connections.

A core strategy of ArcFuels is to facilitate the application of wildfire behavior modeling to help quantify the components of risk, especially the relative burn probability and intensity from future wildfires. Most wildfire losses on public lands stem from large fires that are impossible to predict with empirical data. Wildfire simulation modeling fills this need; with careful calibration, simulations can be used to spatially quantify fire risk under current conditions and to assess various treatment alternatives. Changes in relative risk can be used to see if mitigation efforts would be effective at reducing risk to values of interest. The application of simulation models for wildfire management planning continues to grow, with case studies that span many scales and problems. For instance, at project scales, wildfires are simulated across a planning area to examine how different fuel treatment alternatives affect factors such as potential fire behavior, tree survivability, smoke production, wildlife habitat, and soil within and outside of treatments.

ArcFuels is a geospatial analysis and modeling environment that can be leveraged to design and test fuel treatments at the stand to landscape scales.

In this document, we describe several new developments in ArcFuels10 that include the following:

1. A reengineered version for ArcMap 10^{®1} developed within the Microsoft .NET framework for improved portability and compatibility with newer versions of ArcGIS[®].
2. Implementation on the Forest Service Citrix server, eliminating the need for desktop geographical information systems (GIS), improving connectivity to the corporate geospatial databases housed at the data centers, and enabling sharing of information among Forest Service employees.
3. Implementation of risk analysis forms that were available in previous versions only as experimental releases. These functions automate the calculation of risk components and expected loss as outlined in Calkin et al. 2011.

We envision continued growth for ArcFuels10, especially considering that requirements for fuel treatment planning have expanded to include climate change impacts and carbon accounting. With multiple and varied objectives, including ecosystem restoration, wildlife habitat management, carbon sequestration, and responding to climate change issues, systems like ArcFuels10 that are integrated with corporate geospatial software and databases will provide a platform to address the many issues and analytical tasks associated with wildland fuels management.

ArcFuels10 At a Glance

ArcFuels10 is a custom toolbar designed for use with ArcMap (fig. 1). The ArcMap framework helps users incorporate data from a variety of sources to address project-specific issues that typify many fuel treatment projects. ArcFuels10 was built to accommodate both ArcGIS raster data (such as LANDFIRE data available at <http://www.landfire.gov>) and/or forest inventory data.

ArcFuels10 provides a logical flow from stand-to-landscape analyses of vegetation, fuel, and fire behavior, using a number of different models (table 1, fig. 2) in a simple user interface within ArcMap. Specific functionality of ArcFuels10 includes:

1. An interactive system within ArcMap to simulate fuel treatment prescriptions with the Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) (Rebain 2010).
2. Automated generation of Excel[®] workbooks and Stand Visualization System (SVS) (McGaughey 1997) images, showing how fuel treatments change wildfire behavior and stand conditions over time after FFE-FVS modeling.

¹The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

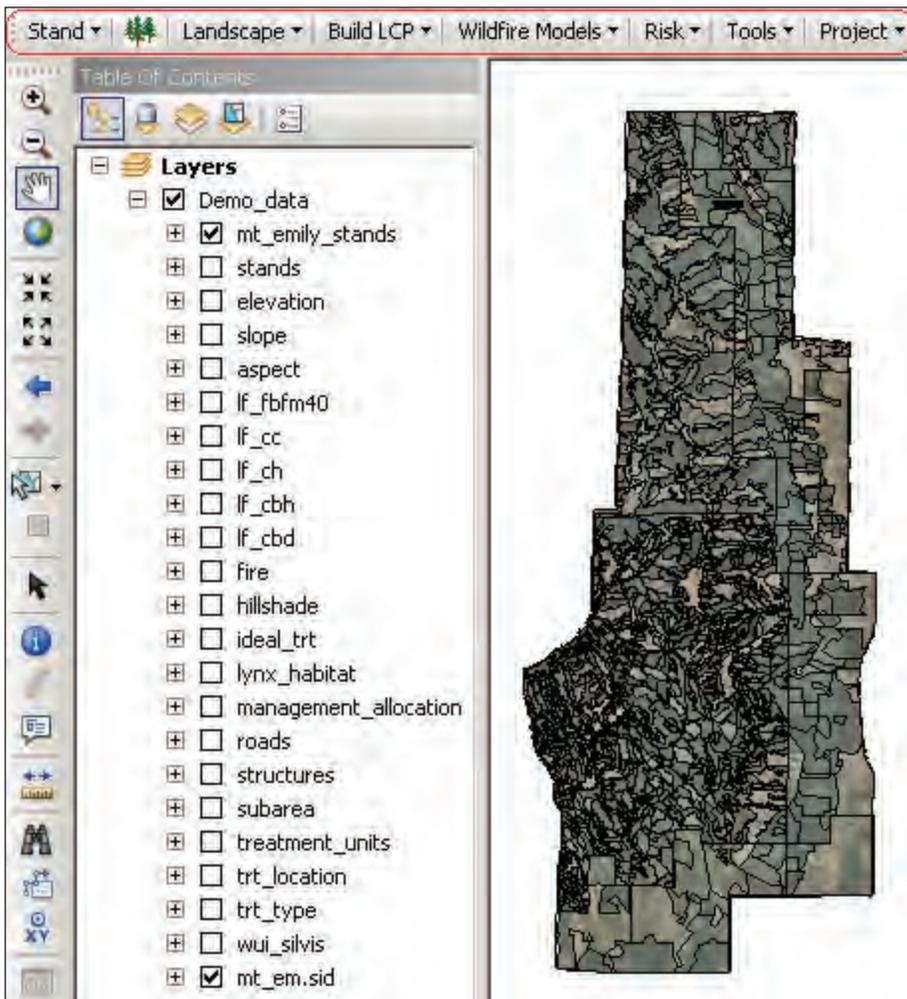


Figure 1—ArcFuels10 toolbar (outlined in red) within ArcMap with the supplied ArcFuels demonstration data loaded.

3. Scale-up of stand-specific treatments to simulate landscape changes in vegetation and fuel from proposed management activities.
4. The ability to modify and reevaluate fuel treatment scenarios.
5. Pre- and postprocessing of files for or from FlamMap (Finney 2006) to simulate landscape-scale fire behavior and to measure fuel treatment performance in terms of wildfire probabilities, spread rates, and fireline intensity.
6. Viewing and analyzing spatial fire behavior outputs in ArcMap.
7. Tools to aid wildfire risk assessments.

Table 1—Description of forest growth and fire behavior models linked to ArcFuels10¹

Model	Description	Linkage within ArcFuels10
Forest Vegetation Simulator (FVS) (Crookston and Dixon 2005) ²	Individual-tree, distance-independent growth and yield model	Calls the program, creates input data, processes output data, plus allows interaction in execution
Fire and Fuels Extension to FVS (FFE-FVS) (Rebain 2010) ²	Stand-level simulations of fuel dynamics, potential fire behavior and fire effects over time	Calls the program, creates input data, processes output data, plus allows interaction in execution
Stand Visualization System (SVS) (McGaughey 1997) ²	Generates graphics depicting stand conditions	Calls the program; creates input data
NEXUS (Scott 1999)	Stand-level spreadsheet that links surface and crown fire prediction models	Calls the program; creates input data
BehavePlus (Heinsch and Andrews 2010)	Stand-level fire behavior, fire effects, and fire environment modeling system	Calls the program; SURFACE module fully integrated in the Behave Calculator
FlamMap (Finney 2006) ²	Landscape-level fire behavior mapping and analysis program	Calls the program, creates input data, processes output data
Fire Area Simulator (FARSITE) (Finney 1998)	Landscape-level fire spread simulator	Calls the program, creates input data, processes output data
First Order Fire Effects Model (FOFEM) (Reinhardt et al. 1997)	Stand-level first-order fire effects modeling system	Calls the program
Landscape Treatment Designer (LTD) (Ager et al. 2012)	Landscape-level fuel treatment planning system	Calls the program
Fire Family Plus (Main et al. 1990)	Analysis of fire danger indices and weather	Calls the program

¹ Adapted from table 1 in Ager et al. 2011.

² FVS, FFE-FVS, SVS and FlamMap are the programs most frequently used with ArcFuels10.

ArcFuels10 Application

ArcFuels10 can be used for both project planning and fuel management research. It has three major applications, listed in order of increasing complexity: (1) modeling fuel treatments with FVS/FFE-FVS, (2) simulating landscape-level fire behavior and fuel treatments, and (3) using burn probability modeling and risk analysis to measure the performance of fuel treatments.

Modeling fuel treatments with FVS/FFE-FVS—

ArcFuels10 adds a spatial context to FVS and facilitates its application for both stand and landscape modeling of fuel treatments. All functionality and extensions available for use within FVS are available in ArcFuels10. This includes the FFE-FVS, which also incorporates the carbon model and the climate extension (Climate-FVS) (Crookston et al. 2010). ArcFuels10 stand-level analysis with FFE-FVS typically involves simulating activities like thinning as well as surface fuel treatments such as pile burning, mastication, or broadcast burns, and examining the changes to fire behavior and effects such as tree mortality. At the stand level, the

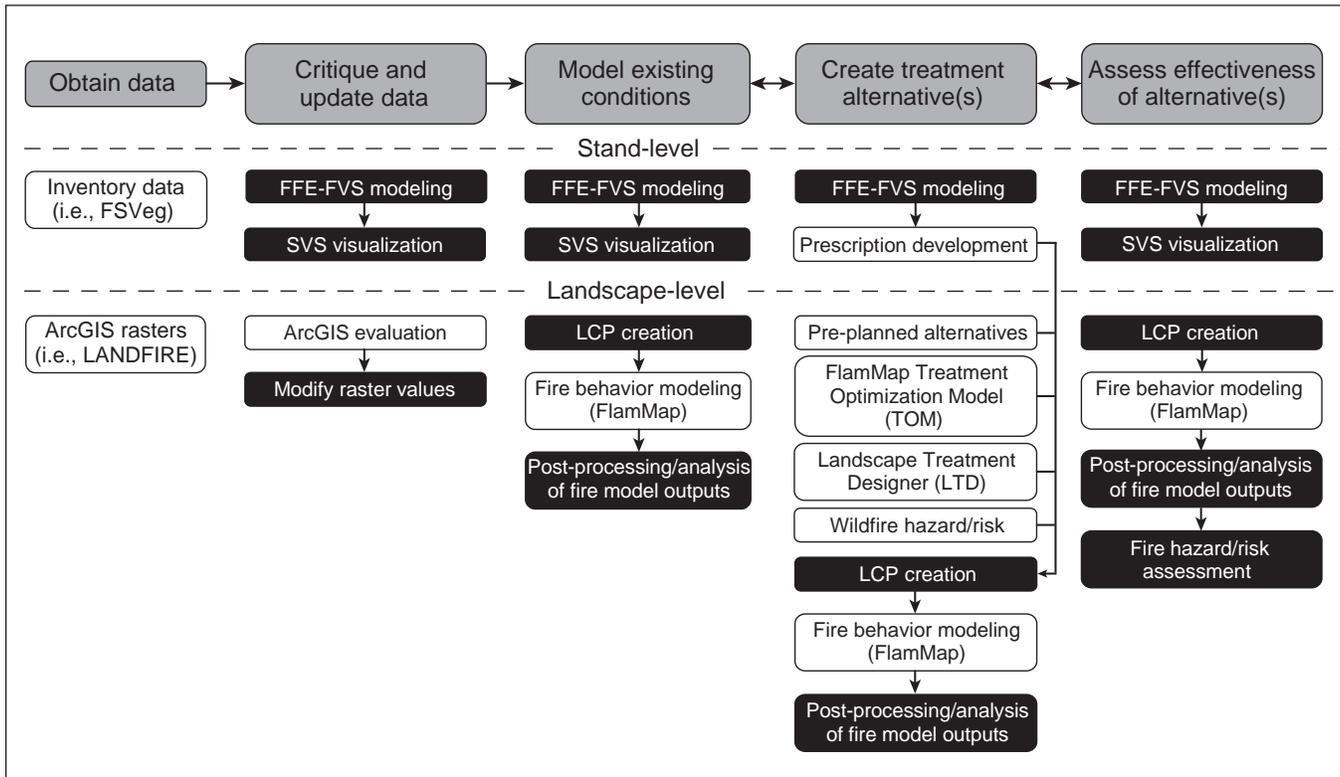


Figure 2—The ArcFuels10 toolbar has been set up to follow a typical fuel treatment planning workflow (gray boxes). Steps include obtaining data, critiquing and updating data, modeling existing conditions, creating treatment alternative(s), and assessing the effectiveness of the alternative(s). Different processes are possible at the stand and landscape levels and are shown accordingly. Black boxes are specific to ArcFuels10 functionality.

intention is for users to have access to digital orthophotos to see the vegetation in stands (delineated by an ArcGIS stand shapefile layer) and be able to point and click on individual stands to run FFE-FVS and SVS. When this is completed, ArcFuels10 generates an Excel workbook with FFE-FVS outputs and graphs generated in each worksheet. At the landscape scale, modeled outputs are written to an Access® database. The selection of which stands to run through FFE-FVS is user-defined and can range from a single stand to the entire landscape. Additionally, ArcFuels10 makes it possible to build landscape files from the FFE-FVS outputs for fire behavior modeling in FlamMap to test treatment alternatives with simulated wildfires.

Much of stand-level modeling involves validating data and iteratively examining different treatment combinations on a suite of stands that collectively comprise a coordinated landscape fuel treatment strategy. Direct links to the prescription files allows efficient editing of the keywords, making easy comparisons possible. The validation or assessment of fuel treatment prescription(s) at the stand level can also be applied to larger landscapes to developed landscape-level treatment alternatives. Posttreatment stand development and fuel dynamics can be used to determine retreatment frequency over time. In addition to running FVS/FFE-FVS

for a single prescription, ArcFuels10 has the ability to analyze treatment prescriptions by altering a single keyword parameter over set step amounts. This provides a way to explore how different management prescriptions affect stand structure and fire behavior.

Simulating landscape fire behavior and fuel treatments—

Landscape analysis of fuel treatment scenarios examines the aggregate effect of all treatments on potential wildfire behavior (Collins et al. 2010). The spatial arrangement, unit size, and total area treated are of importance to fuel treatment effectiveness (Finney 2001, 2007; Finney et al. 2007). Landscape fuel treatment plans can be derived from a number of methods, including the use of models such as the Treatment Optimization Model (TOM) within FlamMap or the Landscape Treatment Designer (LTD), within or outside of ArcFuels10, based on specific needs (point protection of structures), wildfire hazard or risk, or expert opinion.

Regardless of the fuel treatment plan, fuel treatments can be “applied” at the landscape scale two ways in ArcFuels10. The first is by simulating all stands through FFE-FVS with treatment prescription(s). The second is by using appropriate stand-level FFE-FVS runs, monitoring data, or expert opinion to determine treatment adjustment factors to alter raster data to represent posttreatment conditions. Within ArcFuels10, it is possible to store the treatment adjustment factors, then apply the changes to select locations in the landscape in a single step. ArcFuels10 streamlines the preparation of landscape files (LCPs), which characterize the fuel environment for use with spatial fire modeling programs such as FARSITE and FlamMap. With ArcFuels10 LCPs can be created from raster data (such as LANDFIRE) (Rollins 2009), from FFE-FVS simulations, from attributed shapefiles, or from multiple sources. ArcFuels10 also provides tools for quick postprocessing of modeled fire behavior outputs to analyze treatment effects in ArcGIS.

Burn probability modeling and risk analysis—

The incorporation of the minimum travel time (MTT) (Finney 2002) fire spread algorithm into FlamMap makes it feasible to rapidly simulate thousands of fires that can then be used to generate burn probability maps. With the release of FlamMap5, it is now possible to obtain two key files necessary for wildfire risk assessments. FlamMap5 creates a Fire Size List (FSL) file that contains the coordinates and the final fire size of each randomly ignited fire in a MTT burn probability run. In addition, the Flame Length Probability (FLP) file output contains data on the burn probability and intensity from the randomly ignited fires for every pixel within the landscape. The FLP file is used to calculate the conditional flame length. These files are described in more detail in the “Risk” subsection of the “ArcFuels10 Functionality” section of this document.

Burn probability maps coupled with conditional flame length maps can be used to complete wildfire risk assessments. The outputs can be used to create risk matrices to categorize the landscape based on likelihood of a fire occurring (burn probability) and potential intensity (conditional flame length). This categorization can highlight “hot spots” in the landscape for fuel treatment planning (fig. 3a). The outputs can also be used to create risk scatter plots to assess the relative risk between and among values (fig. 3b). Expected loss where there is a direct linkage between fire behavior and fire effects can be calculated and graphed (fig. 3c). Expected loss is possible for factors such as threatened or endangered species habitat (Ager et al. 2007), carbon (Ager et al. 2010a), or trees (Ager et al. 2010b). Finally, for values for which there is no direct linkage between fire behavior and fire effects, such as in the wildland-urban interface, response functions can be applied to calculate expected losses and benefits (Calkin et al. 2010).

One of the key concepts in developing ArcFuels is combining separate, specialized tools to accomplish analysis that draws on a variety of disciplines to answer a variety of questions about the consequences of management decisions.

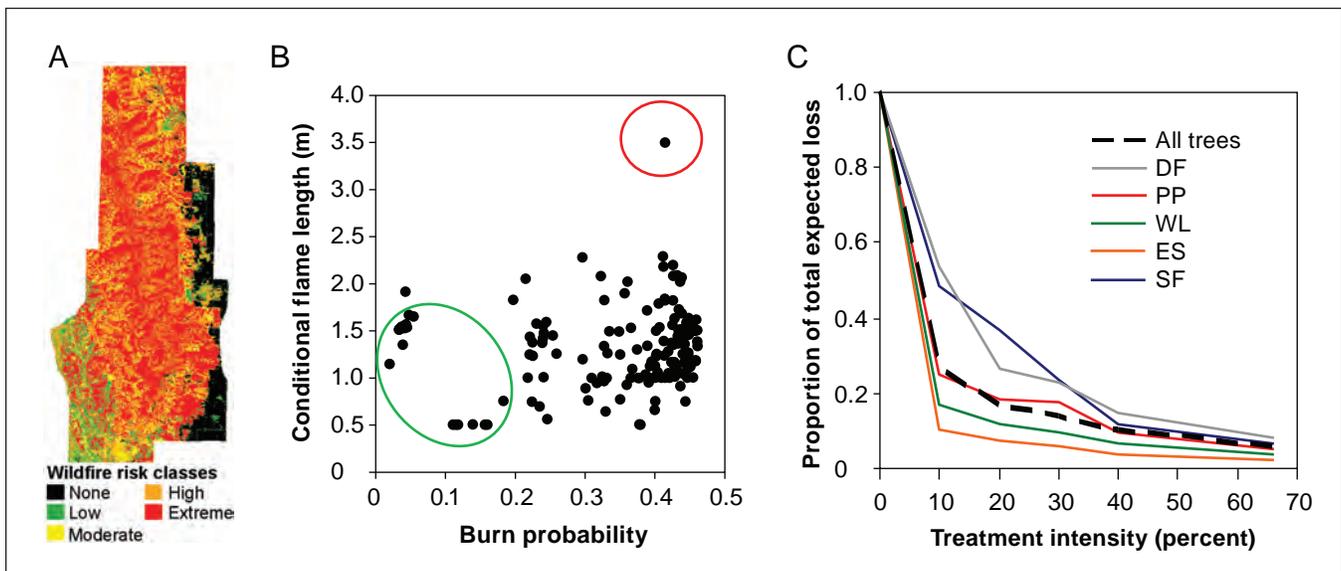


Figure 3—Examples of wildfire risk assessments using FlamMap5. (A) Wildfire risk maps where burn probability (BP) and conditional flame length (CFL) are categorized based on a risk matrix to highlight “hot spots” for fuel treatment planning, (B) wildfire risk scatter plot showing the relative risk of individual structures; structures that have low BP and low CFL (circled in green) have a lower relative risk than those with higher BP and conditional flame length (circled in red), (C) calculated expected loss of individual tree species under varying treatment intensities. Graphs B and C are adapted from Ager et al. 2010b.

How Is ArcFuels10 Different From ArcFuels9?

One of the key concepts in developing ArcFuels is combining separate, specialized tools to accomplish analysis that draws on a variety of disciplines to answer a variety of questions about the consequences of management decisions. The questions may involve the projected impacts on vegetation, wildlife, and watersheds, as well as the risks of wildfire to both human and non-human values. To explore

the impacts of multiple management plans, a researcher or planner must be able to run simulations using a variety of state-of-the-art tools. ArcFuels has always had, at its core, the concept of bringing together tools to aid researchers and planners in exploring the consequences of decisions.

When ESRI released ArcGIS 10, it moved from Visual Basic for Applications (VBA) to the .NET framework as its core programming language. This change prompted a need to reprogram ArcFuels for continued use within ArcMap. We took the opportunity to streamline forms within ArcFuels and design it to better follow a logical workflow by moving menus to more appropriate locations. To the end user, ArcFuels10 is very similar to ArcFuels9, but to the programming community it is quite different.

The .NET framework provides more powerful tools for developing more robust applications and is specifically designed to make it easy for programmers to take advantage of each other's work without reinventing or rewriting the same code. By providing libraries of functions in the form of Dynamic Linked Libraries (DLLs), .NET enables one programmer to write a module that is then incorporated into another programmer's project. Whereas VBA provided a limited ability to use DLLs, support for using DLLs is much greater in .NET and is, in fact, one of its core features. ArcFuels10 is designed to encourage the developers of primary tools to provide those tools in modular form, so that other programmers can combine the core functionality of multiple tools in ways that support the needs of end users.

Using ArcFuels on Citrix

Thin-client or distributed computing is a system of multiple autonomous computers that communicate via a network. Thin-client computing removes software requirements; users do not need to have the necessary programs installed on their machines. This is very helpful in the case of programs such as ArcGIS, where the program is quite large and computing needs are high. People with less powerful computers can use a thin-client to access and run programs they would otherwise be unable to do. All the data applications and data are housed, supported, and deployed from the server (fig. 4).

ArcFuels10 has the same capability within the U.S. Forest Service's Enterprise Production Data Center at Kansas City (also known as "Citrix" or the T-drive). Citrix has ArcGIS and the Microsoft Office® programs required to run ArcFuels10®. The forest growth and fire behavior programs are supplied for the user, similar to running them on your own PC. Citrix is accessed via the Internet (<http://apps.fs.usda.gov/Citrix/auth/login.jsp>), but you must be on the Forest Service network (in the office or via VPN). One main advantage to working in Citrix is that it is not necessary to have ArcGIS loaded on your computer. Other benefits of working

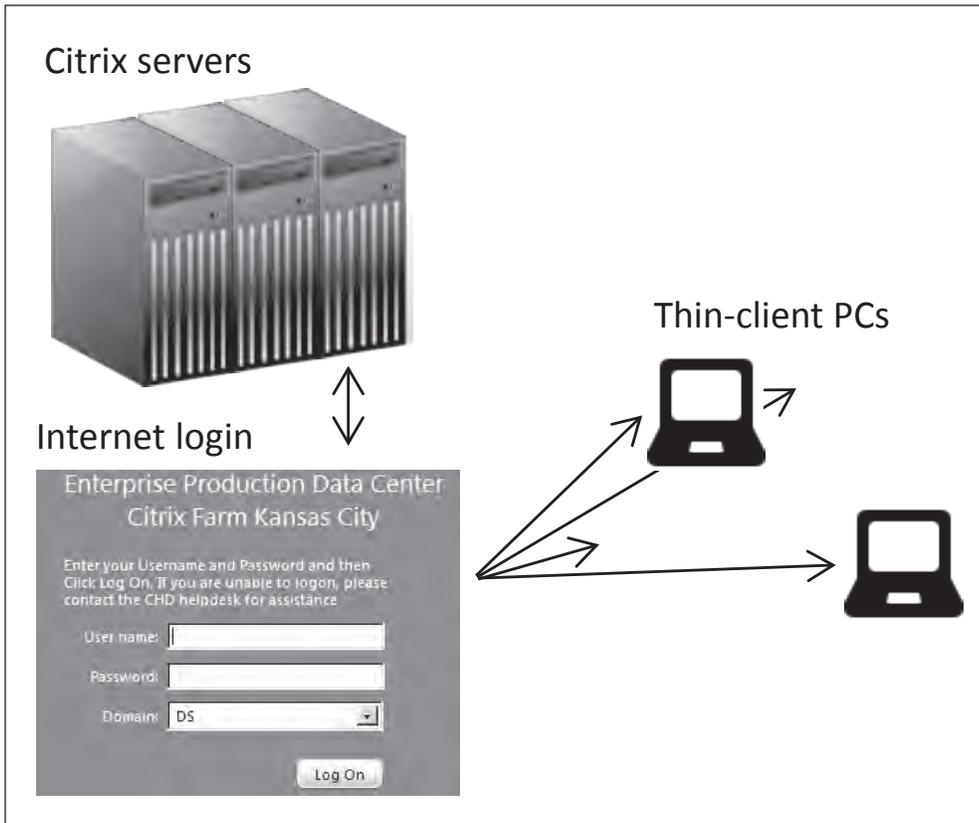


Figure 4—Schematic of thin-client/distributed computing for the USDA Forest Service.

in Citrix are accessing its large data storage capacity and more robust computing speeds, having the ability to share data with other users, and not needing to back up data. Citrix houses all the programs necessary to run ArcFuels10 (`\\ds.fs.fed.us\efs\FS\Reference\GeoTool\agency\Application\ArcFuels\ArcFuels10`).

Other systems, such as the Interagency Fuel Treatment Decision Support System (IFTDSS, <http://iftdss.sonomatech.com>) use the distributed computing concept via their online system. Data and programs are all stored in a single portal for managers to access and share data. However, at this time, IFTDSS is not fully functional.

Overview Assumptions

This overview introduces ArcFuels10 and the tools available within the system. The reader is assumed to have a working knowledge of ArcGIS/ArcMap10, FVS, and FlamMap. Specific details about these programs will not be covered. For a basic introduction to these programs, refer to the ArcFuels10 Tutorial and Supplemental Information (Vaillant and Ager [N.d.]) and for full details, please refer to the tutorials and training provided with the programs.

ArcFuels10 Functionality

As mentioned, ArcFuels10 is a library of ArcGIS macros developed to streamline fire behavior modeling and spatial analyses for fuel treatment planning. These macros are executed via a custom toolbar in ArcMap (fig. 5).

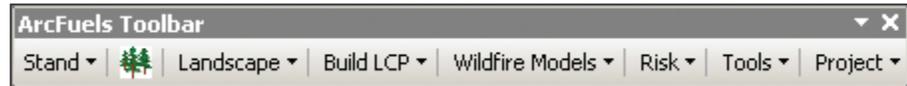


Figure 5—ArcFuels10 toolbar.

The toolbar consists of a number of menus, many with multiple options found in drop-down lists and sometimes multiple tabs in the associated forms. The ArcFuels10 toolbar also has a “tool,” the forest stand icon that is used to select a polygon (stand) or a raster cell from data loaded into the ArcMap table of contents.

The layout of the toolbar is intended to follow the workflow of fuel treatment planning (table 2). The premise is that fuel treatment planning often starts at the stand level to assess fuel treatment impacts that can then be extrapolated to the landscape. Before landscape-level fire behavior simulations can be completed, landscape files need to be created. Finally, ArcFuels10 has a group of tools that are useful for pre- and postprocessing fire behavior outputs and completing wildfire risk assessments.

Table 2—Summary of ArcFuels10 toolbar functionality

Menu	Description
Stand	Set up options for FVS/FFE-FVS. Includes applying fuel treatment prescriptions, treatment analysis, and treatment comparison tools. External linkage to open SVS.
Stand Select Tool	Toggle button to select individual stands within the landscape to run FVS/FFE-FVS.
Landscape	Multiple functions: (1) apply prescriptions to the landscape, (2) set up and running of FVS/FFE-FVS, (3) complete a treatment analysis with FVS/FFE-FVS, (4) a tool to join FVS/FFE-FVS outputs to a stand shapefile, and (5) the inclusion of the LTD program.
Build LCP	Used to build landscape files (LCP) for FlamMap/FARSITE from FVS/FFE-FVS databases, rasters (i.e., LANDFIRE), an attributed shapefile, or a combination of data sources.
Wildfire models	External linkage to open select (NEXUS, FARSITE, FlamMap, BehavePlus, FOFEM, and Fire Family Plus) fire behavior models. Internally coded version of BehavePlus (“Behave Calculator”) for quick stand-level comparisons of fire behavior.
Risk	Tools to streamline wildfire risk assessments coupled with FlamMap5 outputs.
Tools	A mixture of tools to modify raster values, convert ASCII files to rasters, and export attributes to Excel.
Project	Forms to import, update, and export project settings linking ArcFuels10 to the programs listed in table 1 and linking spatial data to programs.

FVS/FFE-FVS = Forest Vegetation Simulator/Fire and Fuels Extension to FVS, SVS = Stand Visualization System, FARSITE = Fire Area Simulator, FOFEM = First Order Fire Effects Model, LTD = Landscape Treatment Designer.

The functionality of each menu will be described in the following sections, moving from left to right across the toolbar.

Stand

ArcFuels10 can be used to interactively run FVS/FFE-FVS for individual stands assuming that the user has the proper data. ArcFuels10 links FVS data to a stand shapefile, making it spatially explicit by linking the unique stand identification number (also known as “STAND_ID”) from a FVS-ready database to the location on the ground via an attributed shapefile (fig. 6). Draping the stand shapefile over aerial imagery aids the user in identifying stands to run with the tool or in visualizing the outputs. If the aerial imagery is current, it can also be used in conjunction with the FVS outputs to validate or update data as needed.

ArcFuels10 can be used to interactively run FVS/FFE-FVS for individual stands, by linking FVS data to a stand shapefile, making the data spatially explicit.

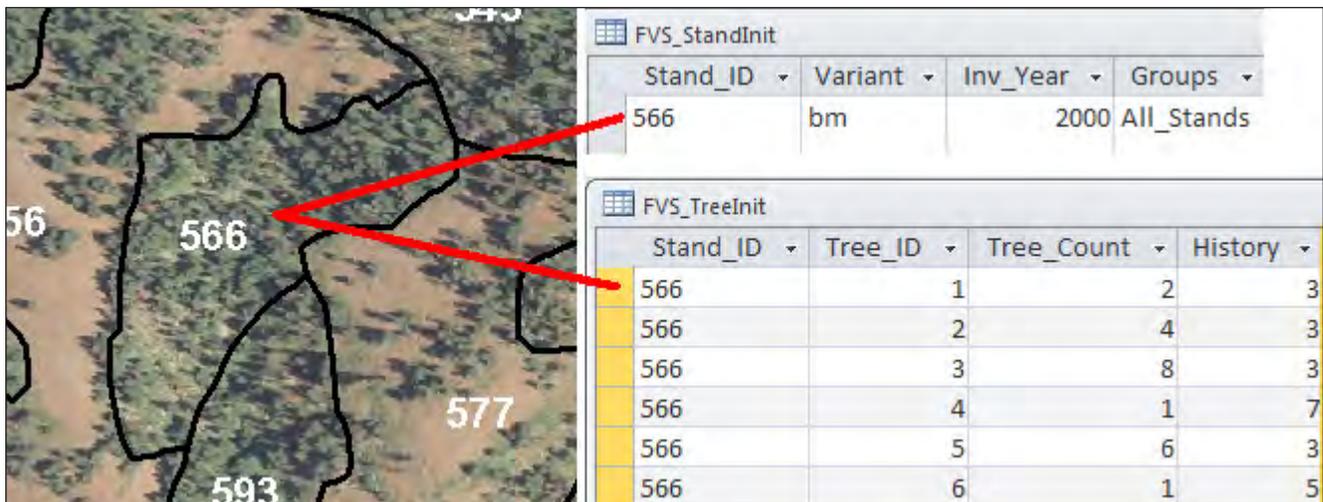


Figure 6—Spatial linkage between the stand shapefile and the FVS_StandInit (top right) and FVS_TreeInit (bottom right) data tables within the FVS-ready database for stand 566 in the supplied ArcFuels demonstration data set. Draping the stand shapefile over aerial imagery can help identify stand(s) of interest.

The stand functionality can be used to run FVS/FFE-FVS for one stand at a time using the FVS interface integrated within ArcFuels10. The user does not need to leave ArcFuels to run FVS. Many of the FFE-FVS functions have been “hardwired” in ArcFuels10 to streamline the fuel treatment planning process. Once the **Select Stand Tool** is activated, the user simply points and clicks on a stand in ArcMap to initiate FVS. If all the settings are correct for the intended purpose, the user can click from one stand to another without having to revisit the FVS settings.

The **Stand** menu has a drop-down list with five options, **Select Stand: Run FVS**, **Select Stand: FVS Treatment Analysis**, **Select Stand: FVS Compare**

Treatments, View FVS Files, and Select Stand: Display Details (fig. 7). The four options with the **Select Stand Tool** icon to the left are used in conjunction with the **Select Stand Tool** (forest stand icon to the right of the **Stand** menu).

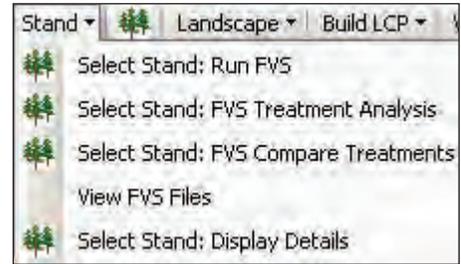


Figure 7—**Stand** menu with the associated drop-down list and **Select Stand Tool** (stand icon to the right of the **Stand** menu) on the ArcFuels10 toolbar. These are used together to do the stand-level forest growth, fuel treatment prescription testing, and fire behavior modeling within ArcFuels10.

Select Stand: Run FVS—

The **FVS Inputs** tab of the **Select Stand: Run FVS** form (fig. 8) is where the linkage between the stand shapefile and FVS database are set. Treatment prescriptions can also be selected by choosing keyword prescription (KCP) files, which outline fuel treatment prescriptions (such as thinning from below, pile burning, broadcast burning, etc.).

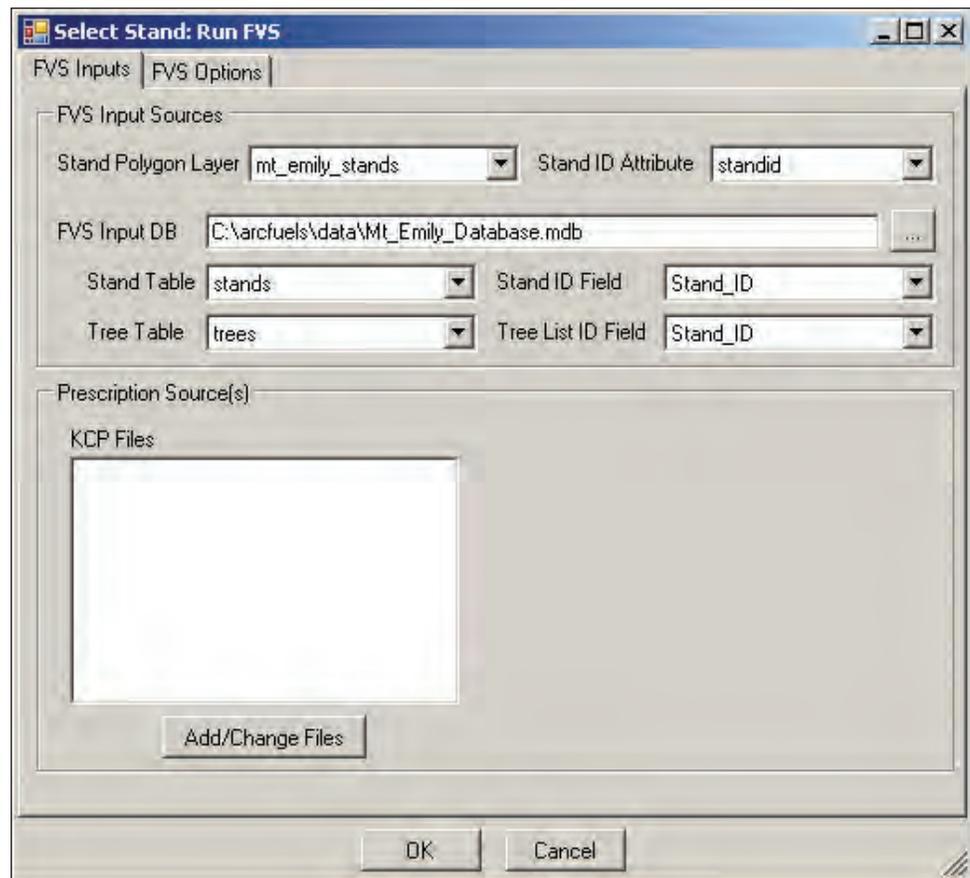


Figure 8—The **FVS Inputs** tab of the **Select Stand: Run FVS** form is where the linkage between the spatial data and FVS database are set, and where keyword component prescription files (KCPs) can be applied. The form is set to run the supplied ArcFuels10 demonstration data.

The **FVS Options** tab of the **Select Stand: Run FVS** form (fig. 9) is where the number of cycles and time steps for FVS runs and the fuel model set(s) that FFE-FVS will use are specified. Other hardwired options include the generation of a tree list for a specified year, a cut list, the ability to pause the FVS run at the end for debugging, and the option to override the FFE-FVS fuel model selections with others in the input database. Output options are also selected using this tab. Options include creating and opening Excel workbooks with or without graphics, writing files for use with NEXUS, and viewing outputs in SVS.

Figure 9—The **FVS Options** tab of the **Select Stand: Run FVS** form is where the options for an FVS/FFE-FVS run are specified and the output types are selected. The form is set to run the Blue Mountain variant of FVS/FVS-FFE for 10 one-year cycles, allowing FVS/FFE-FVS to choose the fuel models from either the Scott and Burgan (2005) or Anderson (1982) sets and to display the outputs in SVS and create an Excel workbook.

Once an FVS run is completed, the user has the option to view the results in SVS (fig. 10) and/or generate an Excel workbook (fig. 11) with or without graphs. These options are in addition to outputting the standard FVS output files.

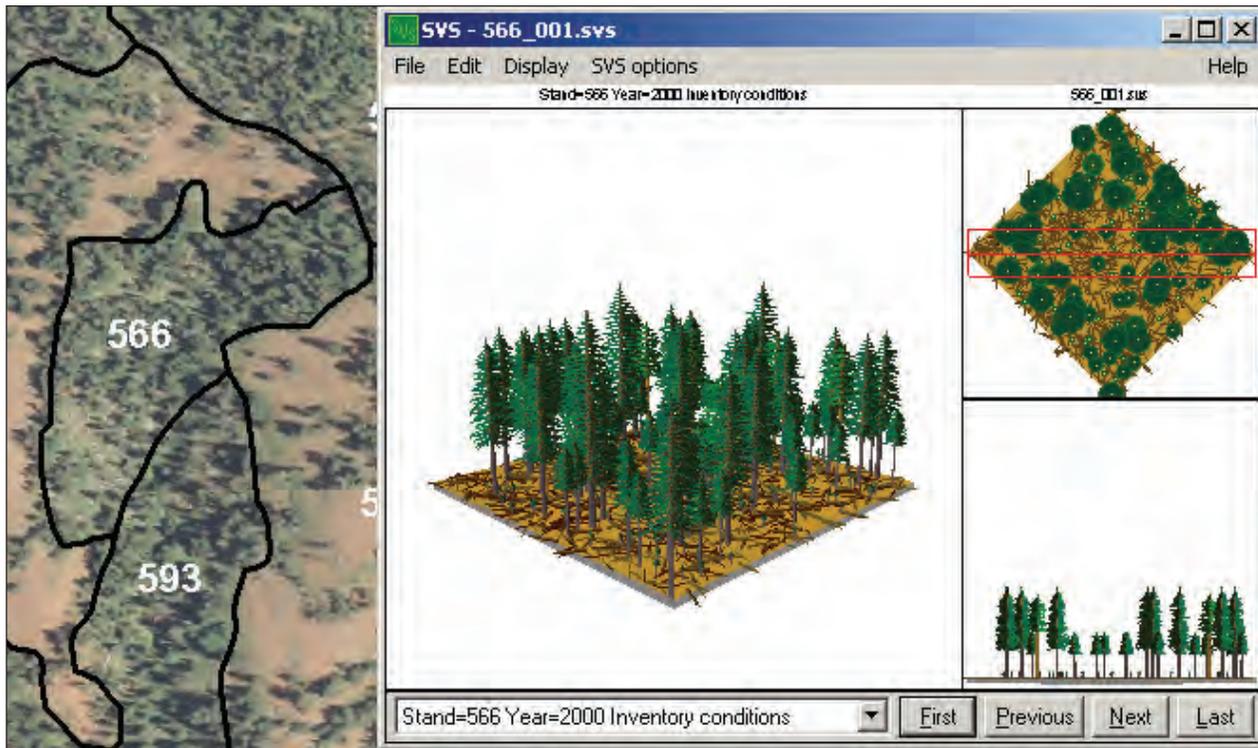


Figure 10—Aerial imagery of stand 566 from the supplied ArcFuels demonstration data and SVS visualization for the initial year (inventory conditions).

	A	B	C	D	E	F	G	H	I	J
1	Id	CaseID	StandID	Year	Surf_Flame_Sev	Surf_Flame_Mod	Tot_Flame_Sev	Tot_Flame_Mod	Fire_Type_Sev	Fire_Type_Mod
2	1	1	566	2000	4.973779678	0.513592958	47.94991302	0.513592958	PASSIVE	SURFACE
3	2	1	566	2001	5.887460709	0.861404896	49.62373352	0.861404896	PASSIVE	SURFACE
4	3	1	566	2002	5.852704048	0.851620317	49.28261948	0.851620317	PASSIVE	SURFACE
5	4	1	566	2003	5.835270405	0.847578108	49.71023178	0.847578108	PASSIVE	SURFACE
6	5	1	566	2004	5.827653885	0.846828699	50.51927567	0.846828699	PASSIVE	SURFACE
7	6	1	566	2005	5.830780983	0.849368036	51.03149033	0.849368036	PASSIVE	SURFACE
8	7	1	566	2006	5.834927559	0.852597833	52.03844452	0.852597833	PASSIVE	SURFACE
9	8	1	566	2007	5.841362476	0.856333137	51.06366348	0.856333137	PASSIVE	SURFACE
10	9	1	566	2008	5.844710827	0.859445333	51.56529617	0.859445333	PASSIVE	SURFACE
11	10	1	566	2009	4.938608646	0.515964091	45.74382019	0.515964091	PASSIVE	SURFACE

Figure 11—Excel workbook displaying the FFE-FVS Potential Fire report for a 10-year simulation run for stand 566 from the supplied ArcFuels demonstration data. Many reports are hardwired to be output for all runs in ArcFuels10; each report is represented in individual worksheets (tabs) in the workbook.

Select Stand: FVS Treatment Analysis—

The **Treatment Analysis** tab of the **Select Stand: FVS Treatment Analysis** form (fig. 12) allows a single parameter to be varied within a KCP to test the effects on modeled outputs such as stand structure or fire behavior. This is handy when trying to determine how intensely to thin a stand or to see the effects of varying wind-speed or fine dead fuel moisture on projected fire behavior. When this is used, FVS/FFE-FVS is run in “batch mode” automatically, running the stand through for

each step amount specified in the form. This form contains the same **FVS Inputs** and **FVS Options** tabs (see figs. 8 and 9, respectively) as the **Select Stand: Run FVS** form. Outputs are saved to an Excel workbook and graphs are created if those options are selected in the **FVS Options** tab (fig. 13).

Keyword	1	2	3	4	5	6	7	8
ThinBBA	2003	60	0.95	0.	999.	0.	999.	

Variable Parameter: 2
 Minimum Value: 20
 Maximum Value: 100
 Step Amount: 20

Figure 12—The **Treatment Analysis** tab of the **Select Stand: FVS Treatment Analysis** form is used to compare the effect of varying a single parameter on modeled outputs. The form is showing an analysis in which thinning intensities are varied to maintain a target of 20 to 100 ft²/ac basal area in 20 ft²/ac increments.

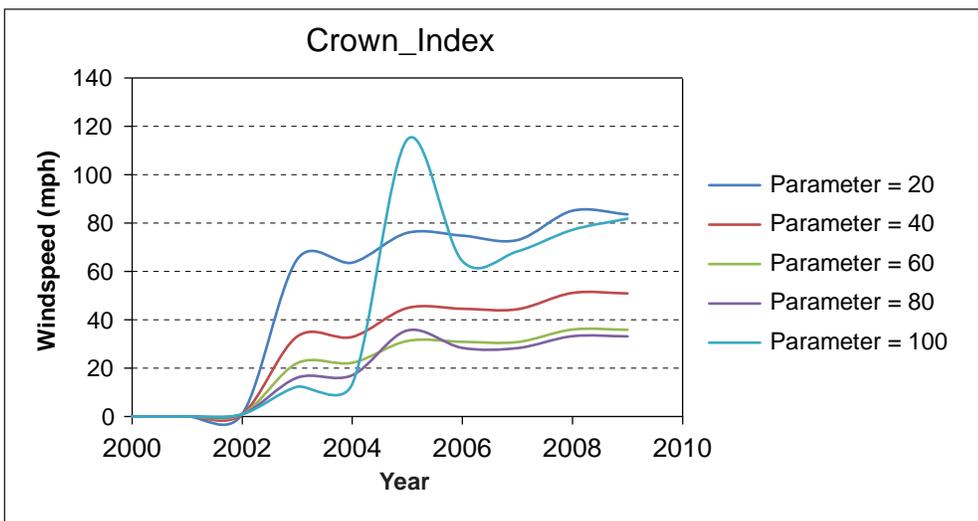


Figure 13—Sample of Excel workbook graph for stand 570 showing the effect on crowning index (the windspeed (mph) required to sustain active crown fire) when varying thinning intensity based on remaining basal area for 20, 40, 60, 80, and 100 ft²/ac.

Select Stand: FVS Compare Treatments—

The **Compare** tab of the **Select Stand: FVS Compare Treatments** form (fig. 14) allows for direct comparison of two treatment alternatives. When this form is used an Excel workbook with graphs is automatically created and opened (fig. 15). This allows for quick comparisons of treatment alternatives over the span of the simulated years. The information can also be used in fuel treatment prescription development when stand data are available for only a subset of a larger landscape. This form contains the same **FVS Inputs** and **FVS Options** tabs (see figs. 8 and 9, respectively) as the **Select Stand: Run FVS** and **Select Stand: FVS Treatment Analysis** forms.

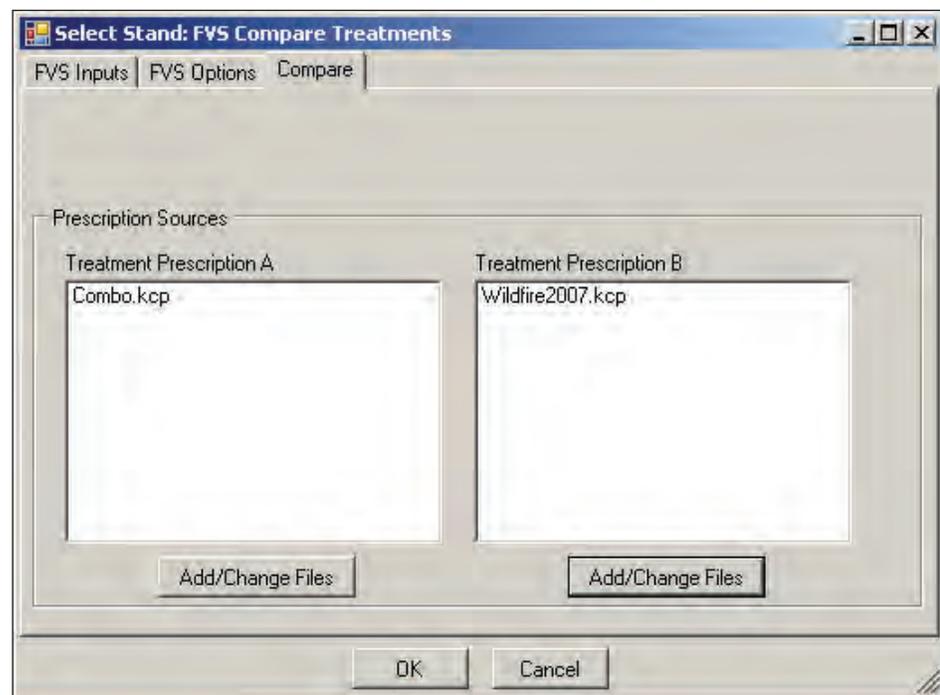


Figure 14—The **Compare** tab of the **Select Stand: FVS Compare Treatments** form is used to compare the modeled output of two different treatment prescriptions. In the form, the two treatment prescriptions being compared are one in which a fuel treatment (thin, fuel movement, and prescribed burn) occurs before a wildfire is simulated in 2007 (Combo.kcp) and a no-treatment alternative with the same simulated wildfire in 2007 (Wildfire2007.kcp).

View FVS Files—

The **View FVS Files** (fig. 16) form is used to quickly view the FVS KEY (*.key) and OUT (*.out) files from past runs (using the drop-down list). The files can be viewed in the text box, or opened in Notepad (using the **Open File in Notepad** button) or Excel (using the **Open Spreadsheet** button). The KEY file is a keyword record file that FVS reads to complete a run and includes information on the location of the stand and tree data, specifics on run duration, and prescriptions applied. The OUT file is a text file containing all the outputs from an FVS run.

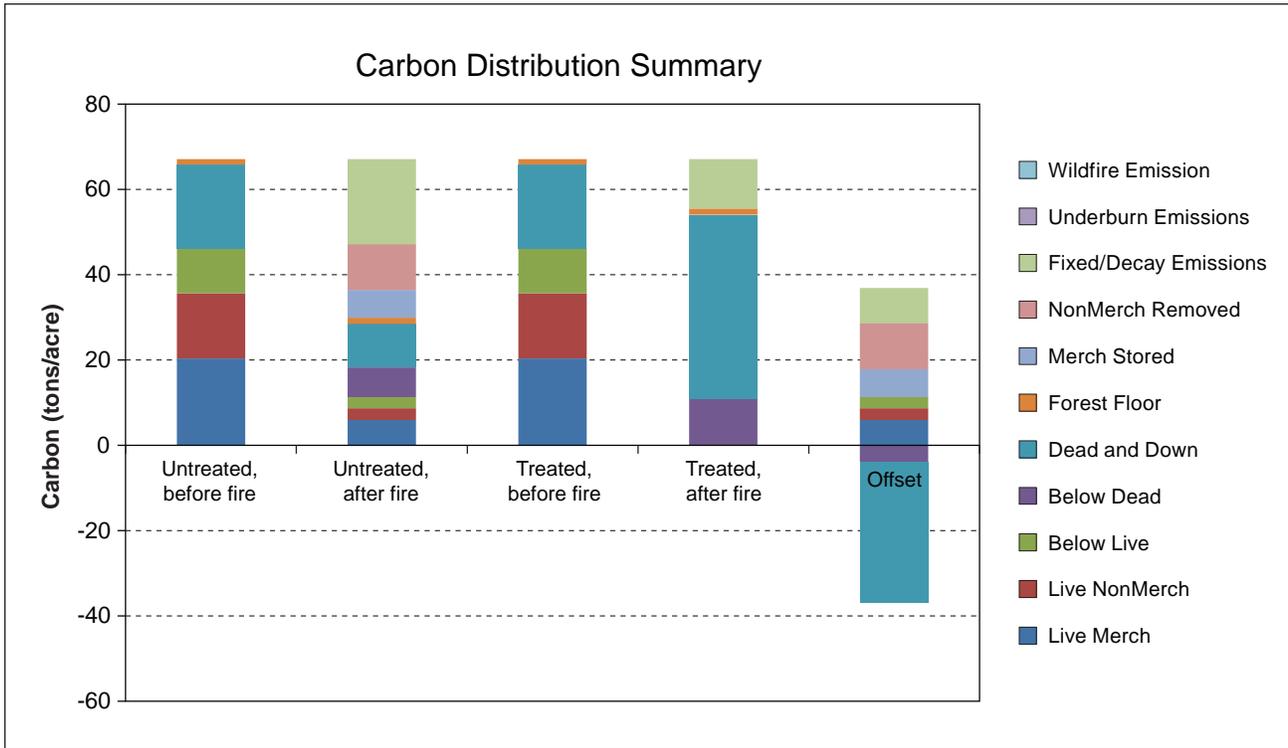


Figure 15— Sample of Excel workbook chart for stand 570 created for various carbon stocks (ton/acre) when comparing the two treatment prescriptions in figure 14.

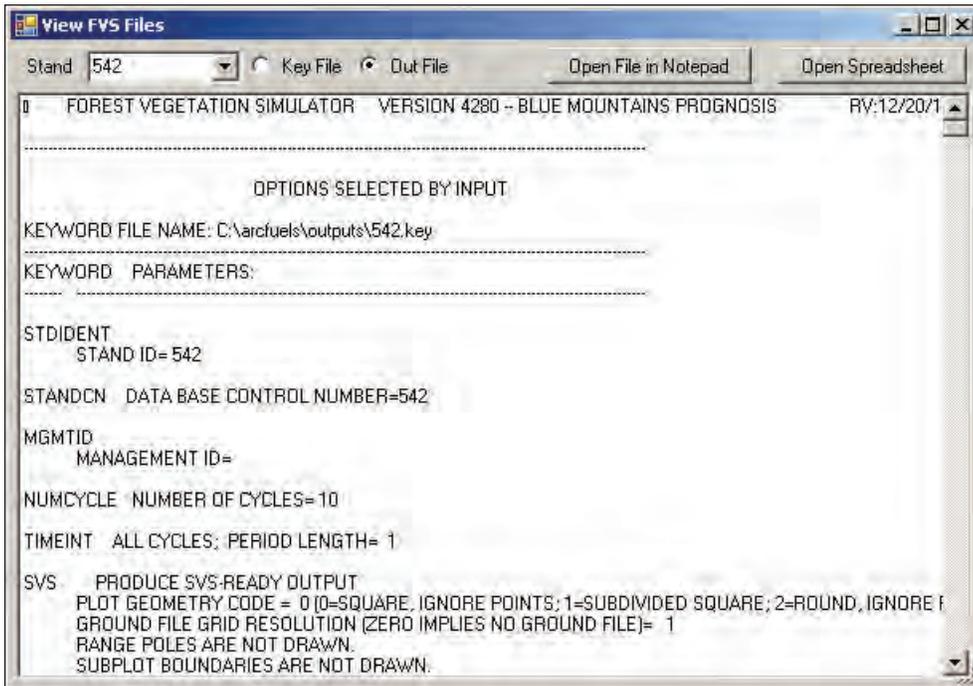


Figure 16—The **View FVS Files** form quickly displays the KEY or OUT files from past FVS/FFE-FVS runs with the additional options of opening the files using Notepad or Excel. The OUT file for stand 542 from the demonstration data is shown.

Select Stand: Display Details—

The **Select Stand: Display Details** form displays information about the trees and fuel loads from the FVS input database for the point selected when the data are available and for the landscape rasters if they are loaded (fig. 17). This still works when only FVS data or raster data are available; both are not needed.

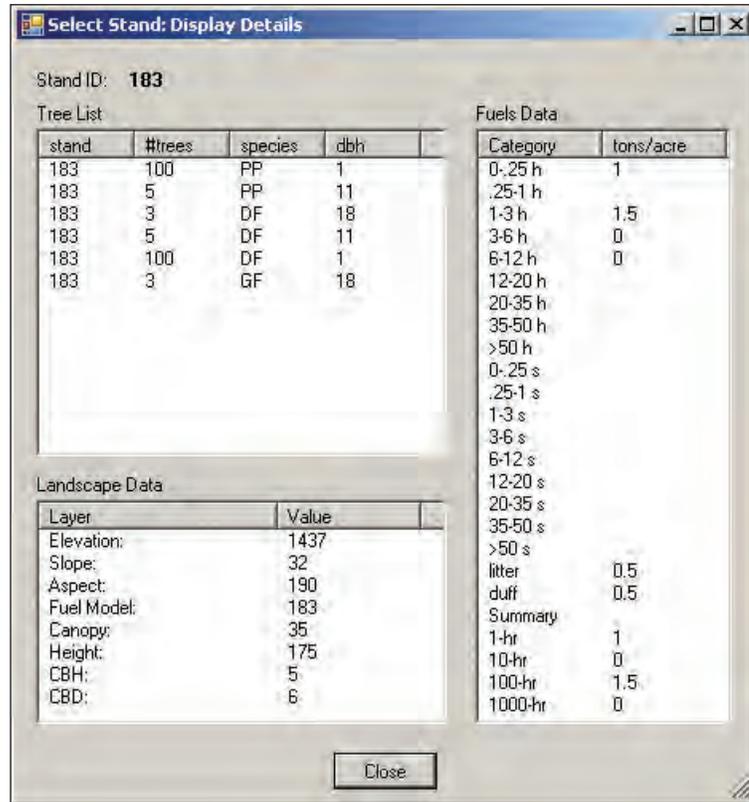


Figure 17—The **Select Stand: Display Details** form, which displays information about the stand and landscape data for a selected point. The Tree List and Fuels Data are from the FVS input database and the Landscape Data are from rasters loaded into ArcMap.

The Landscape menu is used when one desires to run FVS/FFE-FVS for more than one stand at a time.

Landscape

The **Landscape** menu is used when one desires to run FVS/FFE-FVS for more than one stand at a time. Like the stand-level FVS/FFE-FVS functionality, ArcFuels10 links a FVS-ready database to a stand shapefile, making it spatially explicit, and includes a graphical user interface (GUI) to run FVS without leaving the system. It is possible to use data that has a one-to-one linkage between stands represented in the FVS-ready database and the stand shapefile, or a one-to-many relationship in which there are fewer stands in the database than polygons in the shapefile. When a one-to-many relationship exists, the stands in the database are imputed to the various stands in the shapefile, which is the case with Most Similar Neighbor (MSN) (Crookston et al. 2002) data, or to individual raster pixels for Gradient Nearest Neighbor (GNN) (Ohmann and Gregory 2002) data. For Forest Service employees,

the FSVeg Spatial Data Analyzer (http://fsweb.nris.fs.fed.us/products/FSVeg_Spatial_Data_Analyzer/documentation.shtml) can be used to obtain FVS data at the landscape level for use with ArcFuels10.

In addition to FVS/FFE-FVS capabilities, the **Landscape** menu has a link to the LTD program (Ager et al. 2012), which is used to design fuel treatment plans using an attributed stand shapefile. Attributes from FVS/FFE-FVS are often used to populate the stand shapefile for LTD.

The **Landscape** menu has a drop-down list with five options, **Assign FVS Prescriptions**, **Run FVS**, **FVS Treatment Analysis**, **Join FVS Outputs**, and **Landscape Treatment Designer** (fig. 18). The first four options are all associated with running FVS and the last opens the LTD program.

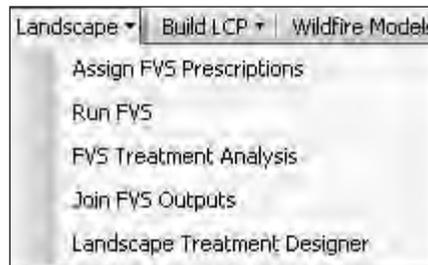


Figure 18—**Landscape** menu with the associated drop-down list from the ArcFuels10 toolbar.

Assign FVS Prescriptions—

The **Assign FVS Prescriptions** form allows the user to assign KCP prescriptions to stands and store them in the FVS database for use with the **Run FVS** and **FVS Treatment Analysis** forms. Records are populated with the KCP file name for each stand using the **Assign FVS Prescriptions** options (fig. 19). This allows the user to create and store unlimited treatment alternatives using multiple KCP files. Although different KCP files can be used in a single alternative, only one can be assigned per stand.

 Figure 19 shows a map of forest stands on the left and a data table on the right. The map displays various stands with numerical IDs. Orange arrows point from specific stand IDs on the map to corresponding rows in the table. The table has three columns: 'Stand_ID', 'Stand_ID_NUM', and 'Alt1_Combo'.

Stand_ID	Stand_ID_NUM	Alt1_Combo
588	588	
589	589	
590	590	Combo.kcp
591	591	Combo.kcp
592	592	
593	593	Combo.kcp
594	594	
595	595	Combo.kcp
596	596	Combo.kcp
597	597	Combo.kcp

Figure 19—Linkage between individual stands and the FVS database and the KCP files assigned for one fuel treatment alternative, “Alt1_Combo.”

The form has three options (buttons) for assigning prescriptions. The first option, **Selecting Individual Stands** (fig. 20), is used in conjunction with the **Select Stand Tool**. Prescriptions are assigned to a user-defined field in the stand table of the FVS database. The user sets the options in the **Assign FVS Prescriptions** form, pushes the **Select Stand: Assign Rx** button, then closes the form, turns on the **Select Stand Tool**, and points and clicks on individual stands to assign KCP files to each.

Each button represents a different method for assigning prescriptions to stands. Select a single method and fill in the data required for that method in the space below.

Selecting Individual Stands Using Arc Selected Stands Using TOM

Stand Shapefile: mt_emily_stands Stand ID Attribute: standid

FVS Input DB: C:\varcfuels\data\Mt_Emily_Database.mdb

Stand Table: stands Stand ID Field: Stand_ID

KCP Folder: C:\varcfuels\programs\kcp\

KCP Filename to be Assigned: Combo.kcp

Target Field in Stand Table: Alt1_Combo Clear Existing Data From Field

After you click the Select Stand: Assign Rx button below, clicking the Select Stand Tool will assign the KCP file named above to each stand you select.

Select Stand: Assign Rx

Close

Figure 20—**Assign FVS Prescriptions** form with the **Selecting Individual Stands** option selected. The form is set to assign the “Combo.kcp” to the “Alt1_Combo” field in the FVS database for each stand selected.

The second option, **Using Arc Selected Stands** (fig. 21), assigns prescriptions to stands selected in ArcMap. The selection options in ArcMap can be used to quickly select stands requiring treatment based on any number of attributes in the stand shapefile (e.g., distance to structures, stand slope, etc.).

Each button represents a different method for assigning prescriptions to stands. Select a single method and fill in the data required for that method in the space below.

Selecting Individual Stands | **Using Arc Selected Stands** | Using TOM

Stand Shapefile: mt_emily_stands Stand ID Attribute: standid

FVS Input DB: C:\arcfuels\data\Mt_Emily_Database.mdb

Stand Table: stands Stand ID Field: Stand_ID

KCP Folder: C:\arcfuels\programs\kcp\

KCP Filename to be Assigned: pileburn.kcp

Target Field in Stand Table: Alt1_WUI Clear Existing Data From Field

Clicking the Assign Prescription button will assign the KCP file to the Stand Table field named above for all stands currently selected.

Assign Prescription

Close

Figure 21—Assign FVS Prescriptions form with the **Using Arc Selected Stands** option selected. The form is set to assign the “pileburn.kcp” to the “Alt1_WUI” field in the FVS database for the Arc Selected stands.

The third option, **Using TOM** (fig. 22), uses an integer raster consisting of only 0s and 1s, where a value of 1 indicates the need for a treatment and a value of 0 is no treatment needed. Treatment Optimization Model (TOM) is a tool in FlamMap that outputs a 0/1 treatment raster. The **Using TOM** option is not limited to treatment rasters output by TOM but can be used with any 0/1 raster created in ArcMap. This function pairs extremely well with the ArcMap Raster Calculator. For example, with the Raster Calculator, new 0/1 rasters based on specific criteria (e.g., all burnable fuels, slopes > 30 percent, south aspects, etc.) can be created, then ArcFuels10 can be used to apply prescriptions.

Because rasters and shapefiles rarely line up exactly or the 0/1 raster might be based on non-stand-specific criteria (such as fire hazard from FlamMap runs), a user-defined treatment threshold is used. The user decides what percentage of the stand must be represented by a value of 1 to have the KCP applied. In addition to

Each button represents a different method for assigning prescriptions to stands. Select a single method and fill in the data required for that method in the space below.

Selecting Individual Stands Using Arc Selected Stands **Using TOM**

Stand Shapefile: mt_emily_stands Stand ID Attribute: standid

FVS Input DB: C:\arcfuels\data\Mt_Emily_Database.mdb

Stand Table: stands Stand ID Field: Stand_ID

KCP Filename to be Assigned: Underburn2003.kcp

KCP Folder: C:\arcfuels\programs\kcp\

Target Field in Stand Table: Alt1_TOM Clear Existing Data From Field

Stand ID Raster: stands TOM Raster: trt_location

Threshold: Treat stands if at least 25 % of pixels are marked Treat (1) in the TOM Raster Layer.

Optional: Compare stands selected to cells recommended

Review how well the stands selected for treatment match the TOM raster

Text Summary File: C:\arcfuels\outputs\Cmp_location.txt

ASCII File: C:\arcfuels\outputs\Cmp_location.asc

Assign Prescription Clicking the Assign Prescription button will assign the KCP file to the Target Field named above for all stands meeting the threshold criteria.

Close

Figure 22—Assign FVS Prescriptions form with the **Using TOM** option selected. The form is set to apply the “Underburn2003.kcp” to the “Alt1_TOM” field based on the 0/1 raster “trt_location.” The program knows to which stands in the FVS database to assign the prescriptions because of the use of a Stand ID Raster.

assigning the KCP files, a text summary file of how many stands were selected for treatment and a new 0/1 ASCII text file for the prescription assignment can be created.

Run FVS—

The **Run FVS** form has two tabs related to running FVS. The landscape **Run FVS** form is similar to that under the **Stand** menu and offers a compact FVS interface with many options. A single stand, a set number of stands, ArcMap-selected stands, only stands with prescriptions, or all the stands in the landscape can be run. Prescriptions can be applied to all stands or to selected stands by linking to the prescription field in the input database (see **Assign FVS Prescriptions** above). The number of FVS cycles and years is set with this form. In addition to

the ability to write and use KCPs, some helpful FVS/FFE-FVS functions are hard-wired in ArcFuels10 as options: fuel model selection, carbon reports, turning off the FFE-FVS reports, creating a tree list for a given year, and generating a cut list. Inputs are set using the **FVS Inputs** (fig. 23) and **FVS Options** (fig. 24) tabs. A few differences between the **Stand** and **Landscape Run FVS** forms exist. With the **Landscape** form, SVS outputs are not created, nor can NEXUS inputs be created, the output file is an Access database rather than an Excel Workbook so no graphs are created, and the Parallel Processing Extension (Crookston and Stage 1991) can be run through the **Landscape** form but not the **Stand** form.

FVS Treatment Analysis—

The **FVS Treatment Analysis** tab has three options (buttons) for analyzing treatment effects on stand characteristics and modeled fire behavior and effects. The **FVS Treatment Analysis** form also has the **FVS Inputs** (fig. 23) and **FVS Options** (fig. 24) tabs. Within the **Treatment Analysis** tab the first option, **Vary Parameter** (fig. 25), is similar to the **FVS Treatment Analysis** function in the **Stand** menu, where a single parameter within the prescription file is varied in a stepwise fashion.

Figure 23—The **FVS Inputs** tab of the **Run FVS** form. The form is set to run all the stands in the supplied ArcFuels demonstration landscape using the Blue Mountain variant of FVS and will apply prescriptions to those stands with them assigned using the “Alt1_Combo” field in the FVS stand data table.

The screenshot shows the 'Run FVS' dialog box with the 'FVS Options' tab selected. The 'FVS Options' section contains the following settings: Cycles is 10, Years per Cycle is 1, Fuel Model Set is 53. There are three unchecked checkboxes: 'Generate tree lists after year/cycle', 'Generate cut lists', and 'Override FFE Fuel Model - pretreat'. There are also two unchecked checkboxes: 'Override FFE Fuel Model - post cut' and 'Override FFE Fuel Model - post fire'. The 'PPE Treatment Priority Variable' is set to 'BSDI' and 'PPE Treatment Proportion' is 1. The 'FVS Process and Outputs' section includes: Output Folder 'C:\arcfuels\outputs\' (with a browse button), Scenario Name 'run', Key File 'run.key', Out File 'run.out', Scenario Index '1'. There are three checkboxes: 'Add pause in batch file' (unchecked), 'Execute' (checked), and 'Minimize FVS window' (checked). There are also two unchecked checkboxes: 'Suppress FFE reports' and 'Carbon reports'. The 'FVS Output DB' is 'C:\arcfuels\outputs\Alt1_Combo.mdb' (with a browse button). At the bottom, there are buttons for 'Run FVS', 'Run PPE', 'Scan Out File for Errors', and 'Close'.

Figure 24—The **FVS Options** tab of the **Run FVS** form. The form is set to run 10 one-year simulations in which FVS/FFE-FVS selects fuel models from both the Scott and Burgan (2005) and Anderson (1982) sets and will write the outputs to the “Alt1_Combo.mdb” database file.

The second option, **Substitute Value** (fig. 26), substitutes a single value based prescription with “<_>” inside a command indicating the value to be altered. The minimum and maximum values and the step amount are specified by the user.

The third option, **FLP Specific** (fig. 27), is used to create loss function databases for use with FlamMap5 or FSim (Finney et al. 2011) specific FLP files. FSim is the large fire simulator used by the Fire Program Analysis (FPA) System (<http://www.fpa.nifc.gov>) to do wildfire risk assessments for the United States (wildfire risk will be described in detail in the “Risk” section later). An FLP file is a gridded-point shapefile that contains information about burn probability and fire intensity for each point. The spacing of the points is user defined within FlamMap5 and FSim. The FLP files generated in FlamMap5 either contain 6 or 20 fire intensity

Each button represents a different method of treatment analysis. Select a single method and fill in the data required for that method in the space below.

Vary Parameter Substitute Value FLP Specific

Specify kcp treatment file(s) on the FVS Inputs tab, then select one file here.
 Combo.kcp

Select the line containing the variable to be analyzed
 ThinBBA 2003 60 0.95 0. 999. 0. 999.

Keyword	Parameters							
	1	2	3	4	5	6	7	8
ThinBBA	2003	60	0.95	0.	999.	0.	999.	

Variable Parameter: 2 Minimum Value: 60 Maximum Value: 90 Step Amount: 10

Create a single Key File and do not run (FVS only)

Run FVS Analysis Run PPE Analysis

Close

Figure 25—**Treatment Analysis** tab with the **Vary Parameter** option selected. The form is set to vary the thin from below part of the “Combo.kcp” file to a target basal area of 60, 70, 80, and 90 ft²/ac.

levels (FILs); those from FSim only contain 6 FILs. An FIL is a measure of fire behavior and is based on flame length. This **FVS Treatment Analysis** option is used in conjunction with a KCP that uses the FLAMEADJ keyword to control the flame length within each FFE-FVS simulation to be coupled with the FLP outputs for further analysis with the **Risk** menu options within ArcFuels10. The **FLP Specific** option not only runs simulations to match the FIL categories for the FLP files, but also runs a no-fire simulation. For more information about FlamMap5 and FSim, please refer to each program’s Web site at <http://www.firemodels.org/index.php/national-systems/flammap> and <http://www.fpa.nifc.gov>, respectively.

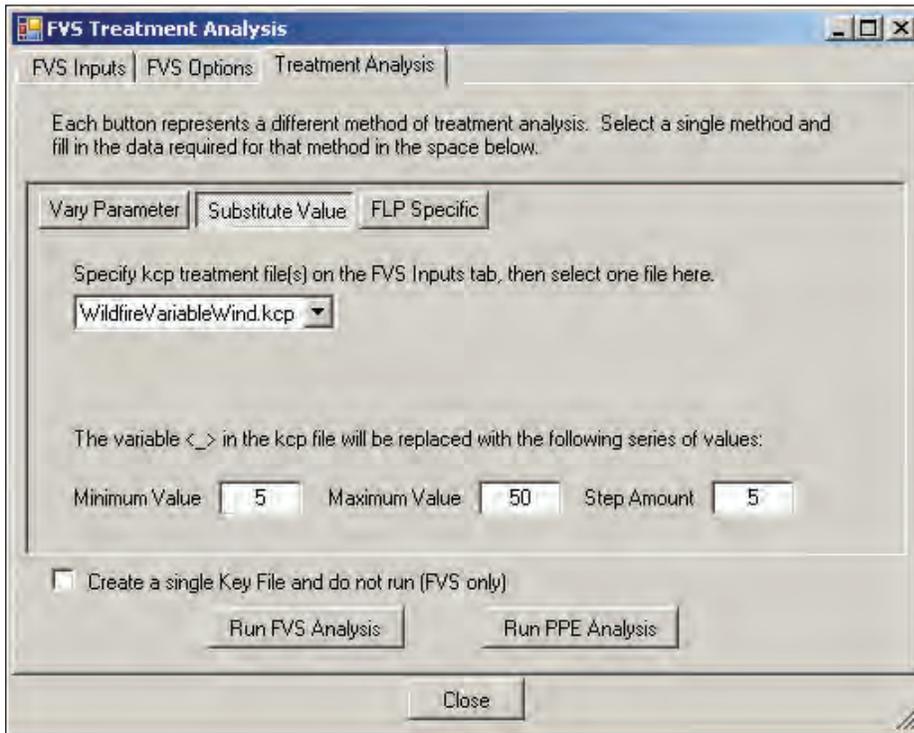


Figure 26—Treatment Analysis tab with the **Substitute Value** option selected. Within the “WildfireVariableWind.kcp,” windspeed will be varied from 5 to 50 mph by 5 mph steps.

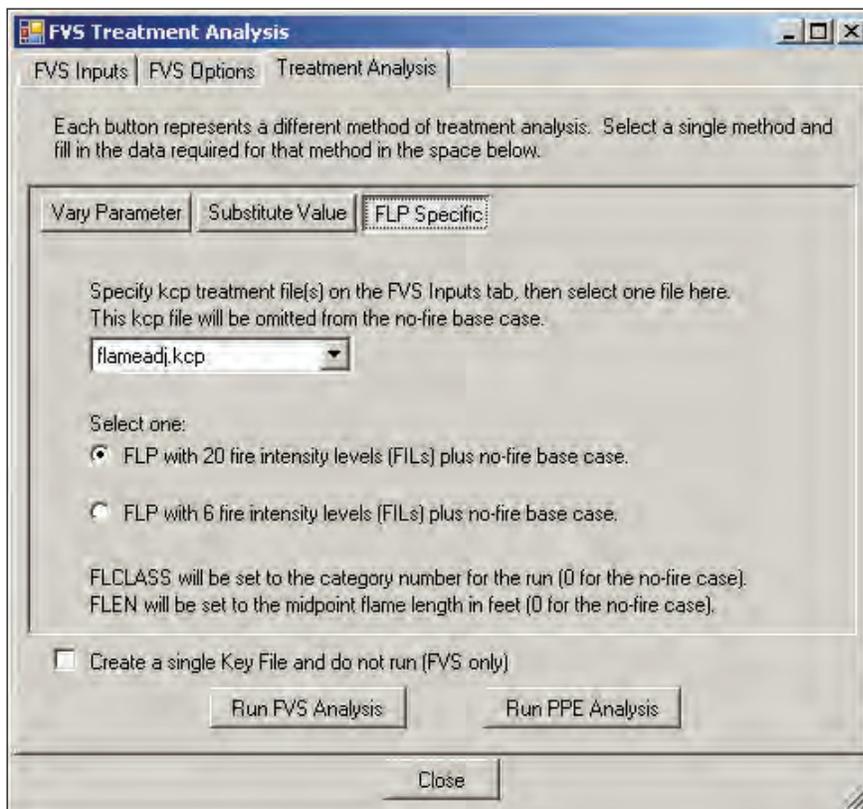


Figure 27—Treatment Analysis tab with the **FLP Specific** option selected set up to run FFE-FVS simulations to build a loss function database for use with an FLP with 20 fire intensity levels (FILs).

Join FVS Outputs—

The **Join FVS Outputs** form (fig. 28) joins FVS/FFE-FVS outputs from any table in the output database for a given year to the stand shapefile layer. This is a very useful tool for visualizing various FVS output metrics across a landscape (fig. 29).

The screenshot shows a dialog box titled "Join FVS Outputs". It has a text field for "FVS Output DB" containing the path "C:\arcfuels\outputs\notreat.mdb". Below it is a dropdown menu for "Table to Join from FVS Output DB" with "FVS_Compute" selected. There are two more dropdown menus: "Year to Join" with "2005" selected and "Scenario" with "1" selected. At the bottom, there are three buttons: "Join", "Remove Joins", and "Close".

Figure 28—The **Join FVS Outputs** form is used to join FVS/FFE-FVS outputs to the stand shapefile layer. The form is set to join the FVS_Compute table for 2005. The FVS_Compute table is specific to ArcFuels10 and includes data pertinent to canopy characteristics relevant for landscape fire behavior modeling and modeled fire behavior from FFE-FVS. See figure 29 for a sample map.

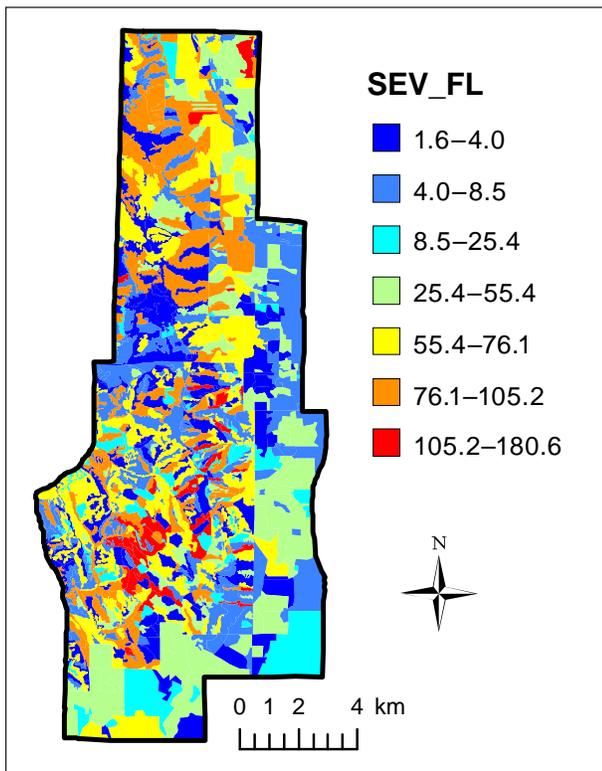


Figure 29—A sample map created after joining the FVS_Compute table with severe flame length (ft) outputs for 2005 from a landscape FFE-FVS run to the stand shapefile for the supplied ArcFuels demonstration area.

ArcFuels10 streamlines the process of building landscape files (LCPs) from FVS/FFE-FVS output databases, an attributed shapefile, or raster data for use in fire behavior modeling programs such as FARSITE and FlamMap.

Landscape Treatment Designer—

The **Landscape Treatment Designer** form (fig. 30) is available when the LTD program is downloaded and linked via the **Edit Project Setting** form, which is described in the “Project” section of this document. The LTD program is a multicriteria spatial prioritization and optimization system to help design and explore landscape fuel treatment scenarios (fig. 31). The program fills a gap in the fuel treatment planning process between fire model programs such as FlamMap and planning systems such as ArcFuels10 by providing a systematic way of planning spatially explicit fuel treatments. The LTD uses inputs on spatial treatment objectives, activity constraints, and treatment thresholds, then identifies optimal fuel treatment locations with respect to the input parameters. The input data represent polygons

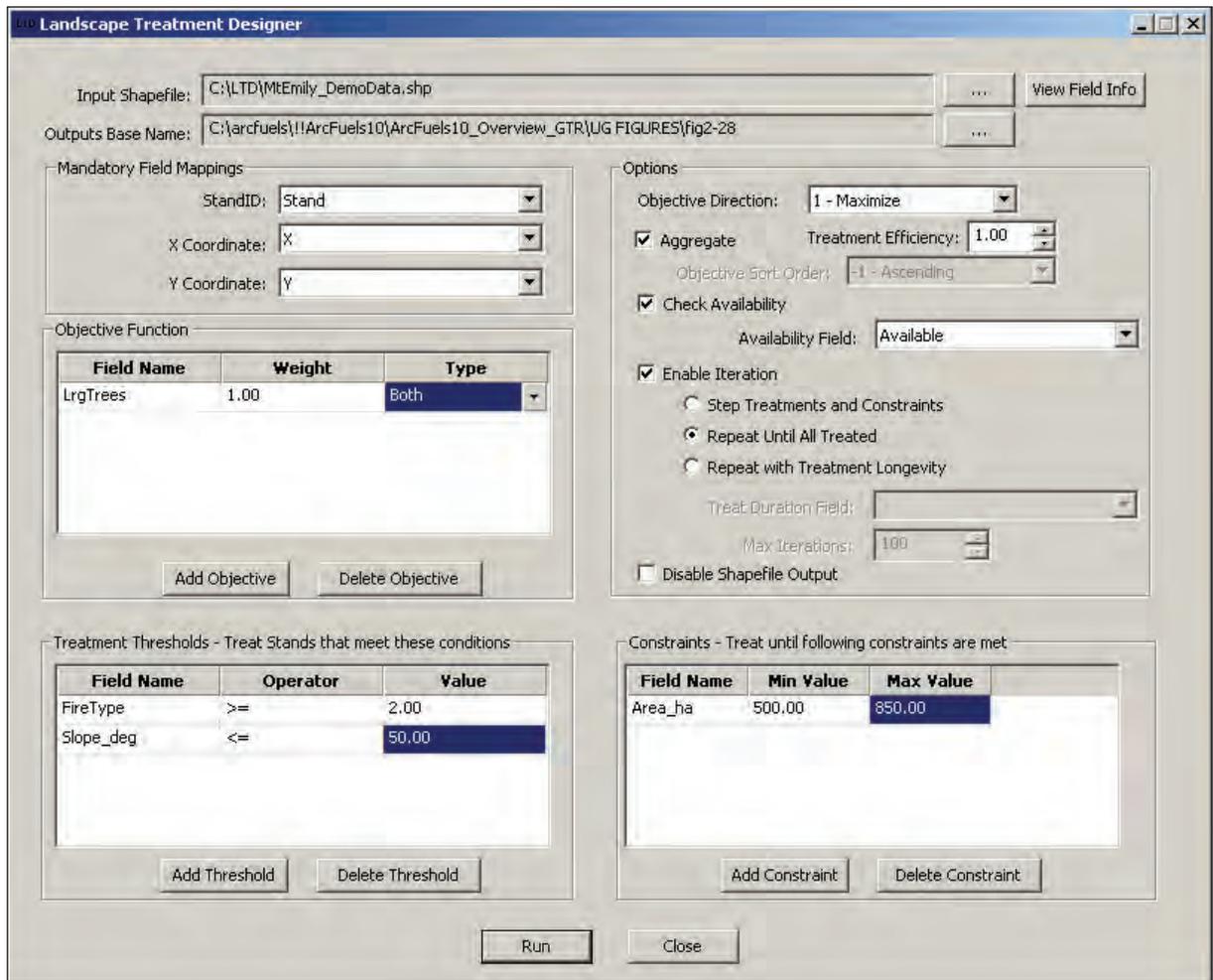


Figure 30—The **Landscape Treatment Designer** (LTD) form, which can be used for fuel treatment planning. LTD is set to create a fuel treatment alternative with aggregated treatment blocks to protect large trees until all stands are included. Stands are considered for treatment only when fire type is passive or active crown fire (FireType>=2.00) and slope is less than or equal to 50 degrees (Slope_deg<=50.00). Each treatment block can treat between 500 and 850 ha but will ultimately be larger with the inclusion of stands not requiring treatment.

that are attributed with information about expected fire behavior and the polygon's overall contribution to one or more landscape management objectives. Four types of output files are generated with each run: (1) a text file with all the input data with treatment locations indicated, (2) a summary text file of input parameters and output results, (3) a results comma separated file with the input parameters and output results, and (4) a shapefile with an attribute table that identifies patch locations and stands selected for treatments. For more detailed information about the LTD, refer to Ager et al. 2012.

Build Landscape File (LCP)

Running FlamMap or FARSITE, two commonly used fire behavior modeling programs, requires a landscape file (LCP). LCPs are binary files containing a compilation or “sandwich” of ASCII data, including elevation, slope, aspect, fuel model, canopy cover, canopy height, canopy base height, and canopy bulk density (fig. 32). In addition to the eight layers listed above, a FlamMap or FARSITE LCP can include duff loading and coarse woody fuels layer, but these are not easily obtained or often used. The new Wildland Fire Assessment Tool (WFAT) (<http://www.frames.gov/partner-sites/nifft/tools/nifft-current-resources/>) also uses an LCP file with additional data requirements (fuel loading model and tree list data) for the fire-effects functionality. For more information about these programs, please visit their Web sites.

ArcFuels10 streamlines the process of building LCPs from FVS/FFE-FVS output database(s), an attributed shapefile, or raster data. ArcFuels10 has the ability to reduce the analysis area based on another raster's extent or coordinates, quickly apply treatments, and export ASCIIs and rasters created along with the LCP.

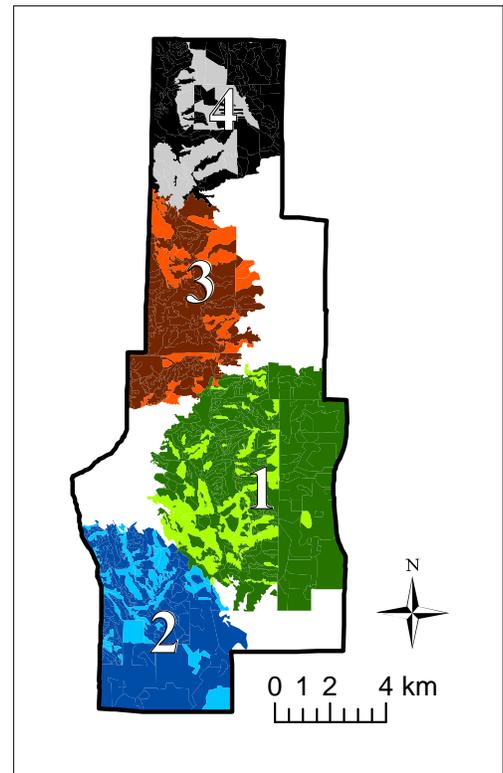


Figure 31—The Landscape Treatment Designer treatment solution from figure 30, in which the lighter shade within each treatment block (1–4) is marked as needing treatment.

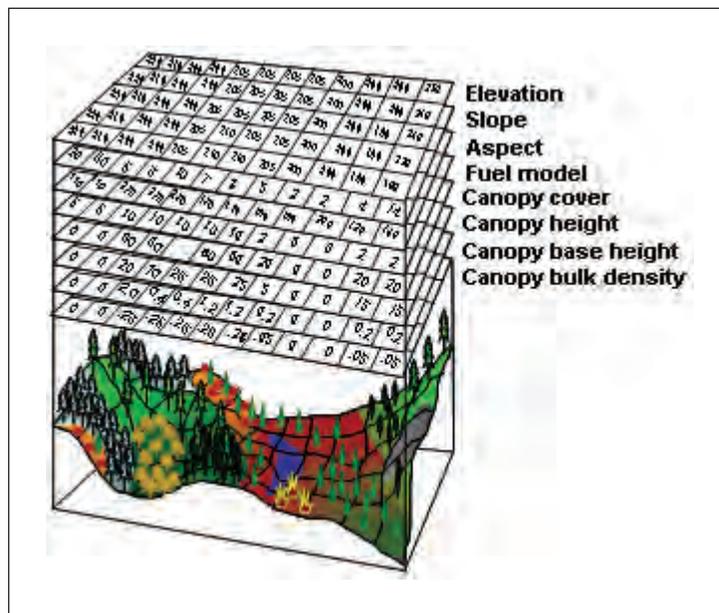


Figure 32—Landscape file (LCP) schematic, adapted from Finney (2006).

The **Build LCP** menu has a drop-down list with four options, **Build LCP using FVS or GNN Data**, **Build LCP using Raster Data**, **Build LCP using Shapefile Data**, and **Build LCP by Merging Data** (fig. 33).

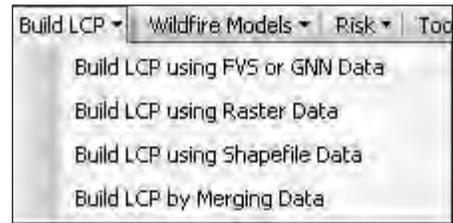


Figure 33—**Build LCP** menu with the associated drop-down list from the ArcFuels10 toolbar.

Build LCP Using FVS or GNN Data—

The **Build LCP Using FVS or GNN Data** form builds LCPs and/or rasters from FVS or GNN (Ohmann and Gregory 2002) output database(s) that are spatially linked via a raster that ties the FVS stand-identification numbers to their spatial location on the landscape. This is a raster version of the stand shapefile.

To use this function, FVS/FFE-FVS must be run first for all unique stands within the landscape. It is possible to have FVS data from one stand be applied to multiple stands in the landscape, as is common with GNN and MSN data. Because FVS/FFE-FVS reports only the fuel model and canopy characteristic layers (canopy cover, canopy height, canopy base height (CBH), and canopy bulk density (CBD), topographic rasters (elevation, slope, aspect) must be obtained and loaded into the ArcMap table of contents to use this tool.

If the FFE-FVS-derived fuel model assignments are not desired, it is possible to override these with another fuel model raster (such as one downloaded from LANDFIRE) by using the *Use ArcGIS Raster Layer* option.

When the *Apply Treatments* option is selected, two FVS/FFE-FVS databases can be combined to build the LCP and rasters. This is often used when running FVS for selected stands with prescriptions, rather than running the entire landscape as a time-saving step. ArcFuels10 replaces data from the *FVS Output Database* (typically a no-treatment run with all stands represented) with that from the *Treated Stands Database* for all stands present.

The **Build LCP Using FVS or GNN Data** form consists of two tabs, **FVS Data** (fig. 34) and **Output** (fig. 35). The **FVS Data** tab is where the data sources are specified (topographic rasters, FFE-FVS output database(s), and related data table and data fields). The **Output** tab is where the desired extent of the output LCP and/or rasters is specified. There are three options: *Default extent: Intersection of the selected data layers*, which is the typically rectangular extent of the topographic and *Stand ID Raster*, *Use another layer to limit the extent*, which uses another raster to build the LCP and/or rasters for a smaller analysis area (this is often used

when the topographic rasters are much larger in extent than the *Stand ID Raster*), and *Manually limit the extent of the output*, where the user types in the bounding coordinates desired.

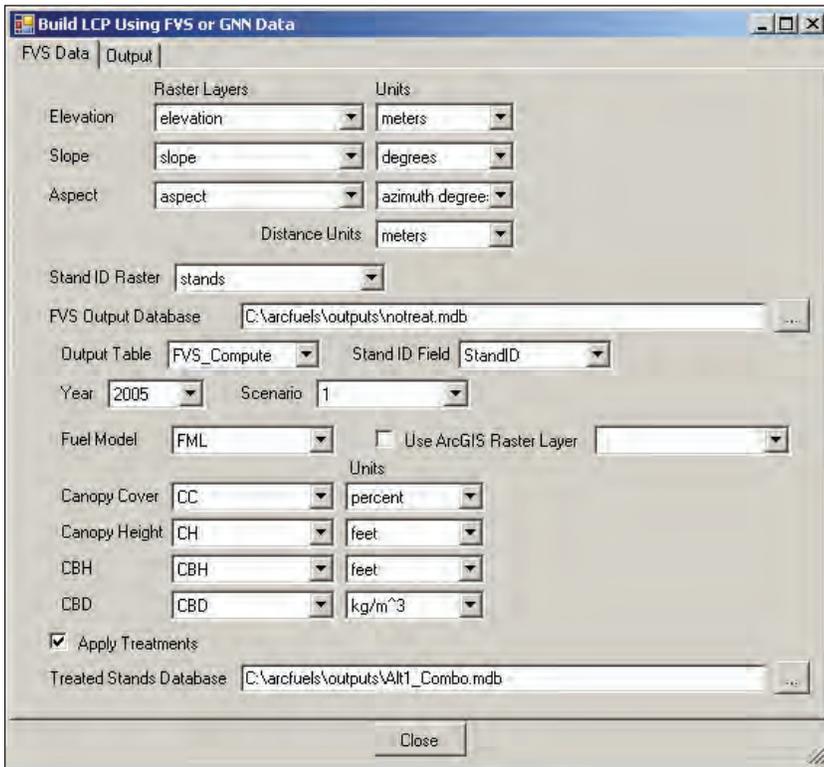


Figure 34—**Build LCP Using FVS or GNN Data** form **FVS Data** tab. The form is set to combine a no-treatment database (notreat.mdb) in which all stands were run through FVS without applying a treatment KCP and a treated database (Alt1_Combo.mdb) where only stands receiving treatment were run through FVS for the year 2005.

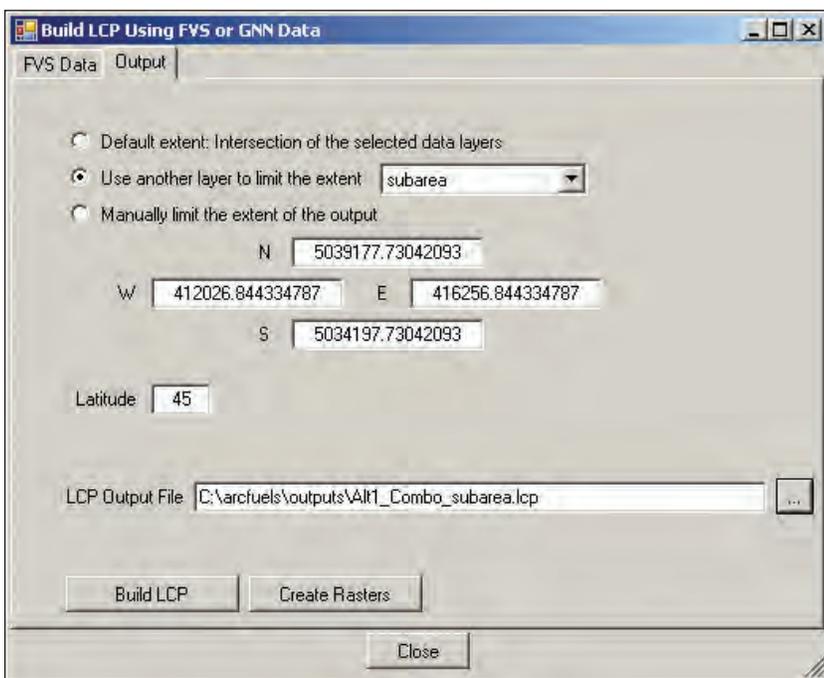


Figure 35—**Build LCP Using FVS or GNN Data** form **Output** tab set to create rasters and a LCP limited by the extent of a smaller area defined by the “subarea” raster.

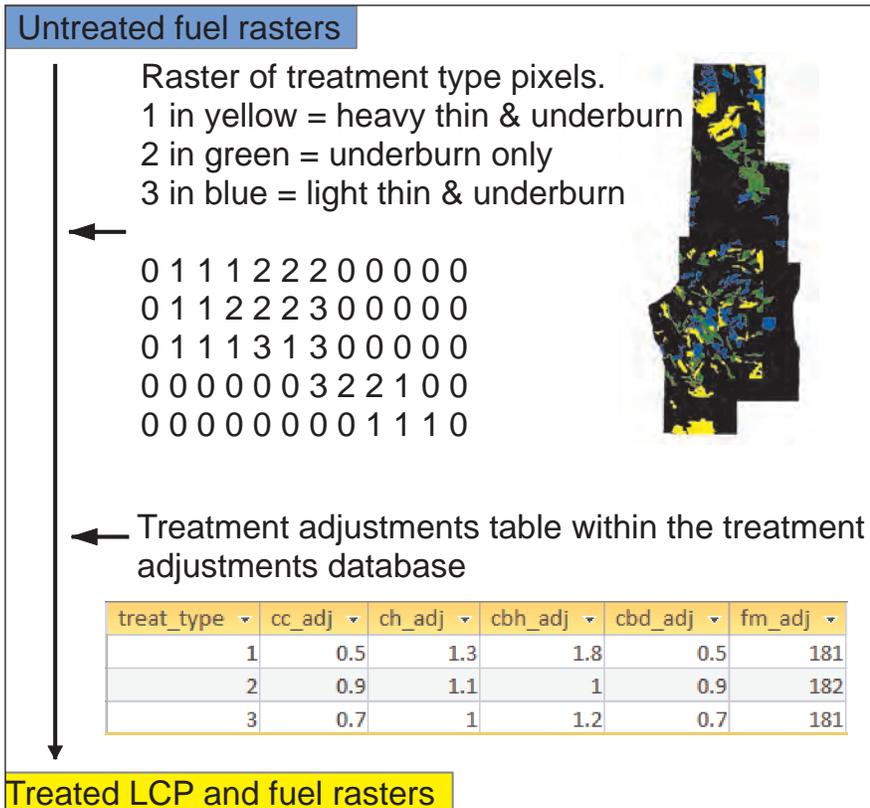


Figure 37—Treatment adjustment factors can be used in conjunction with untreated fuel rasters and a treatment type raster to rapidly apply treatments, build an LCP, and output the treated rasters.

should be applied to a specific polygon. Treatment adjustments can multiplication factors (e.g., 0.2 would reduce input data by 80 percent), replacement factors (e.g., 2 m for CBH), or no change. These options are both convenient ways to build and archive different treatment alternatives. The **Output** tab is identical to **Build LCP Using FVS or GNN Data** (fig. 35).

Build LCP Using Shapefile Data—

The **Build LCP Using Shapefile Data** form builds LCPs and/or rasters from attributes within a shapefile. As with the **Build LCP Using FVS Data** form, topographic rasters (elevation, slope, aspect) must be obtained and loaded into the ArcMap table of contents to use this form.

The **Build LCP Using Shapefile Data** form consists of two tabs, **Shapefile Data** (fig. 38) and **Output** (fig. 35). Raster data are needed to define the stand locations and the topography. The fuel layers (surface fuel model and canopy characteristic) are selected from attributes within the specified stand shapefile. The **Output** tab is identical to **Build LCP Using FVS or GNN Data** (fig. 35).

The screenshot shows a software dialog box titled "Build LCP Using Shapefile Data". It has two tabs: "Shapefile Data" (selected) and "Output".

Raster Layers Section:

- Elevation: elevation (dropdown), Units: meters (dropdown)
- Slope: slope (dropdown), Units: degrees (dropdown)
- Aspect: aspect (dropdown), Units: azimuth degree: (dropdown)
- Distance Units: meters (dropdown)

Attributes Section:

- Stand ID Raster: stands (dropdown)
- Shapefile: mt_emily_stands_FVS_No (dropdown)
- Stand ID: standid (dropdown), Units: (empty dropdown)
- Fuel Model: FML (dropdown)
- Canopy Cover: CC (dropdown), Units: percent (dropdown)
- Canopy Height: CH (dropdown), Units: feet (dropdown)
- CBH: CBH (dropdown), Units: feet (dropdown)
- CBD: CBD (dropdown), Units: kg/m³ (dropdown)

A "Close" button is located at the bottom center of the dialog box.

Figure 38—**Build LCP Using Shapefile Data** form **Shapefile Data** tab. The tab is set to create an LCP file using fuel model and canopy characteristics specific to each stand derived with FVS/FFE-FVS.

Build LCP by Merging Data—

The **Build LCP by Merging Data** form allows the user to mix and match rasters from varying data sources (e.g., LANDFIRE, FFE-FVS, GNN, local, or LiDAR) or mosaic together multiple rasters of different spatial extents into one seamless layer for any given data set needed to create an LCP and/or rasters. It is even possible for the rasters to have different units, but they must be the same resolution and projection, and be snapped.

The **Build LCP by Merging Data** form consists of two tabs, **Merge Data** (fig. 39) and **Output** (fig. 35). The navigation button to the right of each data required opens a new form where the rasters can be selected and the units defined (fig. 40). The **Output** tab is identical to **Build LCP Using FVS or GNN Data** (fig. 35).

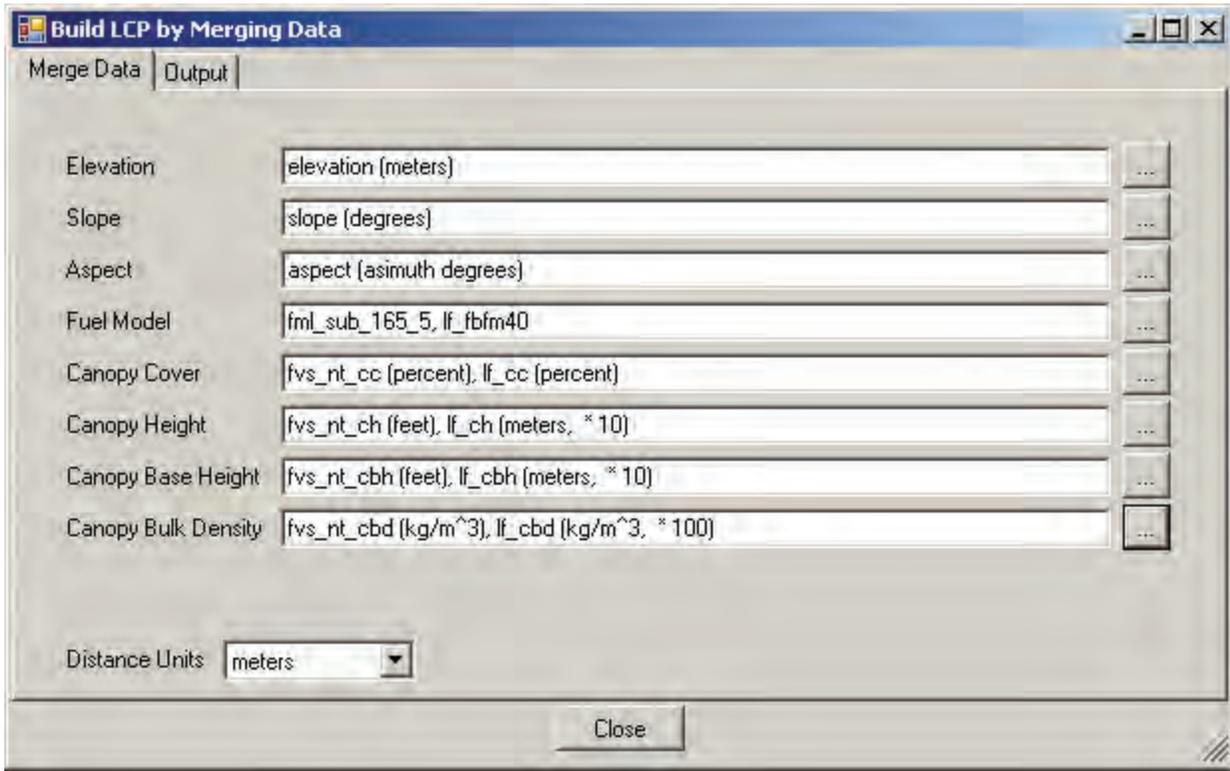


Figure 39—Build LCP by Merging Data form Data Sources tab set to mosaic together LANDFIRE rasters with FVS/FFE-FVS-derived rasters.

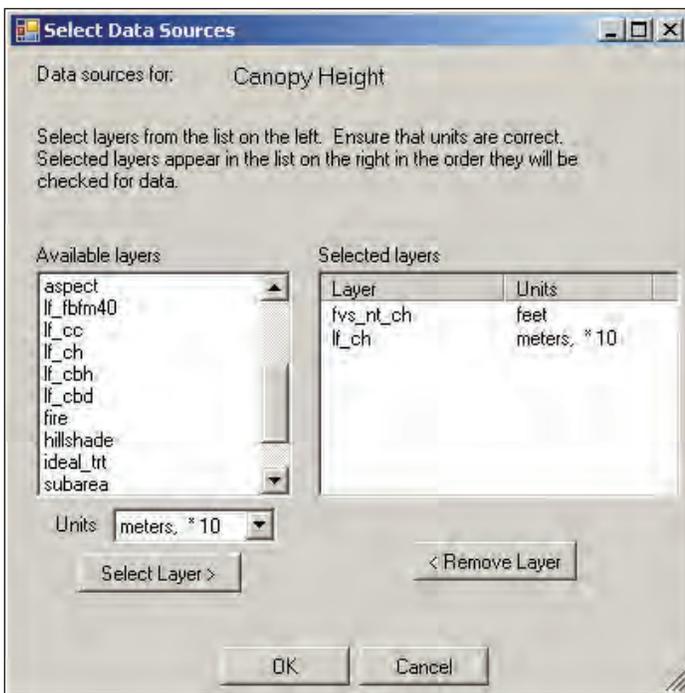


Figure 40—Select Data Sources form shown for combining FVS/FFE-FVS-derived canopy height with LANDFIRE data. The order in which data are selected specifies how they will be used; those listed above replace those below.

ArcFuels10 leverages existing programs and the Wildfire Models menu offers shortcuts to open NEXUS, FARSITE, FlamMap, Behave Plus, FOFEM, and Fire Family Plus.

Wildfire Models

As mentioned, ArcFuels10 leverages existing programs. The **Wildfire Models** menu offers “shortcuts” to open selected fire behavior models (NEXUS, FARSITE, FlamMap, BehavePlus, FOFEM, and Fire Family Plus) for external use (fig. 41). The paths to the programs executable (*.exe) files must be set using the **Edit Paths** form, which is described in the “Project” section. For information about each of the programs, refer to their documentation.

In addition to opening the mentioned programs, ArcFuels10 also has the **Behave Calculator**, which is run through an integrated GUI.



Figure 41—**Wildfire Models** menu with the associated drop-down list from the ArcFuels10 toolbar.

Behave Calculator—

The **Behave Calculator** (fig. 42) is hardwired into ArcFuels10 and uses the same equations as the SURFACE module in Behave Plus. The **Behave Calculator** can be used to quickly assess changes to modeled surface fire rate of spread and flame length for changes to fuel model, slope, fuel moisture, and/or windspeed inputs.

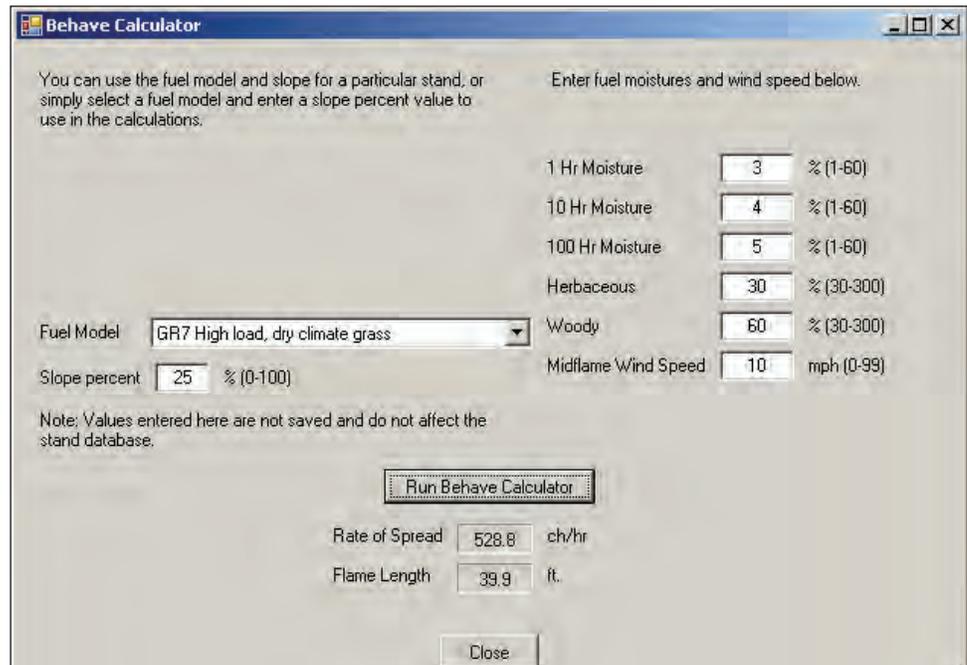


Figure 42—**Behave Calculator** form with calculated rate of spread and flame length for fuel model GR7 (also known as 107) with a 25 percent slope under the specified fuel moisture and windspeed conditions.

Risk

Wildfire risk is the product of the likelihood of a fire occurring, the associated fire behavior when a fire occurs, and the effects of the fire (Calkin et al. 2010, Finney 2005, Scott 2006). Although fire effects can be both positive and negative, in the field of wildfire risk the benefits are most often not considered. Wildfire risk mitigation is achieved when any of the three aspects (likelihood, behavior, or effects) are reduced.

Wildfire likelihood is often quantified with burn probability (BP), which is an estimate of the possibility of a specific location burning given a single random ignition under the burn conditions specified in the simulation. Burn probability modeling represents a major advance in wildfire behavior modeling compared to previous methods, such as those in which fire likelihood was quantified with relatively few (<10) predetermined ignition locations. This advance resulted from the development of an MTT fire spread algorithm (Finney 2002) that makes it computationally feasible to simulate thousands of fires and generate burn probability and intensity maps over large areas (10 000 to 2 000 000 ha). High-performance computers are typically used for MTT simulations within FSim (Finney et al. 2011). The algorithm as implemented in FlamMap (version 3 and version 5, Finney 2006) is adequate for project scale (e.g., <25 000 ha) evaluations. Extensive testing has shown that this algorithm can replicate large fire boundaries in the heterogeneous landscapes that typify much of the wildlands in the western United States. FSim is based on the same platform as FlamMap, in which MTT calculations are used to model fire behavior and is the program used by FPA to do fire risk assessments for the United States.

FSim and FlamMap5 each output an FSL text file for each fire along with a final perimeter shapefile and FLP text file in addition to a BP ASCII raster file. An FSL file contains the location, a unique identification number, and the final fire size in acres for all randomly ignited fires. An FLP file is a gridded point shapefile that lists the location, overall burn probability, and the conditional probability by FIL categories. The FLP files generated in FlamMap5 contain either 6 or 20 FILs; those from FSim contain only 6 FILs. The six FIL categories are expressed as flame lengths in 2-ft (0.61-m) categories (FIL1 – FIL5; FIL6 > 12 ft). The 20 FIL categories are expressed as flame lengths in 0.5-m categories (FIL1 – FIL19; FIL20 > 9.5 m).

A quantitative definition of fire risk includes fire behavior probabilities and fire effects for highly valued resources (HVRs). Finney (2005) calls this quantitative definition expected net value change (NVC). The expected NVC can include financial, ecological or other values at present day, or future discounted values,

Wildfire risk is the product of the likelihood of a fire occurring, the associated fire behavior when a fire occurs, and the effects of the fire

and can include both positive and negative impacts of fire (Finney 2005). When wildfire benefits are not considered, expected NVC can be simplified to expected loss (EL). The calculation of EL is the sum of the product burn probability and loss for different fire intensity levels summed across the area in question (Ager et al. 2007, 2010b):

$$EL = \sum (BP_i) (L_i)$$

where BP_i is the probability of a fire at the i^{th} flame length category (conditional probability) and L_i is the loss (e.g., northern spotted owl habitat, large trees, or carbon) at the i^{th} FIL. Expected loss is then summed by FIL for each scenario. The FLP contains information for BP_i and L_i is within the loss function database created in FVS/FFE-FVS with the **FVS Treatment Analysis** form **FLP Specific** option. In addition to the EL, conditional expected loss (CEL) can be calculated. The CEL is the observed loss given a fire occurs and is calculated as:

$$CEL = \sum (BP_i/BP) (L_i)$$

where BP_i is the probability of a fire at the i^{th} flame length category, BP is the burn probability, and L_i is the loss at the i^{th} flame length category.

When it is not possible to directly link loss to flame lengths as is possible for trees or carbon, response functions can be used instead (Calkin et al. 2010). Response functions translate fire effects into NVC for any given HVR. In each response function, NVC is based on the flame length of the fire and represents both beneficial and adverse effects to the resource. Response functions are developed by considering the different ways in which various HVRs might respond to fire of different intensities (fig. 43; table 3). For computational ease response variables use the midpoint NVC value (table 3).

Conditional flame length (CFL) is the probability-weighted flame length given a fire occurs and is a measure of wildfire hazard. The conditional flame length is calculated using FLP files with the following equation:

$$CFL = \sum (BP_i/BP) (F_i)$$

where BP_i is the probability of a fire at the i^{th} flame length category, BP is the burn probability, and F_i is the flame length midpoint of the i^{th} FIL category.

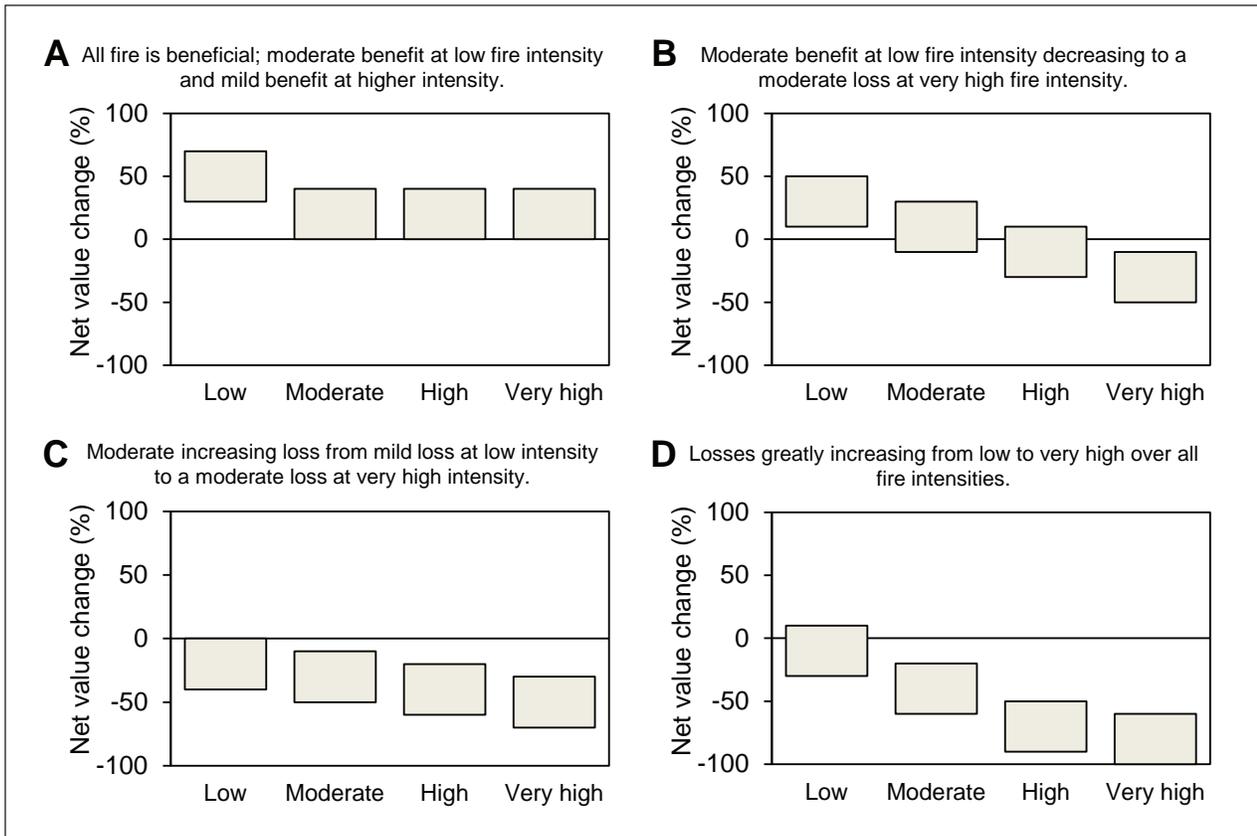


Figure 43 —Sample graphs of response functions of net value change by flame length categories for four different highly valued resources. Adapted from Calkin et al. 2010.

Table 3—Response function examples with percent net value change (± 20 percent) for four flame length categories (low, moderate, high, and very high)¹

Response function description	Low	Moderate	High	Very high
All fire is beneficial; moderate benefit at low fire intensity and mild benefit at higher intensity.	+50	+20	+20	+20
Moderate benefit at low fire intensity decreasing to a moderate loss at very high fire intensity.	+30	+10	-10	-30
Moderate increasing loss from mild loss at low intensity to a moderate loss at very high intensity.	-20	-30	-40	-50
Losses greatly increasing from low to very high over all fire intensities.	-10	-40	-70	-80

¹ Adapted from Calkin et al. 2010.

ArcFuels10 streamlines the calculation and processing of risk metrics such as net value change, expected loss, and conditional flamelength.

ArcFuels10 streamlines the calculation and processing of risk metrics such as NVC, EL, CEL, and CFL within the **Risk** menu. The **Risk** menu has a drop-down menu with nine options, **Convert FLPs**, **Batch Convert FLPs**, **Convert Fire Size List**, **Batch Convert Fire Size Lists**, **Net Value Change**, **Expected Impacts**, **Conditional Flame Lengths**, **Averages**, and **Display Results** (fig. 44).

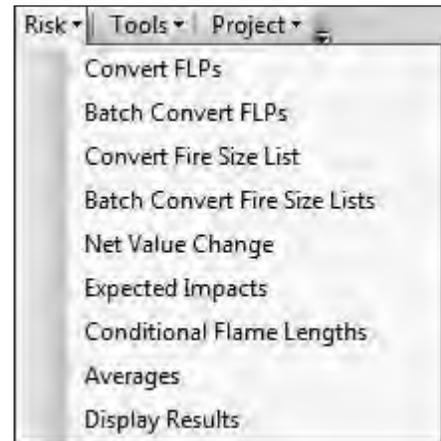


Figure 44—**Risk** menu with the associated drop-down list from the ArcFuels10 toolbar.

Convert FLPs—

The **Convert FLPs** form (fig. 45) converts FLP files from FlamMap5 and FSim into a shapefile (fig. 46). This combines two ArcGIS processing steps into one; it converts an XY text file into an events file, then exports it as a shapefile with defined spatial reference.

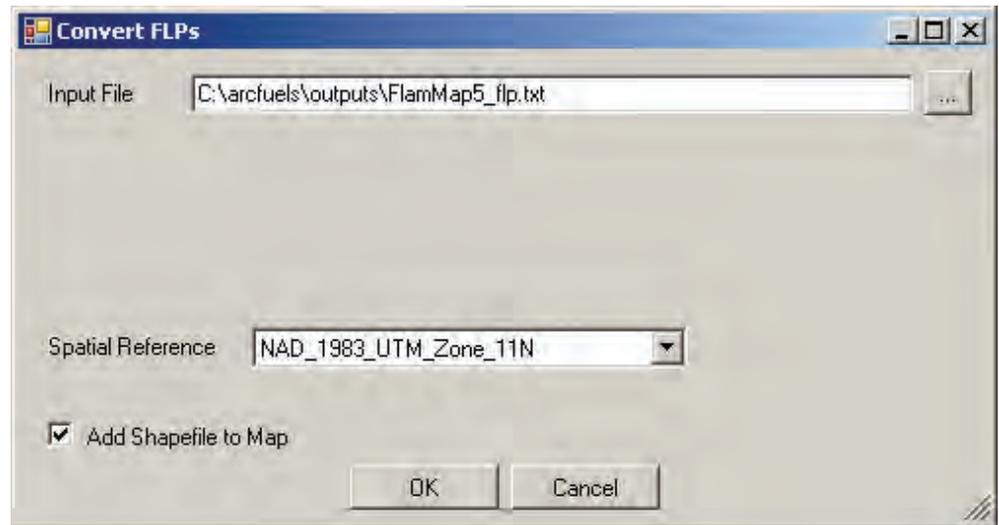


Figure 45—**Convert FLPs** form setup to convert an FLP output from FlamMap5.



Figure 46—Example of converted FLP shapefile attributes table (A) and shapefile (B) for an FLP with six FILs.

Batch Convert FLPs—

The **Batch Convert FLPs** form (fig. 47) has the same functionality as the **Convert FLPs** form with the added benefit of converting multiple files at once.

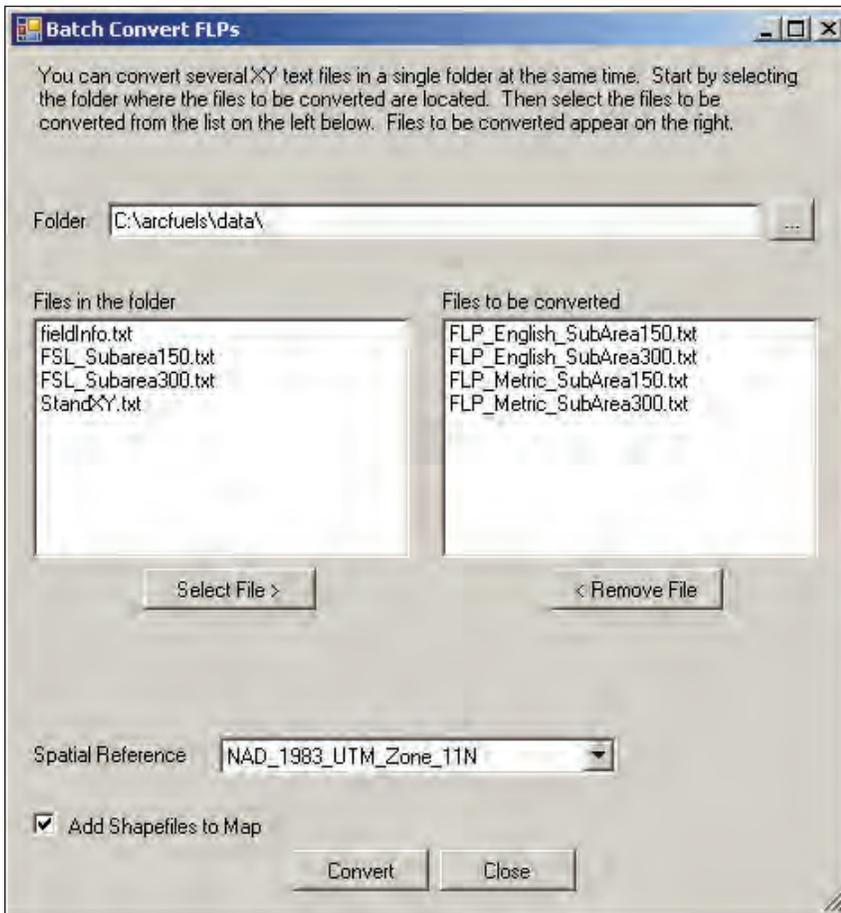


Figure 47—**Batch Convert FLPs** form set to convert four FLP files and define their spatial reference all at once.

Convert Fire Size List—

The **Convert Fire Size List** form (fig. 48) converts FSL files from FlamMap5 and FSim into a shapefile (fig. 49). An FSL file is a text file with information about the location of each ignition and the final fire size for all randomly ignited fires in FlamMap5 or FSim. As in the **Convert FLPs** form, this combines two ArcGIS processing steps into one; it converts an XY text file into an events file, then exports it as a shapefile with defined spatial reference. Because the FSL files have unique attribute names specific to FlamMap5 and FSim for the X and Y coordinates, there are program-specific input options. In addition, an *Other* option has been added and can be used to convert non-FSL information such as plot locations; the X and Y coordinate labels are specified by the user for this function to work.

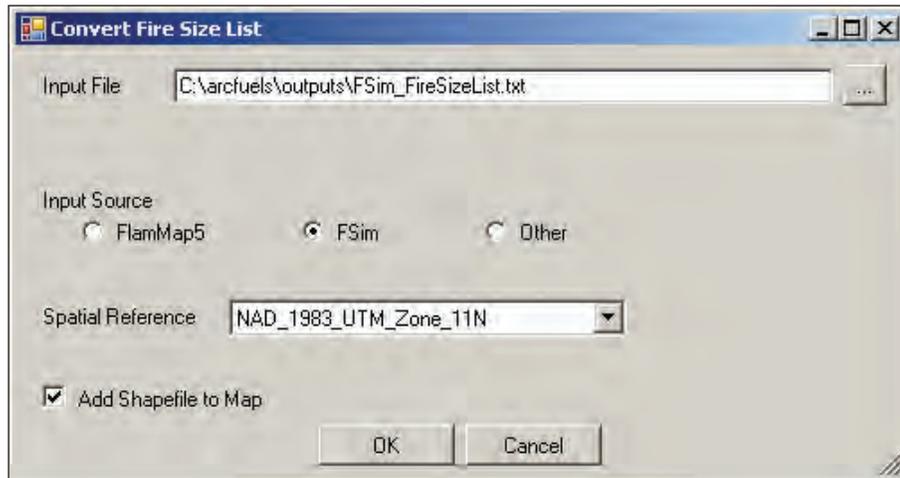


Figure 48—**Convert Fire Size List** form set to convert an FSim file.



Figure 49— Example of converted Fire Size List shapefile attributes table (A) and shapefile (B) showing three ignitions over aerial imagery.

Batch Convert Fire Size List—

The **Batch Convert Fire Size List** form (fig. 50) has the same functionality as the **Convert Fire Size List** form with the added benefit of converting multiple files at once.

The screenshot shows a Windows-style dialog box titled "Batch Convert Fire Size Lists". At the top, there is a blue title bar with standard window controls. Below the title bar is a text area with instructions: "You can convert several XY text files in a single folder at the same time. Start by selecting the folder where the files to be converted are located. Then select the files to be converted from the list on the left below. Files to be converted appear on the right." Below this is a "Folder:" text box containing "C:\arcfuels\outputs" and a browse button "...".

There are two list boxes. The left one is titled "Files in the folder" and contains three entries: "alt1_flp_metric.txt", "alt2_flp_metric.txt", and "alt3_flp_metric.txt". The right one is titled "Files to be converted" and contains three entries: "alt1_fsl.txt", "alt2_fsl.txt", and "alt3_fls.txt". Between these two lists are two buttons: "Select File >" and "< Remove File".

Below the lists is the "Input Source" section with three radio buttons: "FlamMap5" (which is selected), "FSim", and "Other". Below that is a "Spatial Reference" dropdown menu currently showing "NAD_1983_UTM_Zone_11N". At the bottom left is a checked checkbox labeled "Add Shapefiles to Map". At the bottom center are two buttons: "Convert" and "Close".

Figure 50—**Batch Convert Fire Size Lists** form set to convert three Fire Size List (FSL) files and define their spatial reference all at once. With this form, the FSLs must all be from the same program, FlamMap5, FSim, or have the same X and Y coordinate headers specified with the *Other* option.

Net Value Change—

Response functions translate positive and negative fire effects into net value change (NVC) to of highly valued resources (HVRs) based on the flame length categories. The **Net Value Change** form (fig. 51) is used to calculate the NVC for any HVR using an FLP, 0/1 HVR raster, and appropriate response function values (see table 3 for examples). The form calculates both the expected and conditional NVC and appends the values to the input FLP file.

Figure 51—**Net Value Change** form set to calculate the expected and conditional NVC for a FlamMap5 20-bin metric FLP within hypothetical lynx habitat using the stylized Response function 7. The calculated values will automatically be added to the new “ENVC_lynx” and “CNVC_lynx” fields specified in the form.

Expected Impacts—

The **Expected Impacts** form (fig. 52) provides an interface to combine loss function databases created in FVS/FFE-FVS with FLP files to calculate expected and conditional expected loss as well as conditional flame length. The outputs are appended to the FLP shapefile.

To use this form, the “Stand_ID” must be attributed in the FLP file for each point. Also, a loss function database must exist where flame length was varied according to the FLPs FILs. The **FLP Specific** option on the **Treatment Analysis** form (fig. 25) is designed specifically for this function.

FLP Layer: FlamMap5_flp_stands

Attribute with Stand ID: RASTERVALU

FVS output DB: C:\arcfuels\outputs\FlamMap5_FLP.mdb

Table: FVS_Compute Year: 2005

Field with Flame Length Category: FLCLASS

Select fields to be included in the computations:

Available fields	Selected fields
IQ	Input Field
MOD_FLAM	Raw
PCCBD	Normalized
PCHT2LV	MORT21PP
SCENARIO	MORT21PP_r
SEV_FLAM	MORT21PP_n
StandID	LIVE21PP
TMPCCBD	LIVE21PP_r
TMPHT2LV	LIVE21PP_n
WASCUT	
Year	

FLP with 20 fire intensity levels (FILs)
 Compute Conditional Flame Length (meters)

FLP with 6 fire intensity levels (FILs)
 Compute Conditional Flame Length (feet)

Calculate Impacts

Close

Figure 52—**Expected Impacts** form set calculate the expected loss of live and dead large ponderosa pine trees and to calculate conditional flame lengths.

Conditional Flame Lengths—

The **Conditional Flame Lengths** form (fig. 53) is used to calculate CFLs. The CFLs can be appended to a preexisting field in the FLP or a new field can be created. There are two options for calculating CFL; one for FLPs with 20 FILs and one for FLPs with 6 FILs. The output units are the same as the input units for the type of FLP; 20 category FLPs are in meters and 6 category FLPs are in feet.

Figure 53— **Conditional Flame Lengths** form set to calculate the conditional flame lengths in a new attribute field named “CFL_ft” within a FlamMap5-derived FLP with six FILs.

Averages—

The **Averages** form (fig. 54) is used to average or summarize FLP or FSL point data by a shapefile. The shapefile can represent anything of interest, such as forest stands, threatened or endangered species habitat, wildland-urban interfaces (WUIs), or a combination of factors. The **Averages** form has the ability to intersect the FLP or FSL point data or use data that have already been intersected. The output is an Excel workbook summarizing the expected burn probability, and conditional burn probability or average fire size depending on the input, for each polygon within the shapefile (fig. 55).

Figure 54—Averages form set to summarize fire size by forest type in the supplied ArcFuels demonstration data.

	A	B
1	Polygon ID	Fire Size
2		
3	Grand fir	3695.189941
4	Engleman spruce-subalpine fir	3586.783936
5	Subalpine fir	2405.978516
6	Nonforested	3698.14624
7	Douglas-fir	2154.091797
8	Ponderosa pine	1192.953003
9	Western larch	4325.894531
10	Engleman spruce	3752.134766
11	Overall Average	3101.396484

Figure 55—Example of Fire Size List averages output, in which fire size is averaged by forest type, as well as the entire landscape.

These data can be used to create scatter plots and curves to represent risk (fig. 56). Scatter plots and risk curves can be used to show the relative risk of different subunits (polygons) within a landscape (Ager et al. 2010b).

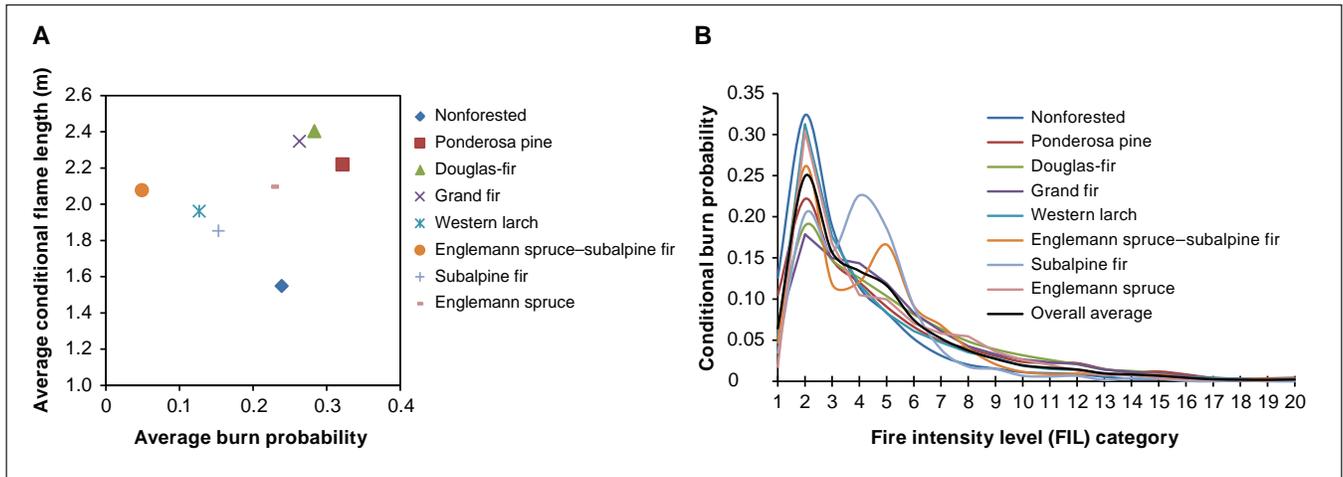


Figure 56—Example of wildfire risk scatter plots (A) and curves (B) from a 20-category FLP averaged by forest type.

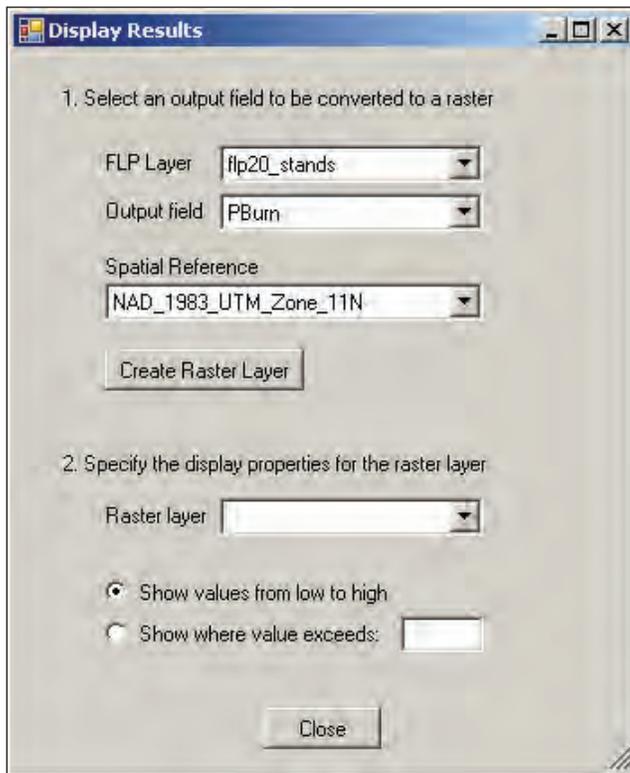


Figure 57—Display Results form set to create a raster of burn probability from a FlamMap5 FLP file.

Display Results—

The **Display Results** form (fig. 57) has two functions: (1) conversion of a field in an FLP shapefile to a raster with defined spatial reference; and (2) customized display of existing raster layers, to either show values in a ramp from low to high, or show values that exceed a user-defined threshold.

Tools

The **Tools** menu is where other functions are housed that are not specific to the other menus in the ArcFuels10 toolbar. This houses a form to update raster values, forms to convert ASCII files to rasters (postprocessing for FlamMap and FSim), and a form to export the attributes of a shapefile to a spreadsheet.

The **Tools** menu has a drop-down list with four options, **Modify Raster Values**, **Convert ASCII to Raster**, **Batch Convert ASCII to Raster**, and **Export Shapefile Attributes** (fig. 58).

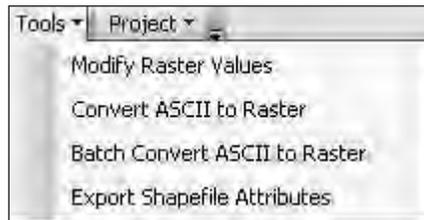


Figure 58—**Tools** menu with the associated drop-down list from the ArcFuels10 toolbar.

Modify Raster Values—

After critiquing data for accuracy (informally, on the ground, using the Stratton (2009) methodology, or otherwise), it is most likely that modifications will be required to reflect local knowledge of fuel models and fire behavior, recent management activities, recent wildfires, etc. Realize, however, that when modeling landscape-level fire behavior, one must accept that there will be some error in the data, but one should always strive to minimize this. It is important to document changes as well as make them incrementally, making it easier to see the effect of the changes and backtrack, if necessary. With ArcFuels10, complex raster value replacements are easily made on the individual raster data components, rather than on the landscape file. Tools such as the FARSITE landscape calculator and the LANDFIRE Total Fuel Change Tool (LFTFC) (<http://www.frames.gov/partner-sites/nifft/tools/nifft-current-resources/>) are available to make changes on the landscape file, but are generally limited to simple changes (Stratton 2009).

Within ArcFuels10, the **Modify Raster Values** form (fig. 59) is available to update or correct raster data. When the form is used, a projected raster file is created and added to ArcMap. The changes can be made to either floating point or integer data. Either discrete values or ranges of values can be replaced, multiplied by, or added to. Options include making changes to the entire landscape or to selected areas using another raster or shapefile to define the location. The output raster extent also need not be identical to the input data.

Within ArcFuels10, the Modify Raster Values form is available to update or correct raster data. Either discrete values or ranges of values can be replaced, multiplied by, or added to. Options include making changes to the entire landscape or to selected areas using another raster or shapefile to define the location.

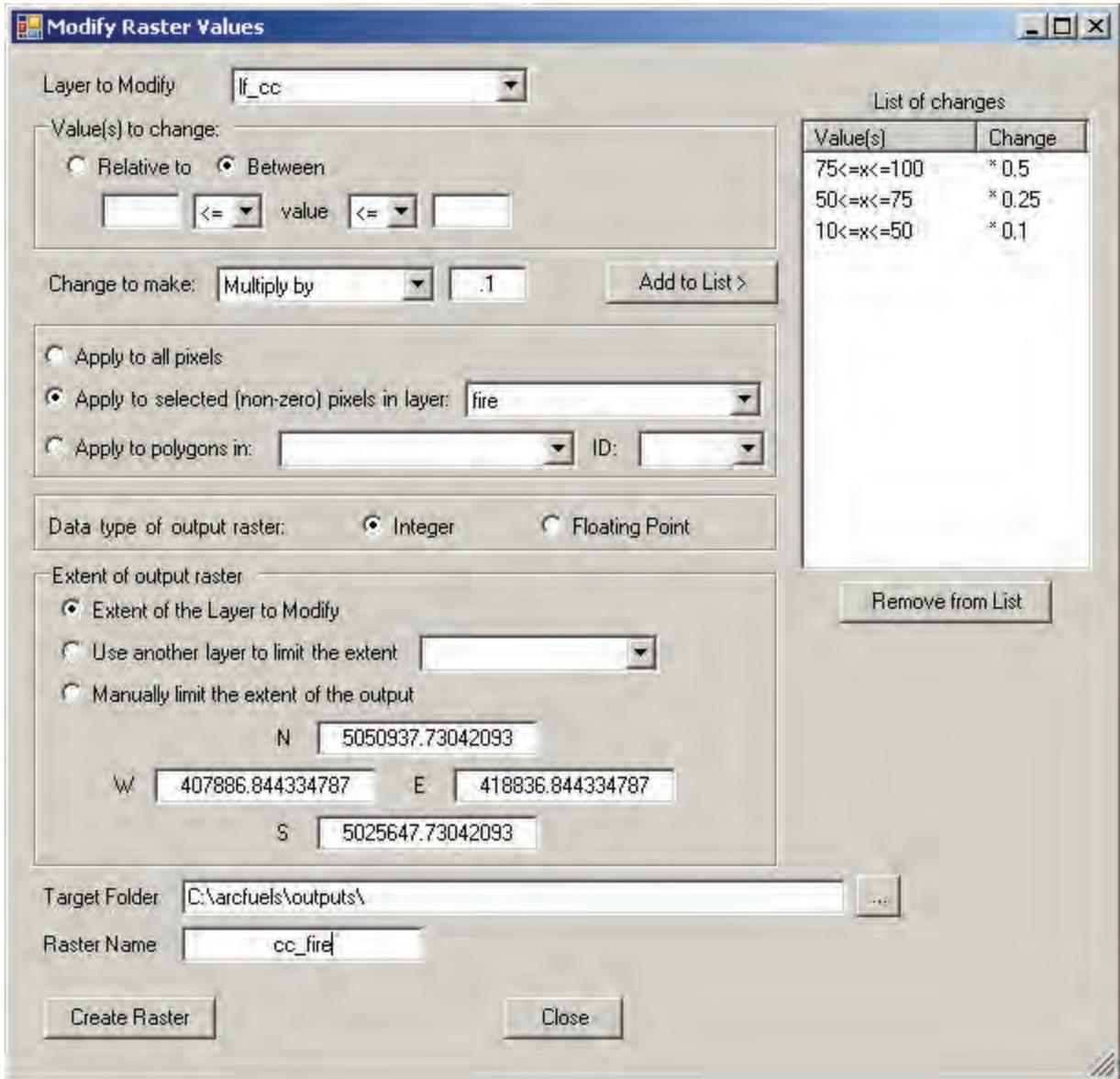


Figure 59—**Modify Raster Values** form set to update canopy cover within a recent fire. When canopy cover is between 75 and 100 percent the value is multiplied by 0.5; when canopy cover is between 50 and 75 percent the value is multiplied by 0.25; and when canopy cover is between 10 and 50 percent, the value is multiplied by 0.1 (to maintain 90 percent of the original cover).

Convert ASCII to Raster—

The **Convert ASCII to Raster** form (fig. 60) combines two ArcGIS processing steps into one. It converts an integer or floating point ASCII file into a raster and defines the spatial reference at the same time. This form is most commonly used to postprocess data created in FlamMap for further analysis and mapping in ArcMap.

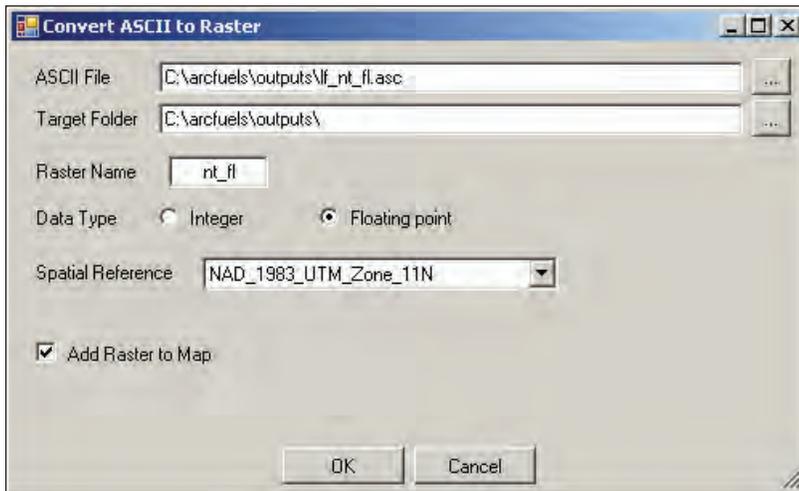


Figure 60—**Convert ASCII to Raster** form set to convert a flame length ASCII file output from FlamMap to a floating point raster file named “nt_fl.”

Batch Convert ASCII to Raster—

The **Batch Convert ASCII to Raster** form (fig. 61) has the same functionality as the **Convert ASCII to Raster** form, with the added benefit of converting multiple files at once.

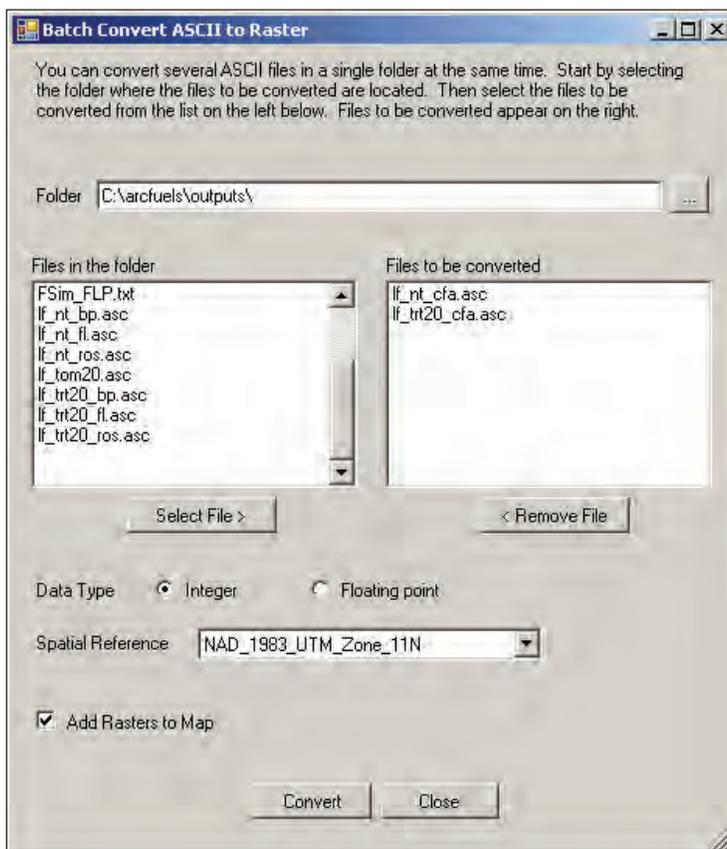


Figure 61—**Batch Convert ASCII to Raster** form set to convert two crown fire activity files created in FlamMap to integer rasters. Not all ASCII files in this folder are being converted together because the remainder should be converted as floating point rather than integer rasters.

Export Shapefile Attributes—

The **Export Attributes to Spreadsheet** form (fig. 62) exports the attributes table from a shapefile into Excel and opens the workbook. This is useful for further analysis outside of ArcMap. The form eliminates the need to export the attributes as another file type, then import the data into Excel.

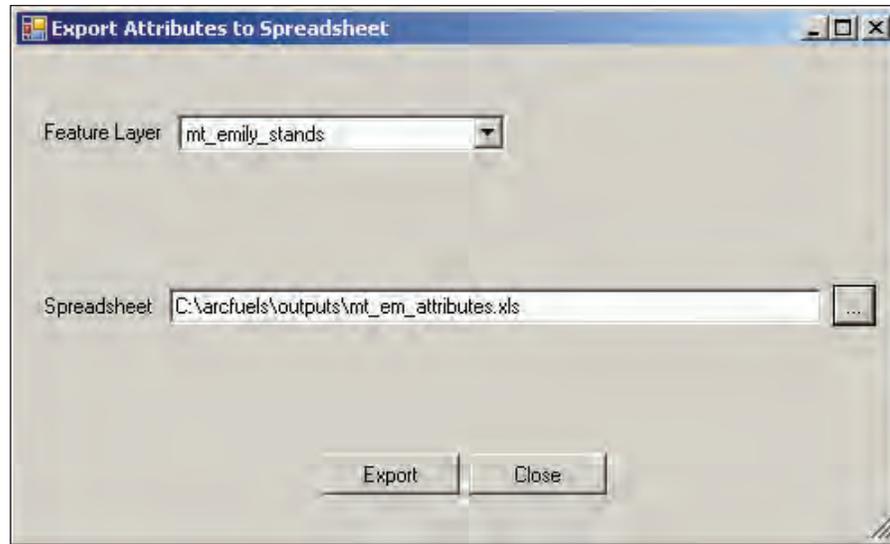


Figure 62—**Export Attributes to Spreadsheet** form set to export the attributes from the “mt_emily_stands” shapefile.

Project

ArcFuels10 saves the settings for the most recent project when the ArcMap session is saved. But people often work on multiple projects at once, alternating between them. The **Project** menu has options for exporting and importing settings, so that once a project is set up and the linkages are defined, the user can quickly move from one project to another.

The **Project** menu has a drop-down list with four options, **Project Settings**, **Import Settings**, **Export Settings**, and **Import Project Settings** (fig. 63).

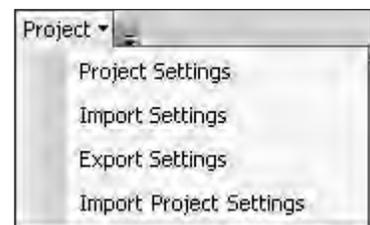


Figure 63—**Project** menu from the ArcFuels10 toolbar.

Project Settings—

The **Projects Settings** form is used to set the linkages to programs ArcFuels10 uses with the **Programs** tab (fig. 64) and the folders necessary to run ArcFuels10 with the **Folders** tab (fig. 65). If programs such as FlamMap or FVS are already installed, the location of the *.exe can be set from the program installation folder rather than by using the supplied files.

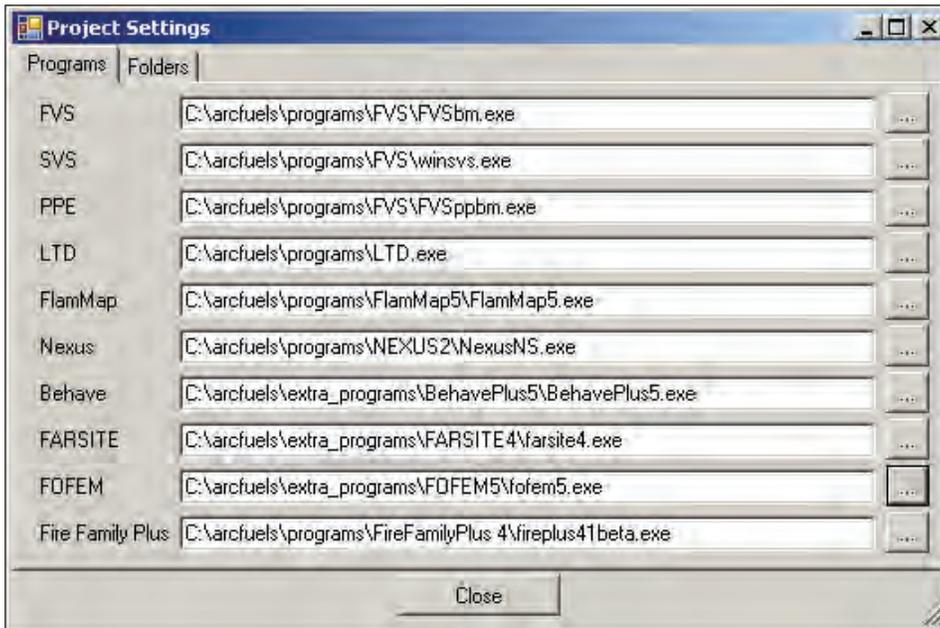


Figure 64—Programs tab of the **Project Settings** form with all supplied programs loaded.

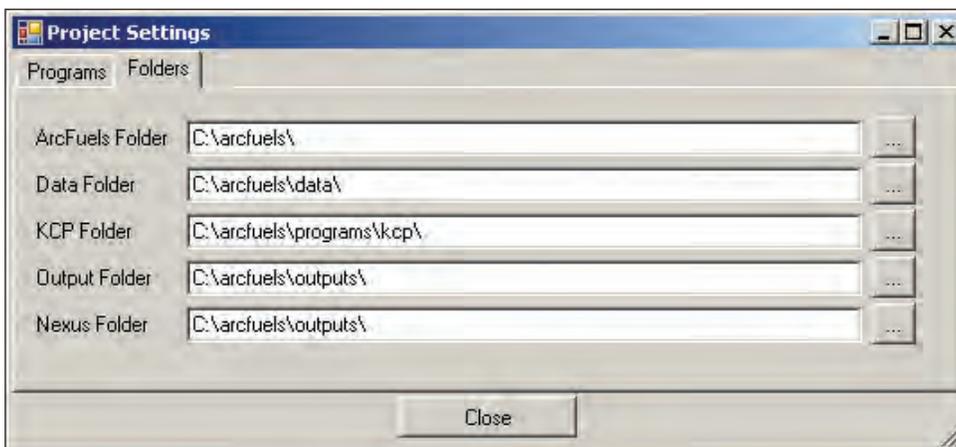


Figure 65—**Folders** tab of the **Project Settings** form.

Not all programs need to be linked in the **Programs** tab, only those planned on being used. FVS, SVS, and FlamMap are the programs most commonly used with ArcFuels10. All the programs listed are available within the programs and extra program folders at the ArcFuels Web page. It is recommended that you visit the program Web pages for the most up-to-date programs before starting new projects.

Import Settings—

The **Import Settings** option loads a preexisting text file with the information for a project. The text file contains information about the data loaded and program locations for an existing project (fig. 66).

```

AspectLayer: aspect
TreeListIDField: Stand_ID
ElevationLayer: elevation
CBDLayer: lf_cbd
CanopyCoverLayer: lf_cc
CBHLayer: lf_cbh
CanopyHeightLayer: lf_ch
FuelModelLayer: lf_fbfm40
FOFEMPath: C:\arcfuels\extra_programs\FOFEM5\fofem5.exe
TreeTable: trees
SlopeLayer: slope
FVSPPath: C:\arcfuels\programs\FVSbin\FVSbm.exe
SVSPPath: C:\arcfuels\programs\fvsbin\winsvs.exe
PPEPath: C:\arcfuels\programs\FVSbin\FVSppbm.exe
FlamMapPath: C:\arcfuels\programs\flammap3\FlamMap3.exe
NexusPath: C:\arcfuels\extra_programs\NEXUS2\NexusNS.exe
FARSITEPath: C:\arcfuels\extra_programs\FARSITE4\farsite4.exe

```

Figure 66—Example of project settings text file created for the supplied ArcFuels10 demonstration data.

Export Settings—

The **Export Settings** form exports the settings for a current project into a text file (see fig. 66 for an example). It is highly recommended that the project settings be exported for each project after setting up the project.

Import Project Settings—

The **Import Project Settings** form (fig. 67) allows settings from a preexisting ArcFuels9 project database to be imported into ArcFuels10. Once it is imported, use the **Export Settings** form to save a new text file for use with future ArcFuels10 sessions.

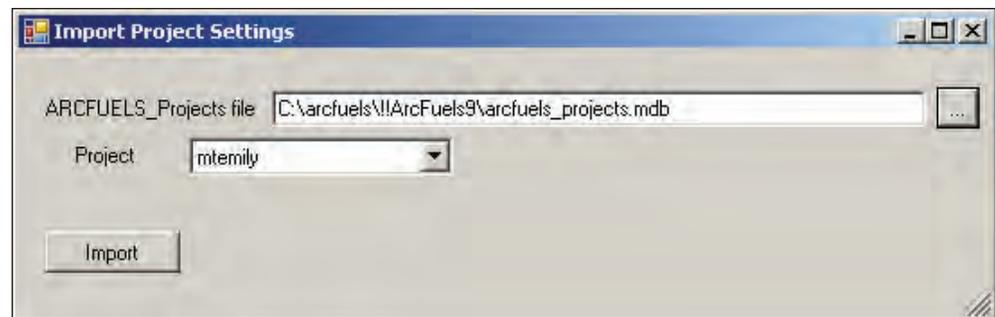


Figure 67—**Import Project Settings** form set to import project settings from ArcFuels9.

ArcFuels10 Download and Installation Instructions

System Requirements

To run ArcFuels10, the following programs are required:

- ArcMap version 10.0 with the Spatial Analyst Extension
- ArcCatalog
- Microsoft Office Excel
- Microsoft Office Access
- Notepad, WordPad, or another text editing program.

Obtaining ArcFuels10

ArcFuels10 is contained in an ESRI ArcGIS Add-In file (*.AddIn). There is no installation program for ArcFuels10 (administrative privileges are not required).

The download sites contain a complete set of demonstration data, programs needed for demonstration purposes, supporting documentation for the programs, and a tutorial (Vaillant and Ager [N.d.]).

1. Create an ArcFuels directory (i.e., C:\arcfuels on your computer or T:\...\arcfuels, where ... is your workspace on the T-drive for use with Citrix) and obtain the following files from the ArcFuels10 Web site (<http://www.fs.fed.us/wwetac/arcfuels/downloads.html>) or the T-drive (T:\FS\Reference\GeoTool\agency\Application\ArcFuels\ArcFuels10):
 - a. ArcFuels10—ESRI ArcGIS Add-In file for ArcFuels10 (i.e., toolbar buttons) and the project settings text file for the demonstration data.
 - b. Data—The folder includes demonstration data for the Mt. Emily project area and will be used throughout the available tutorial.
 - c. Programs—The folder contains FVS/FFE-FVS, SVS, FlamMap5, NEXUS, Fire Family Plus, and LTD.
 - d. Docs —The folder is an optional download. It contains supporting literature about the programs and relevant scientific publications.
 - e. Extra_programs—The folder is an optional download. It contains additional fire behavior models: FARSITE, FOFEM, and Behave Plus.
 - f. Exercise_outputs—The folder is an optional download. It contains the outputs for all exercises in the available tutorial.
2. Unzip (to unzip to C:\arcfuels, **right-click on each zip folder** → **WinZip** → **Extract to here**) or transfer the unzipped folders from the T:\ to your ArcFuels directory. Verify that they are not further nested (i.e., C:\arcfuels\data\data, fig. 68).

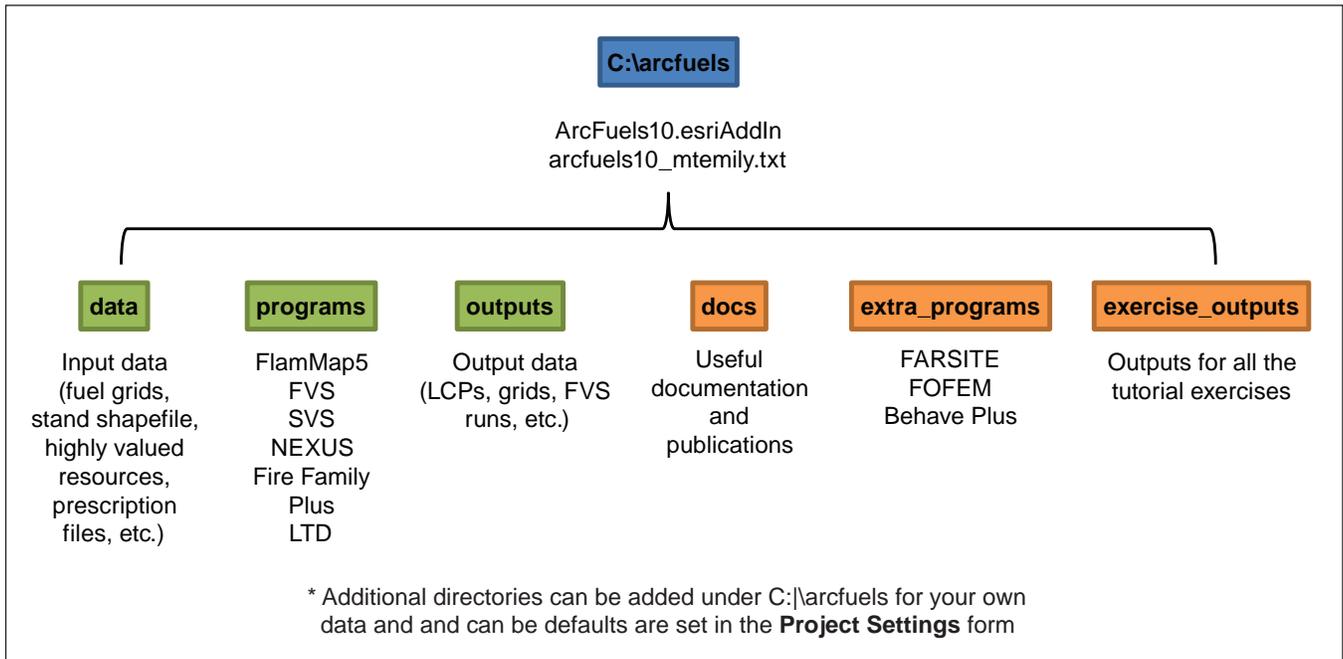


Figure 68—Data structure for ArcFuels10. Be sure the “data,” “outputs,” and “programs” folders are not further nested in other folders.

Installing the ArcFuels10 Add-In

This section will explain how to install the ArcFuels10.esri Add-In file for ArcMap. Two sets of instructions are included for use with ArcMap on your computer and for ArcMap on Citrix. Once the Add-In is installed, it will be available for all future ArcMap sessions. You can turn on and off the ArcFuels10 toolbar the same as all other toolbars in ArcMap.

For ArcMap installed on your computer—

1. Open ArcMap (**Start** → **All Programs** → **ArcGIS** → **ArcMap 10**) from your computer.
2. From the main ArcMap toolbar open the Add-In Manager window (**ArcMap toolbar** → **Customize** → **Add-In Manager...**, fig. 69).
 - a. Click the **Customize...** button to open the **Customize** window (fig. 70).
 - b. Click the **Add from file...** button and navigate to and select the ArcFuels10.esriAddIn file from the C:\arcfuels folder.
 - c. When the **Esri ArcGIS Add-In Installation Utility** window (fig. 71) opens, click the **Install Add-In** button to complete the installation.
 - d. When the **Added Objects...** window (fig. 72) opens, click **OK** to close the window and proceed.
 - e. Verify that the ArcFuels Toolbar was added and is checked (see fig. 70), then click **Close** to close the **Customize** window.

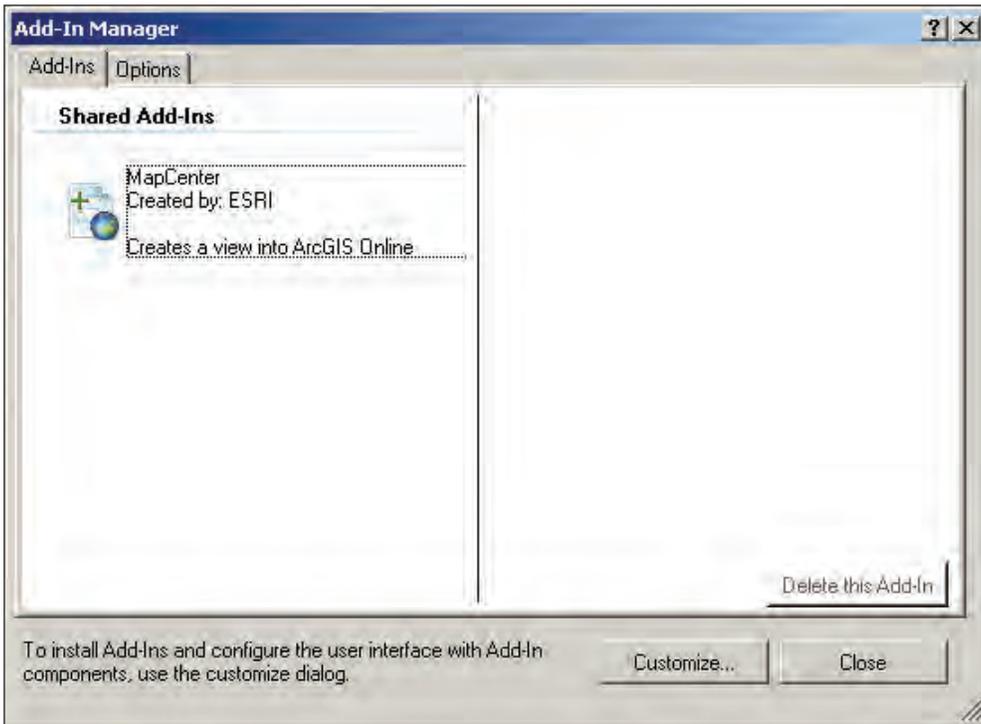


Figure 69—The **Add-In Manager** window is used to add and remove Add-In files in ArcMap.

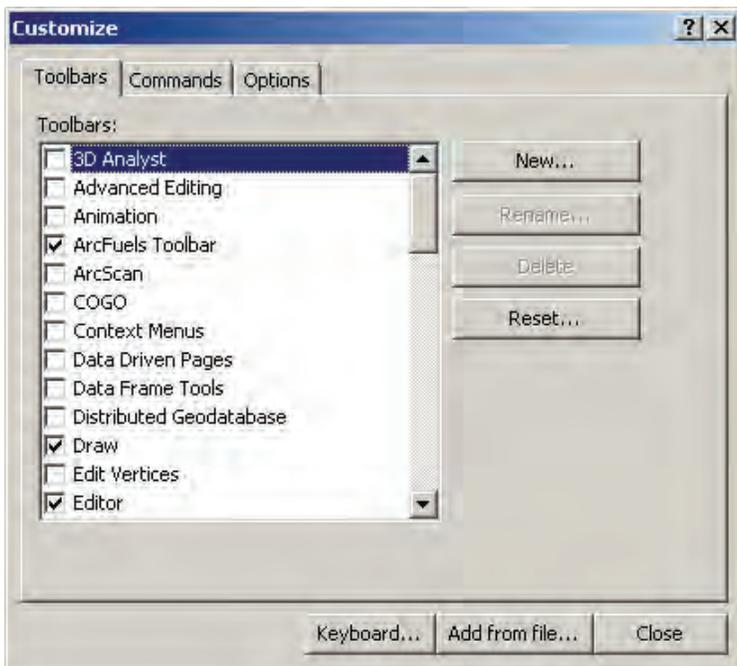


Figure 70—The **Customize** window.

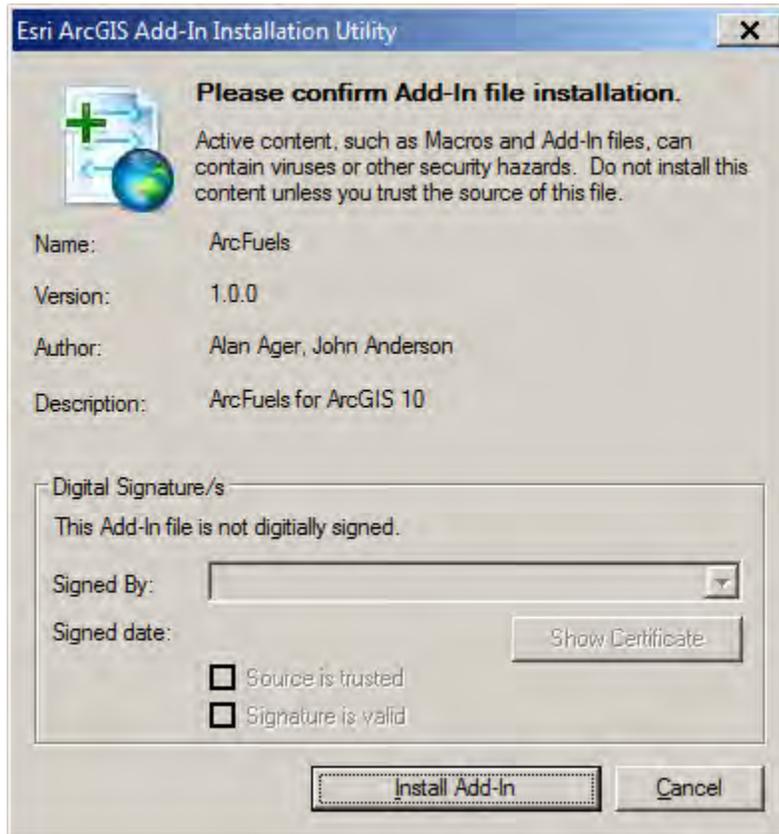


Figure 71—The **ESRI ArcGIS Add-In Installation Utility** window contains information about the version of ArcFuels10 being installed (the version for this figure is 1.0.0). ArcFuels10 is updated periodically as bugs are found and fixed and enhancements are made; check the ArcFuels Web page for updates.

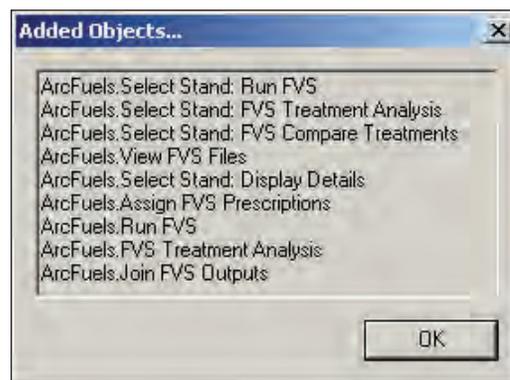


Figure 72—The **Added Objects...** window, showing the ArcFuels forms within the ArcFuels toolbar.

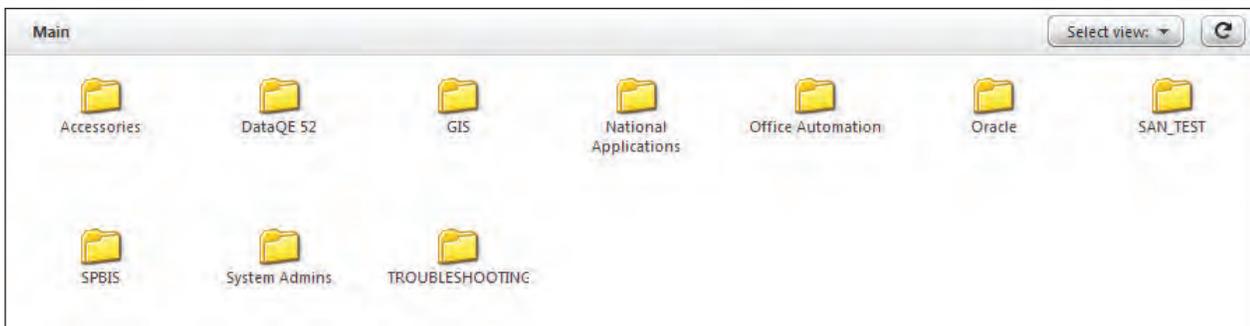
For ArcMap installed on Citrix—

1. From Internet Explorer, open the Citrix Web page: <http://apps.fs.fed.us/Citrix/auth/login.aspx>.
2. Log into Citrix using your username and password (these are the same as your computer login information, fig. 73).



Figure 73—Citrix login screen.

3. From the **Main** (fig. 74) Citrix folder open the GIS folder.
 - a. Within the **GIS** folder, open the **ArcGIS 10** folder and open **ArcMap**.

Figure 74—The **Main** folder within Citrix.

4. Follow step 2 from the *For ArcMap installed on your computer* directions above.

Setting Up the Demonstration Data

This section will explain how to add the demonstration data and load the project setting with ArcMap open and the ArcFuels10.esriAddIn file loaded. Two sets of instructions are included for use with ArcMap on your computer and for ArcMap on Citrix.

For ArcMap installed on your computer—

1. Add the demonstration data layer, Demo_data.lyr, located in the C:\arcfuels\data folder (**ArcMap toolbar** → **File** → **Add Data** → **Add Data**).
2. Load the project settings using the **Import Settings** form (**ArcFuels toolbar** → **Project** → **Import Settings**). Once the form is open, navigate to and select the project setting file, arcfuels10_mtemily.txt, located in C:\arcfuels.

For ArcMap installed on Citrix—

1. Add the demonstration data layer, Demo_data.lyr, located in the T:\...\arcfuels\data folder, where the ... is your workspace (**ArcMap toolbar** → **File** → **Add Data** → **Add Data**).
2. Because your workspace is a different path than where the data layer was created, the data sources needs to be set for all layers (fig. 75).

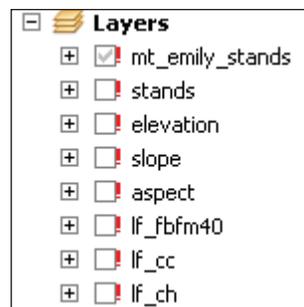


Figure 75—The exclamation points to the left of the file names indicate that they need their data sources defined.

- a. To set the data source, right-click on one of the layers **Data** → **Repair Data Source**, then navigate to the layer in your workspace ArcFuels data folder. This should repair all the data sources for all the layers. If it does not, repeat the process for the remaining layers with the exclamation points to the left.
3. Next, the location of the folders and programs need to be updated for your workspace.

- a. Open the **Project Settings** form (ArcFuels toolbar → **Projects** → **Project Settings**) and select the **Programs** tab. Navigate to and update the program locations according to figure 76 where the ... indicates the path to your workspace.

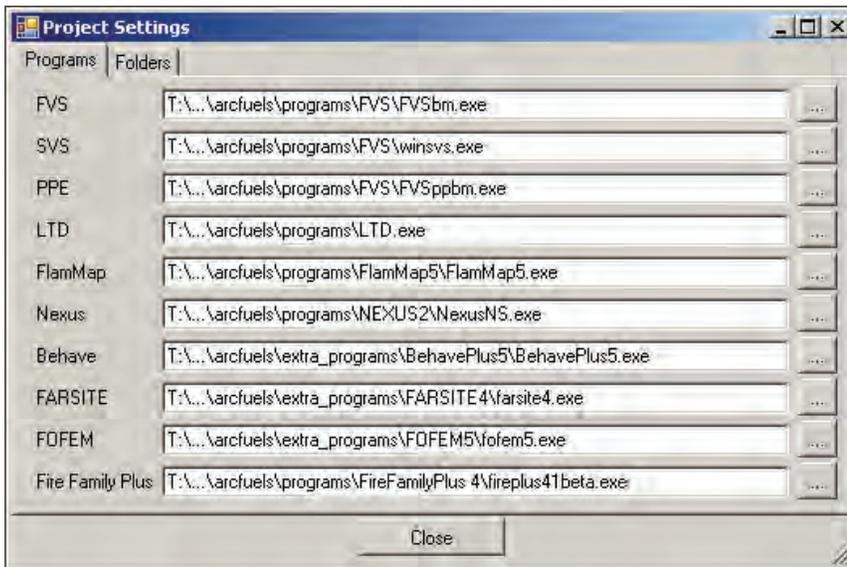


Figure 76—**Project Settings** form **Programs** tab set for use in Citrix where the ... indicates the path to your workspace.

- b. Select the **Folders** tab and update the folder locations according to figure 77 where the ... indicates the path to your workspace.

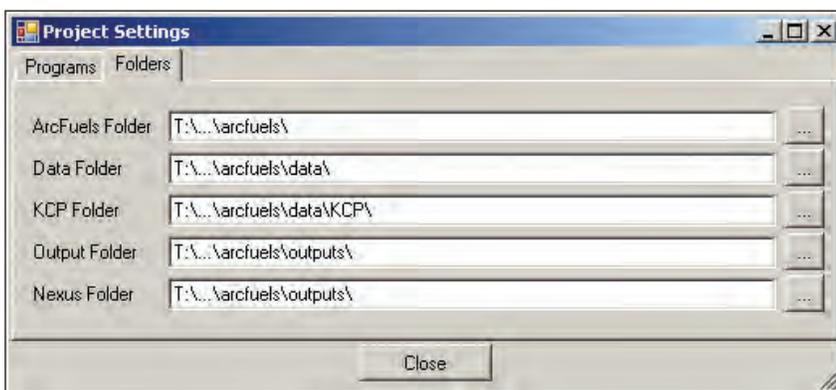


Figure 77—**Project Settings** form **Folders** tab set for use in Citrix where the ... indicates the path to your workspace.

- c. Close the **Project Settings** form by clicking the Close button.
4. Export and save the new project setting in your workspace for future use (ArcFuels toolbar → **Projects** → **Export Settings**).

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English Equivalents

When you know:	Multiply by:	To find:
Meters (m)	3.28	Feet
Hectares (ha)	2.47	Acres
Square meters per hectare (m ² /ha)	4.37	Square feet per acre
Tonnes per hectare (t/ha)	0.446	Tons per acre

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