Oregon Department of Forestry
Certified Burn Manager

Developing Prescriptions

Photo credit: John Punches

Presentation developed by John Punches

COLLEGE OF FORESTRY

Oregon State University

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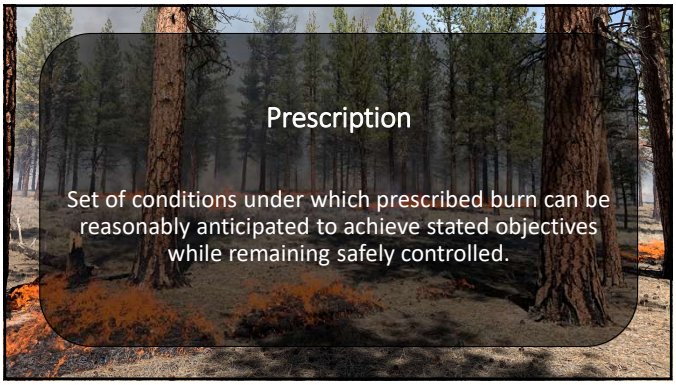

Prescription

Set of conditions under which prescribed burn can be reasonably anticipated to achieve stated objectives while remaining safely controlled.

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Prescription components

- Depend on objectives
- Temp, RH, wind speed and direction, transport winds, fine dead fuel moisture
- May include flame length, rate of spread, etc.
- Allowable range of conditions
- Specific – but not too specific

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	80
20-ft Wind Speed (forecasted)	7	23
20-ft Wind Direction (forecasted)	N, NW, NW, W, SW	
Eye-level Wind Speed (observed)	2	7
Eye-level Wind Direction	Any	
Transport Wind Direction	N, NW, NW, W, SW	
Find Dead Fuel Moisture (%)	4	14
Flame Length (ft)	1	4
Rate of Spread (ch/hr)	1	20

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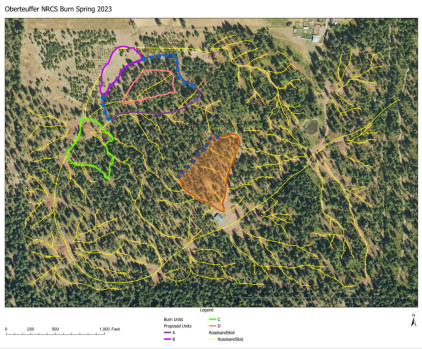
Start with site

- Unit descriptions
- Fuel loading
- Adjacent fuels
- Values at risk
- Holding challenges
- Control line options
- Smoke transport
- Access
- Water
- Pre-burn actions



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Consider goals and objectives

- Fuels reduction/ecological/ag-resource/cultural
- Season of year / stage of development
- How hot?
- Invasive species
- Consult experts
- Consult FEIS

RESOURCE MANAGEMENT GOALS
• Reinvigorate native bunchgrasses and forbs in understory as forage for wildlife. • Reduce intensity of future fire and protect ponderosa pine by managing accumulation of litter and duff, consuming coarse wood, and killing small trees to prevent their development as ladder fuels. • Reduce probability of crow fire by scorching lower crowns to induce crown lift. • Reduce risk of wildfire transmission across property. • Train personnel for prescribed fire responsibilities.
PRESCRIBED FIRE OBJECTIVES
Burn at least 70% of the area within the unit (patchy burn is anticipated). Kill 50 to 70% of seedlings/saplings. Within burned areas consume 40-70% of dead grass thatch and pine litter and 30 to 70% of duff, as observed/estimated at conclusion of burn. Shrub mortality expected to be low but expect 50 percent topkill – any amount of mortality acceptable. Limit scorch height to 30', as observed 1 week after burn. Train personnel in unit preparation, firing, holding, mop-up, and monitoring techniques.

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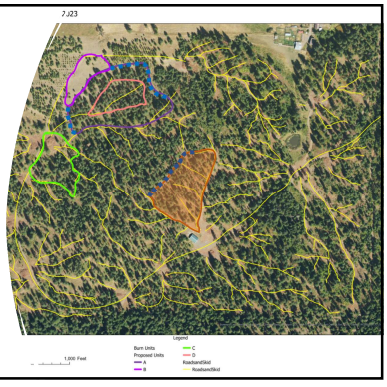
Two stages

- Prescription for "in-unit"
  - Meet burn objectives
- Consideration for "out-of-unit"
  - Holding and contingency requirements



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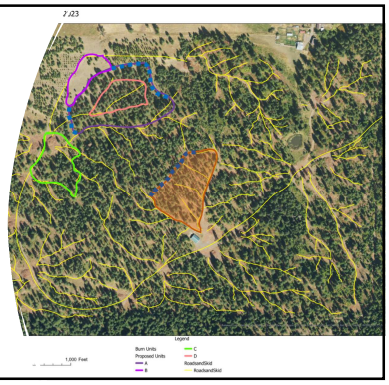
In-unit prescription

- ID fuel that will carry fire
- Slope and aspect
- Live fuel moisture
- Anticipate fire behavior
  - What's acceptable?
  - What accomplishes objectives?



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Prescription components

- Start with desired/acceptable fire behavior
  - Flame length – how much heat is generated. Impacts tactics and plant scorch or mortality.
  - Rate of spread – movement of flaming front. Impacts tactics, how long fire resides in a particular location, how long it takes to complete the burn.

Parameter	Low	High
Temperature (°F)		
Relative Humidity (%)		
20-ft Wind Speed (forecasted)		
20-ft Wind Direction (forecasted)		
Eye-level Wind Speed (observed)		
Eye-level Wind Direction		
Transport Wind Direction		
Find Dead Fuel Moisture (%)		
Flame Length (ft)		
Rate of Spread (ch/hr)		

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Consider crown scorch

- FL < 4' ~ crown scorch < 20'
- FL < 5' ~ crown scorch < 30'
- 2 to 3 mph wind helps disperse heat
- Depends on air temp and fuel model
- Use fire modeling software for more exact estimates – but couple with local knowledge

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Consider tactics/personnel

- FL < 4' = hand crew personnel can make direct attack
- ROS under 20 ch/hr = fire moves less than ¼ mph

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Prescription components

- Start with desired/acceptable fire behavior
  - Flame length (FL) – 0.5 to 4' in this example
  - Rate of spread (ROS) – under 20ch/hr, but not zero

How can I get other parameters that result in desired FL and ROS?

Parameter	Low	High
Temperature (°F)		
Relative Humidity (%)		
20-ft Wind Speed (forecasted)		
20-ft Wind Direction (forecasted)		
Eye-level Wind Speed (observed)		
Eye-level Wind Direction		
Transport Wind Direction		
Find Dead Fuel Moisture (%)		
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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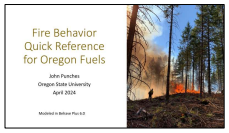
Anticipate fire behavior

- Model it
  - Behave Plus
  - IFTDSS
- Use reference guide



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What drives fire behavior?

- Fuel characteristics (fuel type)
- Fine dead fuel moisture
- Eye-level wind speed
- Topography
- Live fuel moisture (if present)

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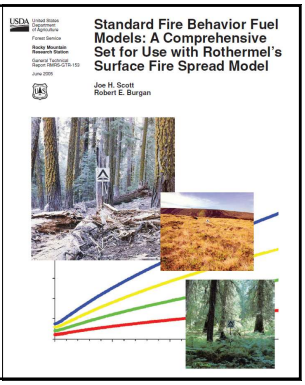
Select your fuel model

- Generally - use one of Scott & Burgan's 40 "new" models
- Sometimes an "original" from the 13 described by Anderson will be appropriate



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Select fuel model

- ID appropriate fuel type for surface fuel that will carry fire
- Use your fuel load data to find most likely model
- Draw on local knowledge if available – use the fuel model that represents observed fire behavior rather than the one the fits the description

Table 7—Fuel model parameters.

Fuel model code	Fuel load (t/ac) 1-hr	10-hr	100-hr	Live herb	Live woody	Fuel model type[a]	SAV ratio (1/ft)[b] Dead 1-hr	Live herb	Live woody	Fuel bed depth (ft)	Dead fuel extinction moisture (percent)	Heat content BTU/lb[c]
GR1	0.10	0.00	0.00	0.30	0.00	dynamic	2200	2000	9999	0.4	15	8000
GR2	0.10	0.00	0.00	1.00	0.00	dynamic	2000	1800	9999	1.0	15	8000
GR3	0.10	0.40	0.00	1.50	0.00	dynamic	1500	1300	9999	2.0	30	8000
GR4	0.25	0.00	0.00	1.90	0.00	dynamic	2000	1800	9999	2.0	15	8000
GR5	0.40	0.00	0.00	2.50	0.00	dynamic	1800	1600	9999	1.5	40	8000
GR6	0.10	0.00	0.00	3.40	0.00	dynamic	2200	2000	9999	1.5	40	9000
GR7	1.00	0.00	0.00	5.40	0.00	dynamic	2000	1800	9999	3.0	15	8000
GR8	0.50	1.00	0.00	7.30	0.00	dynamic	1500	1300	9999	4.0	30	8000
GR9	1.00	1.00	0.00	9.00	0.00	dynamic	1800	1600	9999	5.0	40	8000
GS1	0.20	0.00	0.00	0.50	0.65	dynamic	2000	1800	1800	0.9	15	8000
GS2	0.50	0.50	0.00	0.60	1.00	dynamic	2000	1800	1800	1.5	15	8000
GS3	0.30	0.25	0.00	1.45	1.25	dynamic	1800	1600	1600	1.8	40	8000
GS4	1.90	0.30	0.10	3.40	7.10	dynamic	1800	1600	1600	2.1	40	8000
SH1	0.25	0.25	0.00	0.15	1.30	dynamic	2000	1800	1600	1.0	15	8000
SH2	1.35	2.40	0.75	0.00	3.85	N/A	2000	9999	1600	1.0	15	8000
SH3	0.45	3.00	0.00	0.00	6.20	N/A	1600	9999	1400	2.4	40	8000
SH4	0.85	1.15	0.20	0.00	2.55	N/A	2000	1800	1600	3.0	30	8000
SH5	3.60	2.10	0.00	0.00	2.90	N/A	750	9999	1600	6.0	15	8000
SH6	2.90	1.45	0.00	0.00	1.40	N/A	750	9999	1600	2.0	30	8000
SH7	3.50	5.30	2.20	0.00	3.40	N/A	750	9999	1600	6.0	15	8000
SH8	2.05	3.40	0.85	0.00	4.35	N/A	750	9999	1600	3.0	40	8000
SH9	4.50	2.45	0.00	1.55	7.00	dynamic	750	1800	1500	4.4	40	8000
TU1	0.20	0.90	1.50	0.20	0.90	dynamic	2000	1800	1600	0.6	20	8000
TU2	0.95	1.80	1.25	0.00	0.20	N/A	2000	9999	1600	1.0	30	8000
TU3	1.10	0.15	0.25	0.65	1.10	dynamic	1800	1600	1400	1.3	30	8000
TU4	4.50	0.00	0.00	0.00	2.00	N/A	2300	9999	2000	0.5	12	8000
TU5	4.00	4.00	3.00	0.00	3.00	N/A	1500	9999	750	1.0	25	8000
TL1	1.00	2.20	3.60	0.00	0.00	N/A	2000	9999	9999	0.2	30	8000
TL2	1.40	2.30	2.20	0.00	0.00	N/A	2000	9999	9999	0.2	25	8000
TL3	0.50	2.20	2.80	0.00	0.00	N/A	2000	9999	9999	0.3	20	8000
TL4	0.50	1.50	4.20	0.00	0.00	N/A	2000	9999	9999	0.4	25	8000
TL5	1.15	2.50	4.40	0.00	0.00	N/A	2000	9999	1600	0.6	25	8000
TL6	2.40	1.20	1.20	0.00	0.00	N/A	2000	9999	9999	0.3	25	8000
TL7	0.30	1.40	8.10	0.00	0.00	N/A	2000	9999	9999	0.4	25	8000
TL8	5.80	1.40	1.10	0.00	0.00	N/A	1800	9999	9999	0.3	35	8000
TL9	6.65	3.30	4.15	0.00	0.00	N/A	1800	9999	1600	0.6	35	8000
SB1	1.50	3.00	11.00	0.00	0.00	N/A	2000	9999	9999	1.0	25	8000
SB2	4.50	4.25	4.00	0.00	0.00	N/A	2000	9999	9999	1.0	25	8000
SB3	5.50	2.75	3.00	0.00	0.00	N/A	2000	9999	9999	1.2	25	8000
SB4	5.25	3.50	5.25	0.00	0.00	N/A	2000	9999	9999	2.7	25	8000

[a] Fuel model type does not apply to fuel models without live herbaceous load.
[b] The value 9999 was assigned in cases where there is no load in a particular fuel class or category
[c] The same heat content value was applied to both live and dead fuel categories.

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Fire Behavior Quick Reference for Oregon Fuels

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April 2024

Modeled in Behave Plus 6.0

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Fire Behavior Quick Reference

- Fully cured
- 2/3 cured (60%)
- 0% slope
- 40% slope

Short grass (GR1)
Fully cured, 0% slope, head fire

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h 2	4	6	8	10
4	7.0	18.6	21.4	21.4	21.4
6	6.0	15.9	16.1	16.1	16.1
8	5.4	13.8	13.8	13.8	13.8
10	4.7	10.9	10.9	10.9	10.9
12	3.5	5.8	5.8	5.8	5.8
14	0.8	0.8	0.8	0.8	0.8
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h 2	4	6	8	10
4	1.3	2.1	2.2	2.2	2.2
6	1.2	1.8	1.9	1.9	1.9
8	1.1	1.7	1.7	1.7	1.7
10	1.0	1.5	1.5	1.5	1.5
12	0.8	1.0	1.0	1.0	1.0
14	0.3	0.3	0.3	0.3	0.3
16	0.0	0.0	0.0	0.0	0.0

80 chains = 1 mile

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Fire Behavior Quick Reference

Short grass (GR1)
Fully cured, 0% slope, backing fire

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h 2	4	6	8	10
4	1.0	1.3	1.4	1.4	1.4
6	0.9	1.1	1.1	1.1	1.1
8	0.8	1.0	1.0	1.0	1.0
10	0.7	0.9	0.9	0.9	0.9
12	0.5	0.6	0.6	0.6	0.6
14	0.2	0.2	0.2	0.2	0.2
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h 2	4	6	8	10
4	0.5	0.6	0.6		
6	0.5	0.5	0.5		
8	0.5	0.5	0.5		
10	0.4	0.5	0.5		
12	0.3	0.3	0.3		
16	0.1	0.1	0.1		
16	0.0	0.0	0.0		

Caution: Containment must be estimated based on heading fire ROS

Short grass (GR1)
Fully cured, 40% slope, flanking fire

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h 2	4	6	8	10
4	4.1	5.4	5.4	5.4	5.4
6	3.5	4.3	4.3	4.3	4.3
8	3.1	3.8	3.8	3.8	3.8
10	2.7	3.1	3.1	3.1	3.1
12	1.9	1.9	1.9	1.9	1.9
14	0.4	0.4	0.4	0.4	0.4
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h 2	4	6	8	10
4	1.0	1.2	1.2	1.2	1.2
6	0.9	1.0	1.0	1.0	1.0
8	0.9	0.9	0.9	0.9	0.9
10	0.8	0.8	0.8	0.8	0.8
12	0.6	0.6	0.6	0.6	0.6
14	0.2	0.2	0.2	0.2	0.2
16	0.0	0.0	0.0	0.0	0.0

Caution: Containment must be estimated based on heading fire ROS

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Fuel Models Included In Quick Reference

- 5 grass models
- 3 grass-shrub models
- 4 shrub models
- 5 timber understory models
- 9 timber litter models
- 4 slash-blowdown models

- Skipped models not likely to be utilized in Oregon
- Use *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model* (Scott and Burgan, 2005) for more complete descriptions, fuel bed characteristics, and typical fire behavior (see page 18)

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Determine your acceptable fire behavior

- Objectives
- Effects on plants
- Holding resources
- Safety

Acceptable fire behavior will be a function of fine dead fuel moisture and eye-level wind speed, for a specific fuel, slope, and live fuel moisture

Flame Length (ft) (heading)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	3.3	5.0	6.5	7.9	9.1
6	3.1	4.7	6.1	7.3	8.5
8	2.9	4.4	5.7	6.8	7.9
10	2.6	4.0	5.1	6.2	7.2
12	2.2	3.4	4.4	5.3	6.1
14	0.5	0.5	0.5	0.5	0.5
16	0.0	0.0	0.0	0.0	0.0

Example in which flame lengths under 4' are fully acceptable and 5' is tolerable.

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Firing pattern/spacing alters fire behavior

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Direction of spread has big impact on behavior

BACKING Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	1.4	1.5	1.5	1.5	1.5
6	1.2	1.3	1.4	1.4	1.4
8	1.1	1.2	1.3	1.3	1.3
10	1.0	1.1	1.2	1.2	1.2
12	0.8	0.9	0.9	0.9	0.9
14	0.4	0.4	0.4	0.4	0.4
16	0.0	0.0	0.0	0.0	0.0

FLANKING Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	2.5	2.9	3.3	3.6	3.8
6	2.2	2.6	2.9	3.2	3.4
8	2.1	2.5	2.8	3.0	3.2
10	1.9	2.2	2.5	2.7	2.8
12	1.5	1.8	2.0	2.0	2.0
14	0.7	0.7	0.7	0.7	0.7
16	0.0	0.0	0.0	0.0	0.0

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Acceptable fire behavior reveals range of FDFM and Eye-level wind speed

- Wind: 4 or less
- FDFM: 4-12

- Maybe a bit more wind, or lower FDFM, if live fuel moisture is high.
- Tighter prescription if slope is steep
- Caution if FDFM low and wind high at same time

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	3.3	5.0	6.5	7.9	9.1
6	3.1	4.7	6.1	7.3	8.5
8	2.9	4.4	5.7	6.8	7.9
10	2.6	4.0	5.1	6.2	7.2
12	2.2	3.4	4.4	5.3	6.1
14	0.5	0.5	0.5	0.5	0.5
16	0.0	0.0	0.0	0.0	0.0

Example in which flame lengths under 4' are fully acceptable and 5' is tolerable.

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Eye-level winds and FDFM

- For this example
  - Assume strip head firing
- Eye-level winds
  - Max of 4
  - Min of 1 (some wind is generally desirable for smoke dispersal and predictable fire movement)
- FDFM
  - Min of 4
  - Max of 12

How can I get other parameters that result in desired FL and ROS?

Parameter	Low	High
Temperature (°F)		
Relative Humidity (%)		
20-ft Wind Speed (forecasted)		
20-ft Wind Direction (forecasted)		
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction		
Transport Wind Direction		
Fine Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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Identify min and max temp and RH

- Backtrack from FDFM tables
- Highest FDFM = lowest T, highest RH (assume 1000 hrs)
- Lowest FDFM = highest T, lowest RH (assume 1400 hrs)
- Assume level with fire
- Use table for season
- Consider time of day, aspect, slope, shading

Table A: Reference Fuel Moisture

Dry Bulb Temp (°F)	Relative Humidity (%)																				
	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89	90 to 94	95 to 99	100
10-29	1	2	2	3	4	5	5	6	7	8	8	9	9	10	11	12	12	13	13	14	
30-49	1	2	2	3	4	5	5	6	7	7	8	8	9	9	10	11	12	13	13	13	
50-69	1	2	2	3	4	5	5	6	6	7	7	8	8	9	9	10	11	12	12	12	13
70-89	1	1	2	2	3	4	5	5	6	7	7	8	8	9	9	10	10	11	12	12	13
90-109	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	13
109+	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	12

Table B: 1-hr fuel moisture corrections May-June-July

Aspect	Slope	Unshaded – Less than 50% shading of surface fuels																			
		0800-0959			1000-1159			1200-1359			1400-1559			1600-1759			1800-1959				
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A		
N	0-30	2	3	4	1	1	1	0	0	1	0	0	1	1	1	1	2	3	4		
	31%	3	4	4	1	2	2	1	1	2	1	1	2	1	2	2	3	4	4		
E	0-30	2	2	3	1	1	1	0	0	1	0	0	1	1	1	2	3	4	4		
	31%	1	2	2	0	1	1	0	0	1	1	1	2	2	3	4	4	5	6		
S	0-30	2	3	3	1	1	1	0	0	1	0	0	1	1	1	1	2	3	3		
	31%	2	3	3	1	1	2	0	1	1	0	1	1	1	1	2	2	3	3		
W	0-30	2	3	4	1	1	2	0	0	1	0	0	1	0	1	1	2	3	3		
	31%	4	5	6	2	3	4	1	1	2	0	0	1	0	0	1	1	2	2		
		Shaded – 50 % or more shading of surface fuels due to canopy and/or cloud cover																			
N	All	4	5*	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5		
E	All	4	4*	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	6		
S	All	4	4*	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5		
W	All	4	5*	6	3	4	5	3	3	4	3	3	4	3	4	5	4	4	5		

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Identify min and max temp and RH

- ID reasonable low and high T for your burn area and time of year
- Use tables to find RH associated with your allowable FDFM
- *For this example, assume May, unshaded, S aspect, low slope, level*
- We said FDFM from 4 to 12 was acceptable
- Lowest FDFM = 4 = highest T, lowest RH (assume 1400 hrs)
  - If reasonable max T is 85
  - Then associated lowest RH is 25
- Highest FDFM = 12 = lowest T, highest RH (assume 1000 hrs)
  - If reasonable low T is 40
  - Then associated highest RH is 84

Table A: Reference Fuel Moisture

Dry Bulb Temp (°F)	Relative Humidity (%)																				
	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89	90 to 94	95 to 99	100
10-29	1	2	2	3	4	5	5	6	7	8	8	9	9	10	11	12	12	13	13	14	
30-49	1	2	2	3	4	5	5	6	7	7	8	8	9	9	10	11	12	13	13	13	
50-69	1	2	2	3	4	5	5	6	6	7	7	8	8	9	9	10	11	12	12	12	13
70-89	1	1	2	2	3	4	5	5	6	7	7	8	8	9	9	10	10	11	12	12	13
90-109	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	13
109+	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	12

Table B: 1-hr fuel moisture corrections May-June-July

Aspect	Slope	Unshaded – Less than 50% shading of surface fuels																			
		0800-0959			1000-1159			1200-1359			1400-1559			1600-1759			1800-1959				
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A		
N	0-30	2	3	4	1	1	1	0	0	1	0	0	1	1	1	1	2	3	4		
	31%	3	4	4	1	2	2	1	1	2	1	1	2	1	2	2	3	4	4		
E	0-30	2	2	3	1	1	1	0	0	1	0	0	1	1	1	2	3	4	4		
	31%	1	2	2	0	1	1	0	0	1	1	1	2	2	3	4	4	5	6		
S	0-30	2	3	3	1	1	1	0	0	1	0	0	1	1	1	1	2	3	3		
	31%	2	3	3	1	1	2	0	1	1	0	1	1	1	1	2	2	3	3		
W	0-30	2	3	4	1	1	2	0	0	1	0	0	1	0	1	1	2	3	3		
	31%	4	5	6	2	3	4	1	1	2	0	0	1	0	0	1	1	2	2		
		Shaded – 50 % or more shading of surface fuels due to canopy and/or cloud cover																			
N	All	4	5*	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5		
E	All	4	4*	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	6		
S	All	4	4*	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5		
W	All	4	5*	6	3	4	5	3	3	4	3	3	4	3	4	5	4	4	5		

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Temp and RH

- Reasonable temp range = 40 to 85
- Associated RH for our range of FDFM = 25 to 84

What 20-ft wind speeds are associated with our eye-level range?

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	84
20-ft Wind Speed (forecasted)		
20-ft Wind Direction (forecasted)		
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction		
Transport Wind Direction		
Fine Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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We know our allowable mid-flame wind speeds

- 1 to 4 mph in this example, but depends on FDFM – call out specifics in prescription comments
- Let's convert them to 20-ft winds using the Wind Adjustment Factor tables

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	3.3	5.0	6.5	7.9	9.1
6	3.1	4.7	6.1	7.3	8.5
8	2.9	4.4	5.7	6.8	7.9
10	2.6	4.0	5.1	6.2	7.2
12	2.2	3.4	4.4	5.3	6.1
14	0.5	0.5	0.5	0.5	0.5
16	0.0	0.0	0.0	0.0	0.0

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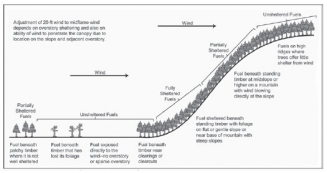
Wind Adjustment Factor Tables



- Degree of sheltering from wind
  - Fully sheltered
  - Partially sheltered
  - Unsheltered
- Consider vegetation and topography

Surface fuel sheltering from the wind	Wind Adjustment Factor (WAF)	Fuel Model
Unsheltered • Surface fuels not sheltered from the wind • No overstory • Sparse overstory • Timber that has lost its foliage • Timber on high ridges where trees offer little sheltering	0.5	• 4, 13 • GR7, GR8, GR9 • SH4, SH5, SH7, SH8, SH9 (depth > 2.7ft, > 0.8m)
	0.4	• 1, 2, 3, 5, 6, 7, 10, 11, 12 • GR2, GR3, GR4, GR5, GR6 • GS1, GS2, GS3, GS4 • SH1, SH2, SH3, SH6 • TU2, TU3, TU5 • SB1, SB2, SB3, SB4 (depth 0.9 - 2.7 ft, 0.3 - 0.8 m)
	0.3	• 8, 9 • GR1 • TU1, TU4 • TL1, TL2, TL3, TL4, TL5, TL6, TL7, TL8, TL9 (depth < 0.9ft, < 0.3m)
Partially sheltered • Patchy timber • Timber at midslope or higher with wind blowing directly at the slope	0.3	• All fuel models
Fully Sheltered • Standing timber on flat or gentle slope • Standing timber near base of mountain with steep slopes	0.2	• **Open stands.** All fuel models
	0.1	• **Dense stands.** All fuel models

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What are the associated 20-ft wind speeds?

- Start with eye-level (mid-flame) speeds
- Work backwards using Wind Adjustment Factor tables
- Divide mid-flame by WAF to get 20-ft

Unsheltered Fuels

- Openings on level ground.
- On high ridges where trees offer little shelter from wind.
- Leafless canopy.
- Surface with average Crown Ratio less than 0.2 (crowns less than 20% of tree height) and Canopy Cover less than 20%.

Wind Adj. Factor (WAF)	Fuel Models	Bed Depth
0.5	Grass (gr7, gr8, gr9) Shrub (4, sh4, sh5, sh7, sh8, sh9) Slash (13, sb4)	More than 2.7 feet
0.4	Grass & Grass-Shrub (1, 2, 3, gr2, gr3,gr4, gr5, gr6, gs1, gs2, gs3, gs4) Shrub (5, 6, 7, sh1, sh2, sh3, sh6) Timber-Understory (10, tu2, tu3) Slash (11, 12, sb1, sb2, sb3	0.9 to 2.7 feet
0.3	All Timber Litter Fuels (8, 9, tl1 thru tl9, gr1, tu1, tu4, tu5)	Less than 0.9 foot

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Getting 20-ft wind speed

- Eye-level winds 1 to 4 mph
- What the fuel type and extent of sheltering from wind?
- For this example, assume unsheltered with a mix of TL8 and TU5 fuels.

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	84
20-ft Wind Speed (forecasted)		
20-ft Wind Direction (forecasted)		
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction		
Transport Wind Direction		
Fine Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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What are the associated 20-ft wind speeds?

Unsheltered Fuels

- Openings on level ground.
- On high ridges where trees offer little shelter from wind.
- Leafless canopy.
- Surface with average Crown Ratio less than 0.2 (crowns less than 20% of tree height) and Canopy Cover less than 20%.

Wind Adj. Factor (WAF)	Fuel Models	Bed Depth
0.5	Grass (gr7, gr8, gr9) Shrub (4, sh4, sh5, sh7, sh8, sh9) Slash (13, sb4)	More than 2.7 feet
0.4	Grass & Grass-Shrub (1, 2, 3, gr2, gr3, gr4, gr5, gr6, gs1, gs2, gs3, gs4) Shrub (5, 6, 7, sh1, sh2, sh3, sh6) Timber-Understory (10, tu2, tu3) Slash (11, 12, sb1, sb2, sb3	0.9 to 2.7 feet
0.3	All Timber Litter Fuels (8, 9, tl1 thru tl9, gr1, tu1, tu4, tu5)	Less than 0.9 foot

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Getting 20-ft wind speed

- Eye-level winds 1 to 4 mph
- What the fuel type and extent of sheltering from wind?
- For this example, assume unsheltered with a mix of TL8 and TU5 fuels.
- WAF = 0.3
- Divide Eye-level by WAF
- 1/0.3= 3.33 (call it 3)
- 4/0.3 = 13.33 (call it 13)

What about wind direction?

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	84
20-ft Wind Speed (forecasted)	3	13
20-ft Wind Direction (forecasted)		
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction		
Transport Wind Direction		
Fine Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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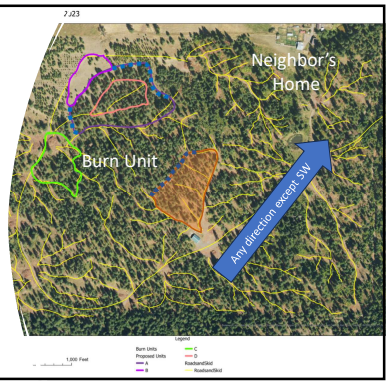
ID allowable wind directions

- Neighbors, livestock, crops
- Fire escape risk
- Values at risk

Allowable directions for transport wind (smoke) may differ from those allowable for surface wind



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20-ft and transport wind direction?

- 20-ft winds NOT blowing at neighbor's house
- Transport winds NOT blowing at neighbor's house
- Or road, or vineyard, or town, or powerline, etc.
- Allowable 20-ft and transport wind directions may not always be the same

What about eye-level wind direction?

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	84
20-ft Wind Speed (forecasted)	3	13
20-ft Wind Direction (forecasted)	Any except SW	
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction		
Transport Wind Direction	Any except SW	
Fine Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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Eye-level wind direction?

- Will eye-level winds always align with 20-ft and/or transport wind directions?

NO

What can you tolerate and still have an effective fire?

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	84
20-ft Wind Speed (forecasted)	3	13
20-ft Wind Direction (forecasted)	Any except SW	
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction		
Transport Wind Direction	Any except SW	
Fine Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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Eye-level wind direction

- Will eye-level winds always align with 20-ft and/or transport wind directions?
- Maybe any direction will work
- Maybe slope aligned will work
- Maybe we can't allow wind blowing toward property line
- Chose what's reasonable

Parameter	Low	High
Temperature (°F)	40	85
Relative Humidity (%)	25	84
20-ft Wind Speed (forecasted)	3	13
20-ft Wind Direction (forecasted)	Any except SW	
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction	Any	
Transport Wind Direction	Any except SW	
Find Dead Fuel Moisture (%)	4	12
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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Use the comments section

- Wind/FDFM combos allowed
- Anticipated trends
- Areas where things may differ
- Watch-out situations
- Containment considerations may restrict prescription

ENVIRONMENTAL PARAMETERS AND FIRE BEHAVIOR					
ENVIRONMENTAL PRESCRIPTION			ACCEPTABLE FIRE BEHAVIOR		
	Low	High		Low	High
Temperature (°F)	40	85	Flame Length (ft)	.2	4
Relative Humidity (%)	25	80	Rate of Spread (ch/hr)	.2	7
20-ft. Wind Speed (Forecasted)	0	23			
20-ft. Wind Direction (Forecasted)	N, NW, NE, W, SW				
Eye-Level Wind Speed (Observed)	0	7			
Eye-Level Wind Direction (Observed)	Any				
Transport Wind Direction	N, NW, NE, W, SW				
Fine Dead (1-Hr) Fuel Moisture	4	14			

Prescription Comments:
Assumes live fuel conditions at 50% MC – will likely be higher and thus decrease flame length and rate of spread. Low intensity conditions (low temp with high RH) may not achieve desired consumption or seedling mortality levels but burning may proceed for training purposes and to reduce needle litter. Scorch height anticipated to be less than 10'. NOTE: Check live fuel moistures in shrub foliage and grass within 48 hours in advance and adjust parameters or holding resources accordingly. Fire behavior will become more active and intense as live fuels approach 30%.

Containment based on 15 chain per hour total line production rate. Achieved under all conditions at 50% live fuel MC, except when FDMC 4 and wind speed 7 or greater. At 30% live fuel MC do not burn if sustained eye-level winds exceed 5mph or FDMC drops to 4.

20-ft wind speed calculation assumes surface fuels are partially sheltered from wind. WAF 0.3.

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Alternate way to organize prescription

- Label as Low Intensity and High Intensity
- Arrange parameters accordingly

Parameter	Low Intensity	High Intensity
Temperature (°F)	40	85
Relative Humidity (%)	84	25
20-ft Wind Speed (forecasted)	3	13
20-ft Wind Direction (forecasted)	Any except SW	
Eye-level Wind Speed (observed)	1	4
Eye-level Wind Direction	Any	
Transport Wind Direction	Any except SW	
Fine Dead Fuel Moisture (%)	12	4
Flame Length (ft)	0.5	4
Rate of Spread (ch/hr)	1	20

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Another alternate way to organize prescription

- Articulate minimum, maximum, and desired ranges

Parameter	Minimum	Desired	Maximum
Temperature (°F)	40	55 to 65	85
Relative Humidity (%)	25	35 to 60	84
20-ft Wind Speed (forecasted)	3	6 to 10	13
20-ft Wind Direction (forecasted)	Any except S or SW	N, NE, E, NW	Any except SW
Eye-level Wind Speed (observed)	1	2 to 3	4
Eye-level Wind Direction	Any except SW	Upslope	Any except SW
Transport Wind Direction	Any except S or SW	N, NE, E, NW	Any except SW
Fine Dead Fuel Moisture (%)	4	5 to 10	12
Flame Length (ft)	0.5	1 to 3	4
Rate of Spread (ch/hr)	1	3 to 10	20

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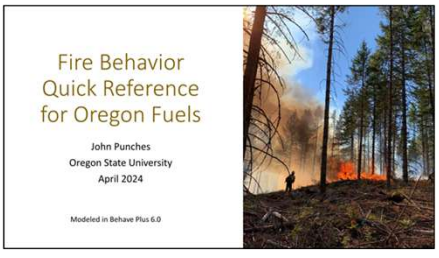
Exercise: Fire Behavior Reference



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Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	1.3	2.1	2.2	2.2	2.2
6	1.2	1.8	1.9	1.9	1.9
8	1.1	1.7	1.7	1.7	1.7
10	1.0	1.5	1.5	1.5	1.5
12	0.8	1.0	1.0	1.0	1.0
14	0.3	0.3	0.3	0.3	0.3
16	0.0	0.0	0.0	0.0	0.0

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	7.0	18.6	21.4	21.4	21.4
6	6.0	15.9	16.1	16.1	16.1
8	5.4	13.8	13.8	13.8	13.8
10	4.7	10.9	10.9	10.9	10.9
12	3.5	5.8	5.8	5.8	5.8
14	0.8	0.8	0.8	0.8	0.8
16	0.0	0.0	0.0	0.0	0.0

GR1 vs GR3

Fully cured
0% slope

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	5.6	8.0	10.0	11.7	13.2
6	4.9	7.0	8.7	10.2	11.5
8	4.4	6.3	7.8	9.1	10.3
10	4.1	5.8	7.2	8.5	9.5
12	3.8	5.5	6.8	8.0	9.0
14	3.7	5.3	6.5	7.7	8.6
16	3.5	5.1	6.3	7.4	8.3

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	29.7	65.0	104.3	146.4	190.9
6	24.6	53.9	86.5	121.6	158.5
8	21.2	46.4	74.4	104.5	136.3
10	18.8	41.2	66.2	92.9	121.1
12	17.2	37.6	60.4	84.8	110.6
14	16.0	34.9	56.1	78.7	102.6
16	14.9	32.6	52.3	73.5	95.8

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GR7
Heading
vs
Backing

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	50.9	124.9	218.9	328.8	452.2
6	43.4	106.6	186.9	280.6	385.9
8	39.3	96.4	168.9	253.6	348.8
10	34.3	84.3	147.6	221.7	305.0
12	25.5	62.7	109.9	165.0	226.9
14	10.5	25.7	45.1	67.8	93.2
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	13.1	19.8	25.6	30.9	35.7
6	11.7	17.7	22.9	27.6	31.9
8	11.0	16.6	21.5	25.9	30.0
10	10.0	15.1	19.6	23.6	27.3
12	7.8	11.8	15.3	18.5	21.4
14	3.5	5.4	6.9	8.4	9.7
16	0.0	0.0	0.0	0.0	0.0

Rate of Spread (ch/h)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	7.4	9.0	9.5	9.7	9.6
6	6.3	7.7	8.1	8.3	8.2
8	5.7	6.9	7.4	7.5	7.4
10	5.0	6.0	6.4	6.5	6.5
12	3.7	4.5	4.8	4.9	4.8
14	1.5	1.8	2.0	2.0	2.0
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	5.4	5.9	6.1	6.1	6.1
6	4.8	5.3	5.4	5.4	5.4
8	4.5	4.9	5.1	5.1	5.1
10	4.1	4.5	4.6	4.7	4.6
12	3.2	3.5	3.6	3.7	3.6
14	1.5	1.6	1.6	1.7	1.6
16	0.0	0.0	0.0	0.0	0.0

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GS2
Heading
vs
Flanking

Rate of Spread (ch/h)

1-hr & 10-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	29.4	53.3	83.6	119.0	158.7
6	26.8	48.6	76.2	108.4	144.6
8	24.7	44.8	70.2	99.9	133.2
10	21.9	39.7	62.3	88.6	118.2
12	17.9	32.4	50.8	72.3	96.4
14	3.3	4.0	4.0	4.0	4.0
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr & 10-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	6.3	8.3	10.2	12.1	13.8
6	5.9	7.7	9.5	11.2	12.8
8	5.5	7.3	8.9	10.5	12.0
10	5.0	6.6	8.1	9.5	10.9
12	4.2	5.5	6.8	8.0	9.1
14	0.9	1.0	1.0	1.0	1.0
16	0.0	0.0	0.0	0.0	0.0

Rate of Spread (ch/h)

1-hr & 10-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	9.0	12.6	16.1	19.2	22.1
6	8.2	11.5	14.7	17.5	20.2
8	7.5	10.6	13.5	16.2	18.6
10	6.7	9.4	12.0	14.3	16.5
12	5.4	7.7	9.8	11.7	13.4
14	1.0	1.1	1.1	1.1	1.1
16	0.0	0.0	0.0	0.0	0.0

Flame Length (ft)

1-hr & 10-hr fuel MC (%)	Midflame Wind Speed (upslope) mi/h				
	2	4	6	8	10
4	3.7	4.3	4.8	5.2	5.6
6	3.4	4.0	4.5	4.8	5.2
8	3.2	3.7	4.2	4.5	4.9
10	2.9	3.4	3.8	4.1	4.4
12	2.4	2.9	3.2	3.5	3.7
14	0.5	0.6	0.6	0.6	0.6
16	0.0	0.0	0.0	0.0	0.0

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Look at:

- TL8 (common for ponderosa pine litter)
  - Suitable for strip heading?
- SB3
  - Would you advise heading, backing, or flanking?

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Summary

- Relate prescription to objectives
- Diligent site assessment
- Know your fuels (model and load)
- Know your plants (season, stage)
- Know what's next door
- Think safety
- Take advantage of heading/backing/flanking behaviors
- Make sure you have reasonable numbers

Expect to adjust once you've modeled adjacent fuels for containment purposes.

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