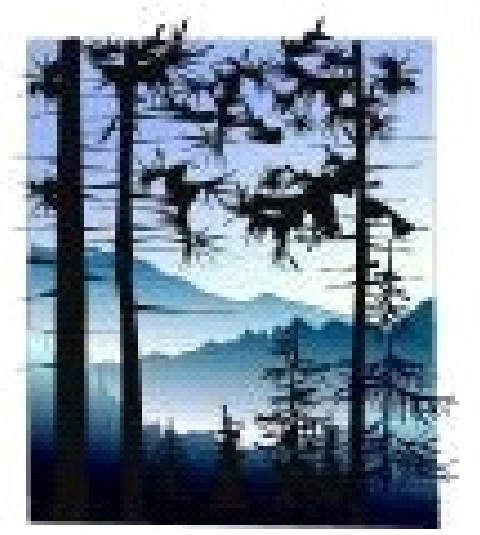
APPENDIX B

FIRE AND FUELS



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Fire Behavior Fuel Model Descriptions (Anderson, 1982)

Fuel Model 1: Short Grass

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The fine, very porous, and continuous herbaceous fuels that have cured or are nearly cured govern fire spread. Fires are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber overstory is present, generally less than 1/3 of the area. Both annual and perennial grasses are included; grasslands and savannas are represented along with grass-shrub combinations that meet the above area constraint

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	0.74 tons/acre
Dead Fuel Load, 0 - ¼-inch	0.74 tons/acre
Live fuel Load, foliage	0 tons/acre
Fuel Bed Depth	1.0 feet

Fuel Model 2: Grass with Timber/Shrub Overstory

Fire spread is primarily through the fine herbaceous fuels, either curing or dead. These are surface fires where the herbaceous material, in addition to the litter and dead-down stem and branch wood from the open shrub and/or timber overstory, contribute to the fire intensity. Open shrub lands or pine/oak/dry Douglas-fir stands that cover 1/3 to 2/3 of the area may generally fit this model; such stands may include clumps of fuels that generate higher intensities and that may produce firebrands.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	4.0 tons/acre
Dead Fuel Load, 0 - ¼-inch	2.0 tons/acre
Live fuel Load, foliage	0.5 tons/acre
Fuel Bed Depth	1.0 feet

The grass group of fuel models described above has a wide range of fire intensities and rates of spread. With wind speeds of 5 miles per hour, dead fuel moisture content of 8%, and live fuel moisture content of 100%, those models have the following fire behavior values:

Fuel Model	Rate of Spread in Chains Per Hour	Flame Length in Feet
1	78	4
2	35	6

Fuel Model 4: Mature Brush

Fire intensity and fast-spreading fires involve the foliage and live and dead fine woody material in the crowns of a nearly continuous secondary overstory. Stands of mature shrubs, 6 or more feet tall, such as California and Oregon mixed chaparral with flammable (volatile) foliage and a significant dead component fit this model. A deep litter layer may also be present. Actual height of the brush qualifying for this model depends on local conditions.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	13.0 tons/acre
Dead Fuel Load, 0 - ¼-inch	5.0 tons/acre
Live fuel Load, foliage	5.0 tons/acre
Fuel Bed Depth	6.0+ feet

Fuel Model 5: Young Brush

Fire is generally carried in the surface fuels that are made up of litter cast by the shrubs and the grasses or forbs in the understory. The fires are generally not very intense because fuel loads are light, the shrubs are young with little dead material, and the foliage contains little volatile material. Usually the shrubs are short and almost totally cover the area. Young, green stands up to 6 feet high with little or no dead wood qualify for this model. The live vegetation produces poor burning properties.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	3.5 tons/acre
Dead Fuel Load, 0 - ¼-inch	1.0 tons/acre
Live fuel Load, foliage	2.0 tons/acre
Fuel Bed Depth	2.0 feet

Fuel Model 6: Intermediate Brush

Fires carry through the shrub layer where the foliage is more flammable than fuel model 5, but this requires moderate winds (> 8 miles/hour at mid-flame height). Fire will drop to the ground at low wind speeds or at openings in the stand. The shrubs are older than in fuel model 5, but not as tall as shrub types of model 4, nor do they contain as much fuel as in model 4. Fuel situations include intermediate stands of chaparral, manzanita, white thorn, deer brush, etc; even hardwood slash that has cured (plantation thinning slash) can be considered.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	6.0 tons/acre
Dead Fuel Load, 0 - ¼-inch	1.5 tons/acre
Live fuel Load, foliage	0.0 tons/acre
Fuel Bed Depth	2.5 feet

The shrub group of fuel models described above has a wide range of fire intensities and rates of spread. With wind speeds of 5 miles per hour, dead fuel moisture content of 8%, and live fuel moisture content of 100%, those models have the following fire behavior values:

Fuel Model	Rate of Spread in Chains Per Hour	Flame Length in Feet
4	75	19
5	18	4
6	32	6

Fuel Model 8: Closed, Short Needle Timber Litter

Slow burning ground fires with low flame lengths are generally the case, although a fire may encounter an occasional "jackpot" or heavy fuels concentration that can flare up. Only under severe weather conditions involving high temperatures, low humidities, and high winds do the fuels pose significant fire hazards.

Closed canopy stands of short-needle conifers or hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and twigs because little undergrowth is present. Representative conifer types are Douglas-fir, true fir, hemlock, and spruce.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	5.0 tons/acre
Dead Fuel Load, 0 - ¼-inch	1.5 tons/acre
Live fuel Load, foliage	0.0 tons/acre
Fuel Bed Depth	0.2 feet

Fuel Model 9: Hardwood or Long Needle Pine Timber Litter

Fires run through the surface litter faster than in model 8 and have longer flame lengths. Both long-needle conifer and hardwood stands are typical. Closed stands of long-needled pine like ponderosa, Jeffrey, and sugar pine and hardwood stands of oak, madrone and tanoak are grouped in this model. Concentrations of dead-down woody material will contribute to possible torching of trees, spotting, and crowning.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	3.5 tons/acre
Dead Fuel Load, 0 - ¼-inch	2.9 tons/acre
Live fuel Load, foliage	0.0 tons/acre
Fuel Bed Depth	0.2 feet

Fuel Model 10: Mature/Overmature Timber and Understory

Fires will burn in the surface and ground fuels with greater intensity than the other timber litter models. Dead-down fuels include greater quantities of 3-inch or larger limbwood resulting from overmaturity or natural events that create a large load of dead material on the forest floor. Crowning out, spotting, and torching of individual trees is more frequent in this fuel model. Any forest type may be considered if heavy down material is present.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	12.0 tons/acre
Dead Fuel Load, 0 - ¼-inch	3.0 tons/acre
Live fuel Load, foliage	2.0 tons/acre
Fuel Bed Depth	1.0 feet

The fire intensities and spread rates of the timber litter group of fuel models described above are indicated by the following fire behavior values when the midflame wind speed is 5 miles per hour, dead fuel moisture content is 8%, and live fuel moisture content is 100:

Fuel Model	Rate of Spread in Chains Per Hour	Flame Length in Feet
8	1.6	1.0
9	7.5	2.6
10	7.9	4.8

Fuel Model 11: Light Slash

2-MC-2

Moderate downfall of limbs and boles in natural stands, light partial cuts or thinning operations in mixed conifer, or hardwood stands are considered for this fuel model. Fires are fairly active in the slash and intermixed herbaceous material. Fire potential can be limited by the shading from the overstory, the aging of the fine fuels, or the spacing of the rather light fuel load.

3-PP & Assoc-4

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	11.5 tons/acre
Dead Fuel Load, 0 - ¼-inch	1.5 tons/acre
Live fuel Load, foliage	0 tons/acre
Fuel Bed Depth	1.0 feet

Fuel Model 12: Medium Slash

Stands of mixed conifer and mixed conifer/hardwood stands that are heavily thinned, clearcuts, and medium or heavy partial cuts are all represented by this fuel model. Rapidly spreading, high intensity fires capable of producing firebrands can occur. When fires do start, they are generally sustained until a break in the fuel continuity or some other change in the fuels is encountered.

7-DFHD-4-CC

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	34.6 tons/acre
Dead Fuel Load, 0 - ¼-inch	4.0 tons/acre
Live fuel Load, foliage	0 tons/acre
Fuel Bed Depth	2.3 feet

Fuel Model 13 Heavy Slash

This model is depicted by clear cuts and heavy partial cuts in mature and over-mature stands where slash load is dominated by greater than 3 inch diameter materials. Fires spread quickly through fine fuels and intensity builds as the large fuels start burning. Active flaming is sustained for long periods and a wide variety of firebrands can be generated.

Fuel Model Values for Estimating Fire Behavior

Total Fuel Load, < 3-inch dead & live	58.1 tons/acre
Dead Fuel Load, 0 - ¼-inch	7.0 tons/acre
Live fuel Load, foliage	0 tons/acre
Fuel Bed Depth	3.0 feet

The fire intensities and spread rates of the slash litter group of fuel models described above are indicated by the following fire behavior values when the midflame wind speed is 5 miles per hour and dead fuel moisture.

Fuel Model	Rate of Spread in Chains Per Hour	Flame Length in Feet
11	6.0	3.5
12	13.0	8.0
13	13.5	10.5

References

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