ASHLAND FOREST ALL-LANDS RESTORATION SUPPLEMENT TO THE 2005 SCOTT AND BURGAN STANDARD FUEL MODEL PHOTO GUIDE

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All photos Keith Perchemlides, The Nature Conservancy, except where noted.

Purpose: This photo-guide is intended to supplement the widely used Scott and Burgan 2005 fuel model guide[1], providing local perspective on fuel model assignment in the mixed conifer-hardwood forests and oak woodland habitats of the Siskiyou mountains and Cascade foothills of southwest Oregon, centered on the watershed for the City of Ashland. Our intent is to provide a field guide for monitoring crews that assists in accurately and consistently applying the Scott and Burgan models to our local habitats and fuels.

In Ashland Forest All-Lands Restoration (AFARI) project, we use the Scott and Burgan fuel models to record stand conditions, plan prescribed burns and estimate change in fuels and fire risk from thinning or burning treatments. At a landscape scale, fuel models are used as inputs in fire-behavior modeling to inform land and fire management planning and assess the effectiveness of forest management to reduce wildfire risk or facilitate safe use of fire.

The 40 fuel models defined by Scott and Burgan are standardized descriptions that allow the user to rapidly categorize wildland fuels and estimated fire behavior. The Scott and Burgan fuel models are for estimating surface and understory fuels and fire, not crown fire scenarios.

Selection of a fuel model identifies:

1. The primary type of fuel expected to carry surface fire
2. Typical fuel loading and characteristics
3. Likely flame length and rate of spread under defined conditions

Strengths of Scott and Burgan fuel models:

1. Generally accurate enough to inform decisions, without excessive precision
2. Widely used by fire professionals; convey significant meaning and multiple interpretations
3. Assignment of fuel model by an experienced technician can be rapid and consistent

Limitations of Scott and Burgan fuel models:

1. Correct model assignment requires experience and practice in the field
2. Calibration is critical for consistent fuel model assignment across observers
3. Photo examples provided by Scott and Burgan are from disparate, widespread forest types from across the country and can be locally misleading
4. Decisions on fuel model assignment can be inconsistent depending on assumed conditions. For example, in prescribed burn planning the fuel model chosen may reflect expected fire behavior under plan conditions, rather than directly representing the actual fuels/loading present.
5. In dry or semi-arid western climates, users of the decision key in Scott and Burgan's publication (p. 10 – 12) can be confused by the distinction between humid and dry (arid) climate types and fuel models, incorrectly assuming that humid models should not be used in our area (see below).
6. The Scott and Burgan publication covers the entire United States. Locally, this means that their guide includes a range of fuel models that are not relevant or appropriate for our area; this can complicate the model selection process.

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[1] Scott, Joe H.; Burgan, Robert E. 2005. **Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model**. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p. Available at: https://www.fs.fed.us/rm/pubs/rmrs_gtr153.pdf

Selecting a fuel model in the field using this guide:

The following photos and descriptions are intended to provide local examples and interpretation to supplement, but not replace, the fuel model guide and descriptions provided by Scott and Burgan. Not all 40 Scott and Burgan models are covered here; models not relevant for our area were left out.

Importantly, the distinction between humid and arid fuel models in Scott and Burgan's guide does *not* mean humid climate models should be avoided locally. **Both humid and dry (arid) fuel models can and should be used** to best characterize the full range of fuels in our area. *(We have consulted with Joe Scott who agrees that ignoring this split is appropriate for our region of southwest Oregon and similar western climate types.)*

Our intent is to assign fuel models for monitoring that represent actual fuels present. In planning prescribed burns, knowledgeable fire staff may appropriately select a different fuel model to best estimate fire behavior during the target prescription conditions. We provide fire behavior estimates under a wide range of burn conditions to aid in selection of models that include all fuels present.

Select a fuel model based on the surface and understory fuels present: the type, amount, structure and arrangement of live and dead fuels and their likely effect on fire behavior:

1. Determine the primary carrier of surface fire: The vegetation or litter type (or combination) most likely to carry surface fire across the relevant area. This is *not necessarily* the dominant live vegetation type. Overstory canopy is not considered except as a source of litter and down wood.

2. Consider all surface fuels present, their abundance, distribution and likely influence on fire behavior. For example, grass may be present in a forest understory – but is it dense and continuous enough to change how the fire burns? Are the shrubs or oaks in a savanna grassland widespread and abundant enough to alter fire behavior across the area?

3. Select the **best-fit fuel type**. Scott and Burgan fuel models are grouped into six fuel types: Grass (**GR**), Grass-Shrub (**GS**), Shrub (**SH**), Timber Understory (**TU**), Timber Litter (**TL**) and Slash/Blowdown (**SB**). For each fuel type we provide a cover-page of general information.

4. Select the **best-fit fuel model**. Within the selected fuel type, evaluate the average or typical fuel bed depth (height), load (abundance), size (diameter) and compactness (aeration) to choose the best fit within the range of models. Table 1 (below) provides typical loadings in tons/acre for fine fuels (1-hour), 10-hour and 100-hour time-lag fuel classes[2] for each fuel model. On each fuel model page below, we provide a brief description and key points for differentiating it from other fuel models, followed by 1 to 3 representative photos from local sites.

5. Check that the predicted fire behavior makes sense. Table 1 gives estimated flame length[3] and rate of spread[4] for each fire model under two scenarios: mild or extreme fire. These estimates are also on each fuel model page. Under the extreme scenario, assume that all surface fuels present, live and dead, are available to burn. Under the mild scenario, some live fuels may not contribute to fire behavior. Be open to selecting a different model or fuel type to better represent expected fire behavior.

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[2] Fine fuels include 1-hour (< ¼ inch) dead surface litter plus live herbaceous and understory fuels;
10-hour fuels are dead fuels ¼ to 1 inch in diameter;
100-hour fuels are dead woody material 1 to 3 inches diameter.

[3] Flame length is the average measure from the base to the tip of the flaming front of the fire, not the vertical height, as flames generally lean with wind and/or slope.

[4] Rate of spread is how quickly the flaming front advances, measured in chains per hour. A chain is a forestry unit of measure equal to 66 feet. For field estimates of fire rate of spread (ROS), chains per hour (ch/hr) can be converted to feet per minute (ft/min) with no significant error.

Fuel model comparison table – fuel loading and estimated fire behavior

Table 1. Comparison of predicted fire behavior and fuel loading for all fuel models covered in this guide. We estimated the average flame length (feet) and rate of spread (chain/hour or feet/min) for each fuel model using the *Compare Models Four* Excel application[5] under mild or extreme fuel moisture and fire weather conditions. See Table 2 for assumed conditions in mild or extreme fire scenarios. Fuel loads (tons/acre) by time-lag class for each model are from Scott and Burgan 2005 (p. 18).

	FLAME LENGTH (FEET)		RATE OF SPREAD (CHAINS/HOUR)		FUEL LOADING BY TIME-LAG CLASS (TONS/ACRE)		
FUEL MODEL	**Mild**	**Extreme**	**Mild**	**Extreme**	**Fine Fuels (1-hour)**	**10-hour Fuels**	**100-hour Fuels**
GR1	1.5	2.5	11	27	0.4	0.0	0.0
GR2	4.0	12.0	32	244	1.1	0.0	0.0
GR3	6.5	18.0	44	348	1.6	0.4	0.0
GS2	4.0	15.0	18	188	2.1	0.5	0.0
GS3	7.5	23.0	32	265	3.0	0.3	0.0
SH5	13.0	33.0	56	329	6.5	2.1	0.0
SH7	12.5	31.0	37	210	6.9	5.3	2.2
TU1	1.5	5.0	2	21	1.3	0.9	1.5
TU2	3.5	9.0	11	79	1.2	1.8	1.3
TU3	7.0	19.5	25	191	2.9	0.2	0.3
TU4	5.0	16.0	11	101	6.5	0.0	0.0
TU5	7.0	17.0	9	46	7.0	4.0	3.0
TL1	0.5	1.0	1	2	1.0	2.2	3.6
TL2	1.0	1.5	1	4	1.4	2.3	2.2
TL3	1.0	2.0	2	5	0.5	2.2	2.8
TL4	1.0	3.0	2	10	0.5	1.5	4.2
TL5	2.0	5.0	4	27	1.2	2.5	4.4
TL6	2.5	7.0	5	39	2.4	1.2	1.2
TL7	2.0	4.5	3	13	0.3	1.4	8.1
TL8	3.0	8.0	5	36	5.8	1.4	1.1
TL9	4.0	11.5	8	53	6.7	3.3	4.2
SB1	3.0	7.5	6	36	1.5	3.0	11.0
SB2	5.5	15.5	13	99	4.5	4.3	4.0

[5] Excel tool for graphical comparison of fire behavior under different fuel models and conditions, available at: https://www.frames.gov/catalog/792

The estimates of fire behavior in Table 1 (above) are simplified examples provided to allow for direct comparison between fuel models under standardized conditions to inform model selection. These estimates are not meant to be predictive of actual fire behavior. We provide fire behavior estimates under two scenarios, mild or extreme fire, defined by the assumptions of wind speed and fuel moisture in Table 2 (below). These two scenarios are intended to provide contrasting examples of the range of fire behaviors for each fuel model. Mild fire conditions are similar to those during local prescribed burns, and extreme conditions could reasonably be encountered during intense wildfire events with fire-driven winds in our area. Actual fire behavior is determined by an even more complex, interactive and dynamic set of factors beyond the scope of this guide.

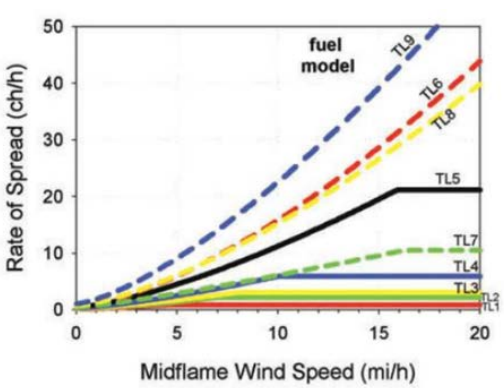
Table 2. Fuel moisture, wind-speed and slope assumptions for mild and extreme fire scenarios in Table 1.

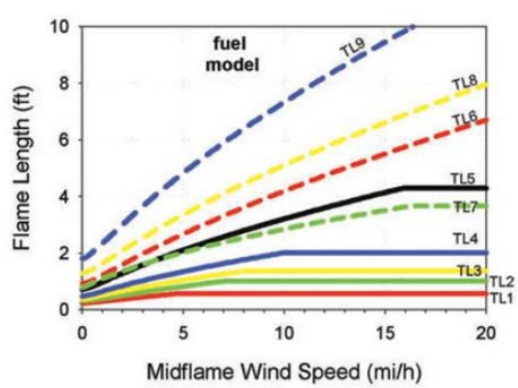
	Mild	**Extreme**
Maximum mid-flame wind speed	5 mph	15 mph
Dead fuel moisture (% by weight)**:**	Moderate	Very Low
1-hour fuels	9%	3%
10-hour fuels	10%	4%
100-hour fuels	11%	5%
Live fuel moisture (% by weight):	Low	Very Low
live herbaceous	60%	30%
live woody	90%	60%
Percent slope:	20%	20%

Interpreting the Scott and Burgan fire behavior graphs included in this guide

The flame length and rate of spread estimates in Table 1 above are included on each fuel model page below. In addition, we include copies of the color-coded flame length and rate of spread graphs from the Scott and Burgan guide. These graphs provide important perspective by showing how the fire behavior of different models vary under the same conditions, or how a single model changes under different fuel moisture levels and wind speeds.

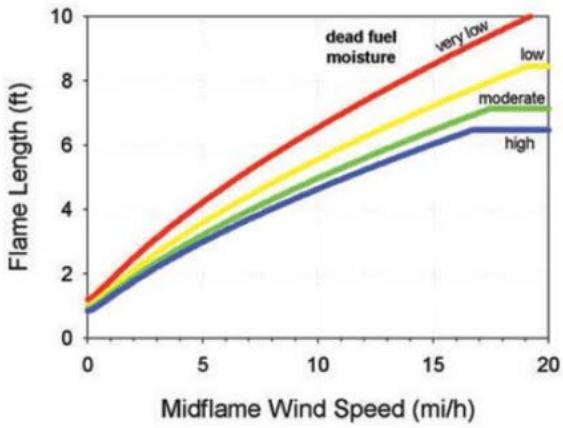
On the cover page for each **fuel type**, a pair of graphs compares fire behavior across the range of models for that fuel type: one graph for flame length, another for rate of spread, with fuel models color-coded.





For example, this pair of Scott and Burgan graphs compare fire behavior across all Timber Litter (TL) models. *In all these fuel model comparison graphs, slope is assumed to be zero and live and dead fuel moistures are both low, only wind speed varies.*

On each **fuel model** page, we include the Scott and Burgan model-specific graph of flame length across a range of color-coded dead fuel moisture scenarios. The model's rate of spread graph is not included.



Here is the graph of flame length by wind-speed for the TL3 fuel model with lines color-coded by dead fuel moisture scenarios from very low to high. *In these model-specific graphs, Scott and Burgan assumed slope to be zero and live fuel moisture to be low, varying only wind speed and dead fuel moisture (Table 3).*

Importantly, we used different assumptions (Table 2) to estimate local fire behavior and the mild or extreme fire estimates we provide (Table 1) differ substantially from those in the Scott and Burgan graphs. Scott and Burgan's assumptions are not always a good fit with local terrain or conditions.

Our flame length and rate of spread estimates (Table 1 and on fuel model pages below) are often higher than those in the Scott and Burgan graphs, especially for extreme fire and for fuel types with a substantial live fuel component. This is because Scott and Burgan consistently used a slope of zero and live fuel moisture of 60% for herbaceous and 90% for woody fuels for their graphs. For our estimates, **we assume a constant 20% slope as a reasonable midpoint for our local terrain**. For the extreme fire scenario, we adjust live fuel moisture to 30% herbaceous and 60% woody to realistically represent wildfire season conditions (Table 2). For dead fuels, we use Scott and Burgan's "moderate" dryness for the mild fire scenario and "very low" for extreme fire – these are defined in Table 3 below.

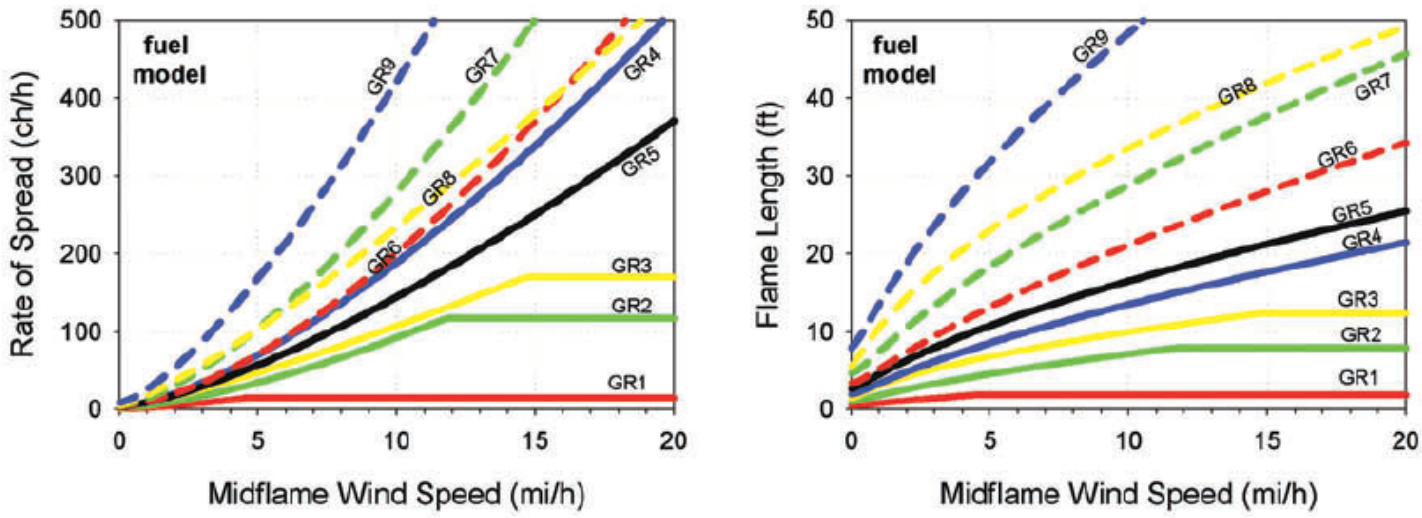
Table 3. Scott and Burgan dead fuel moisture scenarios and percent fuel moistures for 1 to 100-hour fuels.

	D1 **Very low**	D2 **Low**	D3 **Moderate**	D4 **High**
1-hr	3	6	9	12
10-hr	4	7	10	13
100-hr	5	8	11	14

Grass Fuel Models (GR)

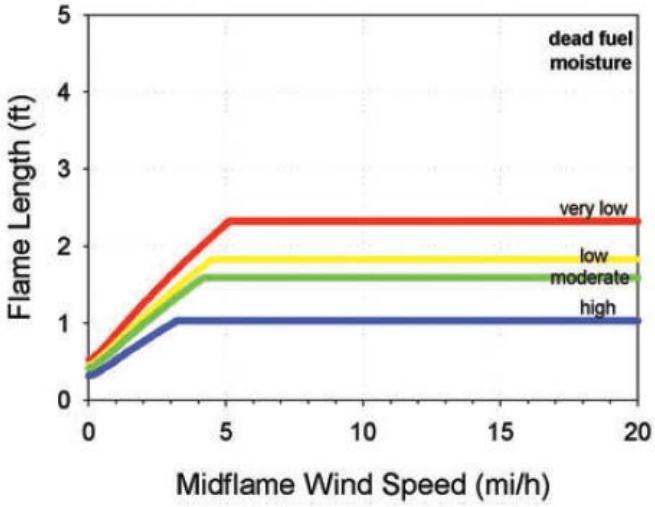
- Herbaceous plants (both grasses and forbs) are the primary carrier of fire.
- Both live and dead herbaceous plants create the fuelbed and determine fire behavior.
- Trees, shrubs, leaf litter and woody fuels may be present in small proportions but are too sparse and discontinuous to substantially alter fire behavior.
- Locally, grass fuel types are found in valley or foothill grasslands, oak or pine savanna, on dry or edaphically limited hillsides, in wetlands, forest gaps and cleared areas, or as high-elevation meadows.
- Grass fuel models GR1 – GR3 are most relevant to our area – see below.
- Grass models GR4 – GR9 are for heavier loads and greater height of grasses than typically occur in our area and are not included here.
- Go to the Grass-Shrub fuel type when shrubs are abundant and continuous enough to alter how the grass fuelbed will burn.
- Go to the Timber-Understory fuel type when leaf litter and woody fuels from an overstory canopy are an important and widespread component of the grass fuelbed.

Comparison of fire behavior metrics across the Grass fuel models (Scott and Burgan 2005).



GR1 (101)

- Primary carrier of fire: sparse grass-herbaceous; small amounts of leaf litter or woody fuel may be present
- GR1 is short, either naturally or by grazing, recent fire or mowing
- Fuel may be sparse or discontinuous
- Often on limited sites, rocky soil
- Fine fuel load is 0.4 ton/ac



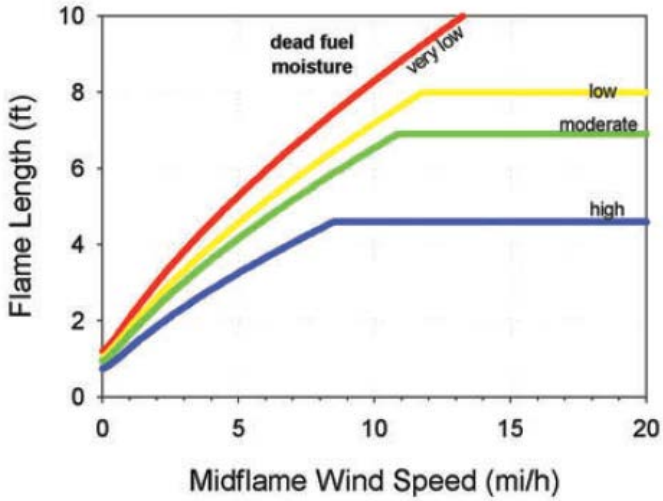
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
1.5	2.5	11	27

GR1 (101)

GR2 (102)

- Primary carrier of fire: grass-herbaceous; small amounts of leaf litter or woody fuel may be present
- Load and depth greater than GR1
- Fuelbed more continuous than GR1
- Typical of Rogue Valley or foothill grassland or savanna habitats
- Fine fuel load is 1.1 ton/ac



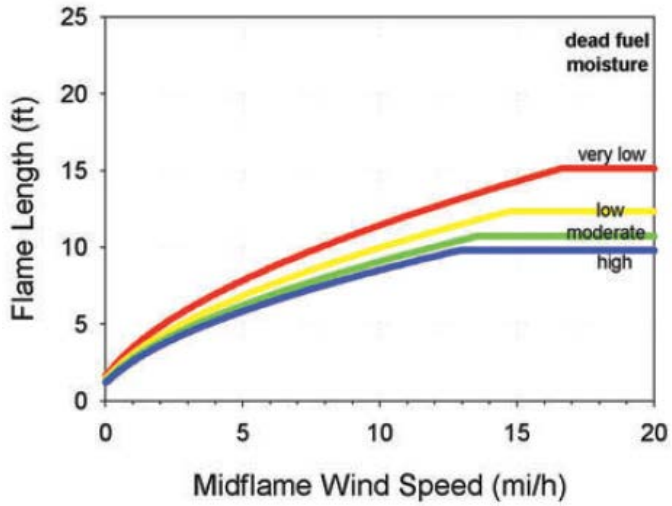
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
4.0	12.0	32	244

GR2 (102)

GR3 (103)

- Primary carrier of fire: grass-herbaceous; small amounts of leaf litter or woody fuel may be present
- Load greater than GR2, depth ~2 ft
- Fuelbed is coarser (thicker stems) than GR2 and more continuous
- Longer-season grasses or forbs
- More productive, higher-elevation or seasonally moist soils
- Fine fuel load is 1.6 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

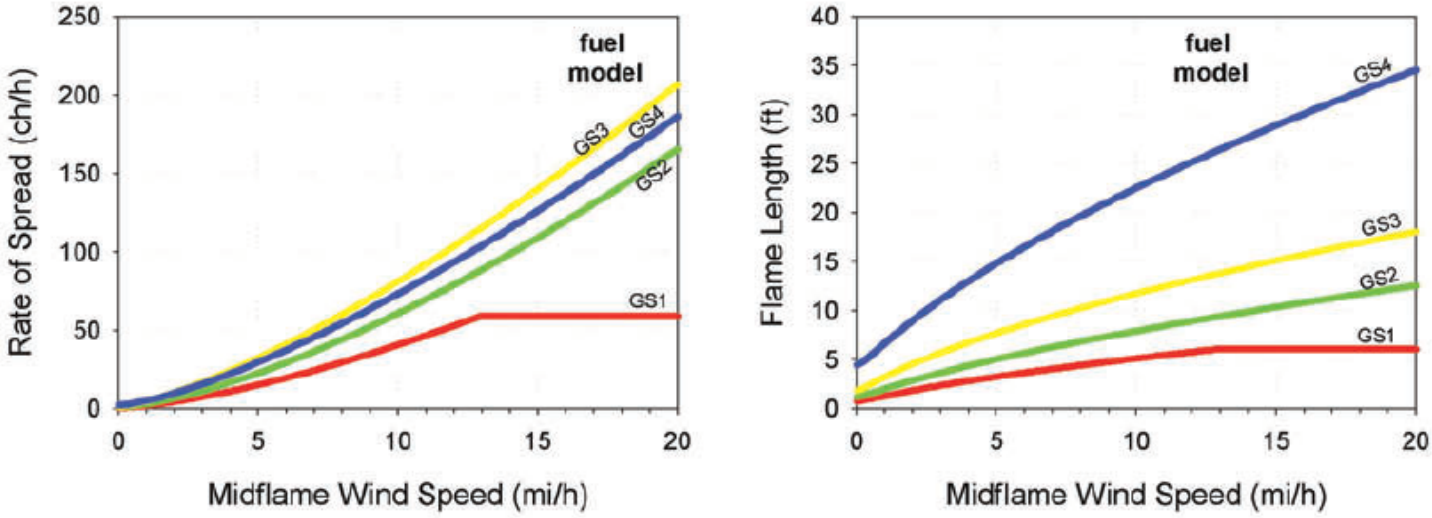
Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
6.5	18.0	44	348

GR3 (103)

Grass-Shrub Fuel Models (GS)

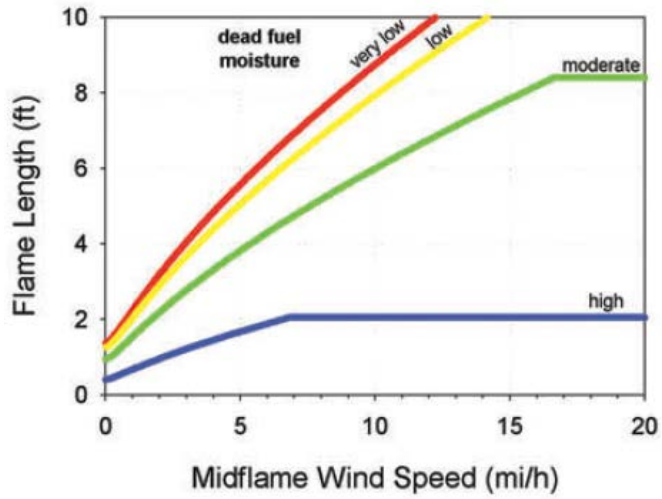
- A combination of herbaceous plants (grasses and forbs) plus shrubs and shrub litter are the primary carrier of fire. Shrubs are usually <50% of plant cover.
- The fuelbed is composed of live and dead shrub and herbaceous fuels of varying heights, ranging from a patchy mosaic to an evenly distributed mix.
- Trees and larger woody fuels may be present but are too sparse to alter fire behavior.
- Think of flame lengths as an average given the range of fuel types and heights.
- Locally, grass-shrub fuel types are found in sparse valley or foothill chaparral (including recently thinned chaparral), savanna or grassland with a strong shrub component, or on dry or edaphically limited hillsides, including serpentine. Could also be used for burn piles in grassy areas without substantial tree cover.
- Grass-shrub fuel models GS2 and GS3 are most relevant to our area – see below.
- Grass-shrub model GS1 shrub heights are too low for our area – more relevant to eastern Oregon; GS4 represents heavier loading of grass and shrub than is typical in our area. Those models are not included here.
- Go to Grass models when shrubs are too sparse or discontinuous/patchy to alter the fire behavior, or Shrub models if herbaceous fuels too sparse to alter fire behavior.
- Go to the Timber-Understory fuel type when the grasses and shrubs are beneath an overstory canopy with tree litter and woody fuels abundant in the fuelbed.

Comparison of fire behavior across the Grass-Shrub fuel models (Scott and Burgan 2005).



GS2 (122)

- Primary carrier of fire: grass-herbaceous and shrubs combined
- Grass matrix comparable to GR2
- Shrubs typically 3 ft tall or less; can use for shrub regeneration
- Can use when shrubs are taller than 3 ft but relatively sparse
- Can use with low grass load (GR1) and shrubs taller than GS1 (1 ft)
- Fine fuel load is 2.1 ton/ac



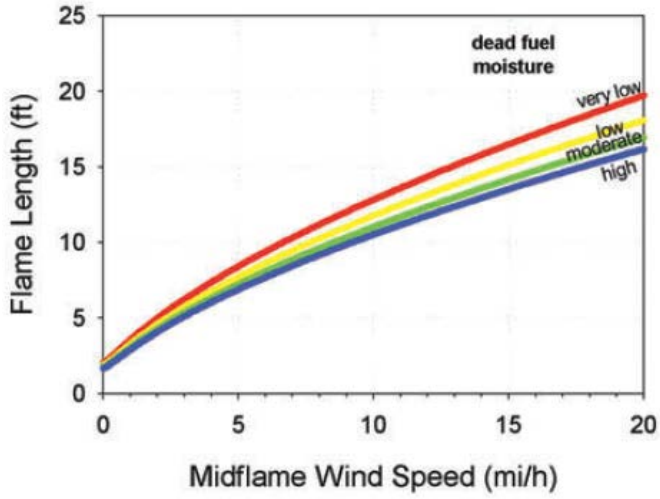
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
4.0	15.0	18	188

GS2 (122)

GS3 (123)

- Primary carrier of fire: grass-herbaceous and shrubs combined
- Used as next step up from GS2
- Grass matrix comparable to GR2
- Shrub load higher than GS2
- Average grass/shrub fuelbed depth can be 2 ft *or taller* locally
- Shrub load lower and less continuous than SH5
- Fine fuel load is 3.0 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

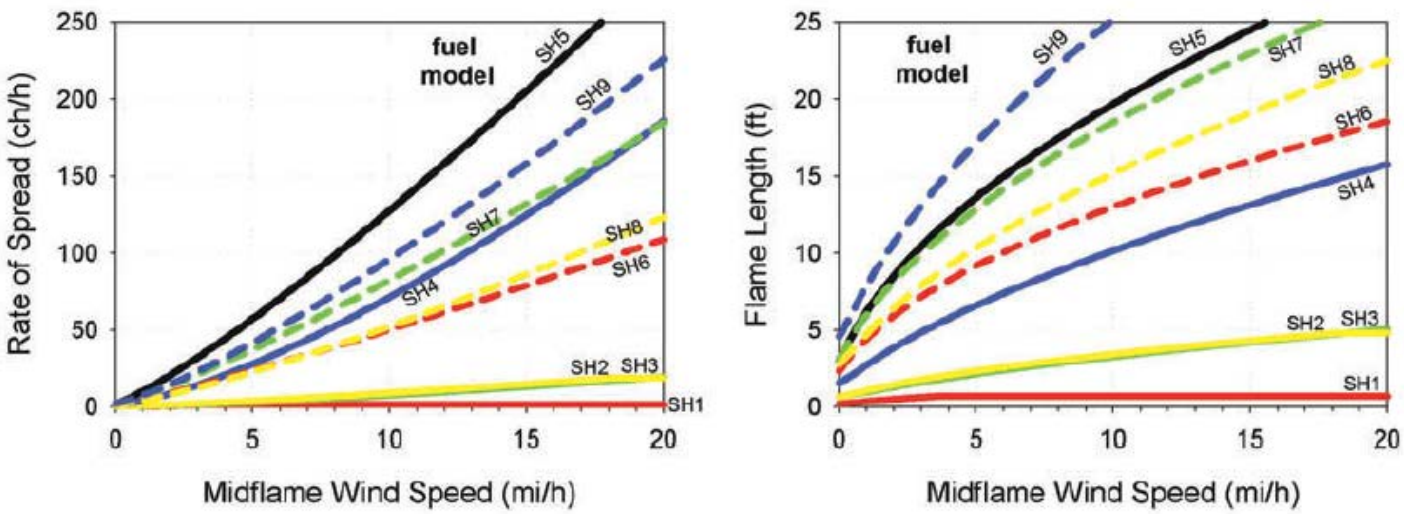
Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
7.5	23.0	32	265

GS3 (123)

Shrub Fuel Models (SH)

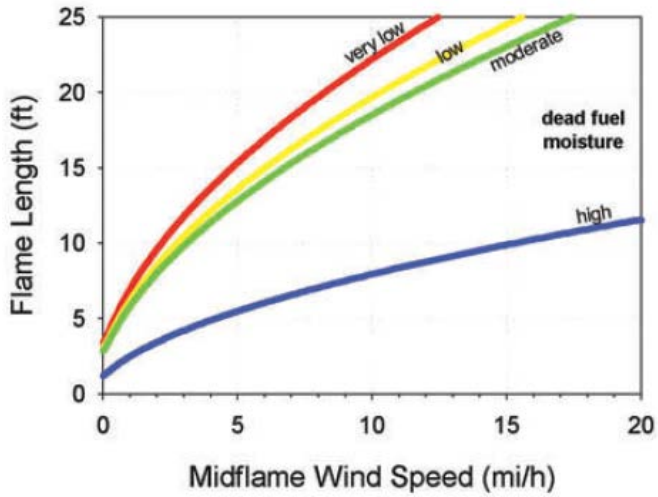
- Fuel from shrubs is the primary carrier of fire, including both live and dead shrubs, shrub litter and wood debris. Locally, these are chaparral fuel models.
- Shrub-dominated areas (>50% cover), herbaceous fuels (grasses and forbs) are typically present as a small proportion or uncommon component of the fuelbed.
- Trees and larger woody fuels may be present but are too sparse to alter fire behavior.
- Locally, shrub fuel types are found in valley or foothill chaparral, as large patches in savanna or grassland, on dry or edaphically limited hillsides and ridges, or as an early successional stage after intense fire or logging.
- Grass-shrub fuel models SH5 and SH7 are most relevant to our area – see below.
- Shrub models SH1 and SH2 are for low sagebrush-type arid shrublands – more relevant to eastern Oregon; SH3, SH4 and SH6 are for humid climates or pine shrub understory not typical for our area or better covered by Timber-Understory models.
- SH8 and SH9 could be appropriately used for higher-elevation shrub-fields that are more humid-type, but those are outside our current scope and not covered here.
- Go to the Grass-Shrub fuel type when shrubs are more sparse or discontinuous and herbaceous fuels are important for carrying fire and determining fire behavior.
- Go to the Timber-Understory fuel type when shrubs are beneath an overstory canopy with tree litter and woody fuels abundant in the fuelbed.

Comparison of fire behavior across the Shrub fuel models (Scott and Burgan 2005).



SH5 (145)

- Primary carrier of fire: live and dead shrubs and shrub litter
- Typical of local buckbrush chaparral or young manzanita
- Heavy shrub load 4 to 6 ft tall
- Shrubs denser and more continuous with higher load than GS2 or GS3
- Shrub fuels finer, smaller diameter woody fuels than in SH7
- Fine fuel load is 6.5 ton/ac



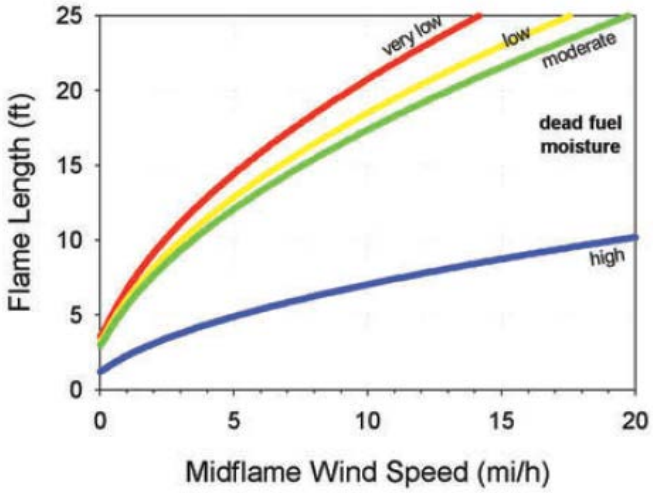
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
13.0	33.0	56	329

SH5 (145)

SH7 (147)

- Primary carrier of fire: live and dead shrubs and shrub litter
- Typical of local mature manzanita chaparral or old stands of buckbrush
- Very heavy shrub load 4 to 6 ft tall
- Higher fuel load than SH5 but lower flame length and rate of spread
- Shrub fuels coarser with larger diameter wood than SH5
- Fine fuel load is 6.9 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
12.5	31.0	37	210

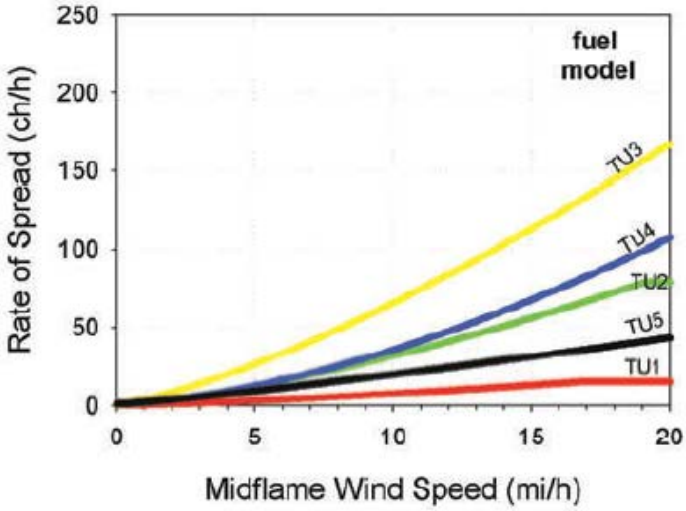
SH7 (147)

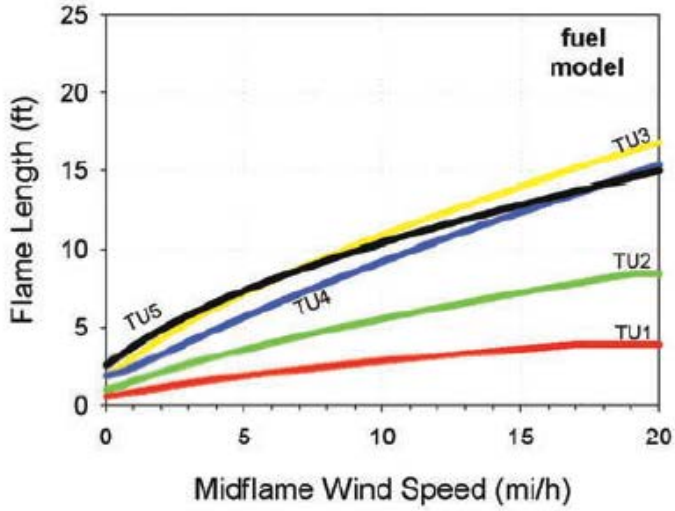
Timber Understory Fuel Models (TU)

- The primary carrier of fire is a *combination* of understory shrub and/or herbaceous fuels mixed with litter and woody debris from overstory trees.
- Fire behavior is more intense than comparable Timber Litter fuel models because of the contribution of abundant and widespread understory fuels.
- Locally typical of relatively open-canopy conifer forest or oak/hardwood stands with substantial light infiltration. Can be applied to stands of very tall (>8 ft), mature shrubs that have developed an understory and have litter accumulations.
- Can apply to recently thinned or cut stands with herbaceous or shrub in-fill but with litter from the removed canopy still strongly present in the fuelbed.
- Resprouting hardwood stumps, conifer regeneration or sparse burn piles can be treated as understory shrub fuels when sufficiently common and abundant.
- Shaded deciduous shrubs or stump-sprouting hardwoods typically provide less available fuel than shrubs with volatile evergreen foliage or abundant dead stems.
- Timber Understory fuel models TU1 and TU2 are most common in our area.
- TU3 and TU5 can apply to dense productive understory, especially in un-thinned pre-treatment areas. TU4 can apply to dense conifer regeneration. See below.

- Go to the Timber Litter fuel type when understory fuels are sparse or discontinuous and forest litter will be the primary fuel to carry fire and determine fire behavior.
- Go to the Grass or Grass-Shrub or Shrub fuel models if the tree litter is not abundant enough to alter fire behavior and the understory alone will be the primary fuel.

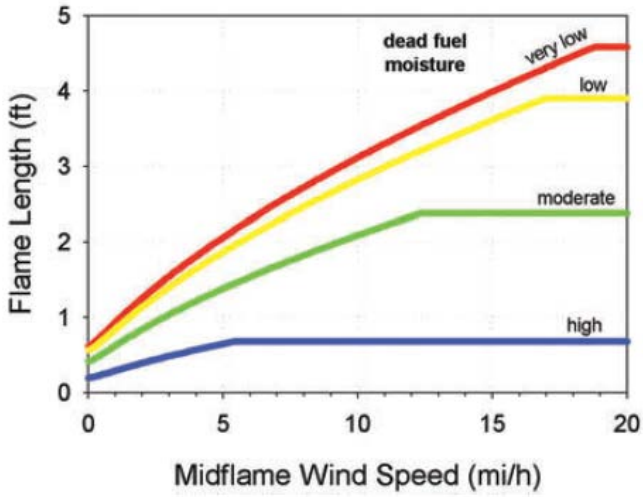
Comparison of fire behavior across Timber Understory fuel models (Scott and Burgan 2005).





TU1 (161)

- Primary carrier of fire: combination of forest litter with shrub and/or herbaceous understory
- Low load of litter and understory
- Fire behavior more intense than TL1 through TL3 fuel models
- Fire behavior less intense than comparable Grass / Shrub models
- Fine fuel load is 1.3 ton/ac



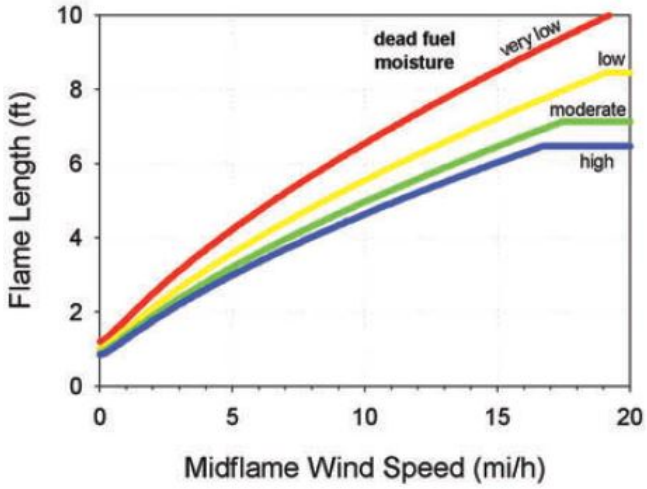
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
1.5	5.0	2	21

TU1 (161)

TU2 (162)

- Primary carrier of fire: combination of forest litter with shrub and/or herbaceous understory
- Litter load greater than TU1, comparable to TL3
- More shrub (or regen) and less fine fuels in the fuelbed than TU1
- Fire behavior more intense than most TL models, comparable to TL8
- Fine fuel load is 1.15 ton/ac



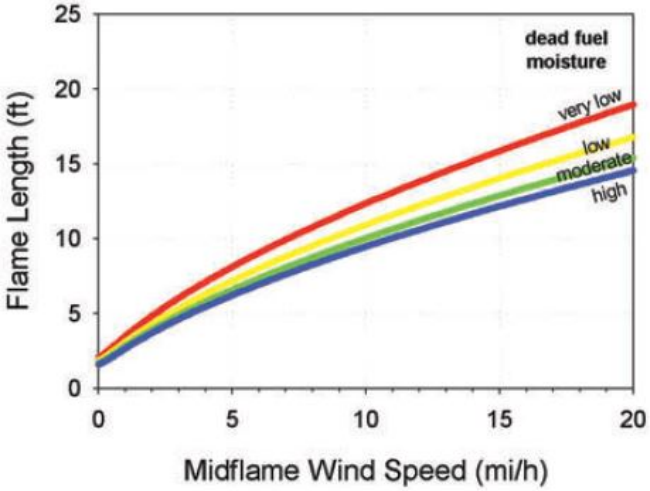
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
3.5	9.0	11	79

TU2 (162)

TU3 (163)

- Primary carrier of fire: combination of moderate forest litter with shrub and/or herbaceous understory
- Fine fuels and understory load greater than TU2, well aerated
- <u>Fire behavior more intense than all other TU models, especially ROS</u>
- Lighter fine fuel load than TU5, less heavy dead and down fuels.
- Fine fuel load is 2.85 ton/ac



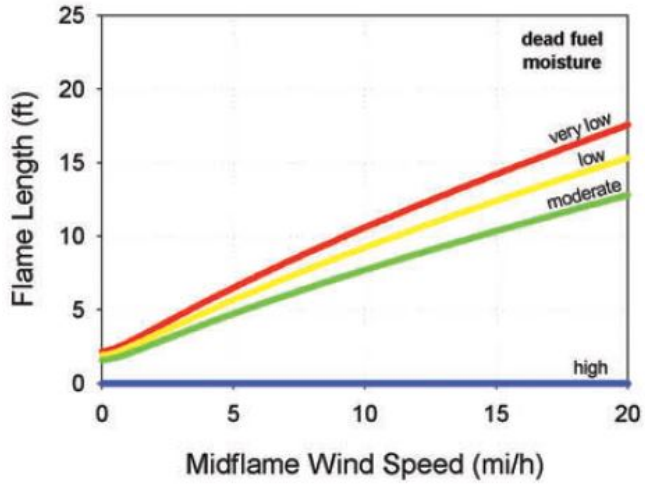
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
7.0	19.5	25	191

TU3 (163)

TU4 (164)

- Primary carrier of fire: combination of forest litter with very dense young conifer regeneration mixed with shrub or herbaceous fuels
- Fine fuels far greater than TU3
- Locally can be used for conifer plantation or post-fire regeneration
- Fire behavior more intense than TL models, like TU3 with slower spread
- Fine fuel load is 6.5 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
5.0	16.0	11	101

Photo: Lomakatsi Restoration Project

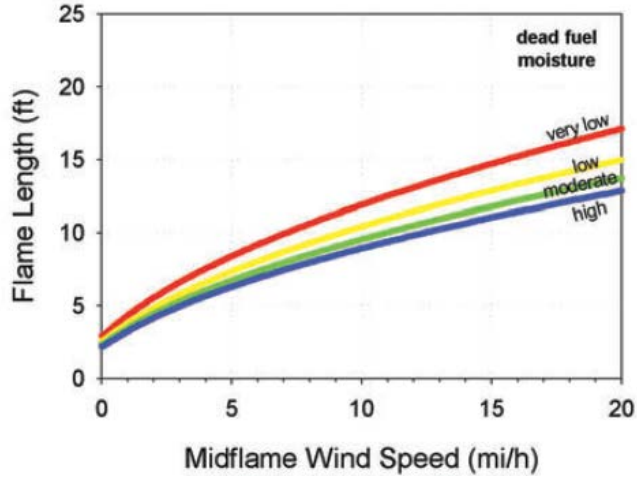
Photo: Lomakatsi Restoration Project

TU4 (164)

Photo: Lomakatsi Restoration Project

TU5 (165)

- Primary carrier of fire: combination of heavy forest litter with shrub and/or small tree understory
- Fine fuels more than double TU3
- Fire behavior more intense than TL models, like TU3 with slower ROS
- TU5 has a higher load of more compact fine fuels, with heavy dead and down or decadent fuels.
- Fine fuel load is 7.0 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

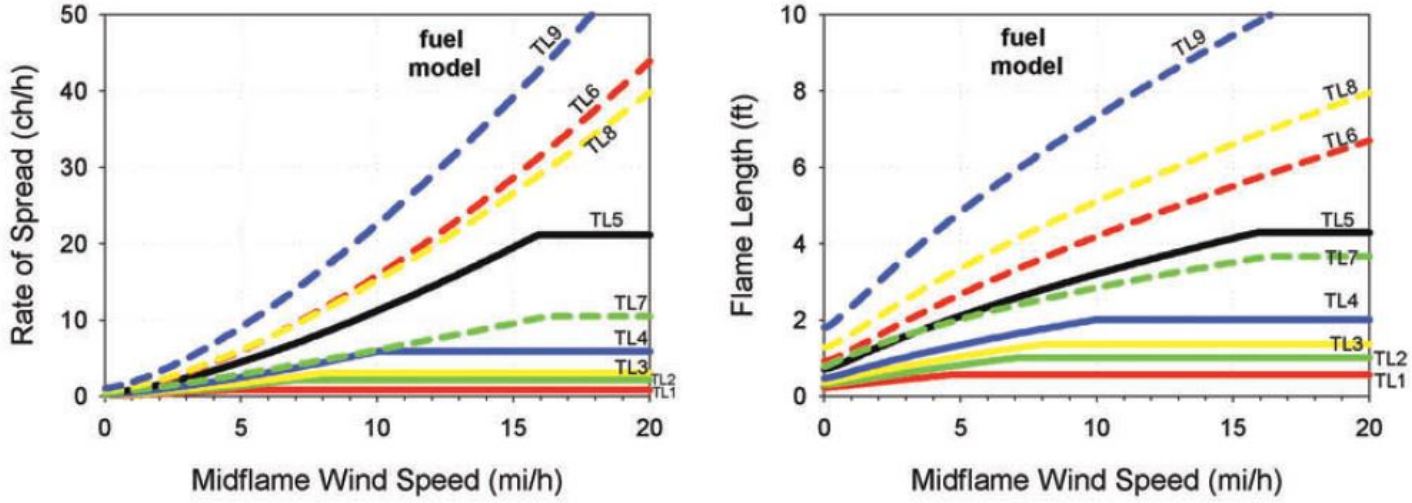
Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
7.0	17.0	9	46

TU5 (165)

Timber Litter Fuel Models (TL)

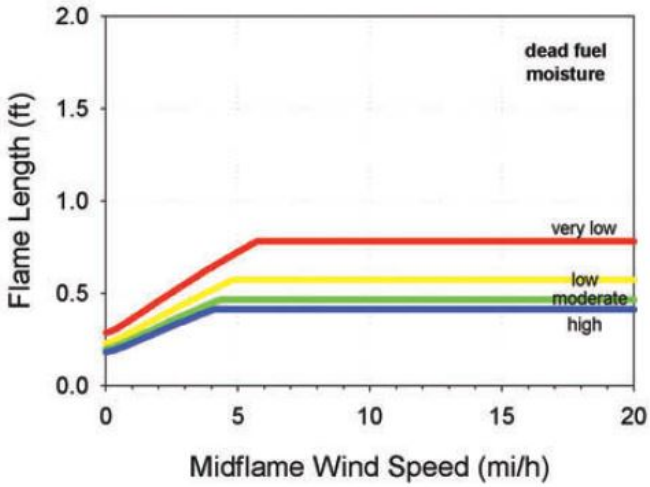
- The primary carrier of fire is litter and woody debris from overstory trees. Live understory fuels are sparse and do not meaningfully change fire behavior.
- Surface fire behavior is generally less intense than Timber Understory models because fine fuel loads are lighter, lower to the ground and more compacted.
- Locally typical for a wide range of conifer or mixed oak/hardwood forest.
- Most TL fuel models apply to conifer forest, with TL8 specific to long-needle pine litter and locally most relevant for ponderosa stands.
- <u>Models TL2, TL6 and TL9 cover broadleaf litter, locally from oak or madrone</u>.
- Down logs and heavier fuels (>100-hour) can greatly increase heat output in models TL4 and TL7 without dramatically changing the flame length or rate of spread.
- Timber Litter fuel models TL1 through TL8 are most relevant to our area. See below.
- Timber Litter model TL9 is limited to very heavy broadleaf fuel loads not typical for our area's drier, lower elevation forests. Compare load and fire behavior to TL6.
- Go to the Timber Understory fuel type when abundant shrubs and/or herbaceous fuels are present within the timber litter fuelbed.
- Go to the Slash/Blowdown fuel models if activity fuels from thinning or timber harvest (either scattered or piled) are dense and abundant in the fuelbed.

Comparison of fire behavior across Timber Litter fuel models (Scott and Burgan 2005).



TL1 (181)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Light and/or compact fuelbed
- Locally typical for recently burned stands or stands with intensive fuel-reduction treatments
- Surface fire behavior is fuel-limited and the lowest of all fuel models
- Fine fuel load is 1.0 ton/ac



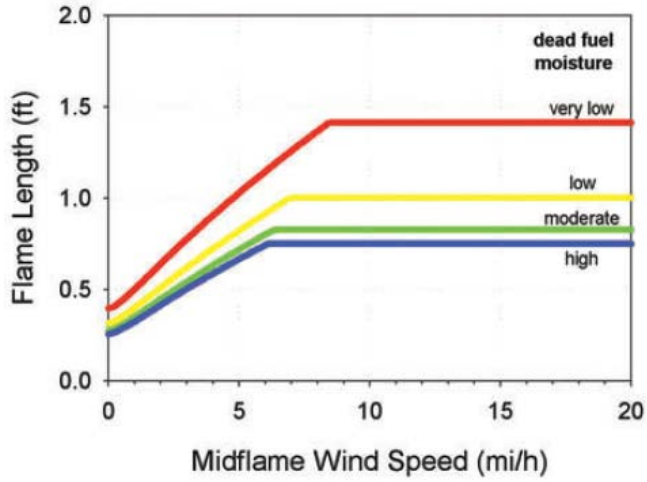
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
0.5	1.0	1	2

TL1 (181)

TL2 (182)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Broadleaf litter, low load, compact
- May include limited conifer litter or understory fuels
- Typical of oak or madrone or mixed hardwood/conifer stands
- Surface fire behavior is limited and mild, a bit higher than TL1
- Fine fuel load is 1.4 ton/ac



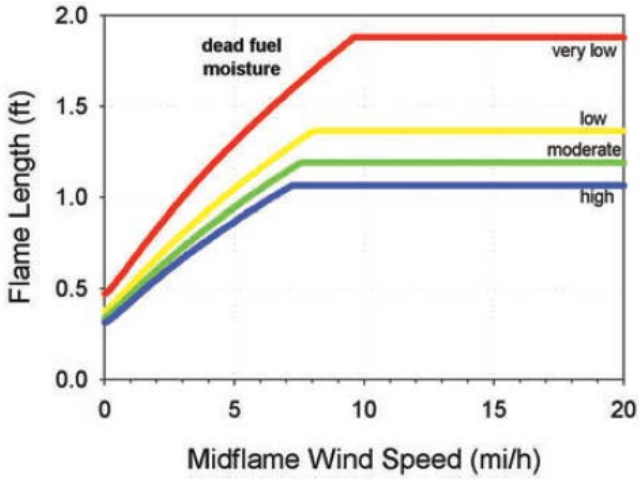
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
1.0	1.5	1	4

TL2 (182)

TL3 (183)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Conifer litter – may include some broadleaf litter or understory fuels
- Coarse fuels (≥ 100-hour) are present but low abundance
- Locally common fuel model for dry mixed conifer forests
- Fire behavior limited, but > TL1
- Fine fuel load is 0.5 ton/ac



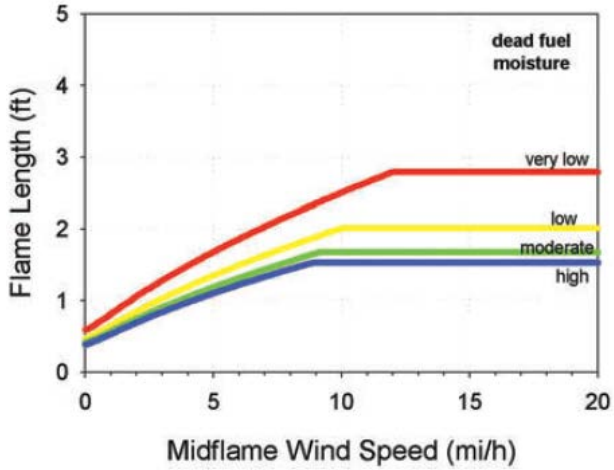
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
1.0	2.0	2	5

TL3 (183)

TL4 (184)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Conifer litter – may include some broadleaf litter or understory fuels
- Coarse fuels (≥ 100-hour) and small diameter logs abundant (> TL3)
- Locally common in thinned stands
- Can include limited burn piles
- Fire behavior and heat more intense
- Fine fuel load is 0.5 ton/ac



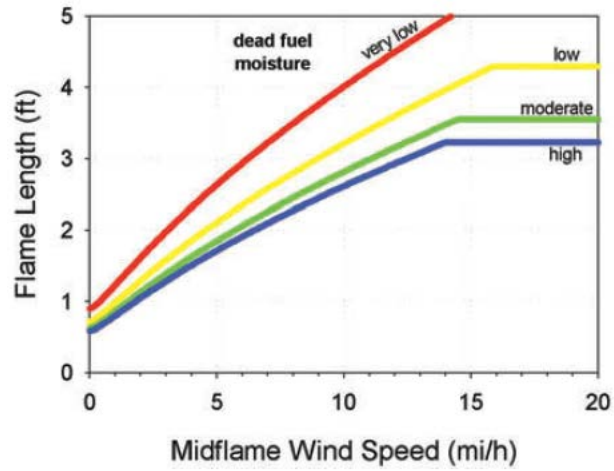
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
1.0	3.0	2	10

TL4 (184)

TL5 (185)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Conifer litter – may include some broadleaf litter or understory fuels
- Heavy build-up of small diameter fuels; logs may also be present
- May include limited activity fuels (slash) as burn piles or scattered
- Fire behavior > TL4, but < SB1
- Fine fuel load is 1.15 ton/ac



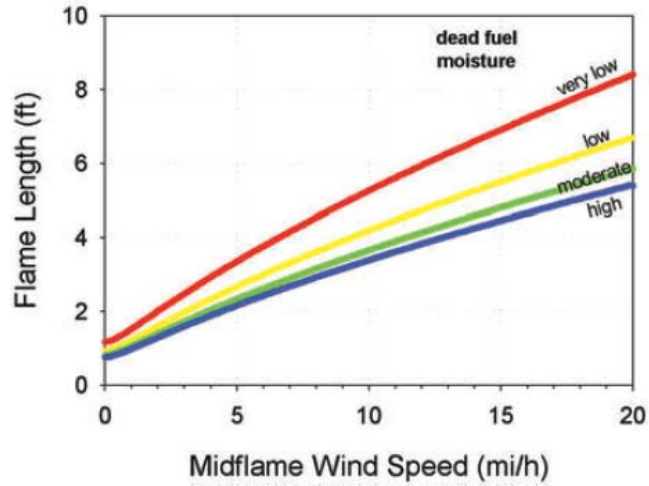
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
2.0	5.0	4	27

TL5 (185)

TL6 (186)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Broadleaf litter - may include limited conifer litter or understory fuels
- Dense oak or madrone or mixed hardwood/conifer stands
- Fine fuel and fuel load >>TL2, <<TL9
- Fire behavior more intense than TL2 or conifer models TL3 through TL7
- Fine fuel load is 2.4 ton/ac



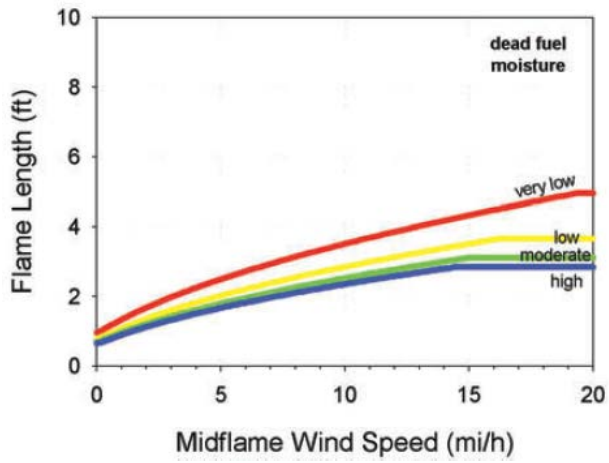
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
2.5	7.0	5	39

TL6 (186)

TL7 (187)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Conifer litter – may include some broadleaf litter or understory fuels
- Heavy build-up of coarse litter and larger diameter logs (≥ 1000-hour)
- Fine fuels limited, similar to TL3
- Less intense fire behavior than TL5, but with greater heat potential
- Fine fuel load is 0.3 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

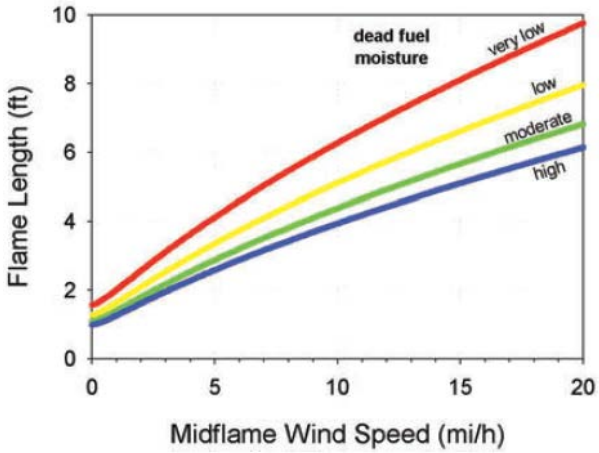
Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
2.0	4.5	3	13

Photo: Pratibah Duwal

TL7 (187)

TL8 (188)

- Primary carrier of fire: forest litter and dead-and-down woody fuels
- Long-needled ***pine*** litter dominated fuelbed – ponderosa or sugar pine locally
- May include some heavier fuels, broadleaf litter or understory fuels
- Heavier load of fine fuels and more intense fire behavior than TL1 – TL7
- Less total heat than TL4, TL5 or TL7
- Fine fuel load is 5.8 ton/ac



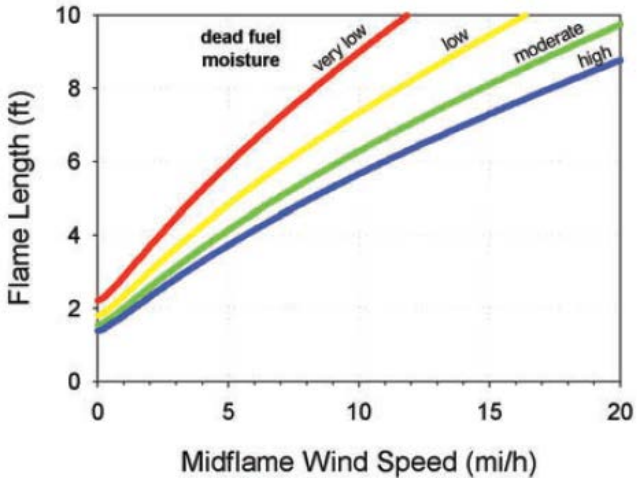
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
3.0	8.0	5	36

TL8 (188)

TL9 (189)

- Primary carrier of fire: very high load of well-aerated “fluffy” forest litter with dead-and-down woody fuels
- Broadleaf litter in oak or madrone
- May be used for heavy needle drape in a mixed pine/hardwood stand
- Fine fuel and fuel load >>TL6, >TL8
- Fire behavior most intense of all TL fuel models, locally uncommon
- Fine fuel load is 6.7 ton/ac



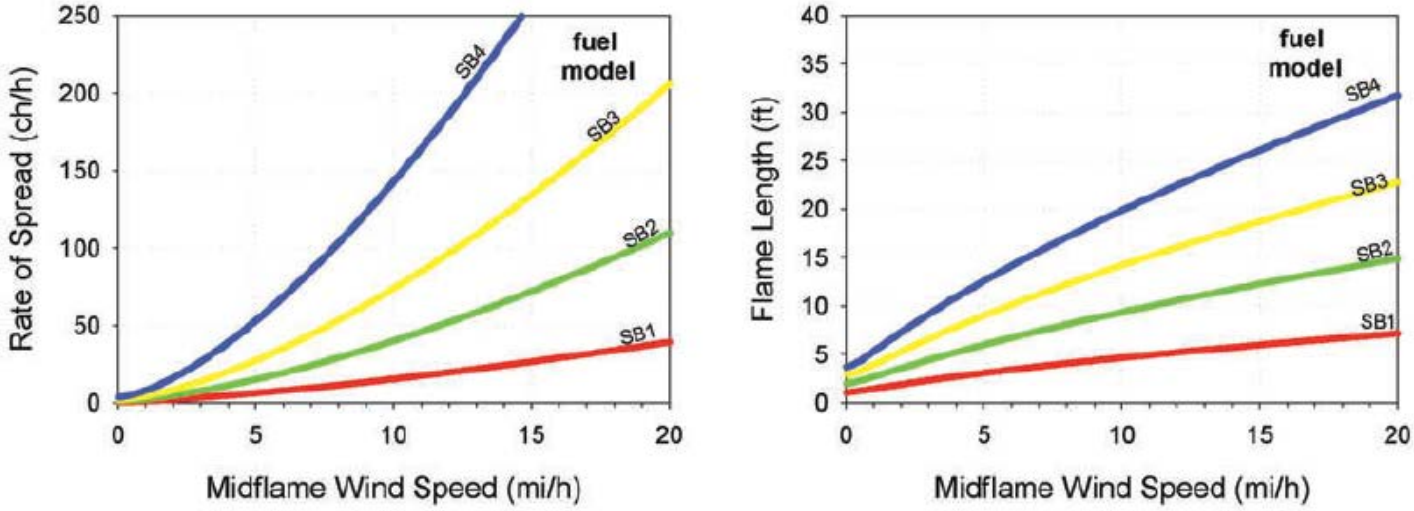
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
4.0	11.5	8	53

Slash-Blowdown Fuel Models (SB)

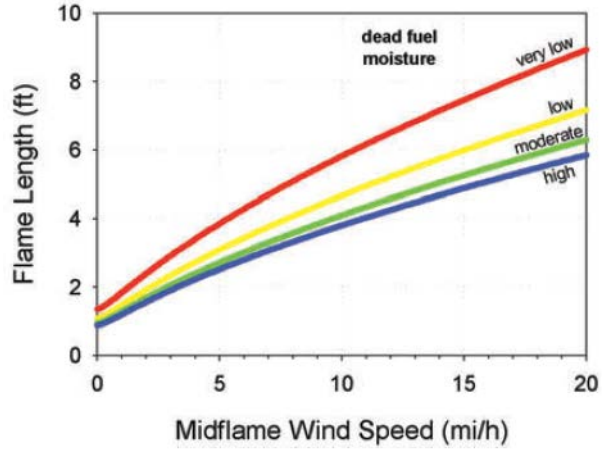
- The primary carrier of fire is woody debris either from thinning or harvest activity or from natural mortality events, typically in combination of forest litter.
- Surface fire behavior is generally more intense than most Timber Litter or Timber Understory models because fuel loads are heavier, drier and well-aerated.
- Locally used for recently treated forest (or shrub-field) stands with abundant activity fuels still present – either scattered or as burn piles.
- Scott and Burgan's guide does not specifically apply SB fuel models to burn piles.
- Limited burn pile fuels can be covered by TL5 (adding to heavy litter), or by Timber Understory or Grass-Shrub fuel models (treated like dense shrub fuels).
- Abundant burn piles/activity fuels can be covered by Slash-Blowdown models. Locally, we assume both forest litter and activity fuels are carrying the fire, with the burn piles strongly altering fire behavior – especially flame length and heat intensity.
- Slash-Blowdown fuel models SB1 and SB2 are most relevant to our area. See below.
- Slash-Blowdown models SB3 and SB4 cover denser and heavier activity or blowdown fuel loads (e.g. from heavy logging or major storm events) than are typical for our scope of monitoring and are not covered here.
- Go to the Timber Understory or Grass-Shrub fuel types when activity fuels are limited and mixed with abundant live shrubs and/or herbaceous fuels.
- Go to the Timber Litter fuel models if activity fuels (either scattered or piled) are limited and are simply augmenting the forest litter fuelbed.

Comparison of fire behavior across Timber Litter fuel models (Scott and Burgan 2005).



SB1 (201)

- Primary carrier of fire: activity fuels combined with forest litter
- Can apply to burn piles
- May include some larger logs or limited understory fuels
- Heavier fuel load and more intense fire behavior than TL4, TL5 or TL7
- Much lower fine fuel load than SB2
- Most activity fuels 1” to 3” diameter
- Fine fuel load is 1.5 ton/ac



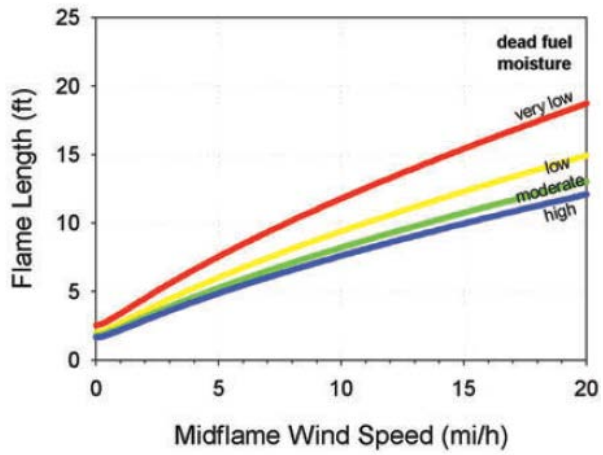
Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
3.0	7.5	6	36

SB1 (201)

SB2 (202)

- Primary carrier of fire: activity fuels combined with forest litter
- Can apply to abundant burn piles
- May include some larger logs or limited understory fuels
- Heavier fuel load and more intense fire behavior than SB1 or TL models
- Much higher fine fuel load than SB2 with more 1 to 10-hour fuels
- Fine fuel load is 4.5 ton/ac



Estimated fire behavior metrics - see page 4 for parameters

Flame length (ft)		Rate of Spread (ch/hr)	
Mild	**Extreme**	**Mild**	**Extreme**
5.5	15.5	13	99