

SpatialFOFEM 1.0

FIRST ORDER FIRE EFFECTS MODEL

SWITCH and FILE DESCRIPTIONS

Oct. 16, 2020



FIRE & AVIATION MANAGEMENT
ROCKY MOUNTAIN RESEARCH STATION
FIRE MODELING INSTITUTE

Duncan C. Lutes

Table of Contents

SpatialFOFEM Consumption and Emissions Input Switches	3
FCCS_Layer_File	3
FCCS_Layer_Number	3
FOFEM_Fuelbeds	3
FOFEM_Fuelbeds_File	5
FOFEM_Use_Consumption_Equation	5
FOFEM_Region	7
FOFEM_Season	7
FOFEM_Percent_Foliage_Branch_Consumed	7
FOFEM_Use_Expanded_Emissions	8
FOFEM_10_Hour_FM	8
FOFEM_10_Hour_File	8
FOFEM_10_Hour_Layer_Number	8
FOFEM_1000_Hour_FM	9
FOFEM_1000_Hour_File	9
FOFEM_1000_Hour_Layer_Number	9
FOFEM_Duff_FM	9
FOFEM_Duff_File	10
FOFEM_Duff_Layer_Number	10
FOFEM_DUFF_1000_Hour_x_3	10
FOFEM_10_Percent_Duff_Moisture	11
FOFEM_Limiting_Shapefile	11
FOFEM_Moisture_Precision	11
SpatialFOFEM Consumption and Emissions Output Switches	12
Emissions outputs	12
Fuel Consumption outputs	12
Sample SpatialFOFEM Input File with Consumption and Emissions Switches	15
Additional Consumption and Emissions Simulation Outputs	16
Warnings.CSV	16
Statistics.CSV	16
SpatialFOFEM Tree Mortality Input Switches	17
FOFEM_Mortality	17
FOFEM_Flame_Length	17
FOFEM_Flame_Length_File	17
FOFEM_Flame_Length_Layer_Number	18
FOFEM_Flame_Length_Precision	18
FOFEM_Mortality_Species	18
FOFEM_Mortality_Size_Classes	19
SpatialFOFEM Tree Mortality Output	19

The FOFEM User Guide is an important resource for those unfamiliar with the model. It is available on the FOFEM web site: <https://www.firelab.org/project/fofem-fire-effects-model>.

SpatialFOFEM Input and Output File Description

SpatialFOFEM Consumption and Emissions Input Switches

The following switches are used by the SpatialFOFEM class.

Switches can be supplied in any order.

Any comment lines in the input file should start with the # character in column 1

FCCS_Layer_File (Required)

Purpose: To define the fuelbeds and SpatialFOFEM calculation grid

Usage: **FCCS_Layer_File**: X

Where X is a complete path to a GeoTIFF containing the FCCS fuel layer.

Example:

FCCS_Layer_File: C:\Data\FCCS_Fuels.tif

FCCS_Layer_Number (Optional, default = 1)

Purpose: To indicate which layer of the FCCS_Layer_File is the fuelbed layer

Usage: **FCCS_Layer_Number**: X

Where X is the layer number in the landscape. Layer numbers start at 1. FlamMap landscapes already reserve layers 1 - 8, so this layer must be 9 or greater in a fire behavior landscape GeoTIFF. This switch is optional, the default is FCCS_Layer_Number: 1

Example: **FCCS_Layer_Number**: 9

Indicates layer number 9 in the GeoTIFF landscape is the FCCS fuels layer.

FOFEM_Fuelbeds (Optional, default uses *fof_fccs.csv* only. Cannot be used with **FOFEM_Fuelbeds_File** switch)

Purpose: To allow for the use of custom fuelbeds.

Usage: **FOFEM_Fuelbeds**: X

Where X is an integer representing the number of fuelbeds listed. Immediately following this line, 27 comma separated model inputs are provided. The fuelbed information following the **FOFEM_Fuelbeds** switch will override fuelbed information in *fof_fccs.csv* for the FCCS fuelbeds included with the switch. Fuelbed information for fuelbeds not included with the switch will be read from *fof_fccs.csv*. This switch can be used instead of **FOFEM_Fuelbeds_File**

Position	Field Name	Description
1	Fuelbed Number	Code representing the fuelbed in the landscape layer. Positive integer.
2	FOFEM Region1	Required, first code for applicable FOFEM region (P=Pacific West, I=Interior West, N=North East, or S=South East)
3	FOFEM Region2	May be blank, or one of P, I, N, or S
4	FOFEM Region3	May be blank, or one of P, I, N, or S
5	FOFEM Region4	May be blank, or one of P, I, N, or S
6	Litter Loading	Litter load in tons per acre; range: 0 – 999 T/ac
7	Duff Loading	Duff Loading in tons per acre; range 0 - 356.78 T/ac
8	Duff Depth	Duff Depth in inches; range 0 – 999 in.
9	Shrub Loading	Shrub loading in tons per acre; range: 0 – 999 T/ac
10	Herb Loading	Herbaceous fuel loading in tons per acre; range: 0 – 999 T/ac
11	1-hour Loading	1-hour fuel loading in tons per acre; range: 0 – 999 T/ac
12	10-hour Loading	10-hour fuel loading in tons per acre; range: 0 – 999 T/ac
13	100-hour Loading	100-hour fuel loading in tons per acre; range: 0 – 999 T/ac
14	3-6 Sound Loading	3-6 inch sound fuel loading in tons per acre; range: 0 – 999 T/ac
15	6-9 Sound Loading	6-9 inch sound fuel loading in tons per acre; range: 0 – 999 T/ac
16	9-20 Sound Loading	9-20 inch sound fuel loading in tons per acre; range: 0 – 999 T/ac
17	20+ Sound Loading	20+ inch sound fuel loading in tons per acre; range: 0 – 999 T/ac
18	3-6 Rotten Loading	3-6 inch rotten fuel loading in tons per acre; range: 0 – 999 T/ac
19	6-9 Rotten Loading	6-9 inch rotten fuel loading in tons per acre; range: 0 – 999 T/ac
20	9-20 Rotten Loading	9-20 inch rotten fuel loading in tons per acre; range: 0 – 999 T/ac
21	20+ Rotten Loading	20+ inch rotten fuel loading in tons per acre; range: 0 – 999 T/ac
22	Crown Foliage Loading	Crown Foliage loading in tons per acre; range: 0 – 999 T/ac
23	Crown Branch Loading	Crown Branch loading in tons per acre; range: 0 – 999 T/ac
24	FOFEM Cover Group	Valid cover group recognized by FOFEM, or blank
25	STSF EF ¹	FOFEM emission factor group number for short-term flaming and smoldering

26	DuffRSC EF ¹	FOFEM emission factor group number for duff residual smoldering combustion
27	CWDRSC ¹	FOFEM emission factor group number for coarse wood residual smoldering combustion

¹Must be specified but used only with the **FOFEM_Use_Expanded_Emissions** switch.

Example:

FOFEM_Fuelbeds: 2

1, I, P, S, N, 1.61, 37, 2, 2.7, 0.2, 0.2, 0.8, 3.5, 0.25, 0.25, 0.5, 0, 1.5, 1.5, 4, 5, 22.94, 5.74, , 3, 8, 7

2, I, P, S, N, 1.57, 45.75, 3, 3.76, 0.16, 1, 2, 4, 1, 1, 3, 6, 0.5, 0.5, 3, 4, 16.83, 4.21, WPH, 3, 8, 7

FOFEM_Fuelbeds_File (Optional, default uses *fof_fccs.csv* only. Cannot be used with **FOFEM_Fuelbeds** switch)

Purpose: To allow for the use of custom fuelbeds in an external file

Usage: **FOFEM_Fuelbeds_File: X**

Where X is the complete path and name of a csv file with fuelbed information in the same format as **FOFEM_Fuelbeds** entries. The fuelbed information in the **FOFEM_Fuelbeds_File** will override fuelbed information in *fof_fccs.csv* for the FCCS fuelbeds included in the file. Fuelbed information for fuelbeds not included in the file will be read from *fof_fccs.csv*. This switch can be used instead of **FOFEM_Fuelbeds**.

Example: **FOFEM_Fuelbeds_File: C:\FOFEM\Data\fuels.csv**

FOFEM_Use_Consumption_Equation (Optional, used only with the **FOFEM_Fuelbeds** and **FOFEM_Fuelbeds_File** switches)

Purpose: To direct SpatialFOFEM to use specific consumption equations for six fuelbed components: litter load consumption, duff load consumption, duff depth reduction, mineral soil exposure (MSE), herb load, and shrub load. If this switch is not used SpatialFOFEM will use the default consumption equations. See the FOFEM User Guide, *Scientific Content – Fuel Consumption and Decision Dependency* sections for more information.

Usage: **FOFEM_Use_Consumption_Equations: 1 or 0**

When set to 1, SpatialFOFEM will use the consumption equations specified in the fuelbeds following the **FOFEM_FuelBeds** switch. When set to 0, SpatialFOFEM will ignore the consumption equations specified in the fuelbeds listed following the **FOFEM_FuelBeds** switch.

If **FOFEM_Use_Consumption_Equations** = 1 each fuelbed must include six equation numbers separated by commas identifying the consumption equations to use. All six must be present if any are used. Use -1 to use the FOFEM default equation). Valid consumption equation numbers:

Litter load consumption: 997, 998, 999, or -1

Duff load consumption: 1, 2, 3, 4, 5, 6, 7, 15, 16, 17, 19, 20, or -1

NOTE: If the Consumption Equations switch is not used, duff reduction and duff consumption will be calculated using the same equation (selected using model logic). If the model logic selects a duff depth reduction equation, FOFEM will calculate the percent change in duff depth and calculate duff load consumed using that percentage. If the model logic selects a duff load consumption equation, FOFEM will calculate the percent change in duff load and calculate duff depth reduction using the same percentage. If the Consumption Equations switch is used and the default equations are used for duff calculations (-1), FOFEM will use model logic to select a duff depth reduction equation and a duff load consumption reduction equation, which will likely be different. The user can specify either a reduction or consumption equation for calculating reduction or consumption. If a consumption type equation is selected for calculating reduction or a reduction type equation is selected for calculating consumption, FOFEM will calculate the percent change and reduce the desired component the calculated amount.

Duff depth reduction: 1, 2, 3, 4, 5, 6, 7, 15, 16, 17, 19, 20, or -1

NOTE: Duff reduction equation is used for emissions estimation

MSE equation: 9, 10, 11, 12, 13, 14, 18, 202, or -1

Herb load consumption: 22, 221, 222, 223, or -1

Shrub load consumption: 23, 231, 232, 233, 234, 235, 236, or -1

Example:

FOFEM_Use_Consumption_Equations: 1

FOFEM_Fuelbeds: 2

1, I,P,S,N,1.61, 37, 2, 2.7, 0.2, 0.2, 0.8, 3.5, 0.25, 0.25, 0.5, 0, 1.5, 1.5, 4, 5, 22.94, 5.74, , 3, 8, 7, -1, -1, -1, -1, -1, -1
 2, I,P,S,N,1.57, 45.75, 3, 3.76, 0.16, 1, 2, 4, 1, 1, 3, 6, 0.5, 0.5, 3, 4, 16.83, 4.21, WPH, 3, 8, 7, 998, 2, 6, 12, 22, 23

FOFEM_Region (Required)

Purpose: To determine Region specific consumption equations used by FOFEM

Usage: **FOFEM_Region**: X

Where X is a valid FOFEM region, one of I, P, N, or S. These translate to InteriorWest, PacificWest, NorthEast, and SouthEast, respectively. The following map illustrates FOFEM defined regions:



Example: **FOFEM_Region**: I

FOFEM_Season (Required)

Purpose: For setting the season of burn. In some cases, season is used to select consumption equations.

Usage: **FOFEM_Season** X

Where X is a recognized FOFEM Season. Valid values are Spring, Summer, Fall, Winter.

Example: **FOFEM_Season**: Summer

FOFEM_Percent_Foliage_Branch_Consumed (Required)

Purpose: To set the percent of foliage and branch fuel consumed.

Range: 0 – 100%

Usage: **FOFEM_Percent_Foliage_Branch_Consumed**: X

Where X is the percent of crown foliage and branches consumed entered as an integer (0 - 100)

Example: **FOFEM_Percent_Foliage_Branch_Consumed**: 75

FOFEM_Use_Expanded_Emissions (Optional)

Purpose: Will use the updated emission factors based on Urbanski (2014) The logic to calculate emissions also differs from the default FOFEM logic.

Usage: **FOFEM_Use_Expanded_Emissions**: 1 or 0

When set to 1, SpatialFOFEM will use the expanded emission factors specified in the fuelbeds listed following the **FOFEM_FuelBeds** switch. When set to 0, SpatialFOFEM will ignore the expanded emission factors specified in the fuelbeds and will use the default FOFEM logic

Example: **FOFEM_Use_Expanded_Emissions**: 1

SpatialFOFEM will use expanded burnup emission factors and logic.

FOFEM_10_Hour_FM (Required)

Purpose: To set the global 10-hour fuel moisture. Entry required even if a geospatial fuel moisture file is supplied. This value will be used when FOFEM_10_Hour_File values are NODATA values. Entered as an integer value. Range: 3 – 298%.

Usage: **FOFEM_10_Hour_FM**: X

Where X is the global 10-hour fuel moisture, applied globally across the landscape

Example: **FOFEM_10_Hour_FM**: 10

FOFEM_10_Hour_File (Optional)

Purpose: To geospatially assign 10-hour fuel moistures. This file must be in the same projection and coordinate system as the **FCCS_Layer_File** and must completely cover the extents of the **FCCS_Layer_File**. In the case of missing or NODATA values, the **FOFEM_10_Hour_FM** value will be used.

Usage: **FOFEM_10_Hour_File**: X

Where X is the complete path and file name of the GeoTIFF containing cellular 10-hour fuel moistures. (units = %moisture/100)

Example: **FOFEM_10_Hour_File**: C:\FOFEM\Data\10hourFM.tif

FOFEM_10_Hour_Layer_Number (Optional, default = 1)

Purpose: To indicate the layer number for 10-hour fuel moistures in the **FOFEM_10_Hour_File**

Usage: **FOFEM_10_Hour_Layer_Number**: X

Where X is the layer number in the **FOFEM_10_Hour_File**. Layer numbers start at 1. This switch is optional, the default is **FOFEM_10_Hour_Layer_Number**: 1

Example: **FOFEM_10_Hour_Layer_Number**: 2

Indicates layer number 2 in **FOFEM_10_Hour_File** is the 10-hour fuel moisture layer.

FOFEM_1000_Hour_FM (Required)

Purpose: To set the global 1000-hour fuel moisture. Entry required even if a geospatial fuel moisture file is supplied. This value will be used when **FOFEM_1000_Hour_File** values are NODATA values. Entered as an integer value. Range: 1 – 300%.

Usage: **FOFEM_1000_Hour_FM**: X

Where X is the global 1000-hour fuel moisture, applied globally across the landscape

Example: **FOFEM_1000_Hour_FM**: 15

FOFEM_1000_Hour_File (Optional)

Purpose: To geospatially assign 1000-hour fuel moistures. This file must be in the same projection and coordinate system as the **FCCS_Layer_File** and must completely cover the extents of the **FCCS_Layer_File**. In the case of missing or NODATA values, the **FOFEM_1000_Hour_FM** value will be used.

Usage: **FOFEM_1000_Hour_File**: X

Where X is the complete path and file name of the GeoTIFF containing cellular 1000-hour fuel moistures.

Example: **FOFEM_1000_Hour_File**: C:\FOFEM\Data\1000hourFM.tif

FOFEM_1000_Hour_Layer_Number (Optional, default = 1)

Purpose: To indicate the layer number for 1000-hour fuel moistures in the **FOFEM_1000_Hour_File**

Usage: **FOFEM_1000_Hour_Layer_Number**: X

Where X is the layer number in the **FOFEM_1000_Hour_File**. Layer numbers start at 1. This switch is optional, the default is **FOFEM_1000_Hour_Layer_Number**: 1

Example: **FOFEM_1000_Hour_Layer_Number**: 4

Indicates layer number 4 in the **FOFEM_1000_Hour_File** is the 1000-hour fuel moisture layer.

FOFEM_Duff_FM (Required)

Purpose: To set the global duff moisture. Entry required even if a geospatial fuel moisture file is supplied. This value will be used when **FOFEM_Duff_File** values are NODATA values. Entered as an integer value. Range 10 -197%.

Usage: **FOFEM_Duff_FM**: X

Where X is the global duff fuel moisture, applied globally across the landscape.

Example: **FOFEM_Duff_FM**: 40

FOFEM_Duff_File (Optional)

Purpose: To geospatially assign duff moistures. This file must be in the same projection and coordinate system as the **FCCS_Layer_File** and must completely cover the extents of the **FCCS_Layer_File**. In the case of missing or NODATA values, the **FOFEM_Duff_FM** value will be used.

Usage: **FOFEM_Duff_File**: X

Where X is the complete path and file name of the GeoTIFF containing cellular duff fuel moistures. (units = %moisture/100)

Example: **FOFEM_Duff_File**: C:\FOFEM\Data\DuffFM.tif

FOFEM_Duff_Layer_Number (Optional, default = 1)

Purpose: To indicate the layer number for duff moistures in the **FOFEM_Duff_File**

Usage: **FOFEM_Duff_Layer_Number**: X

Where X is the layer number in the **FOFEM_Duff_File**. Layer numbers start at 1. This switch is optional, the default is **FOFEM_Duff_Layer_Number**: 1

Example:

FOFEM_Duff_Layer_Number: 5

Indicates layer number 5 in the **FOFEM_Duff_File** is the Duff fuel moisture layer.

FOFEM_DUFF_1000_Hour_x_3 (Optional)

Purpose: Used to set duff moistures to the **FOFEM_1000_Hour_File** value * 3.0.

Usage: **FOFEM_DUFF_1000_Hour_x_3**: 1 or 0

When set to 1, SpatialFOFEM will:

- a) set duff moisture as **FOFEM_1000_Hour_File** cell value x 3 for cells that do not have duff fuel moisture in the **FOFEM_Duff_File** grid or **FOFEM_Duff_File** is not used.
- b) set duff moisture as **FOFEM_1000_Hour_FM** x 3 when no **FOFEM_1000_Hour_File** is defined.
- c) set duff moisture as the **FOFEM_Duff_FM** value for cells that do not have duff fuel moisture in the **FOFEM_Duff_File** grid and **FOFEM_1000_Hour_File** cell value is undefined.

When set to 0, SpatialFOFEM will use the **FOFEM_Duff_FM** value when **FOFEM_Duff_File** value is undefined or **FOFEM_Duff_File** is not used.

Example: **FOFEM_DUFF_1000_Hour_x_3**: 1

FOFEM_10_Percent_Duff_Moisture (Optional)

Purpose: To handle duff consumption when duff moisture is 10% or less.

Usage: **FOFEM_10_Percent_Duff_Moisture**: 1 or 0

When set to 1, SpatialFOFEM will consume 100% of the duff for any cell with 10% or less duff moisture. When set to 0, and a cell's duff moisture is 10% or less, SpatialFOFEM will set the duff moisture to 11% for the cell before running FOFEM for the cell to prevent FOFEM from automatically consuming 100% of the duff.

Example: **FOFEM_10_Percent_Duff_Moisture**: 1

FOFEM_Limiting_Shapefile (Optional)

Purpose: To limit SpatialFOFEM to a subset of the **FCCS_Layer_File**. Cells outside the polygon(s) in this layer will return NODATA for all calculations.

Usage: **FOFEM_Limiting_Shapefile**: X

Where X is the complete path and file name for the desired shapefile. This shapefile must be of a polygon or multipolygon type. SpatialFOFEM will run calculations only on cells whose centers are included in the polygon(s) in the shapefile.

Example: **FOFEM_Limiting_Shapefile**: C:\Data\Perimeter.shp

FOFEM_Moisture_Precision (Optional)

Purpose: To set the decimal precision of duff and fuel moistures when the values are retrieved from a GeoTIFF file. Can greatly increase processing time.

Usage: **FOFEM_Moisture_Precision**: X

Where X is an integer representing the number of decimal places to use for fuel moisture percent. The default is zero, so fuel moistures are always rounded to the nearest integer percent.

Example: **FOFEM_Moisture_Precision**: 2

Would round each cell's 10-hour, 1000-hour, and duff moistures to the nearest hundredth of a percent. E.g. 6.7890% rounds to 6.79%.

Spatial FOFEM Consumption and Emissions Output Switches:

The following switches cause spatial FOFEM to allocate memory for and make available the corresponding output. One switch per line, no options:

Emissions outputs:

FOFEM_FLAMING_CO2: CO2 in lb/acre produced by flaming
FOFEM_FLAMING_CO: CO in lb/acre produced by flaming
FOFEM_FLAMING_CH4: CH4 in lb/acre produced by flaming
FOFEM_FLAMING_NOX: NOX in lb/acre produced by flaming
FOFEM_FLAMING_SO2: SO2 in lb/acre produced by flaming
FOFEM_FLAMING_PM25: PM 2.5 in lb/acre produced by flaming
FOFEM_FLAMING_PM10: PM 10 in lb/acre produced by flaming
FOFEM_SMOLDERING_CO2: CO2 in lb/acre produced by smoldering
FOFEM_SMOLDERING_CO: CO in lb/acre produced by smoldering
FOFEM_SMOLDERING_CH4: CH4 in lb/acre produced by smoldering
FOFEM_SMOLDERING_NOX: NOX in lb/acre produced by smoldering
FOFEM_SMOLDERING_SO2: SO2 in lb/acre produced by smoldering
FOFEM_SMOLDERING_PM25: PM 2.5 in lb/acre produced by smoldering
FOFEM_SMOLDERING_PM10: PM 10 in lb/acre produced by smoldering
FOFEM_TOTAL_CO2: CO2 in lb/acre produced by flaming and smoldering
FOFEM_TOTAL_CO: CO in lb/acre produced by flaming and smoldering
FOFEM_TOTAL_CH4: CH4 in lb/acre produced by flaming and smoldering
FOFEM_TOTAL_NOX: NOX in lb/acre produced by flaming and smoldering
FOFEM_TOTAL_SO2: SO2 in lb/acre produced by flaming and smoldering
FOFEM_TOTAL_PM25: PM 2.5 in lb/acre produced by flaming and smoldering
FOFEM_TOTAL_PM10: PM 10 in lb/acre produced by flaming and smoldering

Fuel Consumption outputs:

FOFEM_TOTAL_FUEL_PREBURN: Total fuel preburn loading (T/acre)
FOFEM_TOTAL_FUEL_CONSUMED: Total fuel consumed (T/acre)
FOFEM_TOTAL_FUEL_POSTBURN: Total fuel postburn loading (T/acre)
FOFEM_TOTAL_FUEL_PERCENT_REDUCED: Total fuel percent reduction
FOFEM_LITTER_PREBURN: Litter preburn loading (T/acre)
FOFEM_LITTER_CONSUMED: Litter inch fuel consumed (T/acre)
FOFEM_LITTER_POSTBURN: Litter inch postburn loading (T/acre)
FOFEM_LITTER_PERCENT_REDUCED: Litter inch percent reduction
FOFEM_1_HOUR_PREBURN: 0-¼ inch preburn loading (T/acre)
FOFEM_1_HOUR_CONSUMED: 0-¼ inch fuel consumed (T/acre)
FOFEM_1_HOUR_POSTBURN: 0-¼ inch postburn loading (T/acre)
FOFEM_1_HOUR_PERCENT_REDUCED: 0-¼ inch percent reduction
FOFEM_10_HOUR_PREBURN: ¼-1 inch preburn loading (T/acre)
FOFEM_10_HOUR_CONSUMED: ¼-1 inch fuel consumed (T/acre)

FOFEM_10_HOUR_POSTBURN: ¼-1 inch postburn loading (T/acre)
FOFEM_10_HOUR_PERCENT_REDUCED: ¼-1 inch percent reduction
FOFEM_100_HOUR_PREBURN: 1-3 inch preburn loading (T/acre)
FOFEM_100_HOUR_CONSUMED: 1-3 inch fuel consumed (T/acre)
FOFEM_100_HOUR_POSTBURN: 1-3 inch postburn loading (T/acre)
FOFEM_100_HOUR_PERCENT_REDUCED: 1-3 inch percent reduction
FOFEM_SOUND_3_6_PREBURN: 3-6 inch Sound preburn loading (T/acre)
FOFEM_SOUND_3_6_CONSUMED: 3-6 inch Sound fuel consumed (T/acre)
FOFEM_SOUND_3_6_POSTBURN: 3-6 inch Sound postburn loading (T/acre)
FOFEM_SOUND_3_6_PERCENT_REDUCED: 3-6 inch Sound percent reduction
FOFEM_SOUND_6_9_PREBURN: 6-9 inch Sound preburn loading (T/acre)
FOFEM_SOUND_6_9_CONSUMED: 6-9 inch Sound fuel consumed (T/acre)
FOFEM_SOUND_6_9_POSTBURN: 6-9 inch Sound postburn loading (T/acre)
FOFEM_SOUND_6_9_PERCENT_REDUCED: 6-9 inch Sound percent reduction
FOFEM_SOUND_9_20_PREBURN: 9-20 inch Sound preburn loading (T/acre)
FOFEM_SOUND_9_20_CONSUMED: 9-20 inch Sound fuel consumed (T/acre)
FOFEM_SOUND_9_20_POSTBURN: 9-20 inch Sound postburn loading (T/acre)
FOFEM_SOUND_9_20_PERCENT_REDUCED: 9-20 inch Sound percent reduction
FOFEM_SOUND_20_PLUS_PREBURN: 20+ inch Sound preburn loading (T/acre)
FOFEM_SOUND_20_PLUS_CONSUMED: 20+ inch Sound fuel consumed (T/acre)
FOFEM_SOUND_20_PLUS_POSTBURN: 20+ inch Sound postburn loading (T/acre)
FOFEM_SOUND_20_PLUS_PERCENT_REDUCED: 20+ inch Sound percent reduction
FOFEM_ROTEN_3_6_PREBURN: 3-6 inch Rotten preburn loading (T/acre)
FOFEM_ROTEN_3_6_CONSUMED: 3-6 inch Rotten fuel consumed (T/acre)
FOFEM_ROTEN_3_6_POSTBURN: 3-6 inch Rotten postburn loading (T/acre)
FOFEM_ROTEN_3_6_PERCENT_REDUCED: 3-6 inch Rotten percent reduction
FOFEM_ROTEN_6_9_PREBURN: 6-9 inch Rotten preburn loading (T/acre)
FOFEM_ROTEN_6_9_CONSUMED: 6-9 inch Rotten fuel consumed (T/acre)
FOFEM_ROTEN_6_9_POSTBURN: 6-9 inch Rotten postburn loading (T/acre)
FOFEM_ROTEN_6_9_PERCENT_REDUCED: 6-9 inch Rotten percent reduction
FOFEM_ROTEN_9_20_PREBURN: 9-20 inch Rotten preburn loading (T/acre)
FOFEM_ROTEN_9_20_CONSUMED: 9-20 inch Rotten fuel consumed (T/acre)
FOFEM_ROTEN_9_20_POSTBURN: 9-20 inch Rotten postburn loading (T/acre)
FOFEM_ROTEN_9_20_PERCENT_REDUCED: 9-20 inch Rotten percent reduction
FOFEM_ROTEN_20_PLUS_PREBURN: 20+ inch Rotten preburn loading (T/acre)
FOFEM_ROTEN_20_PLUS_CONSUMED: 20+ inch Rotten fuel consumed (T/acre)
FOFEM_ROTEN_20_PLUS_POSTBURN: 20+ inch Rotten postburn loading (T/acre)
FOFEM_ROTEN_20_PLUS_PERCENT_REDUCED: 20+ inch Rotten percent reduction
FOFEM_DUFF_PREBURN: Duff preburn loading (T/acre)
FOFEM_DUFF_CONSUMED: Duff fuel load consumed (T/acre)
FOFEM_DUFF_POSTBURN: Duff postburn loading (T/acre)
FOFEM_DUFF_PERCENT_REDUCED: Duff fuel load percent reduction
FOFEM_DUFF_DEPTH_PREBURN: Duff preburn depth (inches)
FOFEM_DUFF_DEPTH_CONSUMED: Duff depth consumed (inches)
FOFEM_DUFF_DEPTH_POSTBURN: Duff postburn depth (inches)

FOFEM_DUFF_DEPTH_PERCENT_REDUCED: Duff depth percent reduced
FOFEM_MINERAL_SOIL_EXPOSED: Percent Mineral Soil Exposed
FOFEM_HERB_PREBURN: Herbaceous preburn loading (T/acre)
FOFEM_HERB_CONSUMED: Herbaceous fuel consumed (T/acre)
FOFEM_HERB_POSTBURN: Herbaceous postburn loading (T/acre)
FOFEM_HERB_PERCENT_REDUCED: Herbaceous fuel percent reduction
FOFEM_SHRUB_PREBURN: Shrub preburn loading (T/acre)
FOFEM_SHRUB_CONSUMED: Shrub fuel consumed (T/acre)
FOFEM_SHRUB_POSTBURN: Shrub postburn loading (T/acre)
FOFEM_SHRUB_PERCENT_REDUCED: Shrub fuel percent reduction
FOFEM_FOLIAGE_PREBURN: Crown foliage preburn loading (T/acre)
FOFEM_FOLIAGE_CONSUMED: Crown foliage fuel consumed (T/acre)
FOFEM_FOLIAGE_POSTBURN: Crown foliage postburn loading (T/acre)
FOFEM_FOLIAGE_PERCENT_REDUCED: Crown foliage fuel percent reduction
FOFEM_BRANCH_PREBURN: Crown branchwood preburn loading (T/acre)
FOFEM_BRANCH_CONSUMED: Crown branchwood fuel consumed (T/acre)
FOFEM_BRANCH_POSTBURN: Crown branchwood postburn loading (T/acre)
FOFEM_BRANCH_PERCENT_REDUCED: Crown branchwood fuel percent reduction
FOFEM_LITTER_CARBON_PREBURN: Litter preburn carbon loading (T/acre)
FOFEM_LITTER_CARBON_POSTBURN: Litter postburn carbon loading (T/acre)
FOFEM_WOOD_CARBON_PREBURN: Wood preburn carbon loading (T/acre)
FOFEM_WOOD_CARBON_POSTBURN: Wood postburn carbon loading (T/acre)
FOFEM_DUFF_CARBON_PREBURN: Duff preburn carbon loading (T/acre)
FOFEM_DUFF_CARBON_POSTBURN: Duff postburn carbon loading (T/acre)
FOFEM_HERB_CARBON_PREBURN: Herbaceous preburn carbon loading (T/acre)
FOFEM_HERB_CARBON_POSTBURN: Herbaceous postburn carbon loading (T/acre)
FOFEM_SHRUB_CARBON_PREBURN: Shrub preburn carbon loading (T/acre)
FOFEM_SHRUB_CARBON_POSTBURN: Shrub postburn carbon loading (T/acre)
FOFEM_FOLIAGE_BRANCH_CARBON_PREBURN: Crown preburn carbon loading (T/acre)
FOFEM_FOLIAGE_BRANCH_CARBON_POSTBURN: Crown postburn carbon loading (T/acre)
FOFEM_TOTAL_CARBON_PREBURN: Total preburn carbon loading (T/acre)
FOFEM_TOTAL_CARBON_POSTBURN: Total postburn carbon loading (T/acre)

Sample SpatialFOFEM Input File with Consumption and Emissions Switches:

```
#Sample SpatialFOFEM inputs file
FCCS_Layer_File: C:\FOFEM\Data\FCCS_Fuels.tif
FCCS_Layer_Number: 1
FOFEM_Use_Consumption_Equations: 1
FOFEM_Fuelbeds: 2
1, P, I, N, S, 1.61, 37, 2, 2.7, 0.2, 0.2, 0.8, 3.5, 0.25, 0.25, 0.5, 0, 1.5, 1.5, 4, 5, 22.94, 5.74, , 3, 8, 7, -1,-1,-1,-1,-1,-1
2, P, I, N, S, 1.57, 45.75, 3, 3.76, 0.16, 1, 2, 4, 1, 1, 3, 6, 0.5, 0.5, 3, 4, 16.83, 4.21, WPH, 3, 8, 7, 998, 2, 6, 12, 22, 23
FOFEM_Percent_Foliage_Branch_Consumed: 75.0
FOFEM_Region: I
FOFEM_Season: Summer
FOFEM_10_Hour_File: C:\FOFEM\Data\10hourFM.tif
FOFEM_1000_Hour_File: C:\FOFEM\Data\1000hourFM.tif
FOFEM_10_Hour_FM: 10
FOFEM_1000_Hour_FM: 15
FOFEM_Duff_FM: 40
#Selected SpatialFOFEM outputs, in this case select all emissions
FOFEM_FLAMING_CO2:
FOFEM_FLAMING_CO:
FOFEM_FLAMING_CH4:
FOFEM_FLAMING_NOX:
FOFEM_FLAMING_SO2:
FOFEM_FLAMING_PM25:
FOFEM_FLAMING_PM10:
FOFEM_SMOLDERING_CO2:
FOFEM_SMOLDERING_CO:
FOFEM_SMOLDERING_CH4:
FOFEM_SMOLDERING_NOX:
FOFEM_SMOLDERING_SO2:
FOFEM_SMOLDERING_PM25:
FOFEM_SMOLDERING_PM10:
FOFEM_TOTAL_CO2:
FOFEM_TOTAL_CO:
FOFEM_TOTAL_CH4:
FOFEM_TOTAL_NOX:
FOFEM_TOTAL_SO2:
FOFEM_TOTAL_PM25:
FOFEM_TOTAL_PM10:
#Select 'total' fuel and carbon outputs
FOFEM_TOTAL_FUEL_PREBURN:
FOFEM_TOTAL_FUEL_CONSUMED:
FOFEM_TOTAL_FUEL_POSTBURN:
FOFEM_TOTAL_CARBON_PREBURN:
FOFEM_TOTAL_CARBON_POSTBURN:
```

Additional Consumption and Emissions Simulation Outputs

Two CSV files are created at run time:

Warnings.CSV Run time warnings present the fuelbed number, 10-hr moisture, 3"+ moisture, duff moisture, cell count and warning/error for the associated warning record.

Upper and lower limits for SpatialFOFEM input file.

Component	Lower Limit	Upper Limit	Note
Duff load (t/ac)	0	999	If duff load is zero, duff depth must be zero. If duff depth>0, then lower duff load limit is 0.1.
Duff depth (t/ac)	0	999	If duff depth is zero, duff load must be zero.
Litter load (t/ac)	0	999	
1-hr (t/ac)	0	999	
10-hr (t/ac)	0	999	
100-hr (t/ac)	0	999	
3"+ (t/ac)	0	999	
Herb (t/ac)	0	999	
Shrub (t/ac)	0	999	
Foliage (t/ac)	0	999	
Branch (t/ac)	0	999	
Duff moisture (%)	10	197	
10-hr moisture (%)	3	298	
3"+ moisture (%)	1	300	

Statistics.CSV This file includes mean, median, 3rd quartile, 1st quartile, mode, minimum, maximum, standard deviation, sample size, total acres, tons and metric tonnes for all inputs and outputs.

Totals are calculated for all cells or those inside the entire polygon that get passed to SpatialFOFEM (for example a fire perimeter).

Example: Cell size is read for the GeoTIFF. For emissions, total metric tons = (total lb/acre / 2000lbs/ton) * (cellsize m²) * (0.00024710538146717 acres/m²) * 0.90718474 metric tons / ton

For fuels, total metric tons = (total tons/acre) * (cellsize m²) * (0.00024710538146717 acres/m²) * 0.90718474 metric tons / ton

SpatialFOFEM Tree Mortality Input Switches

The following switches are used by the SpatialFOFEM class.

Switches can be supplied in any order.

Any comment lines in the input file should start with the # character in column 1

FOFEM_Mortality (Optional, default = 0)

Purpose: Enables calculation for tree mortality using TreeMap database and FOFEM Mortality based on FOFEM Crown Scorch (CRNSCH) equation type using Flame Length.

Usage: **FOFEM_Mortality**: X

Where X is a boolean integer (0 = false, 1 = true) directing SpatialFOFEM to run Mortality and provide mortality outputs.

Example: **FOFEM_Mortality**: 1

Would cause SpatialFOFEM to run Mortality and provide mortality outputs.

FOFEM_Flame_Length (Required if FOFEM_Mortality = 1)

Purpose: Sets the default flame length to be used in Mortality calculations.

Usage: **FOFEM_Flame_Length**: X

Where X is is global flame length to be applied in Mortality calculations.

Example: **FOFEM_Flame_Length**: 4.5

Would cause SpatialFOFEM to use 4.5 as default flame length when calculating mortality.

FOFEM_Flame_Length_File (Optional)

Purpose: To utilize gridded Flame Length values for calculations of tree mortality

NOTE: Flame length must be in feet.

Usage: **FOFEM_Flame_Length_File**: X

Where X is the complete path to the GeoTIFF file containing flame length values. The GeoTIFF must completely cover the fuels layer.

Example: **FOFEM_Flame_Length_File**: C:\Data\FlameLengths.tif

Would cause SpatialFOFEM to use the flame lengths in the grid when calculating mortality.

FOFEM_Flame_Length_Layer_Number (Optional)

Purpose: Indicates the band number in the **FOFEM_Flame_Length_File** that contains flame length data. The default is band 1

Usage: **FOFEM_Flame_Length_Layer_Number: X**

Where X is an integer representing the band number in the GeoTIFF containing the flame length data.

Example: **FOFEM_Flame_Length_Layer_Number: 2**

Would indicate that Band Number 2 in **FOFEM_Flame_Length_File** contains the flame length data.

FOFEM_Flame_Length_Precision (Optional, default = 1)

Purpose: To set the degree of decimal precision for flame length values

Usage: **FOFEM_Flame_Length_Precision: X**

Where X is an integer (0 - 9) indicating the degree of decimal precision for flame length values used in calculating mortality.

Example: **FOFEM_Flame_Length_Precision: 2**

Would cause SpatialFOFEM to use two decimal places of precision (hundredths of a foot) for mortality calculations.

FOFEM_Mortality_Species (Optional)

Purpose: To set the tree species for which SpatialFOFEM will calculate tree mortality. By default, SpatialFOFEM will calculate tree mortality for all species encountered.

Usage: **FOFEM_Mortality_Species: X**

Where X is an integer representing the number of subsequent tree species codes to be analyzed. Immediately following this line should be X lines containing NRCS species codes to run tree mortality on.

Example: **FOFEM_Mortality_Species: 3**

PICO

PIPO

PSME

Would indicate that three (3) species are to be analyzed for mortality, and those species are PICO (lodgepole pine), PIPO (ponderosa pine), and PSME (Douglas-Fir)

FOFEM_Mortality_Size_Classes (Optional)

Purpose: To set the size classes used for calculating and summarizing tree mortality data. The default size classes (inches DBH) are: 0 – 3.9, 4 – 7.9, 8 – 11.9, 12 – 15.9, 16 – 19.9, 20 – 23.9, 24+.

NOTE: Creates FOFEM_Mortality_Size_Classes + 1 size classes.

Usage: **FOFEM_Mortality_Size_Classes:** X

Where X is an integer indicating the desired number of size breaks to use. Immediately following this switch should be X lines containing the lower limits of the DBH size class breakpoints in ascending order.

Example: **FOFEM_Mortality_Size_Classes:** 3

0

6

12

Would cause SpatailFOFEM to use the following size classes (integer values):

0" - 5.9", 6" – 11.9" and 12"+

SpatialFOFEM Tree Mortality Output

All outputs are provided - there are no output switches for tree mortality.

Outputs have the form:

testMortality_*species_lower DBH limit_upper DBH limit_output*

Species is the NRCS species symbol

Lower DBH limit and *upper DBH limit* in inches

Output is one of these seven standard outputs:

Prefire Total: Number of trees in the cell prefire.

Postfire Total: Number of trees in the cell postfire.

Killed_Total: Number of trees killed in the cell.

Prefire TPA: Trees per acre prefire (*Total* x 4.496504 to convert from 900 m² to acres).

PostFireTPA: Trees per acre postfire.

KilledTPA: Trees per acre killed.

Mortality: Average mortality probability for the class.

Example: **testMortality_LAOC_0.0-3.9_PostFireTPA.tif**

Mortality.csv This file includes the same outputs as above plus average dbh (arithmetic mean), average tree height, average crown ratio (crown ratio/10), average flame length and acres, summarized for all the trees in the species/size class across the landscape. If there are no trees of a particular class in a cell, the totals in Mortality.csv do not include 0 and the cell area is not included in the total acres.