Module and Pathway Test Report

Module: FlamMap 3.0.0 (.dll files acquired Fall 2009)
Pathway(s): Calculate fire behavior for individual stands (as implemented in FlamMap)
Calculate fire behavior across a landscape (as implemented in FlamMap)
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Test Period: January 2012

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General Testing Procedures

All modules implemented in IFTDSS undergo two types of testing:

- **Scientific testing** to ensure that the outputs produced by the module are consistent with a range of expected values generated by the native desktop software application and/or provided by the scientific model developer(s). These tests include comparisons for a range of predefined scenarios developed to exercise different parts of the module.

- **Software testing** to ensure that the module is functioning from a usability perspective, accepting inputs, and producing outputs without generating software error reports. These automatic tests also ensure that as updates are made to the models or modeling framework, each individual module produces correct data values.

This document describes Sonoma Technology, Inc.'s test cases.

Scientific Testing

Test Case 1: FlamMap Fire Behavior Module (Spatial)

This test case compared the FlamMap Fire Behavior Module (Spatial) in IFTDSS to the desktop version of FlamMap 3.0 using a heterogeneous test case study area. Ten 30 x 30 meter grid cells were compared using the Finney (1998) and Scott and Reinhardt (2001) crown fire calculation methods, three environmental scenarios, four of the thirteen original fuel models (Anderson, 1982), and four of the additional forty fuel models (Scott and Burgan, 2005). A total of eight output parameters were compared (flame length, rate of spread, fireline intensity, heat per unit area, crown fire activity, mid-flame wind speed, horizontal movement rate, and direction of maximum spread) for a total of 1,920 simulations.

Inputs and Results File Name

- FlamMap test case results (included in the IFTDSS online help under **IFTDSS Compared with Other Systems > Module Test Cases**)

- FlamMap test case summary (Appendix)

Passed/Fail: Passed

Issues: None identified

Test Case 2: FlamMap Surface Fire Behavior Module for Individual Stands

Test - 2 compared the FlamMap Surface Fire Behavior module for individual stands in IFTDSS to the desktop version of FlamMap 3.0 using one 30 x 30 meter grid cell. In this case, the grid cell represents a single stand. This grid cell was compared using Finney (1998) and Scott and Reinhardt (2001) crown fire calculation methods, as well as three environmental scenarios. A total of eight output parameters were compared (flame length, rate of spread, fireline intensity, heat per unit area, crown fire activity, mid-flame wind speed, horizontal movement rate, and direction of maximum spread) for a total of 96 simulations.

Inputs and Results File Name

- FlamMap test case results (included in the IFTDSS online help under **IFTDSS Compared with Other Systems > Module Test Cases**)
- FlamMap test case summary (Appendix)

Passed/Fail: Passed

Issues: None identified

Software Testing

Software testing encompasses both manual and automatic testing.

Manual testing is performed by Software Quality Assurance Engineers and Analysts as well as subject matter experts to ensure that the pathway is functioning correctly, meets performance standards, and that the user interface is efficient and easy to use.

Automated test cases are run each time a developer makes a change to the IFTDSS source code. All tests must pass before the release of a new version of IFTDSS. The input and output values that are used for the automated tests are typically developed as part of the scientific testing process.

Selenium Tests

Selenium is a portable software testing framework for web applications. Selenium provides a record/playback tool for authoring automated software tests. The automated tests can be run against most modern web browsers. Selenium tests ensure that the pathway can run from beginning to end correctly. The benefit of automated tests is that each time a change is made to the underlying software code, the test can be run to identify any issues prior to human-aided testing. **Table 1** shows a summary of the Selenium tests.

Table 1. Selenium test summary.

Selenium Test Name	Description	Inputs	Expected Result
PrescribedBurnFlamMap	Tests the fire behavior for individual stands pathway	All pre-populated default inputs	Test is completed successfully without error messages
prescribedBurnFlamMap13Points	Tests the fire behavior for individual stands pathway	All pre-populated default inputs and the Andersen 13 fire behavior fuel models	The test is completed successfully; flame length output parameter for each fire behavior fuel model is accurate
numStandsValidation	Tests the pathway module configuration step for valid entries	{Stands, Wind Steps} - {Blank, Blank }, {NaN, Nan}, {characters, characters}, {0,0}, {26, 11}, {25, 10}	The test should fail on all inputs except the last set, which is the maximum allowed value for each input
FlamMapStandsVerifyEditInputs	Tests that the pathway is able to run through to the outputs screen, return to a previous screen, edit a data value, and re-run the module	All pre-populated default inputs	Test is completed successfully without error messages

Unit Tests

Unit testing is a method by which individual units of source code are tested to determine if they are fit for use. A unit is the smallest testable part of an application. A unit could be an entire module but is more commonly an individual function or procedure. Unit tests are typically written and run by software developers to ensure that code meets its design and behaves as intended. Its implementation can vary from being very manual (pencil and paper) to being formalized as part of build automation. **Table 2** shows a unit test summary.

Table 2. Unit test summary.

Unit Test Name	Description	Inputs	Expected Result
SpatialFlamMapTest	Runs FlamMap spatially using the Jocko Lakes LCP file and compares the output from SMF to the output of FlamMap desktop	Jocko Lakes LCP file, defaultinputs	The values at each grid point match the values at each grid point of the output generated by FlamMap Desktop
MultiFlamMapTest	Runs the Individual Stands FlamMap module in SMF using the IFTDSS default, minimum, and maximum values and compares the outputs to the desktop version of FlamMap	IFTDSS default values, minimum values and maximum values	The SMF FlamMap module results match the outputs generated by FlamMap Desktop
testFuelModel#	Multiple tests that test each FlamMap using each of the fire behavior fuel models with the default values	Default IFTDSS inputs, with the exception of the fire behavior fuel model	Outputs from IFTDSS version of FlamMap match the desktop version

References

- Peer-reviewed publications
    - Finney, M. A. 2007. A computational method for optimising fuel treatment locations. *International Journal of Wildland Fire* 16: 702-711.
    - Stratton, R. D. 2004. Assessing the effectiveness of landscape fuel treatments on fire growth and behavior. *Journal of Forestry* 102(7): 32-40. (http://www.landsinfo.org/ecosystem_defense/federal_agencies/forest_service/Region_1/Idaho_Panhandle_NF/Bonners_Ferry_District/Myrtle%20HFRA/Myrtle%20Creek%20HFRA%20Objection%20references%20disk%204/stratton2004treatments.pdf)
    - Ager, A. A.; Finney, M. A.; Kems, B. K.; Maffei, H. 2007. Modeling wildfire risk to northern spotted owl (*Strix occidentalis caurina*) habitat in Central Oregon, USA. *Forest Ecology and Management* 246: 45-56.
    - Finney, M. A. 2001. Design of regular landscape level fuel treatment patterns for modifying fire growth and behavior. *Forest Science* 47(2): 219-228.
    - Finney, M. A.; Seli, R. C.; McHugh, C. W.; Ager, A. A.; Bahro, B.; Agee, J. K. 2007. Simulation of long-term landscape-level fuel treatment effects on large wildfires. *International Journal of Wildland Fire* 16: 712-727.

- Non-peer-reviewed publications
    - Stratton, R. D. 2006. Guidance on spatial wildland fire analysis: models, tools, and techniques. General Technical Report RMRS-GTR-183. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Appendix: Scientific Test Cases for the IFTDSS Spatial Surface Fire Behavior Module as Implemented in FlamMap 3.0

Summary of Findings

Both the FlamMap Spatial Fire Behavior and FlamMap Fire Behavior modules for individual stands as implemented in IFTDSS are a scientifically sound representation of the desktop version of FlamMap (v. 3.0). In some cases, there were very small differences in outputs (< 1%) due to rounding differences. These small differences do not affect the scientific or decision-support interpretation of the output data.

Environmental Scenarios

Three environmental scenarios were tested that were expected to produce low, moderate, and high fire behavior (Table 3). Testing under different environmental scenarios allows the comparison of a variety of results between modules.

Table 3. The three environmental scenarios (low, moderate, and high fire behavior) used in the FlamMap test cases.

Input Parameters	Fire Behavior		
	Low	Moderate	High
1-hour fuel moisture (%)	15	7	3
10-hr fuel moisture (%)	18	10	5
100-hr fuel moisture (%)	25	12	8
Live herbaceous fuel moisture (%)	110	75	50
Live woody fuel moisture (%)	140	100	75
20-ft wind speed (miles/hour)	5	25	50
Wind direction (degrees)	180	180	180

Methods

Test Case 1: Fire Behavior Across a Landscape (FlamMap Spatial)

A heterogeneous landscape in Redwood National Park was selected as the test case study area because the tester was familiar with the vegetation and fuel conditions in the area. The area was 14.23 acres (sixty-four 30 x 30 meter grid cells). Ten grid cells were selected for comparison between the FlamMap spatial module implemented in IFTDSS and the FlamMap desktop version (Figure 1). We compared both the Finney (1998) and the Scott and Reinhardt (2001) crown fire calculation methods across the three environmental scenarios (Table 3). Four of the original 13 fuel models (Anderson, 1982) and four of the additional 40 fuel models (Scott and Burgan, 2005) were tested. A total of eight output parameters were compared (flame length, rate of spread, fireline intensity, heat per unit area, crown fire activity, mid-flame wind speed, horizontal movement rate, and direction of maximum spread) for a total of 1,920 comparisons.

Test Case 2: Fire Behavior for Individual Stands (FlamMap for Individual Stands)

Out of the ten grid cells compared in the FlamMap Spatial comparison, one 30 x 30 meter grid cell was selected (the circled grid cell shown in Figure 1) for comparison between the FlamMap Individual Stands module implemented in IFTDSS and the FlamMap desktop version. We compared both the Finney (1998) and the Scott and Reinhardt (2001) crown fire calculation methods across the three environmental scenarios listed in Table 3. A total of eight output parameters were compared (flame length, rate of spread, fireline intensity, heat per unit area, crown fire activity, mid-flame wind speed, horizontal movement rate, and direction of maximum spread) for a total of 96 comparisons.

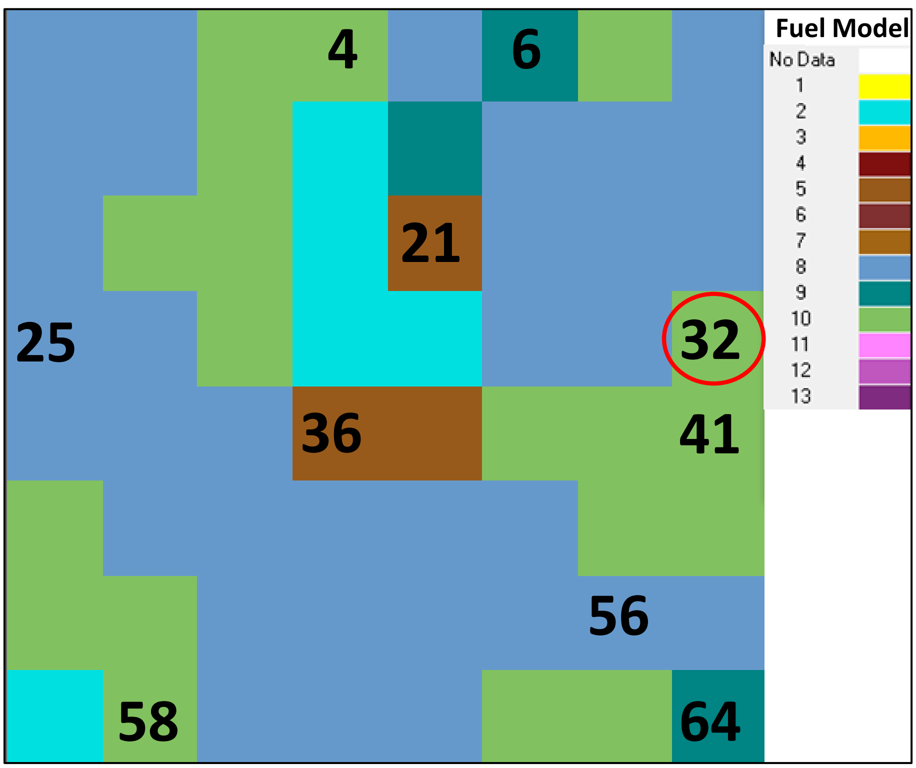

Figure 1. The test case study area represented by the original 13 fuel models (Anderson, 1982). The numbers assigned to the grid cells represent the ten grid cells used in the FlamMap spatial comparison. Grid cell 32, circled in red, was also used in the FlamMap individual stands comparison.

Results

Test Case 1: Across a Landscape

Results from the FlamMap spatial module implemented in IFTDSS and the FlamMap desktop version were comparable (Table 4). In some cases, there were small differences in output values (< 1%) due to rounding, particularly with fireline intensity and heat per unit area, because these output parameters often have values in the thousands and ten thousands. These differences do not affect the scientific interpretation of the data.

Table 4. Results from the FlamMap spatial module comparison using the original 13 fuel models (Anderson, 1982) and the Finney (1998) crown fire calculation. L= low, M = moderate, and H = high fire behavior environmental scenarios.

Module Version	Grid Cell #	Flame Length (ft)			Rate of Spread (ft/min)			Fireline Intensity (Btu/ft/min)		
		L	M	H	L	M	H	L	M	H
IFTDSS	4	2.45	3.71	11.76	2.27	4.79	14.27	39.82	98.24	450.63
FlamMap		2.45	3.71	11.76	2.27	4.79	14.27	39.82	98.25	450.66
IFTDSS	6	1.10	1.70	3.57	1.33	3.05	12.06	6.92	18.02	90.28
FlamMap		1.10	1.70	3.57	1.33	3.05	12.06	6.92	18.02	90.28
IFTDSS	21	1.27	7.45	19.19	3.12	55.79	277.28	9.58	446.18	3490.30
FlamMap		1.27	7.45	19.19	3.12	55.79	277.28	9.58	446.20	3490.47

Test Case 2: Individual Stands

Results from the FlamMap Individual Stands module implemented in IFTDSS and the FlamMap desktop version were comparable (Table 5). In some cases, there were small differences in output values (< 1%) due to rounding differences, particularly with fireline intensity. These differences are minimal and do not affect the scientific interpretation of the data.

Table 5. Results from the FlamMap Individual Stands module comparison using fire behavior Fuel Model 10 and the Finney (1998) crown fire calculation.

Parameter	Units	Low		Moderate		High	
		IFTDSS	FlamMap	IFTDSS	FlamMap	IFTDSS	FlamMap
Flame Length	ft	2.86	2.86	4.42	4.42	61.4	61.40
Rate of Spread	chains/hour	2.89	2.89	6.38	6.38	109.06	107.99
Fireline Intensity	Btu/ft/s	55.71	55.71	143.73	143.74	5379.23	5379.49
Heat Per Unit Area	Btu/ft^2	1050.78	1050.78	1229.43	1229.43	2690.48	2690.48
Crown Fire Activity	class	1	1	1	1	3	3
Mid-Flame Wind Speed	miles/hour	0.49	0.49	2.44	2.44	4.87	4.87
Horizontal Movement Rate	chains/hour	2.6	2.6	5.8	5.8	265.3	265.3
Direction of Maximum Spread	degrees	47	47	30	30	6	6