

FOFEM Tutorials

These tutorials teach the basics of using FOFEM 5, including creating reports, charts and summaries. Do each one in turn to learn the basics of FOFEM operation.

- [Tree Mortality](#)
- [Fuel Consumption](#)
- [Smoke Emissions](#)
- [Soil Heating](#)

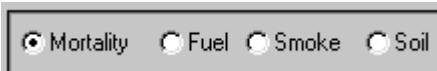
Tree Mortality

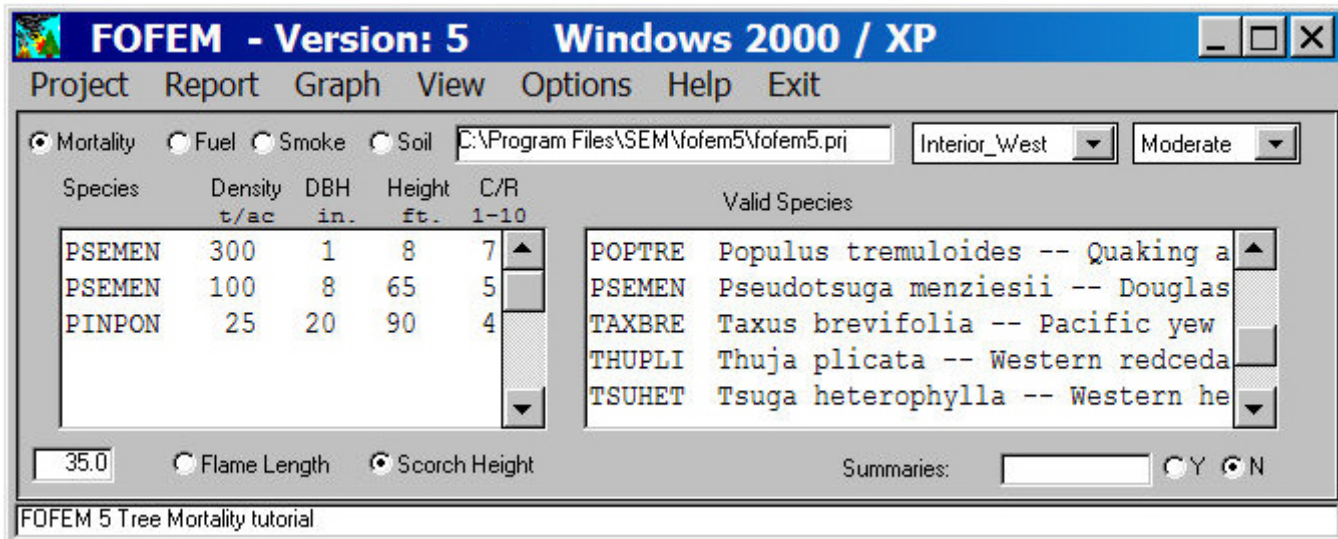
A wildfire burned through a 20-acre picnic area on your unit in the Interior West last summer. Walking through the picnic area shortly after the burn you estimate that about 30% of the area did not burn at all; the rest burned with moderate severity. Your supervisor has asked you to estimate tree mortality in the stand to predict the need for hazard-tree removal in the next few years. No one was present to witness fire behavior during passage of the fire front in the picnic area, but foliage was scorched to a height of 35 feet.

The picnic area is a three-story stand: the understory consists of 300 Douglas-fir trees per acre about 1 inch in diameter and 8 feet tall; the middle story consists of 8-inch Douglas-fir trees again, about 100 per acre and 65 feet tall; and the overstory is ponderosa pine, 25 per acre, about 20 inches in diameter and 90 feet tall.

Use FOFEM 5 to estimate mortality in each stratum and summarize the results for your supervisor.

Solution:

- Open FOFEM 5
- Open the FOFEM 5 default project (**Project > Open**, then choose `..\FOFEM5\fofem.prj` to reset inputs and clear the treelist).
- Click the "**Mortality**" radio button. 
- Using the drop-down menus, choose the region (Interior West) and fire severity (moderate).
- Enter the tree data by typing the tree species code and other information in the text box at the upper left. Use one space to separate values. No information was given about crown ratios; in this case simply use a value for each stratum corresponding to a healthy tree.
- Enter the scorch height in the box at the lower left and select "Scorch Height". The completed input form should appear as follows:



- Save the inputs as a FOFEM project (**Project > Save**) for later use. Save the project file in any folder you wish; name it **TreeMortalityTutorial.prj**
- Choose **Report > Create Report** or press **Ctrl-R** to generate report text in the output window. The complete report is shown in [Appendix 1](#).
- The report is not saved in the project file. If you would like to save it for later viewing select **Report > Save Report to File**.
- Review the report for the information needed -- trees per acre killed, and perhaps probability of mortality:

TREES PER ACRE KILLED BY THE FIRE

Species Code	Diameter classes (in)									
	2	4	6	8	10	12	14	16	18	20
PSEMEN	300	0	0	39	0	0	0	0	0	0
PINPON	0	0	0	0	0	0	0	0	0	2
TOTALS	300	0	0	39	0	0	0	0	0	2

PROBABILITY OF MORTALITY FOR EACH SPECIES/DIAMETER ENTRY

Species Code	Diameter (inch)	Number Trees	Prob Mort	Mort Equ Number
PSEMEN	1	300	1.00	1
PSEMEN	8	100	0.39	1
PINPON	20	25	0.07	1

Summarize the results for your supervisor:

Where the fire did burn, it has likely killed all of the Douglas-fir understory, but as those are only 8 feet tall they pose no hazard in the picnic area. Except in the unburned patches, approximately 39% of the Douglas-fir middle story is expected to be killed by the fire, which means 39 trees per acre. Because only 70% of the 20-acre stand burned, or 14 acres, this means about 550 middlestory Douglas-fir trees are expected to die. Finally, most of the ponderosa pine overstory should survive -- only 8% of the original 25 per acre (2 per acre) are predicted to die as a result of the fire in the places in the stand that did burn, a total of 25 in the picnic area ($25 \text{ t/ac} * 14 \text{ ac} * 7\% \text{ mortality}$). 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 the note some inputs change).

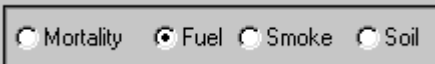
Fuel Consumption

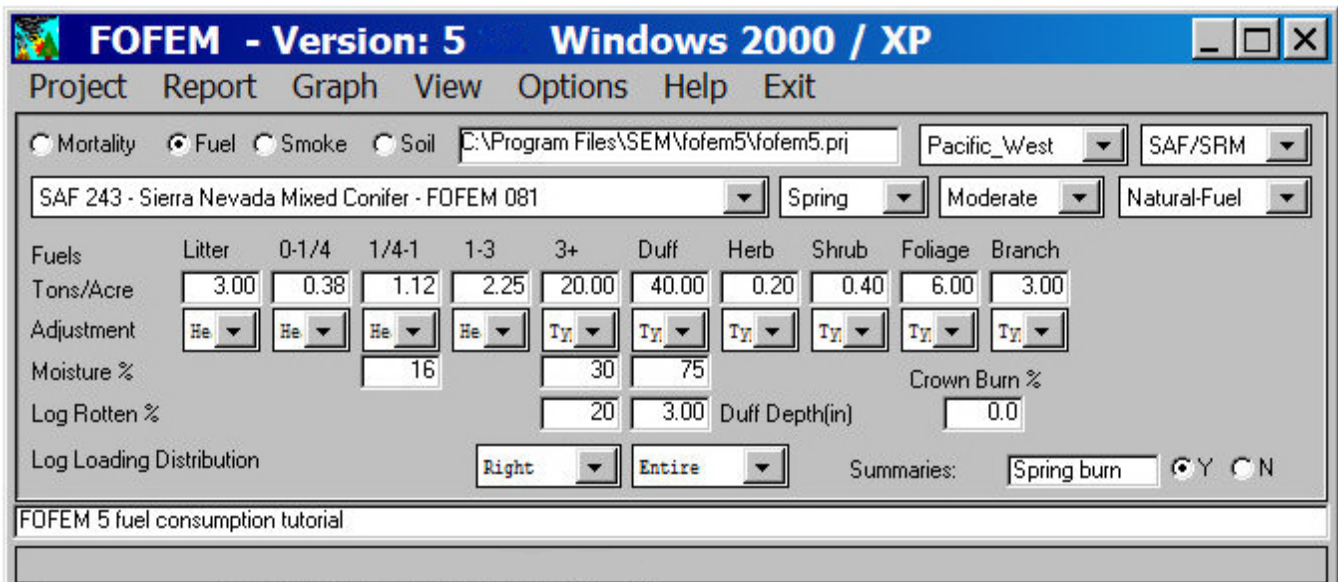
You have been asked to estimate fuel consumption on a potential spring, summer or fall season prescribed surface fire in the Sierra Nevada, California. One objective of the prescribed fire is to reduce future wildfire potential by reducing fine fuel load (0-3 inches diameter) to less than 2 tons per acre. A second objective is to retain 10 tons/acre of large down woody material (3+" diameter) for wildlife. The 300-acre unit is represented by SAF cover type 243 -- Sierra Nevada Mixed Conifer -- FOFEM 081. In this unit, fine fuel load is heavy for 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. Your three burn season/moisture options are:

- moderate moisture in spring
- very dry moisture in summer
- dry moisture in fall

Use FOFEM 5 to predict whether the hazard reduction objective will be met with any of the prescribed conditions; if not, what can be changed to meet the objective. Use the Summaries feature of FOFEM to compare fuel consumption predictions for each of the three seasons.

Solution:

- Open FOFEM 5
- Open the FOFEM 5 default project (**Project > Open**, then choose `..\FOFEM5\fofem.prj` to reset inputs and clear the treelist).
- Click the **"Fuel"** radio button. 
 - Mortality
 - Fuel
 - Smoke
 - Soil
- Using the drop-down menus, enter the burn unit information as described above:
 - Cover type classification is "SAF/SRM"
 - Region is "Pacific West"
 - Cover type is "SAF 243 - Sierra Nevada Mixed Conifer - FOFEM 081"
 - Season is "Spring" to begin, we'll do Summer and Fall later.
 - Moisture condition is "Moderate"
 - Fuel category is "Natural Fuel"
 - Adjustments are "Heavy" for litter, 0-1/4, 1/4-1 and 1-3; "Typical" for the rest (Select in the Adjustment dropdown)
 - Log rotten % is "20.0"
 - Log loading distribution is "Right" (because load is weighted toward larger logs)
 - Crown Burn % is "0.0" (because we will have a surface fire)
 - In the "summaries" window type "Spring burn" and select the "Y" button.



FOFEM - Version: 5 Windows 2000 / XP

Project Report Graph View Options Help Exit

Mortality Fuel Smoke Soil `C:\Program Files\SEM\fofem5\fofem5.prj` Pacific_West SAF/SRM

SAF 243 - Sierra Nevada Mixed Conifer - FOFEM 081 Spring Moderate Natural-Fuel

Fuels	Litter	0-1/4	1/4-1	1-3	3+	Duff	Herb	Shrub	Foliage	Branch
Tons/Acre	3.00	0.38	1.12	2.25	20.00	40.00	0.20	0.40	6.00	3.00
Adjustment	He	He	He	He	Ty	Ty	Ty	Ty	Ty	Ty
Moisture %			16		30	75				
Log Rotten %					20	3.00	Duff Depth(in)			Crown Burn %
Log Loading Distribution					Right	Entire				

Summaries: Spring burn Y N

FOFEM 5 fuel consumption tutorial

- Save the inputs as a FOFEM project (**Project > Save**) for later use. Save the project file in any folder you wish; name it **FuelConsumptionTutorial.prj**

- Choose **Report > Create Report** or press **Ctrl-R** to generate report text in the output window. The output is shown in [Appendix 2](#).
- Keep the report window cursor at the end of the report, then
 - change the summaries name to "Summer burn"
 - change the season to "Summer"
 - change the moisture condition to "Very Dry"
 - finally, select **Report > Create Report** again to append the new prediction.
 -
- Finally, again with the report window cursor at the end of the report,
 - change the summaries name to "Fall burn"
 - change the season to "Fall"
 - change the moisture condition to "Dry"
 - finally, select **Report > Create Report** again to append the new prediction.
- Now choose **Report > Create Summary Report** to add a season of burn summary to the report (in the popup box click "Yes" to clear the stored summaries so they are not included in the next summary you make). Be sure to save this report to a file for later use -- it is not saved in the project file.
- Review the report for the information needed. The following data for the dry moisture fall burn shows 100% consumption of fine fuels. The other burn season/moisture options also show 100% fine fuel consumption.

Fuel Component Name	Preburn Load (t/acre)	FUEL CONSUMPTION TABLE			Equation Reference Number	Moisture (%)
		Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)		
Litter	3.00 +	3.00	0.00	100.0	999	
Wood (0-1/4 inch)	0.38 +	0.38	0.00	100.0	999	
Wood (1/4-1 inch)	1.12 +	1.12	0.00	100.0	999	10.0
Wood (1-3 inch)	2.25 +	2.25	0.00	100.0	999	
Wood (3+ inch) Sound	16.00	7.94	8.06	49.6	999	15.0
Wood (3+ inch) Rotten	4.00	2.79	1.21	69.7	999	15.0
Duff	40.00	26.66	13.34	66.7	2	40.0
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	76.35	44.58	31.77	58.4		

The summary report at the bottom of the report file shows that there is no difference in fine fuel consumption among the three burning season options -- all three result in 100% consumption of the fine fuels. Review the postburn load for the 3"+ fuels in each simulation to see if you met the objective for that component.

Fuel Consumption Summary - (t/acre)

	Id	Litter	wood 0->1/4	wood 1/4->1	wood 1->3	wood 3+	Duff	Herb	Shrub	Crown Folge	Crown Brnch
Spring	burn	3.00	0.38	1.12	2.25	8.03	20.70	0.20	0.24	0.00	0.00
Summer	burn	3.00	0.38	1.12	2.25	11.86	30.07	0.20	0.24	0.00	0.00
Fall	burn	3.00	0.38	1.12	2.25	10.73	26.66	0.20	0.24	0.00	0.00

Summarize the results for your supervisor:

Regardless of season of burn, the prescribed fire is expected to consume all fine fuels -- the post-burn fine fuel load is predicted to be zero -- and the hazard reduction objective will be met. However, in a short time after the fire there may be significant fine fuel added to the surface as scorched needles and branches fall, and fire-caused mortality contributes to surface fuels. FOFEM does not predict these second-order fire effects.

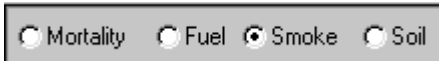
For the constraint of retaining at least 10 tons/acre of coarse woody debris, note that the preburn load is 20 tons/acre (16 tons/acre sound, 4 tons/acre rotten). Therefore 3+ fuel consumption must be less than 10 tons/acre. Reviewing the summary table above we see that only the moderate moisture spring burn will meet the large woody material target.

Smoke Emissions

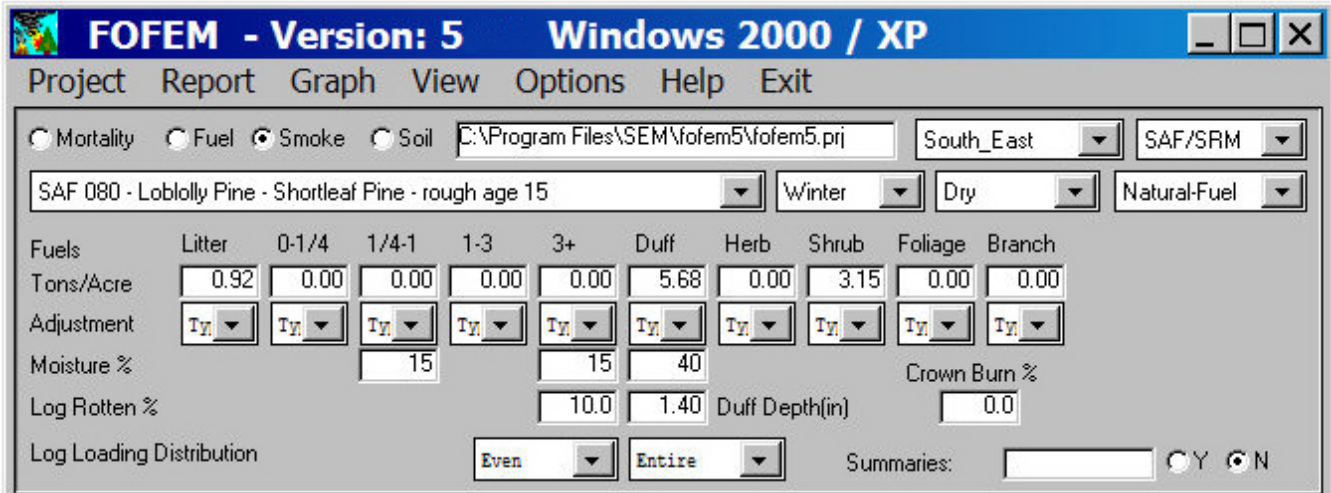
You are planning several large wintertime prescribed fires in Loblolly pine - shortleaf pine that has not been burned in 15 years. Smoke emissions are a primary constraint; regulations limit you to producing no more than 100 tons of PM 2.5 per day. Ten-hour fuel moisture is typically 15% during these burns.

Use FOFEM 5 to estimate the largest unit you can burn without exceeding the PM 2.5 limit.

Solution:

- Open FOFEM 5
- Open the FOFEM 5 default project (**Project > Open**, then choose `..\FOFEM5\fofem.prj` to reset inputs and clear the treelist).
- Click the "**Smoke**" radio button. 
- Using the drop-down menus, enter the burn unit information:
 - Cover type classification is "SAF/SRM"
 - Region is "South East"
 - Cover type is "SAF 080 - Loblolly pine - shortleaf pine - rough age 15"
 - Season is "Winter"
 - Choose the "Dry" moisture regime, then change the 10-hour fuel moisture to 15%
 - Fuel category is "natural fuel"

- Crown Burn % is "0.0" (because we will have a surface fire)



- Choose **Report > Create Report** or press **Ctrl-R** to generate report text in the output window. The output text is shown in [Appendix 3](#).
- Review the report for the information needed -- total PM 2.5 emissions.

	Emissions -- lbs/acre		
	flaming	smoldering	total
PM 10	19	177	196
PM 2.5	16	150	166
CH 4	5	91	96
CO	40	1997	2037
CO 2	10850	8127	18977
NOX	20	0	20
SO2	6	7	13

Summarize the results:

The total smoldering and flaming PM 2.5 emission is estimated to be 166 lbs/acre. Dividing this by 2000 lbs/ton we get 0.083 tons/ac. The statutory maximum daily emission from your burning is 100 tons, therefore you can burn a maximum of 100/0.083, or 1205 acres per day.

Soil Heating

An area of heavy tree mortality has occurred in a Pacific Northwest 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.

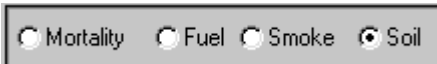
From monitoring data you obtained the following estimates of fuel load (tons/acre):

Component	Sound load	Rotten load
0-.25"	0.4	
.25-1"	1.9	
1-3"	3.2	
3-9"	23.0	5.7
9-20"	21.3	3.2

In addition there is 1.3 tons/acre of litter (0.4 inches deep) and 21.3 tons/ac of duff (1.8 inches deep).

Use FOFEM 5 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. Optionally, save a text file with the graph data for use in an external graphics program.

Solution:

- Open FOFEM 5
- Open the FOFEM 5 default project (**Project > Open**, then choose `..\FOFEM5\fofem.prj` to reset inputs and clear the treelist).
- Click the "Soil" radio button. 
- Using the drop-down menus, enter the burn unit information:
 - Cover type classification is "SAF/SRM"
 - Region is "Interior West"
 - Cover type is "SAF 210 - Interior Douglas-fir"
 - Season is "Summer" to begin, we'll do "Fall" later.
 - Moisture condition is "Very Dry"
 - Fuel category is "Natural Fuel"
 - Soil is "Loamy-Skeletal" and soil moisture is 5%
- 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 do some summaries of the given fuel loads before entering them in the FOFEM screen.
 - Total 3+" fuel load is 55 tons/ac, including sound and rotten
 - Of the total 3+" load, 10.7 is rotten, or 19.5%
 - The monitoring data is not split into 3-6" and 6-9" classes, as FOFEM describes for the distribution input (for more information select **Help > Help** and search the user guide

index for "Distribution"). Given the large load in the 9-20" class, we choose the "Center" distribution, assuming that the majority of the reported 3-9" load is actually in the 6-9" class.

- In the summaries box, enter "very dry summer" and check "Y" to add this to a summary. The completed input form should look like this:

- Save the inputs as a FOFEM project (**Project > Save**) for later use. Save the project file in any folder you wish; name it **SoilHeatingTutorial.prj**
- Choose **Report > Create Report** or press **Ctrl-R** to generate report for the very dry summer burn.
- Next create a report for the moderate fall burn
 - change the summaries name to "moderate fall"
 - change the season to "fall"
 - change the moisture condition to "moderate"
 - select **Report > Create Report** again to append the new prediction.
- Choose **Report > Create Summary Report** to add a summary to the report. If you want to refer to this report later select **Report > Save Report to File**. The two reports and their summary are shown in [Appendix 4](#).

	Soil Summary	
Id	Depth	Depth
very dry summer	>60	>275
moderate fall	7	0
	0	None

- Now create soil heating graphs for both scenarios
 - select “N” for summaries
 - set season to “summer” and moisture to “very dry”
 - choose **Graph > Create Graph** to view a graph of temperature over time at various depths (in the popup keep the default values and click OK)
 - select **Graph > Save to File** and save the graph as **VeryDrySummer**
 - set season to “fall” and moisture to “moderate”
 - choose **Graph > Create Graph**
 - select **Graph > Save to File** and save the graph as **ModerateFall**
- The two soil heating graphs are shown in [Appendix 5](#).
- You can switch the view by choosing **View > Report** or **View > Graph**

Summarize the results:

The summertime wildfire under very dry conditions produced lethal soil temperatures to a depth of 7 cm -- at the soil surface the temperature exceeded 275 C, meaning that changes in soil structure could take place, but not to a significant depth.

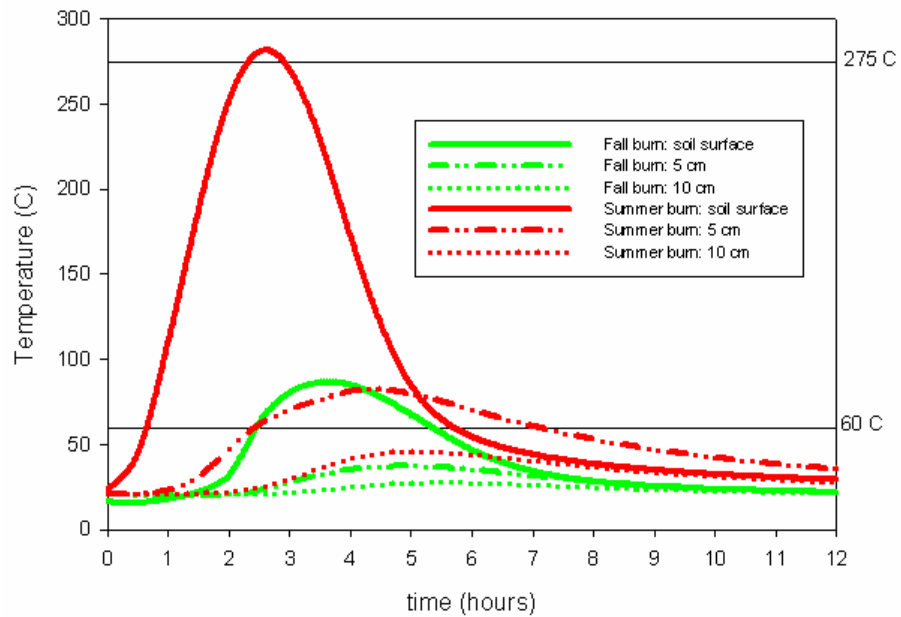
The moderate fuel moisture prescribed fire in the fall would produce much less soil heating. Lethal temperatures would only occur in the first cm. A temperature of 275 C (minimum for physical and chemical changes in soil) do not occur.

FOFEM 5 does not predict the second-order effects of these temperatures on vegetation dynamics or on soil erosion.

Optional: Create soil heating points files for the each set of burning conditions.

- set season to “summer” and moisture to “very dry”
- choose **Options > Save Soil Temp Points File** to save a text file with the graph data. Save the file as **SoilHeatingPointsSummer.txt**
- set season to “fall” and moisture to “moderate”
- choose **Options > Save Soil Temp Points File** to save a text file with the graph data. Save the file as **SoilHeatingPointsFall.txt**

The first 30 points of each simulation are shown in [Appendix 6](#). You can import the two soil heating points files into a spreadsheet program, then select data from each simulation to create the following chart in a scientific graphing program.



Appendices

Appendix 1 – Mortality report

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TITLE: Results of FOFEM model execution on date: 10/8/2003
TREE MORTALITY MODULE:
REGION: Interior_West
SCORCH HEIGHT (FT): 35.00
      Flame Length: 5.23
  
```

ORIGINAL STAND DENSITY AS INPUT TO FOFEM

Species Code	Diameter classes (in)									
	2	4	6	8	10	12	14	16	18	20
PSEMEN	300	0	0	100	0	0	0	0	0	0
PINPON	0	0	0	0	0	0	0	0	0	25
TOTALS	300	0	0	100	0	0	0	0	0	25

DBH classes (in): 2: 0-2, 4: 3-4, 6: 5-6, 8: 7-8, 10: 9-10and so on...

POSTFIRE STAND DENSITY (TREES/ACRE)

Species Code	Diameter classes (in)									
	2	4	6	8	10	12	14	16	18	20
PSEMEN	0	0	0	61	0	0	0	0	0	0
PINPON	0	0	0	0	0	0	0	0	0	23
TOTALS	0	0	0	61	0	0	0	0	0	23

DBH classes (in): 2: 0-2, 4: 3-4, 6: 5-6, 8: 7-8, 10: 9-10and so on...

TREES PER ACRE KILLED BY THE FIRE

Species Code	Diameter classes (in)									
	2	4	6	8	10	12	14	16	18	20
PSEMEN	300	0	0	39	0	0	0	0	0	0
PINPON	0	0	0	0	0	0	0	0	0	2
TOTALS	300	0	0	39	0	0	0	0	0	2

DBH classes (in): 2: 0-2, 4: 3-4, 6: 5-6, 8: 7-8, 10: 9-10and so on...

PROBABILITY OF MORTALITY FOR EACH SPECIES/DIAMETER ENTRY

Species Code	Diameter (inch)	Number Trees	Prob Mort	Mort Equ Number
PSEMEN	1	300	1.00	1
PSEMEN	8	100	0.39	1
PINPON	20	25	0.07	1

AVERAGE MORTALITY PROBS BY SCORCH HEIGHT BY SPECIES/DIAMETER ENTRY

Species Code	Tree DBH	Scorch Height (feet)									
		10	20	30	40	50	60	70	80	90	100
PSEMEN	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

PSEMEN	8	0.36	0.36	0.36	0.58	0.94	0.99	0.99	0.99	0.99	0.99
PINPON	20	0.07	0.07	0.07	0.07	0.07	0.11	0.49	0.88	0.94	0.94
AVERAGES	9	0.48	0.48	0.48	0.55	0.67	0.70	0.83	0.96	0.98	0.98

STAND TREE MORTALITY

Percent mortality: 49
 Number of trees killed by the fire: 341
 Average tree diameter (DBH) of fire killed trees: 1.9
 Percent mortality for trees 4+ in DBH: 23
 Total prefire number of trees: 425
 Stand Basal Area: sq/ft Percent
 Prefire Live: 91.08 100
 Postfire Live: 71.96 79
 Postfire Killed: 19.12 21

Appendix 2 – Fuel consumption report

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 TITLE: Results of FOFEM model execution on date: 10/8/2003  
           FUEL CONSUMPTION CALCULATIONS

Region: Pacific\_West  
 Cover Type: SAF/SRM - SAF 243 - Sierra Nevada Mixed Conifer - FOFEM 081  
 Fuel Type: Natural  
 Fuel Reference: FOFEM 081  
 Project Comment: FOFEM 5 fuel consumption tutorial

FUEL CONSUMPTION TABLE

| Fuel Component Name   | Preburn Load (t/acre) | Consumed Load (t/acre) | Postburn Load (t/acre) | Percent Reduced (%) | Equation Reference Number | Moisture (%) |
|-----------------------|-----------------------|------------------------|------------------------|---------------------|---------------------------|--------------|
| Litter                | 3.00 +                | 3.00                   | 0.00                   | 100.0               | 999                       |              |
| Wood (0-1/4 inch)     | 0.38 +                | 0.38                   | 0.00                   | 100.0               | 999                       |              |
| Wood (1/4-1 inch)     | 1.12 +                | 1.12                   | 0.00                   | 100.0               | 999                       | 16.0         |
| Wood (1-3 inch)       | 2.25 +                | 2.25                   | 0.00                   | 100.0               | 999                       |              |
| Wood (3+ inch) Sound  | 16.00                 | 5.98                   | 10.02                  | 37.4                | 999                       | 30.0         |
| Wood (3+ inch) Rotten | 4.00                  | 2.05                   | 1.95                   | 51.2                | 999                       | 30.0         |
| Duff                  | 40.00                 | 20.70                  | 19.30                  | 51.8                | 2                         | 75.0         |
| 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                        |              |
| <b>Total Fuels</b>    | <b>76.35</b>          | <b>35.92</b>           | <b>40.43</b>           | <b>47.1</b>         |                           |              |

'+' Preburn Load is Heavy/Abundant

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.5 Equation: 6  
 Mineral Soil Exposed (%) 31.0 Equation: 10

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 TITLE: Results of FOFEM model execution on date: 10/8/2003

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West

Cover Type: SAF/SRM - SAF 243 - Sierra Nevada Mixed Conifer - FOFEM 081
 Fuel Type: Natural
 Fuel Reference: FOFEM 081
 Project Comment: FOFEM 5 fuel consumption tutorial

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	3.00 +	3.00	0.00	100.0	999	
Wood (0-1/4 inch)	0.38 +	0.38	0.00	100.0	999	
Wood (1/4-1 inch)	1.12 +	1.12	0.00	100.0	999	6.0
Wood (1-3 inch)	2.25 +	2.25	0.00	100.0	999	
Wood (3+ inch) Sound	16.00	8.79	7.21	55.0	999	10.0
Wood (3+ inch) Rotten	4.00	3.07	0.93	76.8	999	10.0
Duff	40.00	30.07	9.93	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 76.35 49.13 27.22 64.3

'+' Preburn Load is Heavy/Abundant

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 2.0 Equation: 6
 Mineral Soil Exposed (%) 72.7 Equation: 10

~~~~~  
 TITLE: Results of FOFEM model execution on date: 10/8/2003

FUEL CONSUMPTION CALCULATIONS

Region: Pacific\_West  
 Cover Type: SAF/SRM - SAF 243 - Sierra Nevada Mixed Conifer - FOFEM 081  
 Fuel Type: Natural  
 Fuel Reference: FOFEM 081  
 Project Comment: FOFEM 5 fuel consumption tutorial

FUEL CONSUMPTION TABLE

| Fuel Component Name   | Preburn Load (t/acre) | Consumed Load (t/acre) | Postburn Load (t/acre) | Percent Reduced (%) | Equation Reference Number | Moisture (%) |
|-----------------------|-----------------------|------------------------|------------------------|---------------------|---------------------------|--------------|
| Litter                | 3.00 +                | 3.00                   | 0.00                   | 100.0               | 999                       |              |
| Wood (0-1/4 inch)     | 0.38 +                | 0.38                   | 0.00                   | 100.0               | 999                       |              |
| Wood (1/4-1 inch)     | 1.12 +                | 1.12                   | 0.00                   | 100.0               | 999                       | 10.0         |
| Wood (1-3 inch)       | 2.25 +                | 2.25                   | 0.00                   | 100.0               | 999                       |              |
| Wood (3+ inch) Sound  | 16.00                 | 7.94                   | 8.06                   | 49.6                | 999                       | 15.0         |
| Wood (3+ inch) Rotten | 4.00                  | 2.79                   | 1.21                   | 69.7                | 999                       | 15.0         |
| Duff                  | 40.00                 | 26.66                  | 13.34                  | 66.7                | 2                         | 40.0         |
| 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 76.35 44.58 31.77 58.4

'+' Preburn Load is Heavy/Abundant

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.8 Equation: 6  
 Mineral Soil Exposed (%) 50.8 Equation: 10

| Id          | Litter | Wood 0->1/4 | Wood 1/4->1 | Wood 1->3 | Wood 3+ | Duff  | Herb | Shrub | Crown Folge | Crown Brnch |
|-------------|--------|-------------|-------------|-----------|---------|-------|------|-------|-------------|-------------|
| Spring burn | 3.00   | 0.38        | 1.12        | 2.25      | 8.03    | 20.70 | 0.20 | 0.24  | 0.00        | 0.00        |
| Summer burn | 3.00   | 0.38        | 1.12        | 2.25      | 11.86   | 30.07 | 0.20 | 0.24  | 0.00        | 0.00        |
| Fall burn   | 3.00   | 0.38        | 1.12        | 2.25      | 10.73   | 26.66 | 0.20 | 0.24  | 0.00        | 0.00        |

### Appendix 3 – Smoke emissions report

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 TITLE: Results of FOFEM model execution on date: 10/8/2003

FUEL CONSUMPTION CALCULATIONS

Region: South_East
 Cover Type: SAF/SRM - SAF 080 - Loblolly Pine - Shortleaf Pine - rough age 15
 Fuel Type: Natural
 Fuel Reference: FOFEM 441

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	0.92	0.92	0.00	100.0	999	
Wood (0-1/4 inch)	0.00	0.00	0.00	0.0	999	
Wood (1/4-1 inch)	0.00	0.00	0.00	0.0	999	15.0
Wood (1-3 inch)	0.00	0.00	0.00	0.0	999	
Wood (3+ inch) Sound	0.00	0.00	0.00	0.0	999	15.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Wood (3+ inch) Rotten	0.00	0.00	0.00	0.0	999	15.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Duff	5.68	3.31	2.37	58.2	16	40.0
Herbaceous	0.00	0.00	0.00	0.0	22	
Shrubs	3.15	2.13	1.02	67.6	234	
Crown foliage	0.00	0.00	0.00	0.0	37	
Crown branchwood	0.00	0.00	0.00	0.0	38	
Total Fuels	9.75	6.36	3.39	65.2		

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 0.8 Equation: 16
 Mineral Soil Exposed (%) 16.6 Equation: 14

	Emissions flaming	-- lbs/acre smoldering	total
PM 10	19	177	196
PM 2.5	16	150	166
CH 4	5	91	96
CO	40	1997	2037

CO 2	10850	8127	18977
NOX	20	0	20
SO2	6	7	13

	Consumption	Duration
	tons/acre	hour:min:sec
Flaming:	3.05	00:01:00
Smoldering:	3.31	00:19:30
Total:	6.36	
Unit Average Combustion Efficiency:	0.81	

Appendix 4 – Soil heating reports and summary report

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TITLE: Results of FOFEM model execution on date: 10/13/2003

FUEL CONSUMPTION CALCULATIONS

Region: Interior\_West  
 Cover Type: SAF/SRM - SAF 210 - Interior Douglas-fir  
 Fuel Type: Natural  
 Fuel Reference: FOFEM 031

FUEL CONSUMPTION TABLE

| Fuel Component Name   | Preburn Load (t/acre) | Consumed Load (t/acre) | Postburn Load (t/acre) | Percent Reduced (%) | Equation Reference Number | Moisture (%) |
|-----------------------|-----------------------|------------------------|------------------------|---------------------|---------------------------|--------------|
| Litter                | 1.30 u                | 1.30                   | 0.00                   | 100.0               | 999                       |              |
| Wood (0-1/4 inch)     | 0.40 u                | 0.40                   | 0.00                   | 100.0               | 999                       |              |
| Wood (1/4-1 inch)     | 1.90 u                | 1.90                   | 0.00                   | 100.0               | 999                       | 6.0          |
| Wood (1-3 inch)       | 3.20 u                | 3.20                   | 0.00                   | 100.0               | 999                       |              |
| Wood (3+ inch) Sound  | 44.28 u               | 31.38                  | 12.89                  | 70.9                | 999                       | 10.0         |
| Wood (3+ inch) Rotten | 10.72 u               | 9.54                   | 1.18                   | 89.0                | 999                       | 10.0         |
| Duff                  | 21.30 u               | 16.01                  | 5.29                   | 75.2                | 2                         | 20.0         |
| Herbaceous            | 0.00 u                | 0.00                   | 0.00                   | 0.0                 | 22                        |              |
| Shrubs                | 0.00 u                | 0.00                   | 0.00                   | 0.0                 | 23                        |              |
| Crown foliage         | 0.00 u                | 0.00                   | 0.00                   | 0.0                 | 37                        |              |
| Crown branchwood      | 0.00 u                | 0.00                   | 0.00                   | 0.0                 | 38                        |              |
| <b>Total Fuels</b>    | <b>83.10</b>          | <b>63.74</b>           | <b>19.36</b>           | <b>76.7</b>         |                           |              |

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.5 Equation: 6  
 Mineral Soil Exposed (%) 72.7 Equation: 10

Soil Heat Report

Cover Type.....: SAF/SRM - SAF 210 - Interior Douglas-fir  
 Duff Depth.....: Pre-Fire: 4.57 cm., Post-Fire: 0.81 cm.

Soil Layer Maximum Temperature  
 (measurements are in centimeters and Celsius )

|       |     |     |     |     |     |     |     |     |     |     |     |     |     |    |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|
| Depth | 0   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13 |
| Temp. | 281 | 220 | 170 | 132 | 103 | 82  | 69  | 63  | 57  | 52  | 45  | 38  | 30  | 21 |
| Time  | 157 | 176 | 197 | 220 | 241 | 259 | 259 | 261 | 276 | 289 | 302 | 311 | 317 | 1  |

Max Depth Having 60 degrees: 7  
 Max Depth Having 275 degrees: 0

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 TITLE: Results of FOFEM model execution on date: 10/13/2003

FUEL CONSUMPTION CALCULATIONS

Region: Interior_West
 Cover Type: SAF/SRM - SAF 210 - Interior Douglas-fir
 Fuel Type: Natural
 Fuel Reference: FOFEM 031

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	1.30 u	1.30	0.00	100.0	999	
Wood (0-1/4 inch)	0.40 u	0.40	0.00	100.0	999	
Wood (1/4-1 inch)	1.90 u	1.90	0.00	100.0	999	16.0
Wood (1-3 inch)	3.20 u	3.20	0.00	100.0	999	
Wood (3+ inch) Sound	44.28 u	25.26	19.01	57.1	999	30.0
Wood (3+ inch) Rotten	10.72 u	7.82	2.91	72.9	999	30.0
Duff	21.30 u	11.02	10.28	51.8	2	75.0
Herbaceous	0.00 u	0.00	0.00	0.0	22	
Shrubs	0.00 u	0.00	0.00	0.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	

Total Fuels 83.10 50.90 32.20 61.3

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.0 Equation: 6
 Mineral Soil Exposed (%) 31.0 Equation: 10

Soil Heat Report

Cover Type.....: SAF/SRM - SAF 210 - Interior Douglas-fir
 Duff Depth.....: Pre-Fire: 4.57 cm., Post-Fire: 2.16 cm.

Soil Layer Maximum Temperature

(measurements are in centimeters and Celsius)

Depth	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Temp.	86	47	43	41	39	37	35	33	31	29	27	25	23	21
Time	219	262	259	270	282	294	304	313	321	328	333	337	340	1

Max Depth Having 60 degrees: 0
 Max Depth Having 275 degrees: - None -

Fuel Consumption Summary - (t/acre)

Id	Litter	Wood	Wood	Wood	Wood	Duff	Herb	Shrub	Crown Folge	Crown Brnch
		0->1/4	1/4->1	1->3	3+					
very dry summr	1.30	0.40	1.90	3.20	40.93	16.01	0.00	0.00	0.00	0.00
moderate fall	1.30	0.40	1.90	3.20	33.08	11.02	0.00	0.00	0.00	0.00

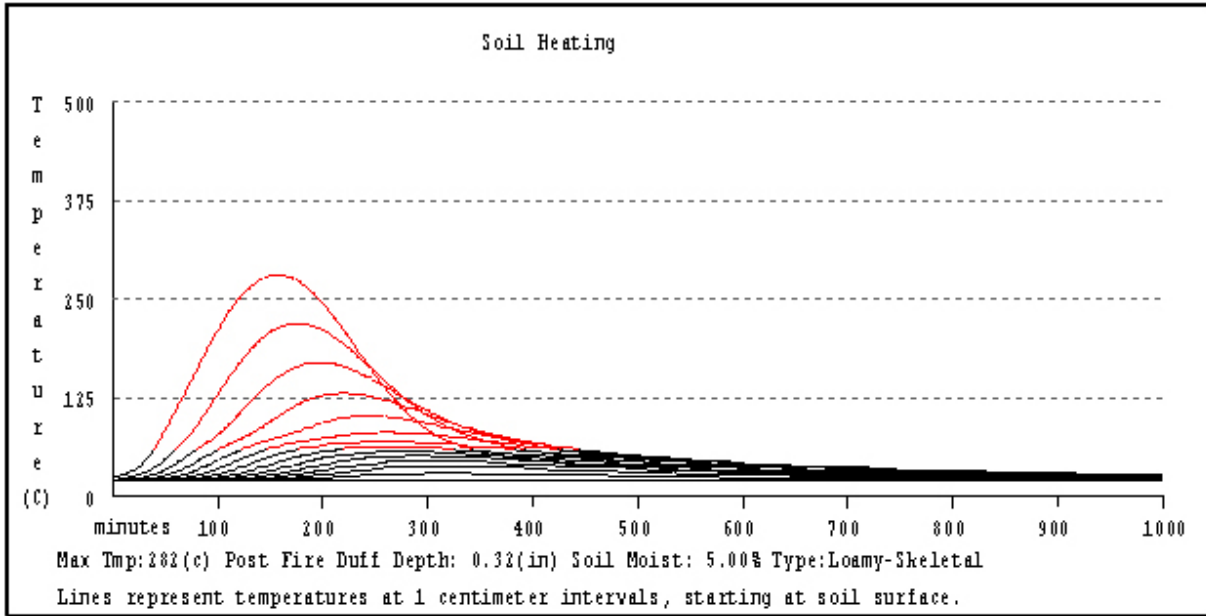
Soil Summary

Id	Depth	Depth
	>60	>275

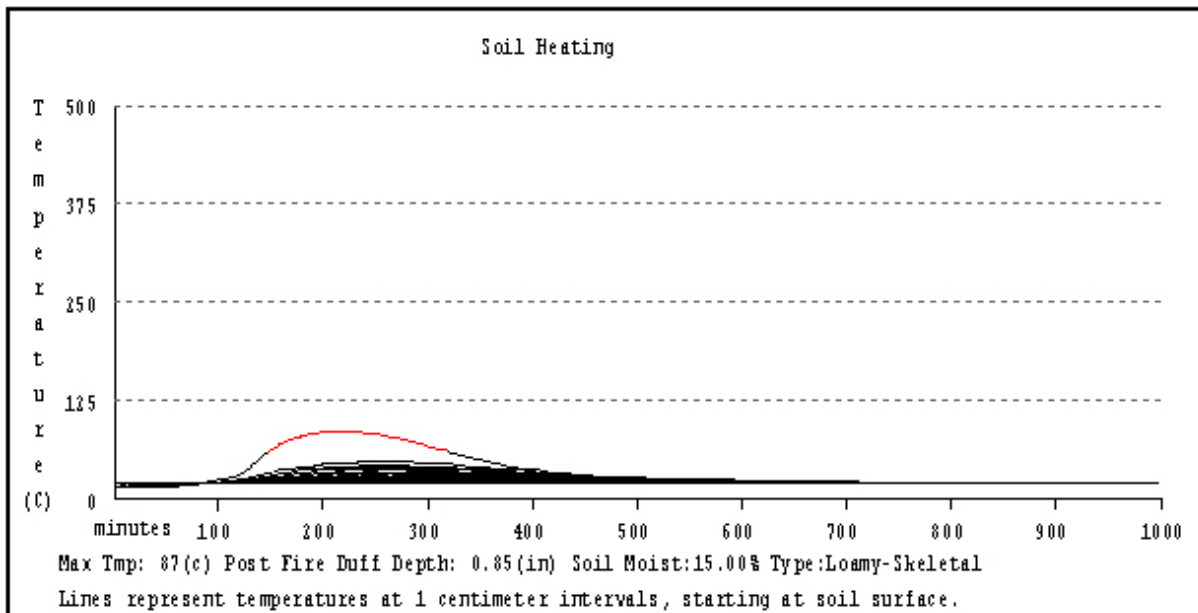
very dry summr	7	0
moderate fall	0	None

Appendix 5 – Soil heating graphs

Graph of soil heating for "very dry - summer" conditions:



Graph of soil heating for "moderate - fall" conditions:



Appendix 6 – Soil heating points files

Points file of soil heating for "very dry summer" conditions (first 30 minutes only):

Time Min.	1cm	2cm	3cm	4cm	5cm	6cm	7cm	8cm	9cm	10cm	11cm	12cm	13cm	14cm
Temp C														
1.0	23.9	21.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
2.0	24.6	21.4	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
3.0	25.2	21.7	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
4.0	25.6	21.9	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
5.0	26.2	22.2	21.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
6.0	26.5	22.4	21.3	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
7.0	27.1	22.6	21.4	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
8.0	27.4	22.9	21.5	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
9.0	28.0	23.1	21.6	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
10.0	28.4	23.4	21.7	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
11.0	28.9	23.7	21.8	21.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
12.0	29.3	23.9	21.9	21.2	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
13.0	30.0	24.2	22.0	21.3	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
14.0	30.4	24.5	22.1	21.3	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
15.0	31.1	24.7	22.3	21.4	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
16.0	31.5	25.0	22.4	21.4	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
17.0	32.3	25.3	22.6	21.5	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
18.0	32.8	25.7	22.7	21.5	21.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
19.0	33.6	26.0	22.9	21.6	21.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
20.0	34.1	26.3	23.0	21.7	21.2	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
21.0	35.0	26.6	23.2	21.8	21.2	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
22.0	35.5	27.0	23.4	21.8	21.3	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
23.0	36.5	27.4	23.6	21.9	21.3	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
24.0	37.6	27.8	23.8	22.0	21.3	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
25.0	38.7	28.2	24.0	22.1	21.4	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
26.0	39.9	28.6	24.2	22.2	21.4	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
27.0	41.1	29.1	24.4	22.3	21.5	21.2	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
28.0	42.4	29.6	24.7	22.4	21.5	21.2	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0
29.0	43.7	30.2	24.9	22.5	21.6	21.2	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0
30.0	45.1	30.7	25.2	22.7	21.6	21.2	21.1	21.0	21.0	21.0	21.0	21.0	21.0	21.0

Points file of soil heating for "moderate fall" conditions (first 30 minutes only):

1.0	17.2	20.5	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
2.0	16.8	20.0	20.8	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
3.0	16.5	19.6	20.6	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
4.0	16.3	19.3	20.5	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
5.0	16.1	19.0	20.3	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
6.0	15.9	18.8	20.2	20.7	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
7.0	15.8	18.5	20.0	20.6	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
8.0	15.7	18.4	19.9	20.6	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
9.0	15.6	18.2	19.7	20.5	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
10.0	15.6	18.0	19.6	20.4	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
11.0	15.5	17.9	19.4	20.3	20.7	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
12.0	15.5	17.8	19.3	20.2	20.7	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
13.0	15.4	17.7	19.2	20.1	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0
14.0	15.4	17.6	19.1	20.1	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0
15.0	15.4	17.5	19.0	20.0	20.5	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0
16.0	15.4	17.4	18.9	19.9	20.5	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0
17.0	15.4	17.3	18.8	19.8	20.4	20.7	20.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0
18.0	15.3	17.3	18.7	19.7	20.4	20.7	20.9	20.9	21.0	21.0	21.0	21.0	21.0	21.0
19.0	15.4	17.2	18.7	19.7	20.3	20.7	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0
20.0	15.4	17.1	18.6	19.6	20.2	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0
21.0	15.4	17.1	18.5	19.5	20.2	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0
22.0	15.4	17.1	18.4	19.5	20.1	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0
23.0	15.4	17.0	18.4	19.4	20.1	20.5	20.8	20.9	21.0	21.0	21.0	21.0	21.0	21.0
24.0	15.4	17.0	18.3	19.3	20.0	20.5	20.7	20.9	20.9	21.0	21.0	21.0	21.0	21.0
25.0	15.4	17.0	18.3	19.3	20.0	20.4	20.7	20.9	20.9	21.0	21.0	21.0	21.0	21.0
26.0	15.5	16.9	18.2	19.2	19.9	20.4	20.7	20.8	20.9	21.0	21.0	21.0	21.0	21.0
27.0	15.5	16.9	18.2	19.2	19.9	20.4	20.7	20.8	20.9	21.0	21.0	21.0	21.0	21.0
28.0	15.5	16.9	18.1	19.1	19.9	20.3	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0
29.0	15.6	16.9	18.1	19.1	19.8	20.3	20.6	20.8	20.9	21.0	21.0	21.0	21.0	21.0
30.0	15.6	16.9	18.1	19.0	19.8	20.3	20.6	20.8	20.9	20.9	21.0	21.0	21.0	21.0