FOFEM Tutorial Exercises

These exercises are provided to teach the basics of using FOFEM, including creating reports, summaries and graphs, and interpreting results. Answers are provided at the end of the exercises.

The FOFEM User Guide is available on the Help menu on the FOFEM interface. It is a great resource for understanding the assumptions, equations and embedded models used by FOFEM to simulate first order fire effects.

Tree Mortality

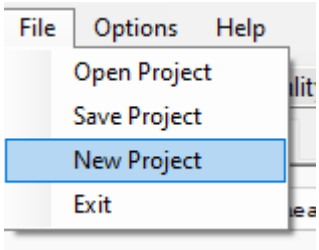
Assume a wildfire burned through a 20-acre picnic area on your unit in the interior western U.S. last summer. Walking through the picnic area shortly after the burn you estimate that about 30% of the area did not burn at all. In the area that did burn, your supervisor has asked you to estimate tree mortality to predict the need for hazard-tree removal in the next few years.

To estimate fire-caused tree mortality, FOFEM needs to know the stand info: tree species, density, diameter, height and crown ratio, and fire info: flame length or scorch height. The picnic area is a three-story stand: A) the understory consists of Douglas-fir trees, 300 per acre, about 1 inch in diameter, 8 feet tall with 70% crown ratio; B) the middle story consists of Douglas-fir, 100 per acre, around 8-inches in diameter, around 65 feet tall and 50% crown; and C) the overstory is ponderosa pine, 25 per acre, about 20 inches in diameter, 90 feet tall and 40% crown.

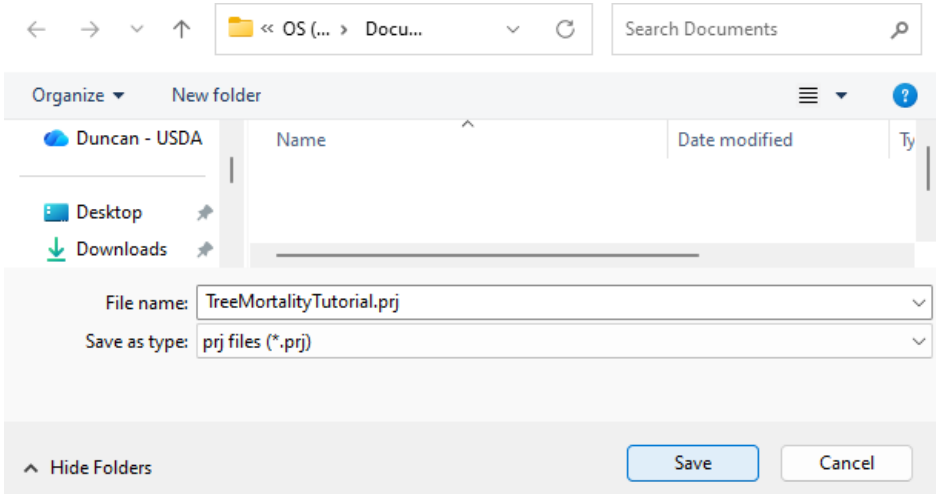
For this example, assume no one was present to witness fire behavior/flame length during passage of the fire front in the picnic area, but you noted during your walk through that the foliage was scorched to a height of 35 feet.

Solution:

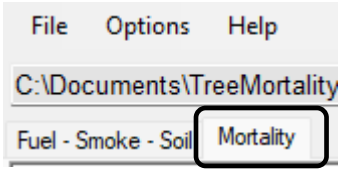
- Open FOFEM by double clicking the FOFEM icon on your computer desktop.
- Create a new project file; select **File > New Project.**



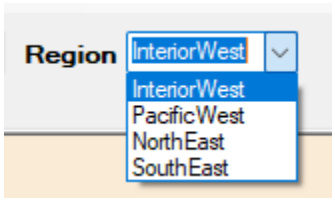
- Name the project file *TreeMortalityTutorial* and **Save** it in the folder of your choice. (E.g., C:\FOFEM)**.**



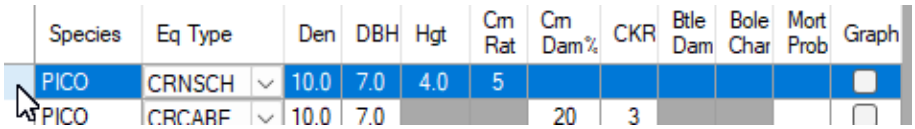
- Click the **Mortality** tab.



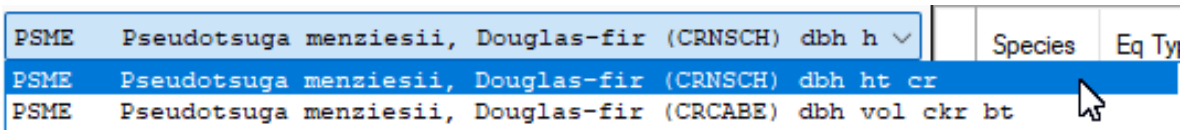
- In the Region dropdown at the top of the FOFEM interface, choose the *InteriorWest* region (if not already selected). FOFEM uses the region to select the cover types, species lists and simulation equations.



- Delete any existing rows in the tree grid before adding any new records. Click your mouse cursor in the empty cell immediately to the left of the **Species** cell. This will highlight the row. Now click the Delete key on your keyboard to remove the row. Do this for all rows in the tree grid that have data in them.



- Begin entering records in the tree data grid. Click the species dropdown at the upper left of the FOFEM interface to open the list and then scroll down to find Douglas-fir, which has a species code PSME. Click on the PSME option that uses the CRNSCH mortality equation (the first one in the list).



- Click the arrow to the right of the species dropdown list to move the species into the tree grid (if you know the NRCS PLANTS species code, you can also just type it into the Species field). Now enter the remaining data for the lowest stratum into the other data fields for the record: Density=300, DBH=1, Height=8, Crown Ratio=70. Enter the fire behavior information for the same record: Flame Scorch=35, F-S=S. This tells FOFEM the scorch height to use for the record is 35 feet. (in the F-S field, F=flame length and S=scorch heigh.)

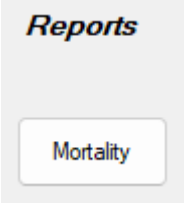
Species	Eq Type	Den	DBH	Hgt	Cm Rat	Cm Dam%	CKR	Btle Dam	Bole Char	Flame Scorch	F-S	Fire Sev	Mort Prob	Graph
PSME	CRNSCH	300	1	8	70					35	S			☐

- Enter data for the mid- and overstory. The completed tree grid should look like this:

Species	Eq Type	Den	DBH	Hgt	Cm Rat	Cm Dam%	CKR	Btle Dam	Bole Char	Flame Scorch	F-S	Fire Sev	Mort Prob	Graph
PSME	CRNSCH	300	1	8	70					35	S			☐
PSME	CRNSCH	100	8	65	50					35	S			☐
PIPO	CRNSCH	25	20	90	40					35	S			☐

NOTE: When an equation type is selected, the required fields for calculating mortality will be shown in white. Gray fields are optional and may be used for calculations not related to mortality, e.g. canopy cover.

- Save the *TreeMortalityTutorial* project by clicking **File > Save Project** and replacing the existing project file.
- Make a report by clicking the **Mortality** button on the left side of the screen.



- The report is not saved in the project file. If you would like to save it for later viewing right-click in the report area and select **Save**.

- Scroll down in the report and review the tables for *TREES PER ACRE KILLED BY THE FIRE* and *PROBABILITY OF MORTALITY FOR EACH SPECIES/DIAMETER ENTRY*:

TREES PER ACRE KILLED BY THE FIRE

Species Code	Midpoint Diameter classes (in) 1	3	5	7	9	11	13	15	17	19
PSME	295	0	0	0	25	0	0	0	0	0
PIPO	0	0	0	0	0	0	0	0	0	0
TOTALS	295	0	0	0	25	0	0	0	0	0

DBH classes (in): 1: 0-<2, 3: 2-<4, 5: 4-<6, ... 39: 38 and over

TREES PER ACRE KILLED BY THE FIRE

Species Code	Midpoint Diameter classes (in) 21	23	25	27	29	31	33	35	37	39+
PSME	0	0	0	0	0	0	0	0	0	0
PIPO	2	0	0	0	0	0	0	0	0	0
TOTALS	2	0	0	0	0	0	0	0	0	0

DBH classes (in): 1: 0-<2, 3: 2-<4, 5: 4-<6, ... 39: 38 and over

PROBABILITY OF MORTALITY FOR EACH SPECIES/DIAMETER ENTRY

Species Code	DBH (inch)	Height (feet)	C/R	Prob Mort	Mortality Number	Equation Name
PSME	1.0	8	7	0.98	20	Douglas-fir
PSME	8.0	65	5	0.25	20	Douglas-fir
PIPO	20.0	90	4	0.06	19	Ponderosa pine and Jeffery pine

Questions:

1) How many acres burned?

2) What is the total number of understory tress that are predicted to die on all acres that burned?

3) What is the total number of midstory tress that are predicted to die on all acres that burned?

4) What is the total number of overstory tress that are predicted to die on all acres that burned?

5) Do you predict much effort, if any, will be needed to deal with the hazard trees in the picnic area?

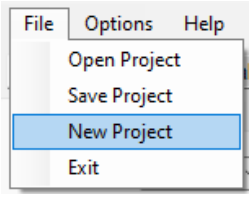
Fuel Consumption

There is a project area in California that has been identified as good candidate for a prescribed fire and you have been asked to estimate fuel moisture regimes that will lead to successfully meeting two objectives. One objective of the prescribed fire is to maintain at least 7 tons/acre of duff to prevent erosion (which corresponds to about 1/2" of duff depth). A second objective is to retain between 5 tons/acre and 17 tons/ace of large down woody material (3"+) for wildlife and soils. The project unit is represented by SAF cover type *243 -- Sierra Nevada Mixed Conifer -- FOFEM 081*. In this unit, duff load is less than typically seen in that vegetation type; load in the rest of the fuel categories is typical. The large down woody fuel consists mainly of large logs from overstory mortality during the last decade; about 20% of the load is rotten. The four moisture regimes are Very Dry, Dry, Moderate and Wet.

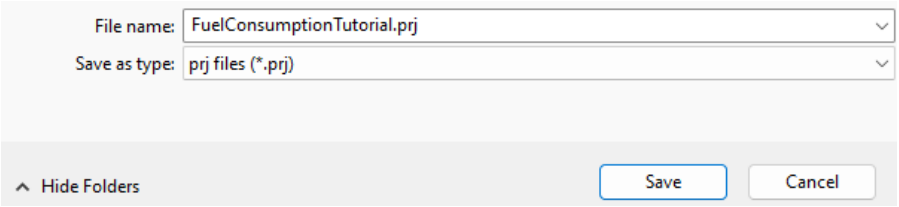
Use FOFEM to predict the moisture regime(s) likely to result in successfully meeting the objectives. Use the summaries feature of FOFEM to compare fuel consumption predictions for each moisture scenario.

Solution:

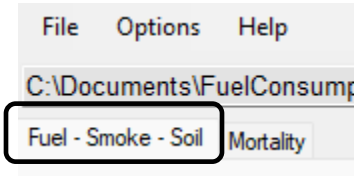
- First, clear the information used in the previous example: click the **Clear Report** button on the left to clear the text from the report window.
- Create a new project file; select **File > New Project.**



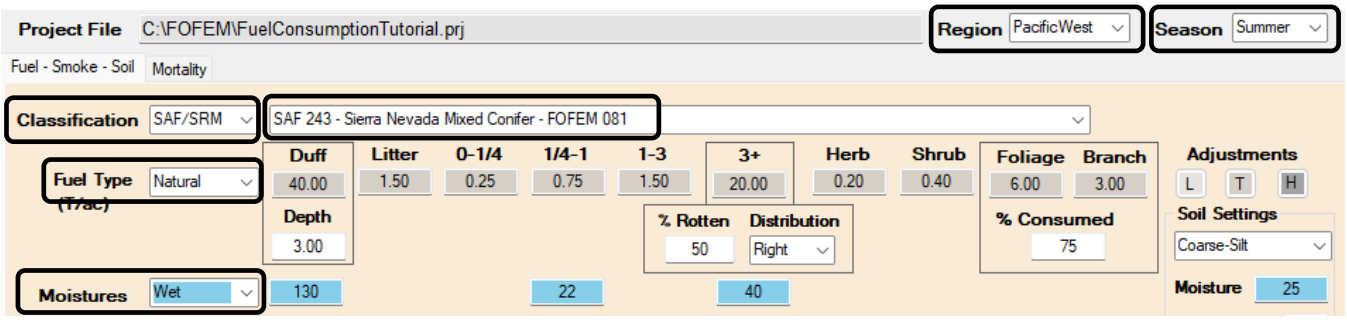
- Name the project file *FuelConsumptionTutorial* and **Save** it in the folder of your choice. (E.g., C:\FOFEM)**.**



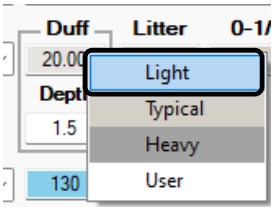
- If not already selected click the **Fuel – Smoke – Soil** tab.



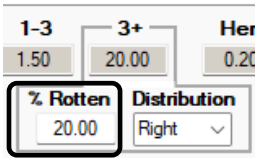
- Using the drop-down menus, enter the burn unit information as described above:
  1) **Region** is *PacificWest*
  2) Set **Season** to *Summer*
  3) **Cover Type** classification is *SAF/SRM*
  4) **Cover type** is *SAF 243 - Sierra Nevada Mixed Conifer - FOFEM 081*
  5) **Fuel Type** is *Natural*
  6) **Moistures** is *Wet*. We'll do the others later.



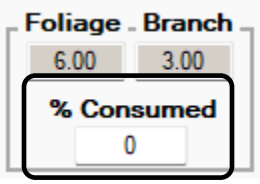
- Now enter the fuels information
  7) Modify the duff loading so it is less than typically seen in the cover type by right-clicking in the **Duff** field and selecting *Light*. The color of the field will turn a lighter gray. Leave the other fuels at the *Typical* loading.



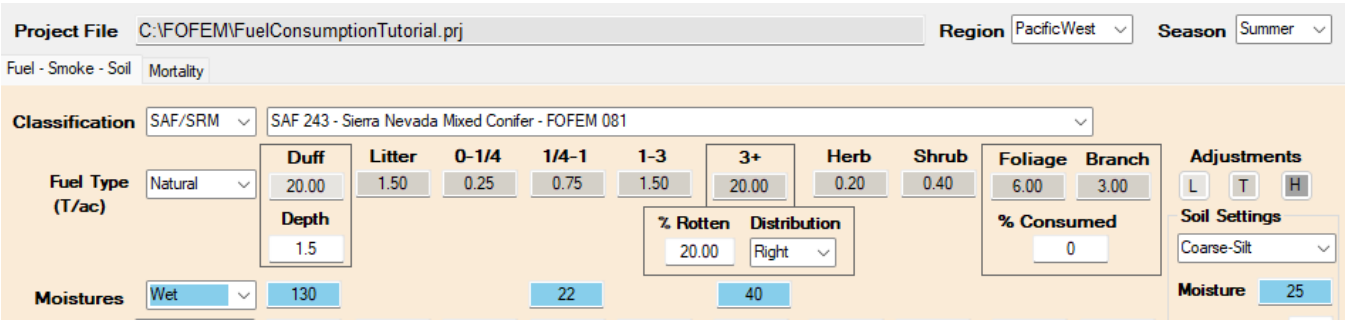
  8) Set **% Rotten** to *20.0*. Leave the log loading distribution set to *Right* (meaning the load is weighted toward larger diameter logs)



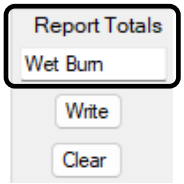
  9) Set % Consumed for the Foliage and Branch to *0* (because we will have a surface fire)



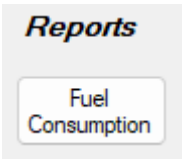
The *Fuel - Smoke - Soil* interface should look like this.



- Save the *FuelConsumptionTutorial* project by clicking **File > Save Project** and replacing the existing project file.
- In the **Report Totals** field type *Wet Burn*.

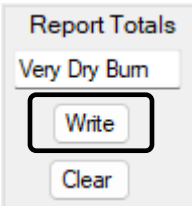


- Click the **Fuel Consumption** button on the left to generate report text in the output window. The Report Totals will automatically be saved.



- As additional simulations are run the reports will be appended in the report window. Before reviewing the report for the first simulation run the next three simulations. Use these settings for the next run:
  - change the **Moistures** to *Moderate*
  - change the **Report Totals** name to *Moderate Burn*
  - click the **Fuel Consumption** button again to append the new prediction
- Use these settings for the next run:
  - change the **Moistures** to *Dry*
  - change the **Report Totals** name to *Dry Burn*
  - click the **Fuel Consumption** button again to append the new prediction
- Finally, use these settings for the last run:
  - change the **Moistures** to *Very Dry*
  - change the **Report Totals** name to *Very Dry Burn*
  - click the **Fuel Consumption** button again to append the new prediction

- Now click **Write** in the **Report Totals** box to add a season of burn summary at the end of the report.



- Review the report for the information needed. The report below shows the results for the very dry moisture burn. In the *Postburn* column, FOFEM reports 11.00 tons/ac, 1.91 tons/ac and 4.96 tons/ac of 3"+ sound, 3"+ rotten and duff, respectively.

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (T/ac)	Consumed Load (T/ac)	Postburn Load (T/ac)	Percent Reduced (%)	Equation Reference Number	Moist. (%)
Litter	1.50	1.50	0.00	100.0	999	
Wood (0-1/4 inch)	0.25	0.25	0.00	100.0	999	
Wood (1/4-1 inch)	0.75	0.75	0.00	100.0	999	6.0
Wood (1-3 inch)	1.50	1.50	0.00	100.0	999	
Wood (3+ inch) Sound	16.00	5.00	11.00	31.3	999	10.0
3->6	1.12	0.96	0.16	85.4		
6->9	2.56	1.40	1.16	54.6		
9->20	4.32	1.43	2.89	33.0		
20->	8.00	1.22	6.78	15.2		
Wood (3+ inch) Rotten	4.00	2.09	1.91	52.4	999	10.0
3->6	0.28	0.28	0.00	100.0		
6->9	0.64	0.56	0.08	87.6		
9->20	1.08	0.65	0.43	60.1		
20->	2.00	0.60	1.40	30.2		
Duff	20.00 -	15.04	4.96	75.2	2	20.0
Herbaceous	0.20	0.20	0.00	100.0	22	
Shrubs	0.40	0.24	0.16	60.0	23	
Crown foliage	6.00	0.00	6.00	0.0	37	
Crown branchwood	3.00	0.00	3.00	0.0	38	
Total Fuels	53.60	26.57	27.03	49.6		

- Scroll to the bottom of the report window and review the post burn duff and 3”+ fuel loading in each simulation to see what moisture regimes may result is meeting the two objectives. Note this report shows the Consumed amounts.

Fuel Consumption Summary - (T/ac)

Id	Litter	Wood 0->1/4	Wood 1/4->1	Wood 1->3	Wood 3+	Duff	Herb	Shrub	Crown Folge	Crown Brnch
Wet Burn	1.50	0.25	0.75	1.28	1.68	5.66	0.20	0.24	0.00	0.00
Moderate Burn	1.50	0.25	0.75	1.50	3.84	10.35	0.20	0.24	0.00	0.00
Dry Burn	1.50	0.25	0.75	1.50	6.14	13.33	0.20	0.24	0.00	0.00
Very Dry Burn	1.50	0.25	0.75	1.50	7.10	15.04	0.20	0.24	0.00	0.00

Questions:

1) What is the maximum tons/ac of duff that can be consumed to successfully meet the first objective to maintain at least 7 tons/acre of duff?

2) Can you meet the objective of maintaining at least 7 tons/ac of duff with any of the simulated conditions?

3) What are the minimum and maximum amounts of 3”+ consumption to successfully meet the second objective to retain between 5 tons/acre and 17 tons/ace of large down woody material (3”+)?

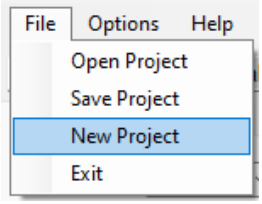
4) Can you meet the objective of maintaining 5 tons/ac to 17 tons/ac of large fuels with any of the simulated conditions?

Smoke Emissions

You are planning several large wintertime prescribed fires in loblolly pine-shortleaf pine forest in the southeastern U.S. that has not been burned in 5 years. Smoke emissions are a primary constraint. Assume regulations limit you to producing no more than 100 tons of $PM_{2.5}$ per day. Ten-hour fuel moisture is typically 15% during these burns. Use the FOFEM to estimate the number of acres you can burn without exceeding 100 tons of $PM_{2.5}$.

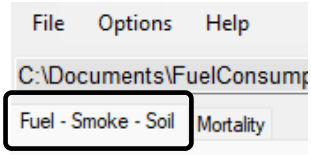
Solution:

- First, clear the information used in the previous example: click the **Clear Report** button on the left to clear the text from the report window. Click **Clear** in the Report Totals section at the lower left of the FOFEM interface.
- Create a new project file; select **File > New Project.**



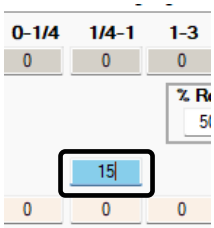
- Name the project file *SmokeEmissionsTutorial* and **Save** it in the folder of your choice. (E.g., C:\FOFEM)**.**

- If not already selected click the **Fuel – Smoke – Soil** tab.

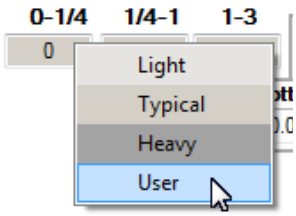


- Using the drop-down menus, enter the burn unit information:
  1) **Region** is *SouthEast*
  2) **Cover Type** classification is *SAF/SRM*
  3) **Cover Type** is *SAF 080 - Loblolly pine - Shortleaf pine - rough age 4*
  4) **Season** is *Winter*
  5) **Fuel Type** is *Natural*
  6) Crown and Foliage **% Consumed** is *0* (because we will have a surface fire)
  7) **Moistures** is *Dry*

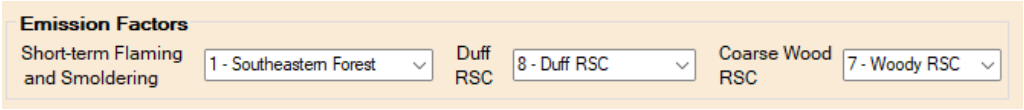
8) Change the 10-hour fuel moisture to *15%* by typing the value in the blue colored field below **1/4-1**.



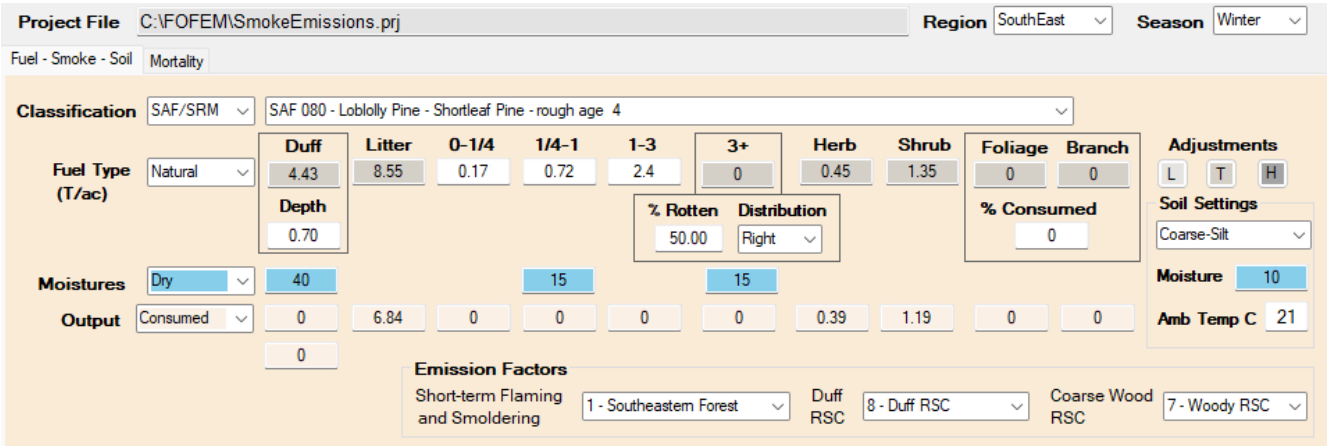
- Now modify the fine fuel loading to reflect some additional fuels information you have. Enter the updated fuel loading for the **0-1/4**, **1/4-1** and **1-3** fuels by right-clicking in the field and selecting *User*. The color of the field will turn white and then you can enter the new values. Leave the other fuels at the *Typical* loading.
  - 0 - 1/4" = 0.17
  - 1/4 - 1" = 0.72
  - 1 - 3" = 2.4



- In the **Emissions Factors** section of the interface note that the emission factors for *Short term Flaming and Smoldering* are automatically set to forests in the southeast U.S. The dropdown has other options for cover types and regions. Currently, there is only one option for the residual smoldering component of both doff and coarse wood (*Duff RSC* and *Coarse Wood RSC*).

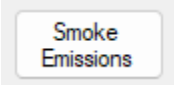


The *Fuel - Smoke - Soil* interface should look like this.



- Save the *SmokeEmissionsTutorial* project by clicking **File > Save Project** and replacing the existing project file.

- Click the **Smoke Emissions** button on the left to view the report.



- Review the report for the information needed -- total $PM_{2.5}$ emissions.

	Emissions -- lb/ac flaming	smoldering	total
CO 2	29003	6109	35112
CO	1294	994	2288
CH 4	40	60	100
NOX	29	0	29
SO2	18	0	18
PM 2.5	214	143	357
PM 10	252	169	421

Questions:

1) How many total *lbs/acre* of $PM_{2.5}$ emissions are produced by the prescribed fire?

2) What is the maximum number of acres you can burn in one day without exceeding the limit of 100 tons of PM2.5?

Soil Heating

An area of heavy tree mortality has occurred in an Oregon mixed-conifer stand dominated by Interior Douglas-fir, and you would like to compare the effects of a potential summer wildfire in very dry conditions to a moderate weather prescribed fire in fall on the potential for heating the loamy-skeletal soil.

From monitoring data you obtained the following estimates of fuel load (tons/acre):

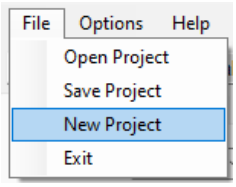
Component	Sound load	Rotten load
0 – 1/4”	0.4	
1/4 - 1”	1.9	
1 - 3"	3.2	
3 - 9"	23.0	5.7
9 - 20"	21.3	3.2

In addition, there are 1.3 tons/acre of litter, 21.3 tons/ac of duff (1.4 inches deep) with a sparse herb and shrub understory.

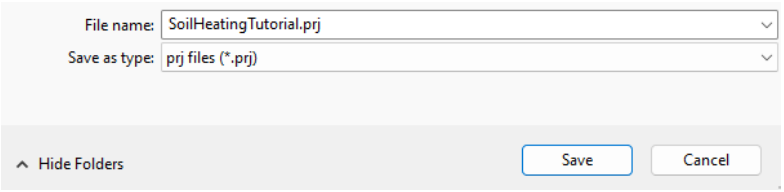
Use FOFEM to simulate soil heating for both the summer wildfire and fall prescribed fire conditions. Determine the depth to lethal temperature (60 C) and depth to changes in soil structure (275 C). Also, create a graph of temperature over time at various depths for each fuel condition.

Solution:

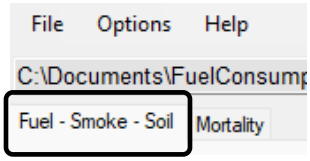
- Clear the information used in the previous example: click the **Clear Report** button on the left to clear the text from the report window.
- Create a new project file; select **File > New Project.**



- Name the project file *SoilHeatingTutorial* and **Save** it in your My Documents folder**.**



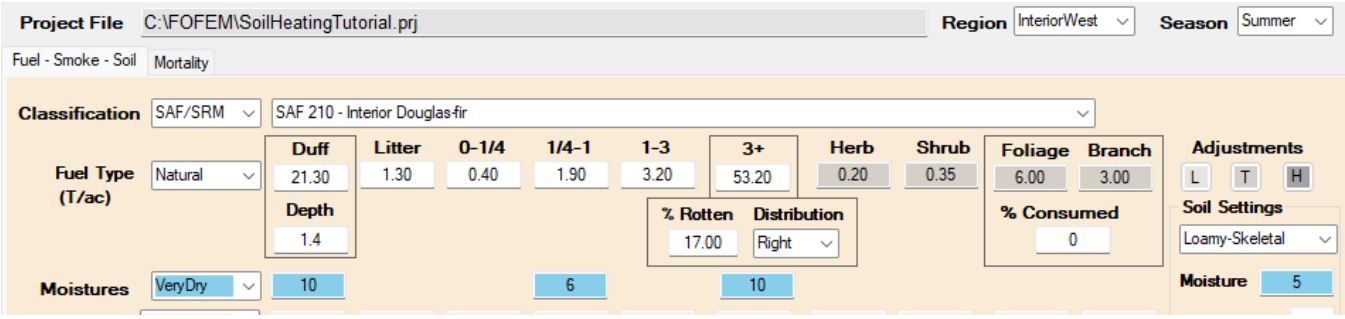
- If not already selected click the **Fuel – Smoke – Soil** tab.



- Using the drop-down menus, enter the burn unit information:

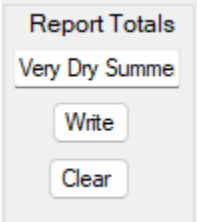
  1) **Region** is *InteriorWest*
  2) **Cover Type** classification is *SAF/SRM*
  3) **Cover Type** is *SAF 210 - Interior Douglas-fir*
  4) **Season** is *Summer.* We'll do *Fall* later.
  5) **Fuel Type** category is *Natural*
  6) **Moistures** condition is *Very Dry*
  7) Select *Loamy-Skeletal* under **Soil Settings**

- Instead of using the default fuel load inputs for the selected cover type we will reference the monitoring data and directly input the fuel loads. But first, we must make some summaries of the given fuel loads before entering them in the FOFEM screen:
  - Total 3+" fuel load is 53.2 tons/ac, including sound and rotten
  - Of the total 3+" load, 8.9 is rotten, or 17%
  - The monitoring data is not split into 3-6" and 6-9" classes, as FOFEM describes for the distribution input (for more information search the FOFEM User Guide for "Distribution"). Given the large load in the 9-20" class, we choose the *Right* distribution, assuming that the majority of the reported 3-9" load is in the 6-9" class.
- Enter the fuels data by right-clicking in each field, selecting *User* and entering the values shown screen shot below. Note the field color changes to white when a *User* value is entered.
- Set the duff moisture to *10%*. This simulates extreme fire conditions by allowing FOFEM to consume 100% of the duff, which eliminates the insulating properties of the duff layer.

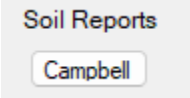


- Save the *SoilHeatingTutorial* project by clicking **File > Save Project** and replacing the existing project file.

- In the **Report Totals** box, enter *Very Dry Summer*.



- Click the **Campbell** button under **Soil Reports** on the left to create a report.



- On the FOFEM interface and make these changes:
  - change the **Season** to *Fall*
  - change the **Moisture** condition to *Moderate*
  - change the **Report Totals** title to *Moderate Fall*
- Click the **Campbell** button on the left to append the new simulation results to the report.
- Click the **Write** button in the **Report Totals** box to add the summary to the report (the abbreviated report is shown below).

```
                        Soil Heat Report - Campbell

                      Soil Layer Maximum Temperature

Depth (cm)    0    1    2    3    4    5    6    7    8    9   10   11   12   13
Temp (C)    346  207  121   81   67   58   50   44   40   36   32   28   24   21
Time (min)  110  110  113  116  117  128  146  171  200  224  240  251  257    0

                      Soil Layer Maximum Temperature

Depth (cm)    0    1    2    3    4    5    6    7    8    9   10   11   12   13
Temp (C)    100   42   36   32   30   28   26   25   24   23   23   22   21   21
Time (min)   75   75   77   82   89   99  110  122  133  142  148  153  155    0

 Report Totals:
                Soil Summary
                 Depth (cm)   Depth (cm)
          Id      >60C         >275C
 ----------------------------------------
 Very DrySummer      4             0
  Moderate Fall      0          None
```

- If desired, click the **Campbell** button under **Soil Graphs** button on the right to create a graph. Next, change the moisture regime to Very Dry to see how the graph changes. It may take a few seconds for the graph to refresh. You can right-click in the graph area to **Save** or **Print** the graph.

Questions

1) Discuss the consequences of the wildfire vs. prescribed fire in regard to sub-surface plant tissues and soil microorganisms?

2) Discuss the consequences of the wildfire vs. prescribed fire in regard to soil structure?

3) What second-order fire effects might you consider important to assess/monitor?

Answers

Tree Mortality

In the 70% of the area that did burn, it has likely killed almost the entire Douglas-fir understory (98%), but as those are only 8 feet tall, they pose no hazard in the picnic area. Approximately 25% of the Douglas-fir middle story is expected to be killed by the fire, which means 25 trees per acre. Because only 70% of the 20-acre stand burned, or 14 acres, this means about 350 middle story Douglas-fir trees are expected to die (25 trees per acre * 14 acres). Finally, most of the ponderosa pine overstory should survive -- only 6% are predicted to die as a result of the fire in the places that did burn. However, these large ponderosa pines could suffer secondary attack by bark beetles, resulting in additional mortality in this stratum that FOFEM does not predict unless additional data is collected (check "postfire injury" and note some inputs change).

1) How many acres burned? *14 acres*
2) What is the total number of understory tress that are predicted to die on all acres that burned? *4130 total trees*
3) What is the total number of midstory tress that are predicted to die on all acres that burned? *350 total trees*
4) What is the total number of overstory tress that are predicted to die on all acres that burned? *28 total trees*
5) Do you predict much effort, if any, will be needed to deal with the hazard trees in the picnic area?
   The removal of hazard trees will likely require moderate effort, it depends on how they are managed. Chipping might be easy. Bucking, piling and burning will take more effort.

Fuel Consumption

There was 20 t/ac of duff pre-burn so to maintain at least 7 t/ac post burn the consumed amount must be less than 13 t/ac. The Wet and Moderate burns successfully meet the objective.

There was 20 t/ac of 3"+ fuel pre-burn so to maintain between 5 t/ac and 17 t/ac post burn, consumption must be between 3 t/ac and 15 t/ac. The Moderate, Dry and Very Dry moisture regimes are successful.

1) What is the maximum tons/ac of duff that can be consumed to successfully meet the first objective? *Pre = 20 t/ac., Min. post = 7 t/ac. Max. consumed = 20 – 7 = 13 t/ac.*
2) Can you meet the objective of maintaining at least 7 tons/ac of duff with any of the simulated conditions? *Yes. The Wet and Moderate regimes maintain 14.34 t/ac and 9.65 t/ac, respectively. Given the variability of fire, duff loading and sampling error it is likely the Dry regime would also be successful. It maintains 6.67 t/ac of duff.*

3) What are the minimum and maximum amounts of 3"+ consumption to successfully meet the second objective?
   Pre = 20 t/ac., Max. post = 17 t/ac. *Min. consumed = 20 – 17 = 3 t/ac*
   Pre = 20 t/ac., Min. post = 5 t/ac. *Max consumed = 20 – 5 = 15 t/ac*
4) Can you meet the objective of maintaining 5 tons/ac to 17 tons/ac of large fuels with any of the simulated conditions? *Yes. The Moderate, Dry and Very Dry moisture regimes are successful.*

Smoke Emissions

The total smoldering and flaming $PM_{2.5}$ emission is estimated to be 357 lbs/acre. Dividing this by 2000 lbs/ton we get 0.178 tons/ac. The statutory maximum daily emission from your burning is 100 tons, therefore you can burn a maximum of 100/0.178, or 560 acres per day.

1) How many total *lbs/acre* of $PM_{2.5}$ emissions are produced by the prescribed fire? *0.178*
2) What is the maximum number of acres you can burn in one day without exceeding the limit of 100 tons of PM2.5? *560*

Soil Heating

Remember fuels vary spatially. Are the fuel loadings used in the simulation representative of the fuels around trees, the spaces between the trees or an average across the site? If an average across the site how different do you think the fuels and fire effects will be around trees and in the spaces between trees? Making simulations using loadings that represent the range fuels observed will better help assess potential post-fire issues than making one simulation with average or typical fuel loading.

1) Discuss the consequences of the wildfire vs. prescribed fire in regard to sub-surface plant tissues and soil microorganisms? *The summertime wildfire under very dry conditions produced lethal soil temperatures (>60 C) to a depth of 4 cm. Many fine roots are in the upper layers of the soil (and duff) so there is a chance these living tissues will be killed if actual burning conditions are similar to the Very Dry Summer burning conditions. Soil temperature was >60 C for about two hours. The Moderate Fall simulation didn't indicate soil heating sufficient to negatively impact subsurface living tissues.*
2) Discuss the consequences of the wildfire vs. prescribed fire in regard to soil structure? *Simulated soil surface temperature was many times higher with the summertime wildfire conditions than with the fall prescribed fire and the soil surface temperature exceeded 275 C so there is potential for soil structure change. The Moderate Fall simulation didn't indicate soil heating sufficient to impact soil structure.*
3) What second-order fire effects might you consider important to assess/monitor? *FOFEM does not predict the second-order effects but - especially when considering the effects of the summertime fire - some items to consider monitoring are soil stability, introduction of, or increasing non-native understory species and delayed tree stress/mortality, which may all be influenced by high soil heating.*