

FuelCalc Tutorial

The tutorial examples are designed to help you understand basic FuelCalc functionality but do not provide a complete description of the options available or the logic used for simulating the various treatments. More information about the FuelCalc application is available in the User Guide available on the FuelCalc web page.

To complete this tutorial you will need to download the *FuelCalc_Tutorial_Files.zip* file from the FuelCalc web page at: www.firelab.org/document/fuelcalc-files. Save the zip file on your computer desktop.

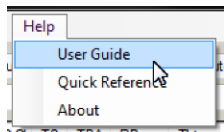
When the download is complete right-click the zip file and select *Extract All...* Extract the files to the recommended folder. The folder contains two files with the prefix *FuelCalc Tutorial*: 1) the *.ffi* file includes all the macro plot data and fuels data, and 2) the *.tre* file includes the tree list for all the plots in the *.ffi* file. The *.ffi* and *.tre* files are both required and must have the same prefix. E.g., *FuelCalc_Tutorial*.

NOTE: FuelCalc .ffi and .tre files can be saved in most folders on your computer but the examples below assume the tutorial files are in the FuelCalc_Tutorial_Files folder saved on your desktop. It is recommended to save the tutorials folder on the desktop while completing the example simulations in this document.

Overview

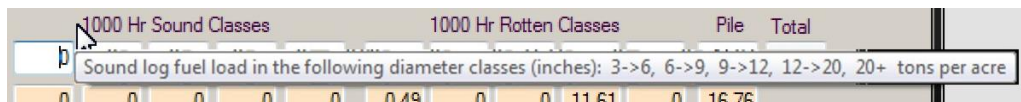
Getting Help

There are several ways to get help in FuelCalc. The most exhaustive information is provided in the User Guide. 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.

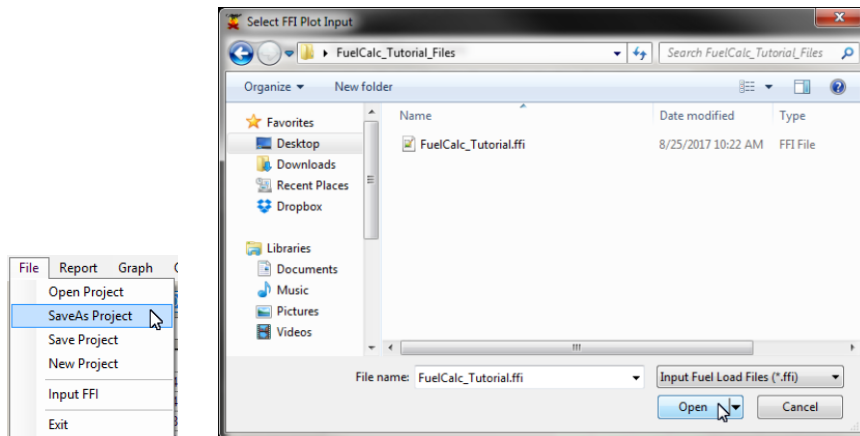


1000 Hr Sound Classes	1000 Hr Rotten Classes	Pile	Total
Sound log fuel load in the following diameter classes (inches): 3->6, 6->9, 9->12, 12->20, 20+ tons per acre			
0	0	0	0
0	0.49	0	0
0	0	11.61	0
0	0	0	16.76

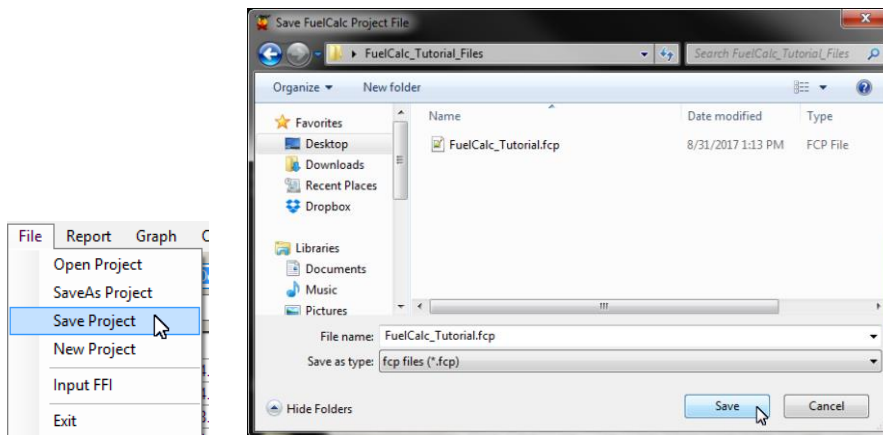
Finally, the *Crown Ratio Help* button on the *Settings* window and the *Quick Reference* button on the *Graph – Fuel Stand* window provide information specific to those windows.

Initial Setup

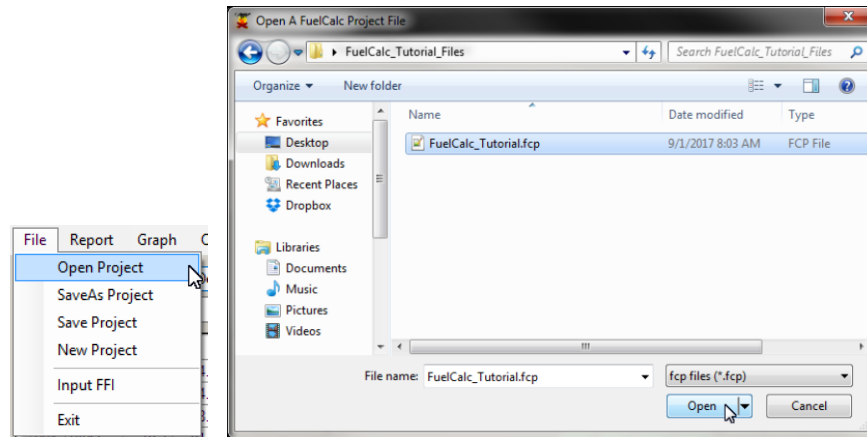
1. Make sure the *FuelCalc_Tutorial_Files* folder is on your computer desktop.
2. Run the FuelCalc application by double-clicking the **FuelCalc** icon on your desktop. FuelCalc will probably open using default sample files but you will use different files to complete the example exercises.
3. First, you will need to select a *.ffi* file. Select **File>Input FFI**, navigate to the *FuelCalc_Tutorial_Files* folder on your computer desktop, select *FuelCalc_Tutorial.ffi* and click **Open**.



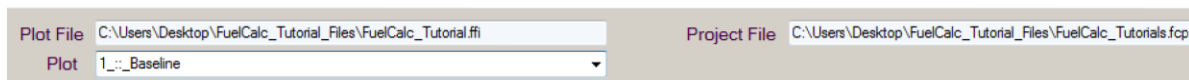
4. Next you will create a “Project File” file that provides links to the associated *.ffi* and *.tre* files and stores the treatment, retention priority and species group settings you will create. Click **File>SaveAs Project**, navigate to the *FuelCalc_Tutorial_Files* folder on your computer desktop, name the project file *FuelCalc_Tutorial.fcp* and click **Save**.



5. Now open the project file you just saved. Click **File>Open Project**, navigate to the *FuelCalc_Tutorial_Files* folder on your computer desktop and select *FuelCalc_Tutorial.fcp*.



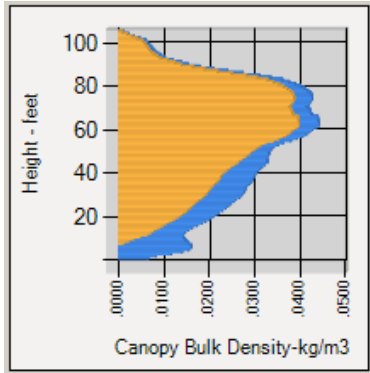
6. The main screen is divided into several sections. At the top is the main menu and fields for the current plot file (*.ffi* extension), the selected project (*.fcp* extension) and the current plot selection. Other plots are available in the *Plot* field dropdown.



7. The data grid or “treelist” displays the records in the *.tre* file with additional columns for *Retention Priority (RP)*, *Thinned* and *Killed*; 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	
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	

8. 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.



9. 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	3.01	0.040	12.0	103	120.0	222.5	41.2	151	15.2 20.5

10. 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	50
Post	100	54

11. 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	
Post Thinning Slash -----						0.07	0.03	0.06	0.14	0	0	0	0	0	decimals 2 <input type="text" value="2"/>						
Post Prune Slash -----						0	0	0	0											0	0.30
Consumed -----	5.67	0.25	0	0	0.10	7.06	0.07	0.52	1.98	0	0	0	0	0	0.96	0	0	10.97	0	0	27.57
Post-treatments	2.32	0	0	0	0.06	0.61	0	0	0	0	0	0	0	0	0.02	0	0	12.25	0	0	15.27

12. 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.

The screenshot shows the FuelCalc software interface with the following settings:

- Calculate** button
- Treatment Name**: Restore (dropdown)
- Save Treatment** button
- Retention Priority Set**: Low (dropdown)
- Thinning** (checked):
 - TreeDensity: 200.0
 - Thin To Target: 200.0
 - Cut Efficiency %: 90
 - Merch dia >=: 4.0
 - Top Diameter: 2.0
 - Yard Loss %: 20
 - 0 <DBH> 8.0
- Prune** (unchecked):
 - Height: 0
 - M R C R %: 0
- Pile** (unchecked):
 - Surface %: 0
 - Slash %: 0
 - Consumed %: 0
- Broadcast Burn** (checked):
 - Pre-burn Duff Depth (in): 0.80
 - Scorch Hgt (ft): 10.0
 - Moss+Lichen %: 90
 - Moisture: Dry (dropdown)
 - 10 Hr: 12
 - 1k Hr: 14
 - Duff: 30
 - Region: InteriorWest (dropdown)
 - Season: Summer (dropdown)
 - Emission Factor: Expanded (radio button)
- Fire Behavior Fuel Model Selector**:
 - All (dropdown)
 - Arid (dropdown)
 - Herb: 1800
 - Shrub: 1500
 - 1 Hr: 2000
 - SAV: 1800
 - Pre-treatment Model: TL9
 - Post-treatment Model: TL5
- Short-term Flaming and Smoldering**: 4 - Western Forest - WI (dropdown)
- Duff RSC**: 8 - Duff RSC (dropdown)
- Coarse Wood RSC**: 7 - Woody RSC (dropdown)

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 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 on your computer desktop, select the *FuelCalc_Tutorial.fcp* file and click **Open**.

The screenshot shows the FuelCalc software interface with the following settings:

- Plot File**: C:\Users\Desktop\FuelCalc_Tutorial_Files\FuelCalc_Tutorial.fci
- Plot**: 1_:_Baseline (dropdown)
- Project File**: C:\Users\Desktop\FuelCalc_Tutorial_Files\FuelCalc_Tutorials.fcp

2. The *Plot* dropdown list includes all the plots in the .fci. For the examples you will use the first plot: *1_:_Baseline*.

The screenshot shows the FuelCalc software interface with the following settings:

- Plot File**: C:\Users\Desktop\FuelCalc_Tutorial_Files\FuelCalc_Tutorial.fci
- Plot**: 1_:_Baseline (dropdown)
- Project File**: C:\Users\Desktop\FuelCalc_Tutorial_Files\FuelCalc_Tutorials.fcp

3. Set up a *Thinning* simulation. Check the box for *Thinning* treatment and enter the values shown below.

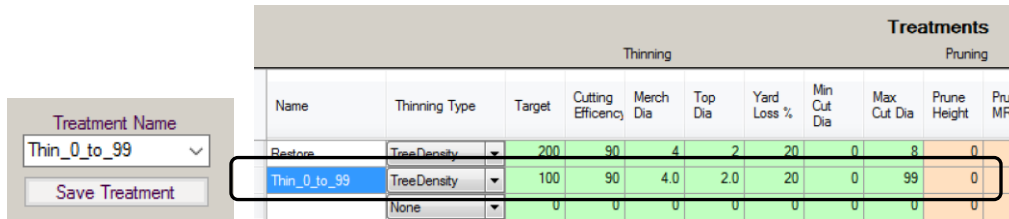
The screenshot shows the FuelCalc software interface with the following settings:

- Thinning** (checked):
 - TreeDensity: 100
 - Thin To Target: 100
 - Cut Efficiency %: 90
 - Merch dia >=: 4.0
 - Top Diameter: 2.0
 - Yard Loss %: 20
 - 0 <DBH> 99

4. Uncheck the boxes for the *Prune*, *Pile* and *Broadcast Burn* treatments, if they are checked.

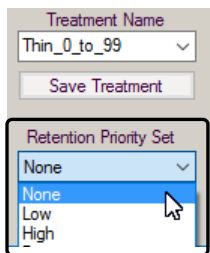


5. Save the treatment settings so it can be reused later. Type *Thin_0_to_99* in the *Treatment Name* field (spaces are not allowed in *Treatment Names*) and click the **Save Treatment** button below the field. The *Settings* window will open and the new treatment will be displayed. You can leave the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



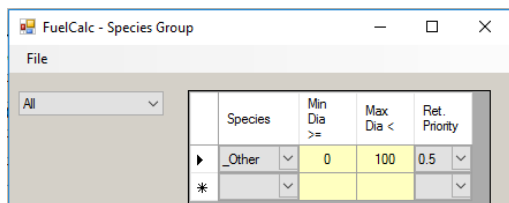
NOTE: You may open the Settings window at any time by clicking **Option>Settings**.

6. *Retention Priority Sets* are used to set retention preferences for some species; they will be explained more in the third example. For now, set the *Retention Priority Set* to **None** by selecting it in the dropdown.



7. Click **File>Save Project**, select *Fuelcalc_Tutorial.fcp*, click **Save** and click **Yes** to overwrite the file. 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. To see the Species Group retention priorities click open the Settings window (**Options>Settings**) and click the **Species Group** button at the bottom of the window.



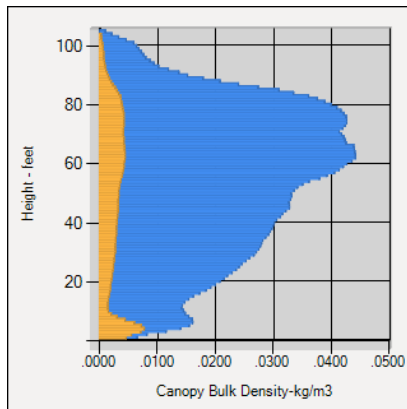
In this example, all retention priorities for the *None* retention priority set equal 1 and in the Species Group all tree species (*_Other*) are set to 0.5. The product of those is $1 \times 0.5 = 0.5$, so all records are assigned that retention priority (dead trees do not get assigned retention priority). If tree records have the same *RP* trees then 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	GrCl	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 of 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/m^3 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 removes approximately 90% of the standing volume, providing approximately 21,870 merchantable board feet per acre (MB Ft). Other volume values are cubic feet (Cubic Ft) and merchantable cubic feet (MC Ft)

Timber Volume			
	Cubic Ft	MC Ft	MB 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 50 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 50 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: some surface fuels increased, the CBH was lower post-treatment and 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 50	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	Target met
Basal area	Too low
Merchantable material	Provides substantial merchantable volume
Fire risk	Crowning Index increases; Torching Index unchanged

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.

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

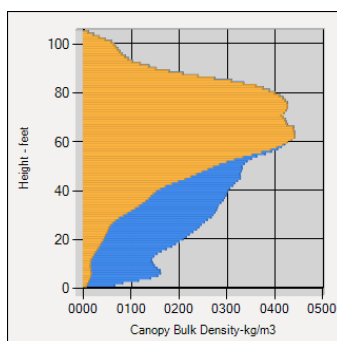
3. Click **File>Save Project** to save the changes. If you don't save your project the new treatment will be lost when FuelCalc is closed.

4. Click **Calculate**.

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

Nun	Species	DBH	TH	CBH	GrCl	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	4642	4242	22860
Harvested	364	302	1440

9. The Torching Index (TORI) increased to 58 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											
		Duff	Herb	Lichen	Moss	Shrub	Litter	1 Hr	10 Hr	100 Hr			
Pre	0	50	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84		
Post	58	50	Surface Fuel Piled					0	0	0	0		
			Post Thinning Slash					0.34	0.13	0.26	0.46		

Treatment Review:

Component	Result
Stand density	Target met
Basal area	Too high
Merchantable material	Provides little merchantable volume
Fire risk	Crowning Index unchanged, Torching Index increased

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	Open/Grow	None	CRspec	CRmax	Diameter	Species Group		
None	Has no influence	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	All	▼
Low	Default Low Thinning	1.0	0.7	0.2	0.0	1.0	0.9	0.6	1.0	0.1	1.0	1.0	0.5	0.6	0.8	All	▼	
High	Default High Thinning	1.0	0.7	0.2	0.0	0.4	0.5	1.0	0.1	1.0	1.0	1.0	0.5	0.6	0.6	PIPO	▼	
Dam	Default diameter limit harvest	1.0	0.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.1	None	▼	
▶	Restoration	1	0.5	0.5	0	1	1	0.5	1	0.2	0.8	1	1	1	1	PIPO	▼	
*		0	0	0	0	0	0	0	0	0	0	0	0	0	0		▼	

Note: To delete a grid row, select row and hit Delete key
Retention Priority Factors must be a value from 0 to 1

Crown Ratio Help Settings Report Species Group **Apply**

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. Select the PIPO species group from the dropdown on the left.

FuelCalc - Species Group

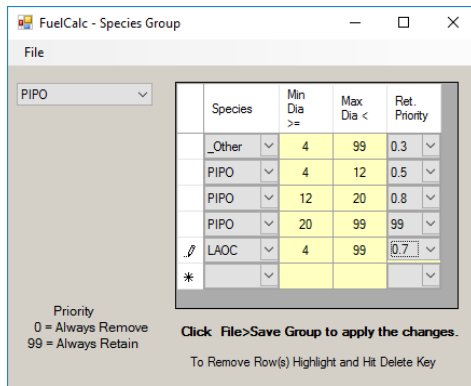
File

PIPO ▼

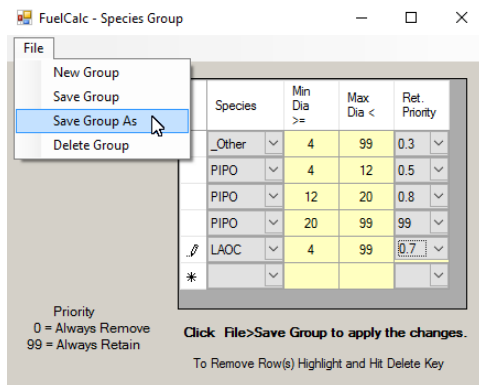
Species	Min Dia >=	Max Dia <	Ret. Priority
▶ _Other	0	100	0.5
PIPO	0	100	99
*			

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.

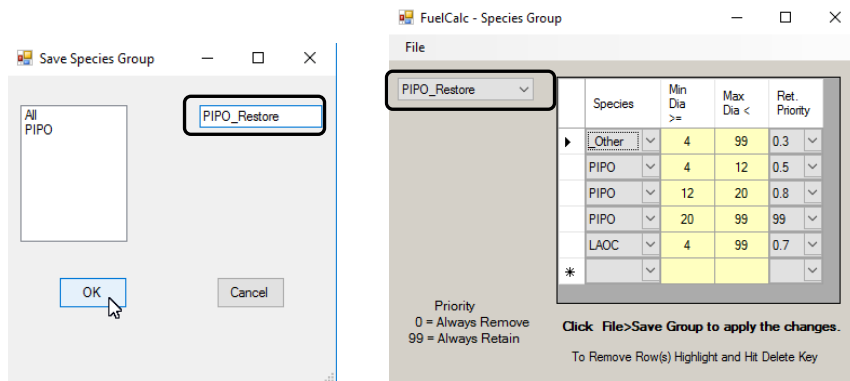
NOTE: To delete a row in the table click the gray area to the left of the row to highlight it and then click the Delete key on your keyboard.



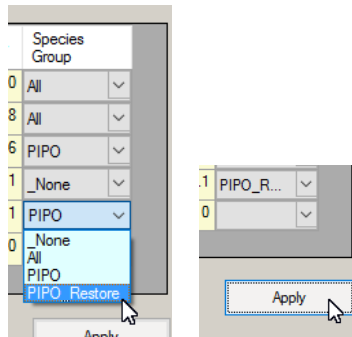
4. In the *Species Group* window click **File>Save Group As**.



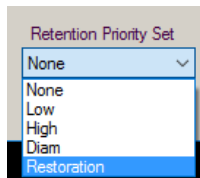
5. Type the species group name *PIPO_Restore* in the field at the upper right and click **OK**. The new Species Group name will display in the dropdown field. Close the *Species Group* window by clicking "X" in the upper right.



6. In 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.

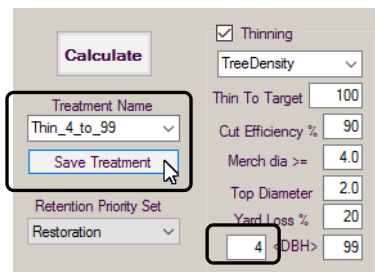


7. Select the **Restoration** Retention Priority Set in the dropdown at the lower left on the main screen.



8. 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.



9. Make the 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**.

NOTE: There is a bug in FuelCalc 1.6 that sometimes causes the moisture values to be set to 0. If this happens simply select the desired moisture regime from the dropdown and the correct moisture values will be assigned.

☒ Broadcast Burn

Pre-burn Duff Depth (in) 0.80

Scorch Hgt (ft) 4

Moss+Lichen % 90

Moisture 10 Hr 1k Hr Duff

Moderate 16 30 75

Region InteriorWest Season Summer

NOTE: Tree mortality is a function of scorch height and DBH. The other settings in the Broadcast Burn box are used to modify fuel consumption and emissions.

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

Calculate

Treatment Name Thin_4_to_99

Save Treatment

Retention Priority Set Restoration

☒ Thinning

Tree Density

Thin To Target 100

Cut Efficiency % 90

Merch dia >= 4.0

Top Diameter 2.0

Yard Loss % 20

4 <DBH> 99

☐ Prune

Height 0

M R C R % 0

☐ Pile

Surface % 0

Slash % 0

Consumed % 0

Short-term Flaming and Smoldering 4 - Western Forest - WI

Duff RSC 8 - Duff RSC

Coarse Wood RSC 7 - Woody RSC

☒ Broadcast Burn

Pre-burn Duff Depth (in) 0.80

Scorch Hgt (ft) 4

Moss+Lichen % 90

Moisture 10 Hr 1k Hr Duff

Moderate 16 30 75

Region InteriorWest Season Summer

Emission Factor ☐ Default ☒ Expanded

Fire Behavior Fuel Model Selector

All Arid

Herb Shrub 1 Hr

SAV 1800 1500 2000

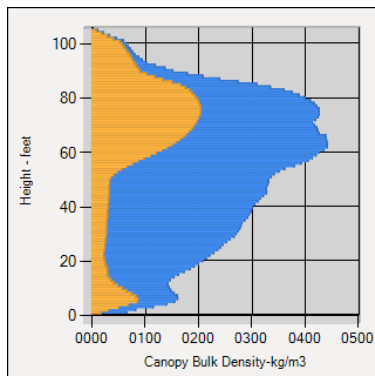
Pre-treatment Model TL9

Post-treatment Model TU1

11. 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.

12. Click **Calculate**.

13. 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.



14. 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

15. 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.

16. 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

17. 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

18. 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

19. 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.

	TORI	CRNI
Pre	0	62
Post	100	100

Review:

Component	Result
Stand density	Target met
Basal area	Target met
Merchantable material	Provides merchantable volume
Fire risk	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	0.54
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:

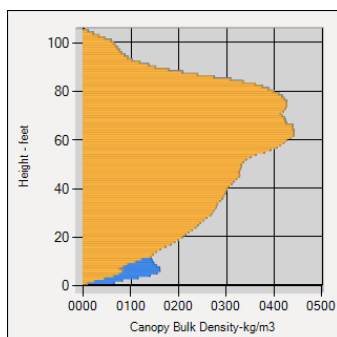
Fire Behavior Fuel Model Selector
 All: Arid:
 Herb: Shrub: 1 Hr:
 SAV:
 Pre-treatment Model:
 Post-treatment Model:

Prune Treatment Simulation

1. Select the *Thin_0_to_99* Treatment, set *Retention Priority Set* to **Restoration** and uncheck the boxes for the *Thinning* and *Broadcast Burn* 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-treatment* 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 10
 M R C R % 50

☒ Pile
 Surface % 50
 Slash % 75
 Consumed % 90

2. The *Surface Fuel Piled* row shows 50% of the *Pre-treatment* row and 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	decimals 2 <input type="text" value="2"/>						
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 the in 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	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	decimals 2							
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	

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	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

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).

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*.

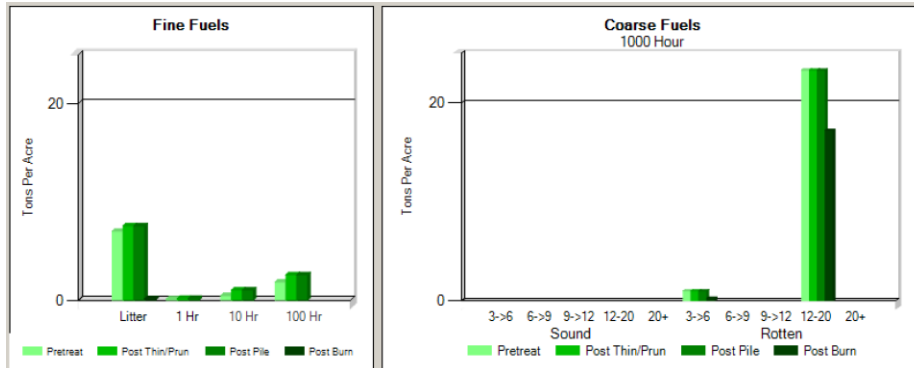
	A	B	C	D	E	F	G	H	I	J	K	L
1		Duff	Herb	Lichen	Moss	Shrub	Litter	1Hr	10Hr	100Hr	SC1snd	SC2s1
2		T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac	T/ac
3	Pre-Treatment	7.99	0.25	0	0	0.16	6.99	0.04	0.46	1.84	0	
4	Thinned						0.2	0.08	0.15	0.24	0	
5	Pruned						0.02	0.01	0.02	0.01		
6	Consumed	-4.13	-0.25	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.

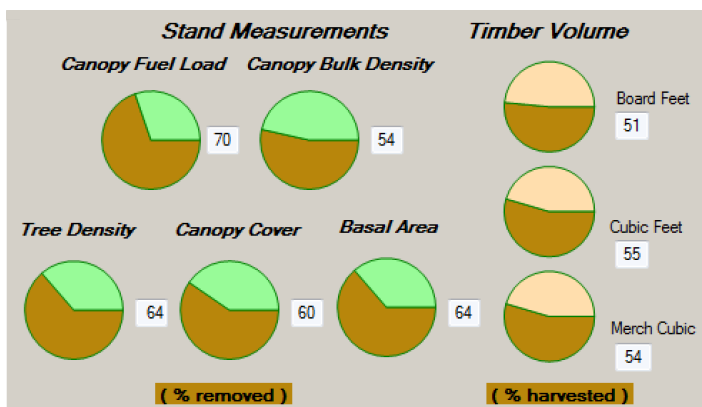
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		TN	RPS	TreeNum	Species	DBH	TH	CBH	CC	TS	TD	RPV	Thinned	Killed
2						in	ft	ft			trees/ac		trees/ac	trees/ac
3	1 :: Baseline	Thin_0_to_99	Restoration	1	PIPO	23.7	104	57	D	H	10	99	0	1
4	1 :: Baseline	Thin_0_to_99	Restoration	2	LAOC	22.7	94	62	D	H	10	0.63	0	0
5	1 :: Baseline	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	13.5	60	12	C	H	10	0.56	0	1

Graphs – Fuel Stand

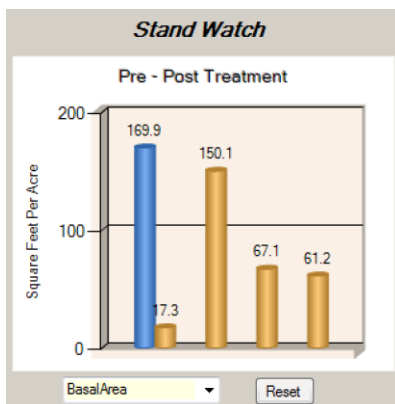
Click **Graph>Fuel Stand** to view a window with several graphs. The top bar graphs show the pre-treatment, post-thinning and pruning, post-pile and post-burn loading for fine and coarse fuels. Right-click the graph area for options to save or print the graphs.



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



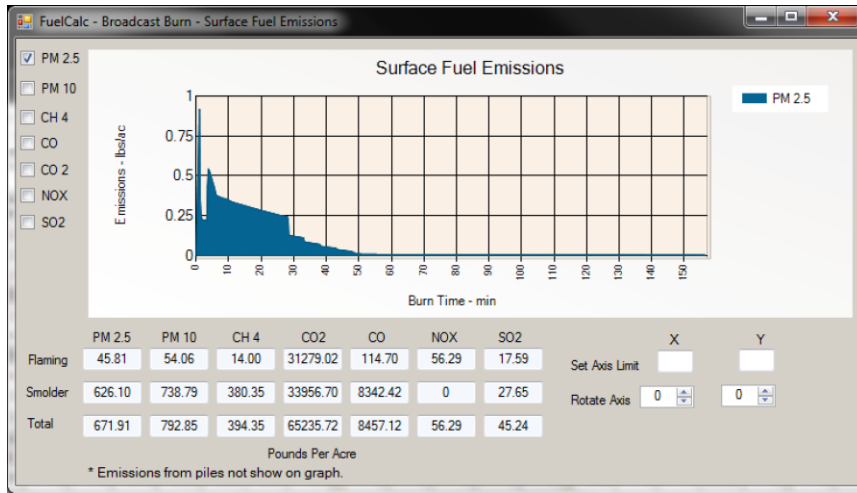
The *Stand Watch* graph updates automatically as treatments are changed on the user interface. The value that is graphed is selected in the dropdown below the graph: *Canopy Fuel Load*, *Canopy Bulk Density*, *Tree Density* and *Basal Area*. Right-click the graph area for options to save or print the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



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.



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.

