Exercise Answers

1. **Compare the fire types using fuel models TU1, TU3, TU5, 8 and 10 for a range of 1-h dead fuel moistures. Use a canopy bulk density of 0.015 lb/ft^3 and a canopy base height of 6 ft. Use your experience to estimate the other inputs.**

   - Open **SurfaceCrown.bpw**.
   - Based on the information in the question, fill in the Worksheet as follows. Your answers will differ depending on the inputs you have selected.

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Inputs: SURFACE, CROWN

Description		Crown Fire Spread Exercise 1
Fuel/Vegetation, Surface/Understory		
Fuel Model		8, 10, tu1, tu3, tu5
Fuel/Vegetation, Overstory		
Canopy Base Height	ft	6
Canopy Bulk Density	lb/ft3	0.015
Fuel Moisture		
1-h Moisture	%	5 10 15
10-h Moisture	%	7
100-h Moisture	%	9
Live Herbaceous Moisture	%	30
Live Woody Moisture	%	125
Foliar Moisture	%	100
Weather		
20-ft Wind Speed (upslope)	mi/h	20
Wind Adjustment Factor		0.2
Terrain		
Slope Steepness	%	35

Run Option Notes

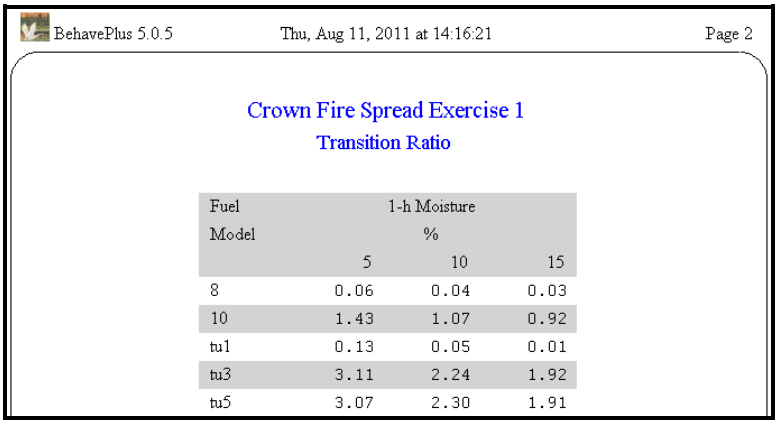
None

Output Variables

Transition Ratio [CROWN]
Active Ratio [CROWN]
Fire Type [CROWN]

Notice that the SURFACE module is selected, but there are no SURFACE outputs. The SURFACE module will calculate the Fireline Intensity necessary for the Transition Ratio.

- **Calculate** the Run.



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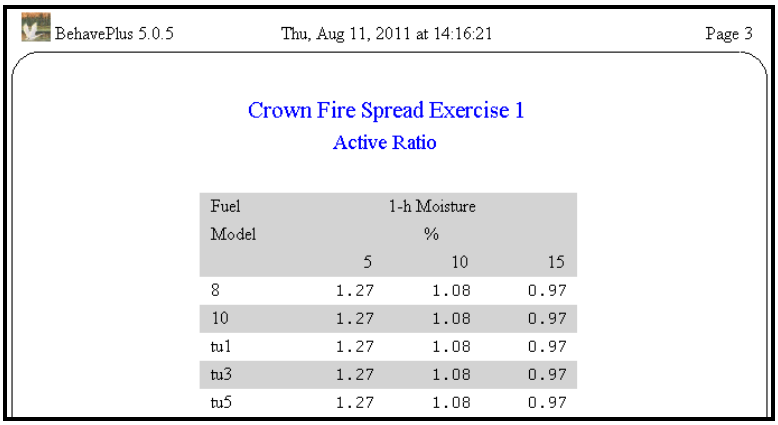
Crown Fire Spread Exercise 1

Transition Ratio

Fuel Model	1-h Moisture %		
	5	10	15
8	0.06	0.04	0.03
10	1.43	1.07	0.92
tu1	0.13	0.05	0.01
tu3	3.11	2.24	1.92
tu5	3.07	2.30	1.91



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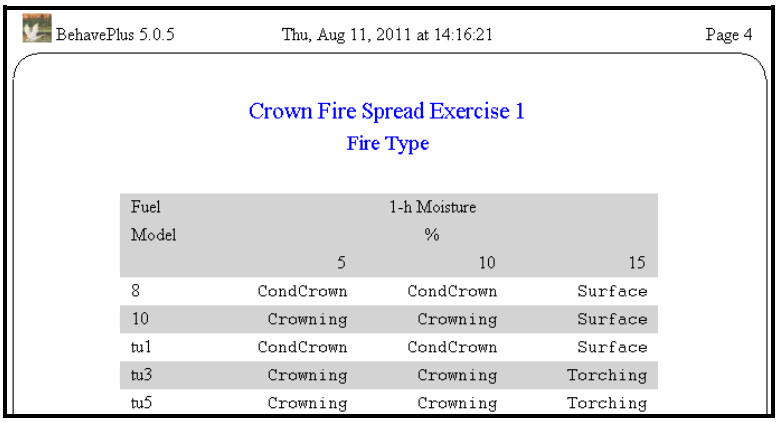
Crown Fire Spread Exercise 1

Active Ratio

Fuel Model	1-h Moisture %		
	5	10	15
8	1.27	1.08	0.97
10	1.27	1.08	0.97
tu1	1.27	1.08	0.97
tu3	1.27	1.08	0.97
tu5	1.27	1.08	0.97



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Crown Fire Spread Exercise 1

Fire Type

Fuel Model	1-h Moisture %		
	5	10	15
8	CondCrown	CondCrown	Surface
10	Crowning	Crowning	Surface
tu1	CondCrown	CondCrown	Surface
tu3	Crowning	Crowning	Torching
tu5	Crowning	Crowning	Torching

Fire type is one of four types:

- Surface (understory fire)
- Torching (passive crown fire; surface fire with occasional torching trees)
- Conditional Crown (active crown fire possible if fire transitions to the overstory)
- Crowning (active crown fire, fire spreading through the overstory crowns)

Assignment of Fire Type depends on the variables Transition to Crown Fire and Active Crown Fire.

Fire Type		**Active Crown Fire? $A_R \geq 1.0$?**	
		No	Yes
Transition to Crown Fire? $T_R \geq 1.0$?	No	Surface	Conditional Crown
	Yes	Torching	Crowning

How close are the ratios to 1? Knowing the uncertainty in the model inputs, how confident are you in the answers? Values for the Transition Ratio are fairly different from 1 for 4 of the 5 fuel models. Therefore, you would have more confidence in your ability to predict the transition to crown fire than whether or not an active crown fire could be sustained at a 1-h fuel moisture greater than 5%.

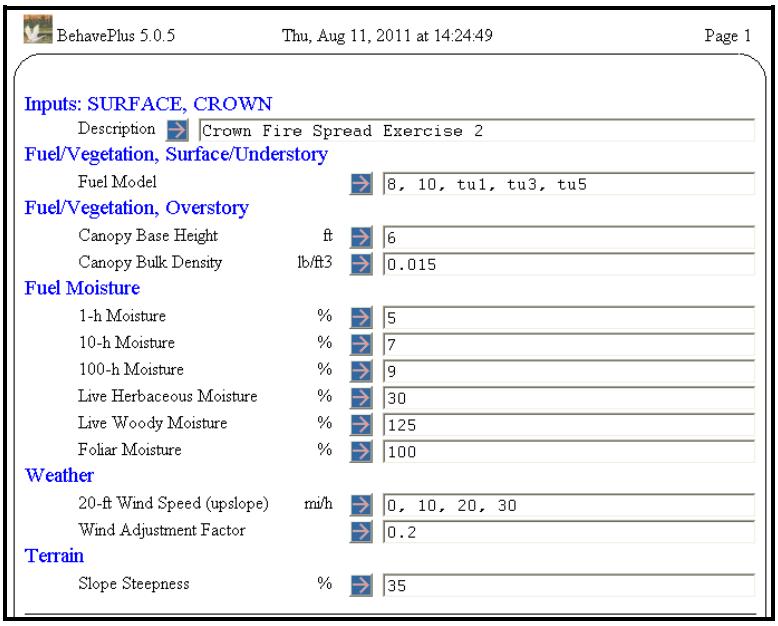
In this exercise, Fuel Model 8 shows **CondCrown** when the 1-h Fuel Moisture is 5% and 10%; this results from a **No** for Transition to Crown Fire? and a **Yes** for Active Crown Fire? (Crowning requires a **Yes** answer to both questions.)

Fuel models TU1 and TU3 are dynamic fuel models, so at 30% Live Fuel Moisture, the entire Live Herbaceous Load in the Fuel Model parameter file is transferred to the dead category. This increase in 1-h Fuel Load can increase the Flame Length, which affects transition to crown fire.

2. Modify the run for Exercise 1 to compare the fire types using fuel models TU1, TU3, TU5, 8 and 10 for a range of wind speeds while holding the fuel moistures constant.

In Exercise 1, you examined the effect of fuel moisture on the Fire Type. In Exercise 2, you will examine the effect of wind speed on Fire Type.

- Change the 1-h Moisture from a range of values (5 to 15% in our example) to a single value. We changed the 1-h Moisture to 5%.
- Select a range of reasonable 20-ft Wind Speed (upslope) values. We selected a range of values from 0 to 30 mi/h.
- Your Worksheet should look similar to the following.



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Inputs: SURFACE, CROWN

Description		Crown Fire Spread Exercise 2
Fuel/Vegetation, Surface/Understory		
Fuel Model		8, 10, tu1, tu3, tu5
Fuel/Vegetation, Overstory		
Canopy Base Height	ft	6
Canopy Bulk Density	lb/ft3	0.015
Fuel Moisture		
1-h Moisture	%	5
10-h Moisture	%	7
100-h Moisture	%	9
Live Herbaceous Moisture	%	30
Live Woody Moisture	%	125
Foliar Moisture	%	100
Weather		
20-ft Wind Speed (upslope)	mi/h	0, 10, 20, 30
Wind Adjustment Factor		0.2
Terrain		
Slope Steepness	%	35

- **Calculate** the Run.

The tabular results indicate that conditions may be met for all four Fire Types.

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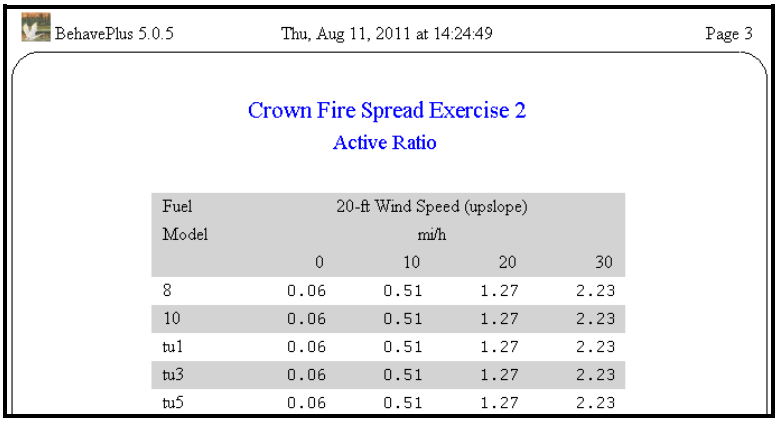
Crown Fire Spread Exercise 2

Transition Ratio

Fuel Model	20-ft Wind Speed (upslope) mi/h			
	0	10	20	30
8	0.02	0.04	0.06	0.10
10	0.44	0.81	1.43	2.20
tu1	0.04	0.07	0.13	0.20
tu3	0.78	1.69	3.11	4.82
tu5	0.95	1.89	3.07	4.37



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Crown Fire Spread Exercise 2

Active Ratio

Fuel Model	20-ft Wind Speed (upslope) mi/h			
	0	10	20	30
8	0.06	0.51	1.27	2.23
10	0.06	0.51	1.27	2.23
tu1	0.06	0.51	1.27	2.23
tu3	0.06	0.51	1.27	2.23
tu5	0.06	0.51	1.27	2.23

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Crown Fire Spread Exercise 2

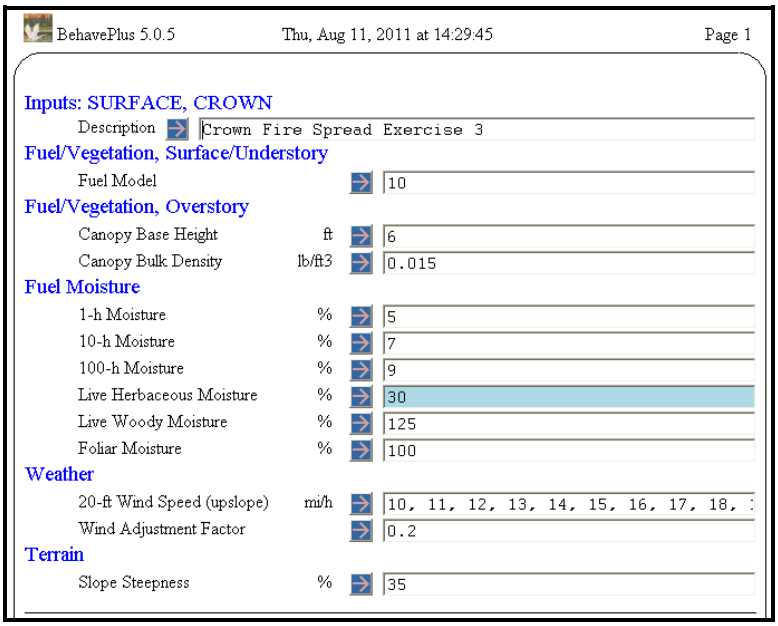
Fire Type

Fuel Model	20-ft Wind Speed (upslope) mi/h			
	0	10	20	30
8	Surface	Surface	CondCrown	CondCrown
10	Surface	Surface	Crowning	Crowning
tu1	Surface	Surface	CondCrown	CondCrown
tu3	Surface	Torching	Crowning	Crowning
tu5	Surface	Torching	Crowning	Crowning

This comparison shows that as wind speeds increase, fire behavior increases from surface to crown fire, depending on the fuel model. Fuel models 8 and TU1 do not progress to crown fire conditions, due to the lower flame lengths compared to the other fuel models. Fuel model 10 results in surface fire at 10 mi/h and crowning at 20 mi/h.

3. Modify the Run in Exercise 2 to determine at which wind speed the Fire Type changes for Fuel Model 10 under these conditions. Remove all fuel models except Fuel Model 10 and use a range of wind speeds based on your results from Exercise 2. This will provide more information on the influence of wind speed on Fire Type for this Fuel Model.

- Remove all Fuel Models *except* Fuel Model 10.
- Change 20-ft Wind Speed to range from 10 to 20 mi/h with a Step of 1.
- Ensure your outputs include at least the following:
  - Transition Ratio
  - Transition to Crown Fire?
  - Active Ratio
  - Active Crown Fire?
  - Fire Type



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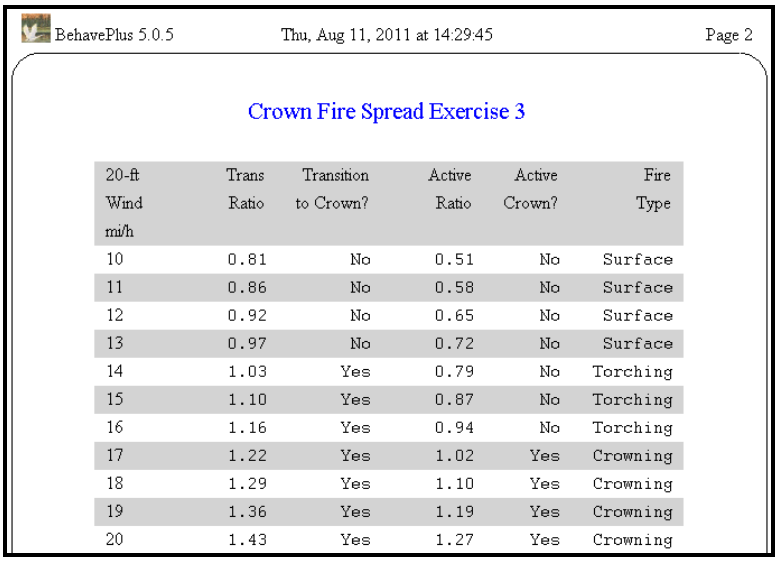
Inputs: SURFACE, CROWN

Description		Crown Fire Spread Exercise 3
Fuel/Vegetation, Surface/Understory		
Fuel Model		10
Fuel/Vegetation, Overstory		
Canopy Base Height	ft	6
Canopy Bulk Density	lb/ft3	0.015
Fuel Moisture		
1-h Moisture	%	5
10-h Moisture	%	7
100-h Moisture	%	9
Live Herbaceous Moisture	%	30
Live Woody Moisture	%	125
Foliar Moisture	%	100
Weather		
20-ft Wind Speed (upslope)	mi/h	10, 11, 12, 13, 14, 15, 16, 17, 18,
Wind Adjustment Factor		0.2
Terrain		
Slope Steepness	%	35

- **Calculate** the Run.



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Crown Fire Spread Exercise 3

20-ft Wind mi/h	Trans Ratio	Transition to Crown?	Active Ratio	Active Crown?	Fire Type
10	0.81	No	0.51	No	Surface
11	0.86	No	0.58	No	Surface
12	0.92	No	0.65	No	Surface
13	0.97	No	0.72	No	Surface
14	1.03	Yes	0.79	No	Torching
15	1.10	Yes	0.87	No	Torching
16	1.16	Yes	0.94	No	Torching
17	1.22	Yes	1.02	Yes	Crowning
18	1.29	Yes	1.10	Yes	Crowning
19	1.36	Yes	1.19	Yes	Crowning
20	1.43	Yes	1.27	Yes	Crowning

The Fire Type changes from Surface to Torching at 14 mi/h when the Transition to Crown Fire? variable is **Yes**, and to an active crown fire at 17 mi/h under these conditions, when the Active Crown Fire? variable is also **Yes**.