# Module and Pathway Test Report

**Module:** FOFEM 5.7 (acquired in September 2009)
**Pathway(s):** Calculate consumption and emissions (IFT-FOFEM)
Calculate tree mortality (IFT-FOFEM)
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**Test Period:** February 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 model produces correct data values.

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

# Scientific Testing

## Test Case 1: FOFEM Consumption and Emissions

This test case compared the FOFEM Consumption and Emissions module in IFTDSS to the desktop version of FOFEM 5.7 (batch mode) using three stands, each simulated in three environmental scenarios expected to generate low, moderate, and high fire effects. The fuels data of the three stands were based on the Fuel Characteristic Classification System (FCCS) fuel beds:

- # 24 – Pacific ponderosa pine – Douglas fir forest
- # 41 – Idaho fescue – Wheatgrass grassland
- # 237 – Huckleberry – Heather shrubland

A total of 43 output parameters were compared.

### Inputs and Results File Name

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

**Passed/Fail:** Passed

**Issues:** None identified

**Special Note:** The outputs from the desktop FOFEM shown in this test report were produced using the Batch Processing mode. There are different ways to input 1,000-hour fuels in desktop FOFEM, which could cause differences in the outputs. To replicate the results of this test case, the Batch Processing mode must be used and 1,000-hour fuels must be entered as four individual size classes (3–6 inch, 6–9 inch, 9–20 inch, and 20-inch and larger woody fuels) for both sound and rotten fuels.

## Test Case 2: FOFEM Tree Mortality

Test Case 2 compared the FOFEM Tree Mortality module in IFTDSS to the desktop version of FOFEM 5.7 (batch mode) using three stands. The simulations were set up to estimate different levels of fire effects,

low, moderate, and high, based on the stand and fire input parameters. Flame length was used in the low and high fire effect simulations, while scorch height was used for the medium fire effect simulation. A total of nine output parameters were compared.

### Inputs and Results File Name

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

**Passed/Fail:** Passed

**Issues:** None identified

**Special Note:** To replicate the results from desktop FOFEM, one can use either the batch mode or the normal mode of the program. Should one choose to run the Tree Mortality module through the normal mode, the three test stands must be run separately (one run per stand). If the three stands were entered together and the program was run only once, the normal mode would combine them into one stand and subsequently produce different results.

## References


Non-peer-reviewed publications:

- Reinhardt, Elizabeth. Using FOFEM 5.0 to estimate tree mortality, fuel consumption, smoke production, and soil heating from wildland fire. 7 p (http://www.fire.org/downloads/fofem/5.2/FOFEM5Using.pdf)

# Appendix: Scientific Test Cases for the IFTDSS Calculate Consumption and Emissions Module and Calculate Tree Mortality Module (IFT-FOFEM)

## Summary of Findings

Both the FOFEM Consumption and Emissions and FOFEM Tree Mortality modules as implemented in IFTDSS are scientifically sound representations of the desktop version of FOFEM 5.7. In very few cases, there were small differences in output values (< 5%) due to rounding. These differences do not affect the scientific or decision-support interpretation of the output data.

## Environmental Scenarios

Three environmental scenarios were tested for the FOFEM consumption and emissions module that were expected to produce low, moderate, and high fire effects (Table 1). Testing under different environmental scenarios allows the comparison of a variety of results between modules.

Table 1. The three environmental scenarios (low, moderate, high fire effects) used in the FOFEM test cases.

| Input Parameter | Fire Effect | | |
|---|---|---|---|
| | Low | Moderate | High |
| 10-hr fuel moisture (%) | 18 | 10 | 5 |
| 1000-hr fuel moisture (%) | 25 | 12 | 8 |
| Duff fuel moisture (%) | 40 | 30 | 25 |
| Duff Moisture Method | Entire | Adjusted NFDR | Lower |
| Region | Pacific West | South East | Interior West |
| Season | Spring | Fall | Summer |

## Methods

### Test Case 1: FOFEM Consumption and Emissions

Three FCCS fuelbeds representing three vegetation types (forest, grassland, and shrubland) were selected; fuels data for these fuelbeds were used as inputs for three stands (Table 2). The selected fuel beds were # 24 – Pacific ponderosa pine – Douglas fir forest, # 41 – Idaho fescue – Wheatgrass grassland, and # 237 – Huckleberry – Heather shrubland. The consumption and emissions for these three stands were estimated in IFTDSS FOFEM and desktop FOFEM (batch mode) under three different

environmental scenarios expected to produce low, moderate, and high fire effects. A total of 43 output parameters were analyzed for a total of 774 comparisons.

Table 2. Input fuels data used for the FOFEM Consumption and Emissions module test case.

| Input Fuels Data | Unit | Stand Identification | | | | | |
|---|---|---|---|---|---|---|---|
| | | 24 | | 41 | | 237 | |
| | | IFTDSS | FOFEM | IFTDSS | FOFEM | IFTDSS | FOFEM |
| Fuel Category | | Natural | Natural | Natural | Natural | Natural | Natural |
| Cover Group | | None | None | None | None | None | None |
| 1-hour Woody Fuel Loading | tons/acre | 0.1 | 0.1 | 0 | 0 | 0 | 0 |
| 10-hour Woody Fuel Loading | tons/acre | 0.2 | 0.2 | 0 | 0 | 0 | 0 |
| 100-hour Woody Fuel Loading | tons/acre | 0.75 | 0.75 | 0 | 0 | 0 | 0 |
| 1000-hour Sound Woody Fuel Loading 3–6 in. | tons/acre | 0.6 | 0.6 | 0 | 0 | 0 | 0 |
| 1000-hour Sound Woody Fuel Loading 6–9 in. | tons/acre | 1.4 | 1.4 | 0 | 0 | 0 | 0 |
| 1000-hour Sound Woody Fuel Loading 9–20 in. | tons/acre | 0.8 | 0.8 | 0 | 0 | 0 | 0 |
| 1000-hour Sound Woody Fuel Loading 20+ in. | tons/acre | 0 | 0 | 0 | 0 | 0 | 0 |
| 1000-hour Rotten Woody Fuel Loading 3–6 in. | tons/acre | 0.54 | 0.54 | 0 | 0 | 0 | 0 |
| 1000-hour Rotten Woody Fuel Loading 6–9 in. | tons/acre | 1.26 | 1.26 | 0 | 0 | 0 | 0 |
| 1000-hour Rotten Woody Fuel Loading 9–20 in. | tons/acre | 0.2 | 0.2 | 0 | 0 | 0 | 0 |
| 1000-hour Rotten Woody Fuel Loading 20+ in. | tons/acre | 0.5 | 0.5 | 0 | 0 | 0 | 0 |
| Litter Fuel Loading | tons/acre | 1.98 | 1.982 | 0.52 | 0.52 | 1.263 | 1.26 |
| Duff Fuel Loading | tons/acre | 4.96 | 4.96 | 0 | 0 | 0 | 0 |
| Herbaceous Fuel Loading | tons/acre | 0.5 | 0.5 | 0.65 | 0.65 | 0.06 | 0.06 |
| Shrub Fuel Loading | tons/acre | 0 | 0 | 0 | 0 | 2.19 | 2.19125 |
| Crown Foliage Fuel Loading | tons/acre | 3.8 | 3.79679 | 0 | 0 | 0 | 0 |
| Crown Branch Fuel Loading | tons/acre | 3.8 | 3.79679 | 0 | 0 | 0 | 0 |
| Duff Depth | inches | 0.6 | 0.6 | 0 | 0 | 0 | 0 |
| Percent of Crown Burn | percent | 60 | 60 | 60 | 60 | 60 | 60 |

## Test Case 2: FOFEM Tree Mortality

Three simulations were set up in both the IFTDSS FOFEM Tree Mortality module and desktop FOFEM (batch mode) to estimate different levels of fire effects (low, moderate, and high) based on the tree

stand and fire input parameters shown in Table 3. Flame length was used in the low and high fire effect simulations, while scorch height was used for the medium fire effect simulation to test different functions in the module. A total of nine output parameters were compared for a total of 27 comparisons.

Table 3. The tree stand and fire input data used for the FOFEM tree mortality module test case.

| Input Parameter | Unit | Low Fire Effect | Moderate Fire Effect | High Fire Effect |
|---|---|---|---|---|
| Tree Species | | Ponderosa Pine | Douglas Fir | Jeffrey Pine |
| Stand Density | Trees/acre | 3 | 10 | 15 |
| Diameter at Breast Height | inches | 48 | 36 | 24 |
| Tree Height | ft | 60 | 40 | 20 |
| Crown Ratio | | 3 | 4 | 6 |
| Flame Length | ft | 5 | 10 | 15 |
| Scorch Height | ft | 10 | 20 | 10 |
| Use Flame Length or Scorch Height? | | Flame Length | Scorch Height | Flame Length |
| Fire Severity | | Low | Moderate | Very High |

# Results

## Test Case 1: FOFEM Consumption and Emissions

Results from the FOFEM Consumption and Emissions module implemented in IFTDSS and the FOFEM desktop version were comparable (Table 4). In very few cases, there were small differences in output values (<5%) due to rounding, particularly with $PM_{10}$ and $PM_{2.5}$ emissions in the smoldering phase. These differences do not affect the scientific interpretation of the data.

Table 4. Results from the FOFEM Consumption and Emissions module comparison for 4 of 43 output parameters.

| Fire Effects Scenario | Stand ID | Method | 1000-hour Sound Woody Fuel Loading (consumed) in tons/acre | Shrub Fuel Loading (consumed) in tons/acre | Crown Foliage Fuel Loading (consumed) in tons/acre | $PM_{2.5}$ Emissions (smoldering) in tons/acre |
|---|---|---|---|---|---|---|
| Low | 24 | IFTDSS | 0.3 | 0 | 2.28 | 0.11 |
| | | FOFEM | 0.3 | 0 | 2.28 | 0.114 |
| | 41 | IFTDSS | 0 | 0 | 0 | 0 |
| | | FOFEM | 0 | 0 | 0 | 0 |
| | 237 | IFTDSS | 0 | 1.31 | 0 | 0 |
| | | FOFEM | 0 | 1.31 | 0 | 0 |
| Moderate | 24 | IFTDSS | 0.41 | 0 | 2.28 | 0.1 |
| | | FOFEM | 0.41 | 0 | 2.28 | 0.1015 |
| | 41 | IFTDSS | 0 | 0 | 0 | 0 |
| | | FOFEM | 0 | 0 | 0 | 0 |
| | 237 | IFTDSS | 0 | 1.6 | 0 | 0 |
| | | FOFEM | 0 | 1.6 | 0 | 0 |
| High | 24 | IFTDSS | 0.72 | 0 | 2.28 | 0.16 |
| | | FOFEM | 0.72 | 0 | 2.28 | 0.157 |
| | 41 | IFTDSS | 0 | 0 | 0 | 0 |
| | | FOFEM | 0 | 0 | 0 | 0 |
| | 237 | IFTDSS | 0 | 1.31 | 0 | 0 |
| | | FOFEM | 0 | 1.31 | 0 | 0 |

## Test Case 2: FOFEM Tree Mortality

Results from the FOFEM Tree Mortality module implemented in IFTDSS and the FOFEM desktop version for the three simulations tested were identical (Table 5).

Table 5. Results from the FOFEM tree mortality module comparison.

| Output Parameter | Unit | Low Fire Effect | | Moderate Fire Effect | | High Fire Effect | |
|---|---|---|---|---|---|---|---|
| | | IFTDSS | FOFEM | IFTDSS | FOFEM | IFTDSS | FOFEM |
| Pre-fire Tree Density | trees/acre | 3 | 3 | 10 | 10 | 15 | 15 |
| Post-fire Tree Density | trees/acre | 3 | 3 | 9 | 9 | 3 | 3 |
| Trees per Acre Killed | trees/acre | 0 | 0 | 1 | 1 | 12 | 12 |
| Percent Mortality | percent | 6 | 6 | 12 | 12 | 80 | 80 |
| Pre-fire Basal Area | $ft^2$/acre | 37.7 | 37.7 | 70.69 | 70.69 | 47.12 | 47.12 |
| Post-fire Basal Area Live | $ft^2$/acre | 35.35 | 35.35 | 62.51 | 62.51 | 9.45 | 9.45 |
| Post-fire Basal Area Killed | $ft^2$/acre | 2.35 | 2.35 | 8.17 | 8.17 | 37.67 | 37.67 |
| Pre-fire Canopy Cover | percent | 6 | 6 | 15 | 15 | 14 | 14 |
| Post-fire Canopy Cover | percent | 6 | 6 | 13 | 13 | 3 | 3 |