

FuelCalc Tutorial Exercises



The tutorial examples are designed to help you understand the basic FuelCalc functionality, but they do not provide a complete description of the options available, or the logic used for simulating the various treatments.

For these exercises, you will need to create a folder on your C: drive named *FuelCalc_Tutorial_Files*.

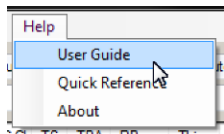
Unzip *Fuelcalc_1.8_Tutorial_Files.zip* and extract the three files you will need to complete the exercises. Copy the files into *C:\FuelCalc_Tutorial_Files*

- FuelCalc_Tutorial.fcp - the FuelCalc project file where your simulation settings get saved
- FuelCalc_Tutorial.ffi – includes plot name and fuel loading information
- FuelCalc_Tutorial.tre – the tree list used in the simulations

Overview

Getting Help

There are several ways to get help in FuelCalc. The User Guide has the most complete information. Click **Help>User Guide** from the main menu and the PDF version of the user guide will open.



The *Quick Reference* option displays a window with field descriptions and other information.

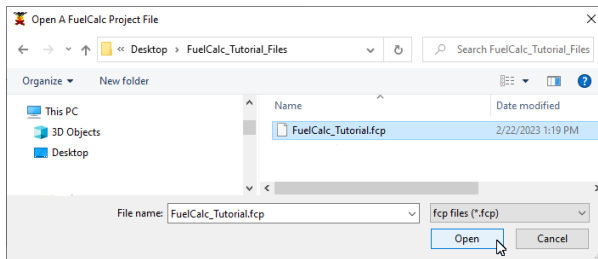
For field definitions (including units) hover the mouse cursor over the field of interest. The definition of the 1000-hr classes is displayed in the screen shot below.

1000 Hr Sound Classes					1000 Hr Rotten Classes					Pile	Total
Sound log fuel load in the following diameter classes (inches): 3->6, 6->9, 9->12, 12->20, 20+ tons per acre											
0	0	0	0	0	0.49	0	0	11.61	0	16.76	

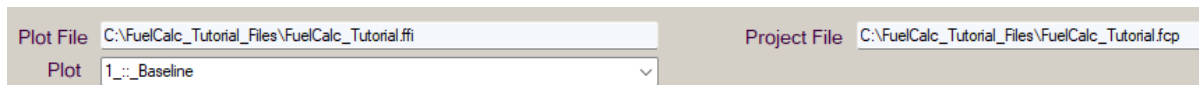
Finally, the *Crown Ratio Help* button on the *Settings* window and the *Quick Reference* button on the *Graph – Fuel Stand* window provide information specific to those windows.

Tutorial Setup

1. Run the FuelCalc application by double-clicking the **FuelCalc** icon on your desktop. FuelCalc will probably open using default sample files, but you will use different files to complete the example exercises.
2. Open the project file used for the tutorials. Select **File>Open Project File**, navigate to *C:\FuelCalc_Tutorial_Files*, select *FuelCalc_Tutorial.fcp* and click **Open**.



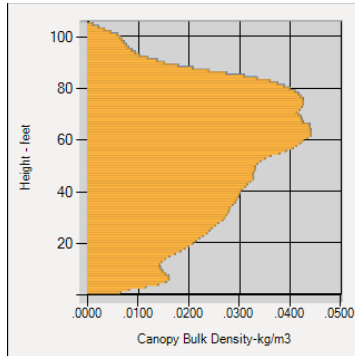
3. The main screen is divided into several sections. At the top are the main menu and fields for the current plot file (.ffi extension), the selected project (.fcp extension) and the current plot selection. Other plots are available in the *Plot* field dropdown.



4. The data grid or “treelist” displays the records in the .tre file with additional columns for *Retention Priority (RP)*, *Thinned* and *Killed*, which are values calculated based on simulation settings. Grayed rows are dead trees that are not included in any simulation outputs. Data in white cells can be modified but the changes will not be saved in the tree or project files. Permanent file changes will need to be made in the .tre file, which can be modified in a text editor or, if the extension is changed to .csv, in Excel.

Nurr	Species	DBH	TH	CBH	GrCl	TS	TPA	RP	Thinned	Killed
001	PIPO	23.7	104.0	57.0	D	H	10.0	1.0000	9.0	
002	LAOC	22.7	94.0	62.0	D	H	10.0	1.0000	9.0	
003	PIPO	20.9	88.0	52.0	C	H	10.0	1.0000	9.0	
004	PIPO	19.7	91.0	48.0	C	H	10.0	1.0000	9.0	
005	PIPO	17.0	86.0	54.0	C	H	10.0	1.0000	9.0	
006	LAOC	15.1	76.0	0.0	C	D	10.0	0.0000	0	
007	PSME	13.2	69.0	28.0	C	H	10.0	1.0000	9.0	
008	PIPO	13.8	65.0	42.0	C	H	10.0	1.0000	9.0	
009	PIPO	12.5	60.0	12.0	C	H	10.0	1.0000	9.0	
010	PIPO	11.8	58.0	17.0	C	H	10.0	1.0000	9.0	

5. The canopy bulk density graph shows a profile of available canopy fuel – all the foliage and half of the 0 to ¼” branch material – of live, standing trees on the plot, by height. The blue area is the pre-treatment canopy bulk density profile, and the orange area is post-treatment profile. Double-click the graph to see a larger version. Right-click the graph to see printing and saving options.



6. In the Stand Measurements section the pre-treatment and post-treatment Canopy Fuel Load (CFL), Canopy Bulk Density (CBD), Canopy Base Height (CBH), Stand Height (SH), Tree Density (TD), Stand Density Index (SDI), Canopy Cover (CC), Basal Area (BA), Quadratic Mean Diameter (QMD) and 75th Percentile Diameter (Q75) values are displayed.

Stand Measurements										
	CFL	CBD	CBH	SH	TD	SDI	CC	BA	QMD	Q75
Pre	3.79	0.044	1.00	103	280.0	255.0	48.7	170	10.5	20.1
Post	3.79	0.044	1.00	103	280.0	255.0	48.7	170	10.5	20.1

7. Torching Index (TORI) and Crowning Index (CRNI) are calculated for pre-treatment and post-treatment conditions. Torching Index includes surface and crown fuels and is the minimum 20-foot wind speed needed to initiate passive crowning or torching of individual trees. Crowning Index includes only crown fuels and is the minimum 20-foot wind speed needed to sustain an active crown fire. Clicking the *Moistures* button displays the moistures used to calculate the indices.

	TORI	CRNI
Pre	0	62
Post	0	62
Moistures		

8. The middle section displays the fuel loading of various components. The *.ffi* file includes all pre-treatment fuel information. Values in the *Pre-treatment* row can be modified in the user interface, but the changes will not be saved in the plot or project files. Permanent file changes will need to be made in the *.ffi* file, which can be modified in a text editor or, if the extension is changed to *.csv*, in Excel.

Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr	1000 Hr Sound Classes					1000 Hr Rotten Classes					Pile	Total
Pre-treatment	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	0	41.93
Surface Fuel Piled						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post Thinning Slash						0	0	0	0	0	0	0	0	0							
Post Prune Slash						0	0	0	0											0	0
Consumed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post-treatments	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	0	41.93

9. The bottom section is dominated by options for setting the four available treatments: *Thinning*, *Prune*, *Pile* and *Broadcast Burn* treatments. Treatments are simulated in order from left to right.

Calculate
 Treatment Name

 Save Treatment
 Retention Priority Set

☐ **Thinning**
 Tree Density
 Thin To Target
 Cut Efficiency %
 Merch dia >=
 Top Diameter
 Yard Loss %
 0 <DBH>

☐ **Prune**
 Height
 M R C R %
 Short-term Flaming and Smoldering
 Duff RSC
 Coarse Wood RSC

☐ **Pile**
 Surface %
 Slash %
 Consumed %
 4 - Western Forest - WI
 8 - Duff RSC
 7 - Woody RSC

☐ **Broadcast Burn**
 Pre-burn Duff Depth (in)
 Scorch Hgt (ft)
 Moss+Lichen %
 Moisture
 10 Hr 1k Hr Duff
 Region Season

Fire Behavior Fuel Model Selector
 All Arid
 SAV Herb Shrub 1 Hr
 Pre-treatment Model
 Post-treatment Model

Example Thin and Burn Treatments

Assume you want to thin a stand to: 1) reduce stand density to about 100 trees per acre, 2) reduce basal area to about 50 square feet per acre, 3) provide some merchantable material, while leaving stock for a future thin, and 4) reduce fire risk. You will use the *Stand Measurements*, *Timber Volume* and *Torching* and *Crowning* indices sections of the user interface, respectively, to evaluate three alternative treatments.

Thin Treatment Simulation 1

Run a basic simulation to reduce stand density to 100 trees per acre (TPA) with 90% efficiency and 10% yard loss. Assume merchantable trees have a 4" top.

1. Make sure the *FuelCalc_Tutorial* project file is open. If not, click **File>Open Project**, navigate to the *FuelCalc_Tutorial_Files* folder, select the *FuelCalc_Tutorial.fcp* file and click **Open**.

Plot File C:\FuelCalc_Tutorial_Files\FuelCalc_Tutorial.ffi
 Plot 1:_Baseline

Project File C:\FuelCalc_Tutorial_Files\FuelCalc_Tutorial.fcp

2. The *Plot* dropdown list includes all the plots in the *.ffi*. For the tutorial exercises you will use the first plot: *1:_Baseline*.

Plot File C:\FuelCalc_Tutorial_Files\FuelCalc_Tutorial.ffi
 Plot 1:_Baseline

Project File C:\FuelCalc_Tutorial_Files\FuelCalc_Tutorial.fcp

3. Set up a *Thinning* simulation. In the bottom section of the interface, check the box for a *Thinning* treatment and enter the values shown below.

☒ Thinning

TreeDensity ▼

Thin To Target 100

Cut Efficiency % 90

Merch dia >= 4.0

Top Diameter 2.0

Yard Loss % 20

0 <DBH> 99

4. Leave the boxes for the *Prune*, *Pile* and *Broadcast Burn* treatments unchecked.

☒ Thinning ☐ Prune ☐ Pile ☐ Broadcast Burn

5. Save the treatment settings so it can be reused later. Type *Thin_0_to_99* in the *Treatment Name* field (spaces are not allowed in *Treatment Names*) and click the **Save Treatment** button below the field. The *Settings* window will open and the new treatment will be displayed in the top table. You can leave the Settings window open, minimize it or close it by clicking the “X” in the upper right of the window.

Treatment Name

Thin_0_to_99 ▼

Save Treatment

Treatments										
Thinning							Pruning			
Name	Thinning Type	Target	Cutting Efficiency	Merch Dia	Top Dia	Yard Loss %	Min Cut Dia	Max Cut Dia	Prune Height	Prune MRCR
Thin_0_to_99	TreeDensity ▼	100	90	4.0	2.0	20	0	99	0	0
	None ▼	0	0	0	0	0	0	0	0	0

NOTE: The *Settings* window can be opened at any time by clicking **Option>Settings**.

6. *Retention Priority Sets* are used to set retention preferences for records in the treelist; they will be explained more in the third example. **None** should be selected in the *Retention Priority Set* dropdown. If not, select it.

Treatment Name

Thin_0_to_99 ▼

Save Treatment

Retention Priority Set

None ▼

7. Click **File>Save Project**. Click **OK** on the popup dialog. If you don't save your project the new *Treatment* will be lost when FuelCalc is closed.

8. Click the **Calculate** button to run the simulation. First, look at the treelist in the upper left. The three rightmost shaded columns display Retention Priority (*RP*), *Thinned* and *Killed*. Retention priority ranks the tree records for thinning with higher priority trees more likely to be retained. The retention priority for each record in the tree list is the product of all retention priorities defined in the Retention Priorities

table on the Settings window and those assigned to each species in the Species Group table. If the Settings window isn't already open, select **Options>Settings** to open it. All the retention priorities for the *None* retention priority set equal 1. The last column shows the *All* species group is assigned to the retention priority group.

Retention Priorities																	
Tree Status							Crown Class					Crown Ratio					
	Name	Desc	Healthy	Unhealthy	Sick	Dead	Dominant	Codominant	Intermediate	Emergent	Suppressor	Open/Grow	None	CRspec	CRmax	Diameter	Species Group
▶	None	None	1	1	1	1	1	1	1	1	1	1	1	1	1	1	All
*			0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Click the **Species Group** button at the bottom of the Settings window. In the *All* species group, all tree species (*_Other*) are set to 0.5.

FuelCalc - Species Group				
File				
All				
Species	Min Dia >=	Max Dia <	Ret. Priority	
▶ _Other	0	100	0.5	▼
*				▼

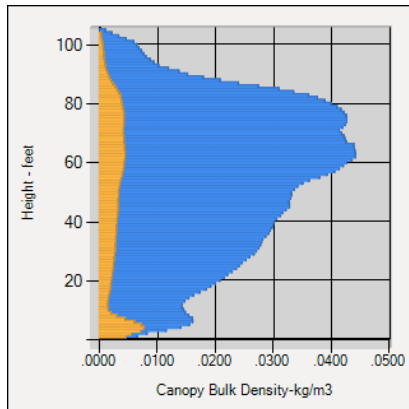
The product of the retention priorities for all trees in the simulation is $1 \times 0.5 = 0.5$, so all the tree records have the same retention priority (dead trees do not get assigned retention priority). If tree records have the same *RP*, they are thinned by *Num*, which is the tree record number, in ascending order. On this plot the trees were entered with descending DBH, so the largest trees are thinned first. Check the *Thinned* column as you scroll down in the treelist and note the last record with thinned trees is row 23. No additional trees need to be thinned to meet the target of 100 TPA. Only 9 of the 10 trees per record were thinned because the *Cut Efficiency* is set to 90%. No trees were killed because a Broadcast Burn was not included in the simulation.

Nurr	Species	DBH	TH	CBH	CrCl	TS	TPA	RP	Thinned
017	PSME	2.3	20.0	2.0	I	U	10.0	0.5000	9.0
018	PSME	1.8	13.0	4.0	I	H	10.0	0.5000	9.0
019	PSME	1.8	14.0	0.0	I	D	10.0	0.0000	0
020	PIPO	1.5	12.0	4.0	S	U	10.0	0.5000	9.0
021	PSME	1.5	11.0	2.0	S	U	10.0	0.5000	9.0
022	PSME	1.3	10.0	0.0	I	H	10.0	0.5000	9.0
023	PSME	1.2	9.0	1.0	S	U	10.0	0.5000	9.0
024	LAOC	1.1	9.0	0.0	I	D	10.0	0.0000	0
025	PSME	1.1	9.0	0.0	I	H	10.0	0.5000	0.0
026	PSME	1.0	8.0	1.0	S	U	10.0	0.5000	0.0

Species Codes

PIPO: ponderosa pine
LAOC: western larch
PSME: Douglas-fir
ABGR: grand fir

9. The Canopy Bulk Density (CBD) profile shows how available crown fuels (all the foliage and half of the 0 to ¼" branch material) are distributed by height as an aggregate across the trees in the treelist. The blue area is CBD density before the thinning and orange shows CBD after thinning.



10. Post-treatment tree density (TD) is the desired 100 TPA but the basal area (BA) and quadratic mean diameter (QMD) are quite low, indicating mostly small diameter trees remain after thinning. Canopy base height (CBH) remains unchanged.

Stand Measurements										
	CFL	CBD	CBH	SH	TD	SDI	CC	BA	QMD	Q75
Pre	3.79	0.044	1.00	103	280.0	255.0	48.7	170	10.5	20.1
Post	0.43	0.008	1.00	97.0	100.0	26.8	8.18	17.3	5.63	19.9

NOTE: In FuelCalc, CBH is the lowest point where the 5-foot running mean canopy bulk density (CBD) is equal to the "Threshold" CBD. When maximum CBD is equal to or greater than 0.12 kg/m³ then the Threshold CBD is 0.012 kg/m³. If the maximum CBD does not exceed 0.12 kg/m³ then FuelCalc calculates the Threshold CBD as 10% of maximum CBD. Stand height (SH) is the highest point where CBD exceeds the Threshold CBD.

11. The treatment removed approximately 90% of the standing volume, providing approximately 21,870 merchantable board feet per acre (M B Ft). Other volume values are cubic feet (Cubic Ft) and merchantable cubic feet (M C Ft)

Timber Volume			
	Cubic Ft	M C Ft	M B Ft
Standing	503	454	2430
Harvested	4503	4090	21870

NOTE: Consider the Timber Volume values in FuelCalc as estimates. They are calculated with general species-specific volume equations and merchantable volume is not reduced to account for defects such as rot and checks.

12. The thinning increased the minimum 20-foot wind speed needed to maintain an active crown fire (Crowning Index - CRNI) from 62 to 100 mph. This is because the maximum CBD was reduced by the thinning, so it is more difficult to maintain an active crown fire in the treated stand. A 20-foot wind speed of 62 mph would be pretty unusual so the increase to 100 may not be considered important. The

minimum 20-foot wind speed needed to initiate passive crowning (Torching Index – TORI) remained at 0 mph because: a) some surface fuels increased, b) the CBH was unchanged by the treatment and c) the thinned stand modified the wind speed reduction factor. The litter, 1-, 10- and 100-hr fuels shown in the *Post Thinning Slash* row are yard loss (as set in the *Yard Loss %* field) and additional fuels from limb breakage, etc.

	TORI	CRNI	Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr
Pre	0	62	Pre-treatment	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84
Post	0	100	Surface Fuel Piled						0	0	0	0
			Post Thinning Slash						0.80	0.18	0.86	1.18

Treatment Review:

Component	Result
Stand density (100 tpa)	Target met
Basal area (50 ft ² /ac)	Too low
Merchantable material	Provides substantial merchantable timber
Fire risk (increase TORI and CRNI)	Torching Index unchanged; Crowning Index increased

Thin Treatment Simulation 2

1. In the first simulation most of the large trees were thinned. In this exercise you will exclude the larger trees from the treatment. Change the upper DBH range of trees to be considered for thinning to 12.

☒ Thinning

TreeDensity ▼

Thin To Target 100

Cut Efficiency % 90

Merch dia >= 4.0

Top Diameter 2.0

Yard Loss % 20

0 <DBH: 12

2. Change the Treatment Name to *Thin_0_to_12*, click **Save Treatment**. Minimize or close the *Settings* window.

Treatment Name

Thin_0_to_12 ▼

Save Treatment

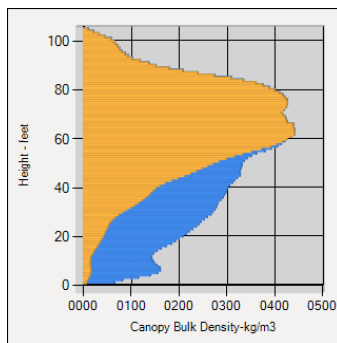
3. Click **File>Save Project** to save the changes.

4. Click **Calculate**.

5. In this simulation the larger trees are retained - the first thinned tree record is number 10 – PIPO 11.8 DBH.

Num	Species	DBH	TH	CBH	CrCl	TS	TPA	RP	Thinned
002	LAOC	22.7	94.0	62.0	D	H	10.0	0.5000	0.0
003	PIPO	20.9	88.0	52.0	C	H	10.0	0.5000	0.0
004	PIPO	19.7	91.0	48.0	C	H	10.0	0.5000	0.0
005	PIPO	17.0	86.0	54.0	C	H	10.0	0.5000	0.0
006	LAOC	15.1	76.0	0.0	C	D	10.0	0.0000	0
007	PSME	13.2	69.0	28.0	C	H	10.0	0.5000	0.0
008	PIPO	13.8	65.0	42.0	C	H	10.0	0.5000	0.0
009	PIPO	12.5	60.0	12.0	C	H	10.0	0.5000	0.0
010	PIPO	11.8	58.0	17.0	C	H	10.0	0.5000	9.0
011	PSMF	8.1	52.0	5.0	C	H	10.0	0.5000	9.0

6. The CBD graph clearly shows the crown material of the smaller trees that were thinned (blue area).



7. The post-treatment tree density is 100 TPA as in the first exercise but the BA and QMD are substantially higher because the large trees were not thinned. Also note the CBH has increased to 22 feet due to the removal of the smaller diameter trees.

Stand Measurements										
	CFL	CBD	CBH	SH	TD	SDI	CC	BA	QMD	Q75
Pre	3.79	0.044	1.00	103	280.0	255.0	48.7	170	10.5	20.1
Post	2.78	0.044	22.0	103	100.0	214.2	38.5	150	16.6	21.2

8. Harvested merchantable timber is a lot lower in this simulation – just 1440 board feet per acre – because only small trees were harvested and just some of those harvested had DBH greater than the 4” merchantable diameter cutoff (*Merch dia* >=). Only trees greater than or equal to the cutoff are included in the merchantable Timber Volume.

Timber Volume			
	Cubic Ft	M C Ft	M B Ft
Standing	4641	4242	22860
Harvested	363	302	1440

9. The Torching Index (TORI) increased to 73 mph post-treatment primarily because the CBH increased to 22 feet. The same number of trees were thinned but they were smaller and had less crown material so there is less *Post Thinning Slash* than in the first simulation. Crowning Index remained the same because the maximum CBD remained unchanged by the thinning treatment.

TORI CRNI		Tons Per Acre										
Pre	Post	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr		
0	62	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84		
73	62	Surface Fuel Piled					0	0	0	0		
		Post Thinning Slash					0.34	0.13	0.26	0.46		

Treatment Review:

Component	Result
Stand density (100 tpa)	Target met
Basal area (50 ft ² /ac)	Too high
Merchantable material	Provides little merchantable timber
Fire risk (increase TORI and CRNI)	Torching Index increased; Crowning Index unchanged

Thin and Burn Treatment Simulation

The first two exercises thinned only small trees or large trees. Both met the tree density target. The first provided substantial timber volume but didn't reduce fire risk. The second reduced fire risk but didn't provide much timber. In this exercise you will set up a treatment to thin all trees greater than 4" DBH and use the *Retention Priority* table to prioritize the trees that are retained. You will also simulate a broadcast burn with the goal of reducing the density of trees less than 4" DBH.

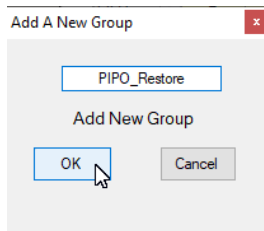
1. FuelCalc allows you to save *Retention Priority Sets* that use tree status, crown class and crown ratio to prioritize tree retention. Select **Options>Settings** and enter data in a new row of the *Retention Priorities* table (the bottom table on the page). In the bottom blank row of the table, name the new set **Restoration** and enter the other values shown below. Click the **Apply** button below the table when finished.

Retention Priorities																		
Tree Status				Crown Class							Crown Ratio							
Name	Desc	Healthy	Unhealthy	Sick	Dead	Dominant	Codominant	Intermediate	Emergent	Suppressed	OpenGrow	None	CRspec	CRmax	Diameter	Species Group		
None	None	1	1	1	1	1	1	1	1	1	1	1	1	1	1	All		
Restoration	Thin to restore PIPO	1	0.5	0.5	0	1	1	0.5	1	0.2	0.8	1	1	1	1	None		
*		0	0	0	0	0	0	0	0	0	0	0	0	0	0			

The priorities are to retain a tree; trees with values closer to 1.0 are more likely to be retained. The *RP* shown in the treelist on the main screen is the product of the individual retention priority values. The retention priorities you just added in the *Restoration* Retention Priorities Set will preferentially retain healthy, dominant, codominant, emergent and open grown trees over trees in the other *Tree Status* and *Crown Classes*.

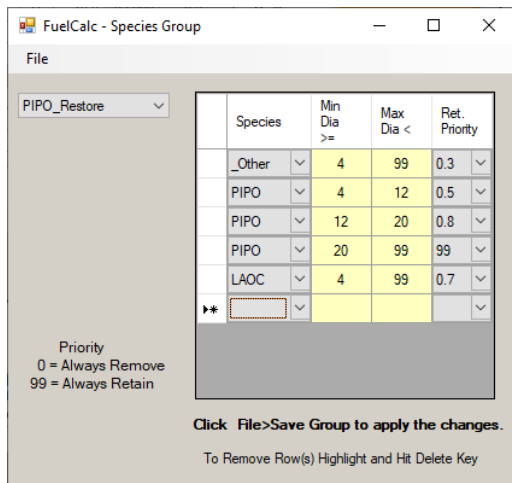
2. You can also create a list of species-specific retention priorities to favor retention of certain tree species over others. In this exercise you will set PIPO in the largest class to always be retained. The other settings will retain PIPO and LAOC with variable preference over other species.

Click the **Species Group** button at the lower right of the *Settings* window. In the new window that opens, select **File>New Group** and name the group *PIPO_Restore*. Click **OK**.

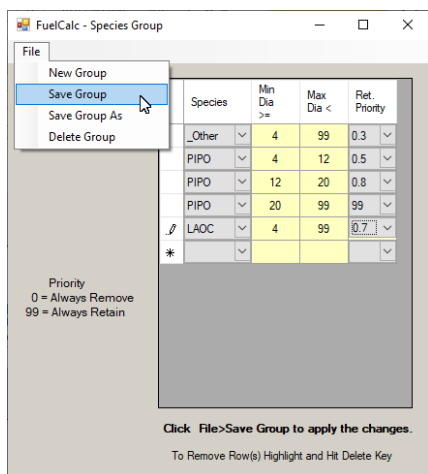


3. Enter the values in the screen shot below. You can click in any populated cell to change the value. Add new rows at the bottom. It is important to always include a row for the species *_Other* to identify the retention priority for the species not shown in the remainder of the table. The note at the lower left defines special codes used to always remove or always retain trees identified in the row.

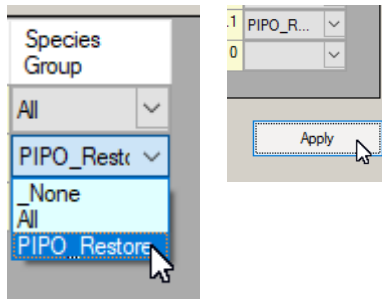
NOTE: To delete a row in the table, click the gray area to the left of the row to highlight it and then click the Delete key on your keyboard.



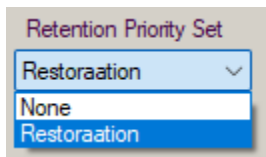
4. In the *Species Group* window click **File>Save Group**. Click the X in the upper right of the Species Group table to close the dialog.



5. Return to the **Settings** window, click the *Species Group* dropdown for the *Restoration* Retention Priorities group and select **PIPO_Restore**. Click **Apply** at the lower right below the *Retention Priorities* table. Minimize or close the *Settings* window.

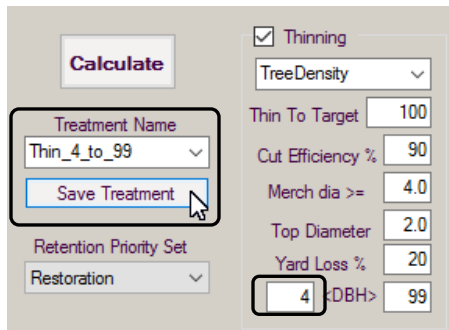


6. Select the **Restoration** Retention Priority Set in the dropdown at the lower left on the main screen.



7. In reality, small trees will probably not be thinned by a saw crew, so modify the treatment to thin just trees greater than 4" DBH. Select the *Thin_0_to_99* treatment, change the lower DBH limit to **4"**, change the treatment name to *Thin_4_to_99* and click **Save Treatment**.

NOTE: The retention priority rules in the Species Group will be applied to all trees within the DBH range entered in the Thinning group box.



8. Add settings to simulate a burn to remove some of the trees less than 4" DBH. Check the box to include a *Broadcast Burn* and set the Scorch Height (*Scorch Hgt (ft)*) to 4'. Set the *Moisture* regime to **Moderate**. Make sure the other *Broadcast Burn* fields are set to the values in the screen shot.

NOTE: If you get an error that the moisture fields are set to 0, reselect the desired moisture regime from the dropdown and the correct moisture values will be assigned.

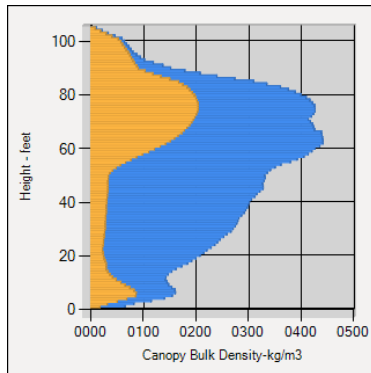
NOTE: Tree mortality is a function of species, scorch height and DBH. The other settings in the Broadcast Burn box are used to modify fuel consumption and emissions and can be ignored for this exercise.

9. Click **Save Treatment** to update the *Thin_4_to_99* treatment. Your simulation settings should look like this.

10. Click **File>Save Project** save the changes in the project file. If you don't save your project all the unsaved *Treatments*, *Retention Priorities* and *Species Groups* will be lost when FuelCalc is closed.

11. Click **Calculate**.

12. Compared to the first two examples, the crown material reduction is more evenly distributed throughout the canopy. The crown material for the large trees and, to a lesser extent, small trees remaining after the treatments are evident.



13. The *Thinned* and *Killed* columns show the trees removed by the thinning and burning treatment, respectively. The thinning rules removed many large trees (rows where *Thinned* > 0.0) and the burn killed two of the largest PIPO.

Num	Species	DBH	TH	CBH	CrCl	TS	TPA	RP	Thinned	Killed
001	PIPO	23.7	10...	57.0	D	H	10.0	99.0...	0.0	1.0
002	LAOC	22.7	94.0	62.0	D	H	10.0	0.7000	9.0	0.0
003	PIPO	20.9	88.0	52.0	C	H	10.0	99.0...	0.0	1.0
004	PIPO	19.7	91.0	48.0	C	H	10.0	0.8000	9.0	0.0
005	PIPO	17.0	86.0	54.0	C	H	10.0	0.8000	9.0	0.0
006	LAOC	15.1	76.0	0.0	C	D	10.0	0.0000	0	0
007	PSME	13.2	69.0	28.0	C	H	10.0	0.3000	9.0	0.0
008	PIPO	13.8	65.0	42.0	C	H	10.0	0.8000	9.0	0.0
009	PIPO	12.5	60.0	12.0	C	H	10.0	0.8000	9.0	0.0
010	PIPO	11.8	58.0	17.0	C	H	10.0	0.5000	9.0	0.0
011	PSME	8.1	52.0	5.0	C	H	10.0	0.3000	9.0	0.0

14. The *Species Group* you created included a rule to retain all PIPO ≥ 20 " DBH and those trees are identified in the treelist with the code 99 in the *RP* column (e.g., record #1). Tree records coded 99 will not have trees removed by thinning but they may be removed by burning. The *RP* for the second record is 0.7. This value is the product of all retention priorities assigned to the record:

Component	Setting	Retention Priority
Tree Status	Healthy	1.0
Crown Class	Dominant	1.0
Species Group	LAOC 4"– 99"	0.7

Q: Why was one, each, of the largest PIPO trees killed by the fire but smaller diameter PIPO were not killed?

A: The number of killed trees is the product of the probability of mortality ($P(m)$) and tree density. The $P(m)$ for the three largest PIPO records is 0.06 (this value is not shown in FuelCalc). None of the trees in records #1 or #3 were thinned so post-thin tree density is 10 TPA. The

number killed is: $10 \times 0.06 = 0.6$; which gets rounded to 1. Nine of the ten trees in record #4 were thinned so tree density is 1 TPA. The number killed is: $1 \times 0.06 = 0.06$, which gets rounded to 0.

15. Scroll down in the treelist and you will note trees less than 4" DBH were not thinned (*Thinned* = 0.0) because of the diameter range selected for the thin, but some were killed by the fire.

Num	Species	DBH	TH	CBH	CrCl	TS	TPA	RP	Thinned	Killed
015	PSME	5.3	32.0	2.0	I	H	10.0	0.1500	9.0	0.0
016	PSME	2.3	17.0	0.0	I	D	10.0	0.0000	0	0
017	PSME	2.3	20.0	2.0	I	U	10.0	0.1250	0.0	3.0
018	PSME	1.8	13.0	4.0	I	H	10.0	0.2500	0.0	1.0
019	PSME	1.8	14.0	0.0	I	D	10.0	0.0000	0	0
020	PIPO	1.5	12.0	4.0	S	U	10.0	0.0500	0.0	1.0
021	PSME	1.5	11.0	2.0	S	U	10.0	0.0500	0.0	3.0
022	PSME	1.3	10.0	0.0	I	H	10.0	0.2500	0.0	4.0
023	PSME	1.2	9.0	1.0	S	U	10.0	0.0500	0.0	4.0
024	LAOC	1.1	9.0	0.0	I	D	10.0	0.0000	0	0
025	PSME	1.1	9.0	0.0	I	H	10.0	0.2500	0.0	5.0

16. The combined thin and burn treatments reduced tree density and basal area to near the desired levels of 100 TPA and 50 ft², respectively.

NOTE: It is possible that the Treatment, Retention Priority and/or Species Group settings will restrict the tree records available for thinning to the point the thinning target cannot be met. When this happens settings will need to be modified if meeting the target is a priority.

Stand Measurements										
	CFL	CBD	CBH	SH	TD	SDI	CC	BA	QMD	Q75
Pre	3.79	0.044	1.00	103	280.0	255.0	48.7	170	10.5	20.1
Post	1.15	0.020	5.00	104	102.0	86.1	19.5	61.2	10.5	22.5

17. The thinning treatment removed just over half of the merchantable material providing over 12,000 board feet while maintaining growing stock for the remaining stand.

Timber Volume			
	Cubic Ft	M C Ft	M B Ft
Standing	2258	2084	11790
Harvested	2749	2460	12510

18. Torching index increased substantially and, while Crowning Index was already high, it also increased. In FuelCalc, the maximum wind speed for Crowning Index and Torching Index is 100 mph so following these thin and burn treatments the simulated fire risk is at its lowest of the three simulations.

	TORI	CRNI
Pre	0	62
Post	100	100

Review:

Component	Result
Stand density (100 tpa)	Target met
Basal area (50 ft ² /ac)	Target met
Merchantable material	Provides merchantable volume while maintaining residual timber.
Fire risk (increase TORI and CRNI)	Both indices indicate low risk

Example Prune and Pile Treatments

The following simulations will demonstrate the *Prune* and *Pile* treatments.

Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr	1000 Hr Sound Classes					1000 Hr Rotten Classes					Pile	Total
Pre-treatment	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	0	41.93
Surface Fuel Piled							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post Thinning Slash							0.13	0.06	0.11	0.24	0	0	0	0	0	0	0	0	0	0	0
Post Prune Slash							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Consumed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post-treatments	7.99	0.25	0	0	0.16	7.12	0.10	0.57	2.08	0	0	0	0	0	0.98	0	0	23.22	0	0	42.47

☐ Thinning
 Tree Density:
 Thin To Target:
 Cut Efficiency %:
 Merch dia >=:
 Top Diameter:
 Yard Loss %:
 0 <DBH> 99.0

☐ Prune
 Height:
 M R C R %:

☐ Pile
 Surface %:
 Slash %:
 Consumed %:

☐ Broadcast Burn
 Pre-burn Duff Depth (in):
 Scorch Hgt (ft):
 Moss+Lichen %:
 Moisture: 10 Hr: 1k Hr: Duff:
 Region: Season:

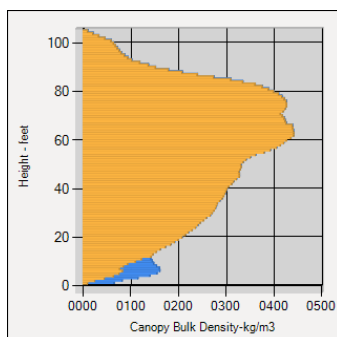
Fire Behavior Fuel Model Selector
 All: Arid:
 Herb: Shrub: 1 Hr:
 SAV:
 Pre-treatment Model:
 Post-treatment Model:

Prune Treatment Simulation

1. Select the *Thin_0_to_99* Treatment, set *Retention Priority Set* to **Restoration** and uncheck the box for the *Thinning* treatment.
2. There are two fields in the *Prune* group box. The first is for the maximum height that crown material will be pruned (*Height*). The second is the minimum remaining crown ratio (*MRCR %*). The MRCR % setting will stop pruning at a height where the crown ratio of the tree record equals the MCRC %. Check the box to perform a pruning treatment. Set *Height* to **10** and *MRCR %* to **50**. It is probably not realistic that managers would prune small trees so these settings will minimize pruning of them. Click **Calculate**.

☒ Prune
 Height:
 M R C R %:

3. The CBD profile shows how the lower part of the crown was modified by the pruning.



4. The *Post Prune Slash* row shows a small amount of material added to the surface fuels. Note that FuelCalc does not calculate the loading of 1000-hr pruning slash. The *Post-treatments* row shows total fuels.

Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr	1000 Hr Sound Classes					1000 Hr Rotten Classes				Pile	Total
Pre-treatment ---	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	41.93
Surface Fuel Piled -----						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post Thinning Slash -----						0	0	0	0	0	0	0	0	0						
Post Prune Slash -----						0.08	0.04	0.06	0.02										0	0.20
Consumed -----	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post-treatments	7.99	0.25	0	0	0.16	7.07	0.08	0.52	1.86	0	0	0	0	0	0.98	0	0	23.22	0	42.13

Prune and Pile Treatment Simulation

1. The *Pile* treatment allows piling of a percentage of the pre-treatment fuels (*Surface %*), slash fuels (*Slash %*) and sets the percentage of large size/coarse fuel loading consumed when the piles are burned (*Consumed %*). Leave the *Prune* box checked and keep the settings the same. Check the *Pile* box and set *Surface %* to **50**, *Slash %* to **75** and *Consumed %* to **90**. Click **Calculate**.

☒ Prune
 Height
 M R C R %

☒ Pile
 Surface %
 Slash %
 Consumed %

2. The *Surface Fuel Piled* row shows 50% of the *Pre-treatment* row plus 75% of the *Post Prune Slash* fuels were piled. The value in the *Pile* column is the total of only the piled *Pre-treatment* fuels. Note FuelCalc even piled half of the 12" to 20" class but in reality, these large size 1000-hr fuels may not be piled because they are too heavy to move.

Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr	1000 Hr Sound Classes					1000 Hr Rotten Classes				Pile	Total
Pre-treatment ---	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	41.93
Surface Fuel Piled -----						3.56	0.05	0.27	0.94	0	0	0	0	0	0.49	0	0	11.61	0	16.76
Post Thinning Slash -----						0	0	0	0	0	0	0	0	0						
Post Prune Slash -----						0.02	0.01	0.01	0.01										0.15	0.20
Consumed -----	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.70	15.70
Post-treatments	7.99	0.25	0	0	0.16	3.52	0.03	0.24	0.93	0	0	0	0	0	0.49	0	0	11.61	0	26.42

3. The *Post Prune Slash* row now shows 25% of the total loading in the litter, 1-, 10- and 100-hr pruning material as un-piled and the remaining 75% in the *Pile* column at the right.

Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr	1000 Hr Sound Classes					1000 Hr Rotten Classes				Pile	Total
Pre-treatment ---	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	41.93
Surface Fuel Piled -----						3.56	0.05	0.27	0.94	0	0	0	0	0	0.49	0	0	11.61	0	16.76
Post Thinning Slash -----						0	0	0	0	0	0	0	0	0						
Post Prune Slash -----						0.02	0.01	0.01	0.01										0.15	0.20
Consumed -----	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.70	15.70
Post-treatments	7.99	0.25	0	0	0.16	3.52	0.03	0.24	0.93	0	0	0	0	0	0.49	0	0	11.61	0	26.42

4. The consumed pile material is displayed in the *Pile* column of the *Consumed* row. The *Consumed Pile* amount includes 100% of the fine material and 90% of the coarse material (as set in the *Consumed %* field): $4.815 + (12.1 \times 0.9) = 15.705$ tons/acre consumed.

Tons Per Acre	Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr	1000 Hr Sound Classes					1000 Hr Rotten Classes					Pile	Total
Pre-treatment ---	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	0	0	0	0	0.98	0	0	23.22	0	0	41.93
Surface Fuel Piled -----						3.56	0.05	0.27	0.94	0	0	0	0	0	0.49	0	0	11.61	0		16.76
Post Thinning Slash -----						0	0	0	0	0	0	0	0	0							
Post Prune Slash -----						0.02	0.01	0.01	0.01											0.15	0.20
Consumed -----	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.70	15.70
Post-treatments	7.99	0.25	0	0	0.16	3.52	0.03	0.24	0.93	0	0	0	0	0	0.49	0	0	11.61	0	1.21	26.42

Reports and Graphs

FuelCalc includes basic Report and Graph features. Reports are available for individual plots only.

Reports

Click **Report>Plot Report**. This report shows: 1) pre- and post-treatment fuel loading, the loading of un-piled *Thinning* and *Prune* slash and consumed fuels, if the associated treatments are simulated, 2) pre- and post-treatment *Stand Measurements* and 3) emissions from broadcast and/or pile burning.

Click **Report>Tree Report** to see a copy of the records in the treelist for the currently selected plot, Standing and Harvested *Timber Volume*, *Treatment Name*, thinning type and *Broadcast Burn* (Yes, No).

NOTE: The Plot and Tree report views are not automatically updated when treatment changes are made so be sure to create new report every time you change your treatment.

The Plot CSV file (**Report>Plot CSV File**) reproduces the fuel loading portion of the user interface (pre-through post-treatment fuels), *Stand Measurements*, torching and crowning index and *Timber Volume*.

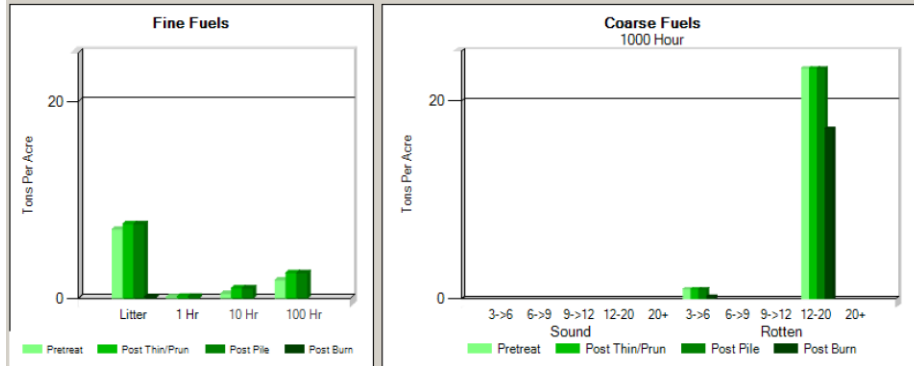
	A	B	C	D	E	F	G	H	I	J	K	L
1		Duff	Herb	Lichen	Moss	Shrub	Litter	1Hr	10Hr	100Hr	SC1snd	SC2s
2		T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac
3	Pre-Treatment	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	
4	Thinned						0.2	0.08	0.15	0.24	0	
5	Pruned						0.02	0.01	0.02	0.01		
6	Consumed	-4.13	-0.25	0	0	-0.1	-3.72	-0.11	-0.4	-1.07	0	
7	Post-Treatment	3.86	0	0	0	0.06	0.21	0	0	0.11	0	

The Tree CSV file (**Report>Tree CSV File**) reproduces the treelist and also includes the *Treatment Name* and *Retention Priority Set* name.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		TN	RPS	TreeNum	Species	DBH	TH	CBH	CC	TS	TD	RPV	Thinned	Killed
2						in	ft	ft			trees/ac		trees/ac	trees/ac
3	1 :: Baseline	Thin_0_to_99	Restoration	1	PIPO	23.7	104	57	D	H	10	99	0	1
4	1 :: Baseline	Thin_0_to_99	Restoration	2	LAOC	22.7	94	62	D	H	10	0.63	0	0
5	1 :: Baseline	Thin_0_to_99	Restoration	3	PIPO	20.9	88	52	C	H	10	99	0	1
6	1 :: Baseline	Thin_0_to_99	Restoration	4	PIPO	19.7	91	48	C	H	10	0.56	0	1
7	1 :: Baseline	Thin_0_to_99	Restoration	5	PIPO	17	86	54	C	H	10	0.56	0	1
8	1 :: Baseline	Thin_0_to_99	Restoration	6	LAOC	15.1	76	0	C	D	10	0	0	0
9	1 :: Baseline	Thin_0_to_99	Restoration	7	PSME	13.2	69	28	C	H	10	0.21	9	0
10	1 :: Baseline	Thin_0_to_99	Restoration	8	PIPO	13.8	65	42	C	H	10	0.56	0	1
11	1 :: Baseline	Thin_0_to_99	Restoration	9	PIPO	12.5	60	12	C	H	10	0.56	0	1

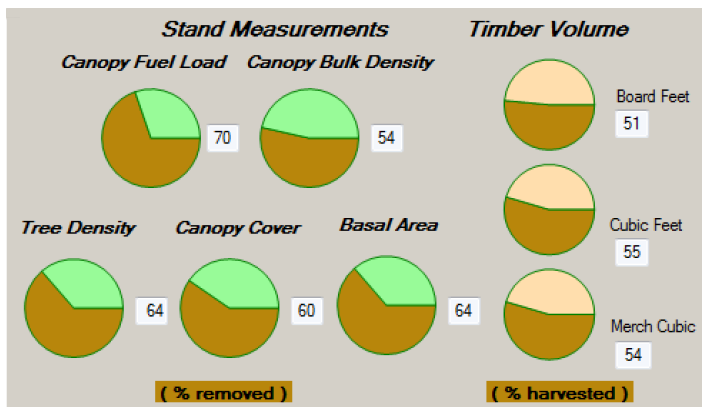
Graphs – Fuel Stand

Click **Graph>Fuel Stand** to view a window with several graphs. The top bar graphs show the pre-treatment, post-thinning and pruning, post-pile and post-burn loading for fine and coarse fuels. Right-click the graph area for options to save or print the graphs.



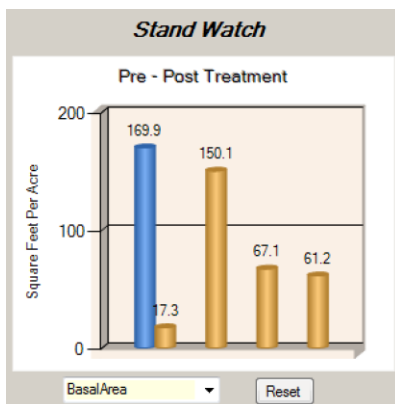
This graph is from the *Thin_4-to_99* treatment simulation

Pie charts show the percentage removed for a number of the *Stand Measurements* and percentage harvested *Timber Volume*.



These charts are from the *Thin_4-to_99* treatment simulation

The *Stand Watch* graph updates automatically as treatments are changed on the user interface. The value that is graphed is selected in the dropdown below the graph: *Canopy Fuel Load*, *Canopy Bulk Density*, *Tree Density* and *Basal Area*. Right-click the graph area for options to save or print the graph. Click **Reset** to clear the *Stand Watch* graph. It will clear automatically after 50 simulations.

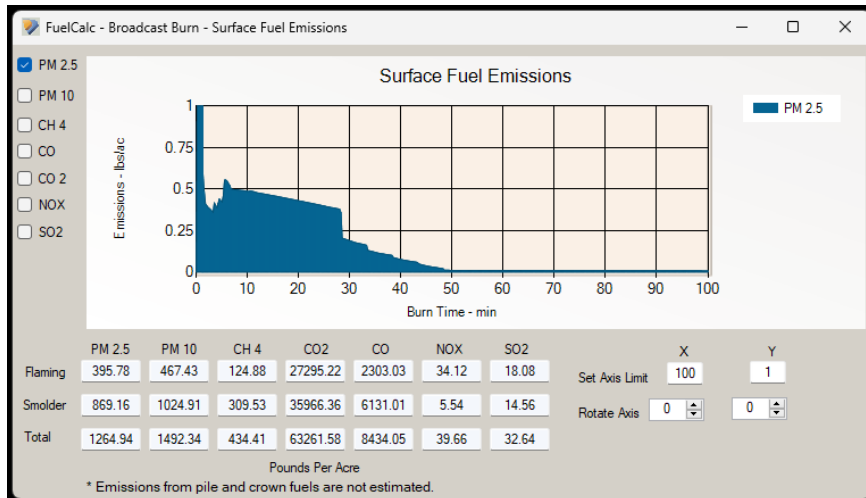


This graph shows basal area change in the first four simulations of the tutorial

Graphs - Emissions

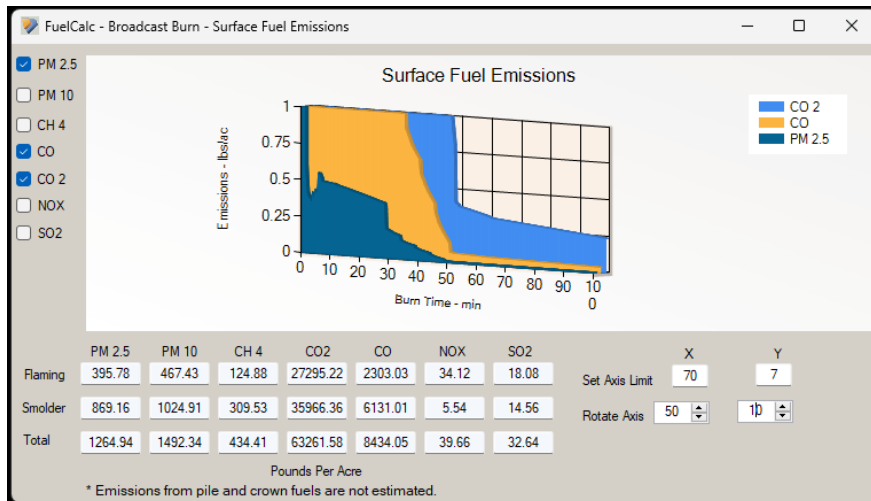
Select the *Thin_4_to_99* treatment, click **Calculate** and click **Graph>Emission** to view a graph of emissions from the broadcast burn.

The graph opens displaying the PM_{2.5} emissions (pounds per acre) by time (minutes). The jagged appearance of the emission graph is because different fuel components burn at different rates. The checkboxes in the upper left are used to select the smoke component(s) of interest. *Flaming*, *Smoldering* and *Total* emissions by component are shown for seven smoke components at the bottom. Fields to limit and rotate axes are on the right.



This graph shows PM2.5 emissions from the *Thin_4_to_99* treatment with changes to the graph axis limits

The graph below displays PM_{2.5}, CO and CO₂ emissions. The axis limits have been set and rotated to more clearly display the relationship of the three components over time.



This graph shows emissions from the *Thin_4_to_99* treatment with changes to the graph axis limits