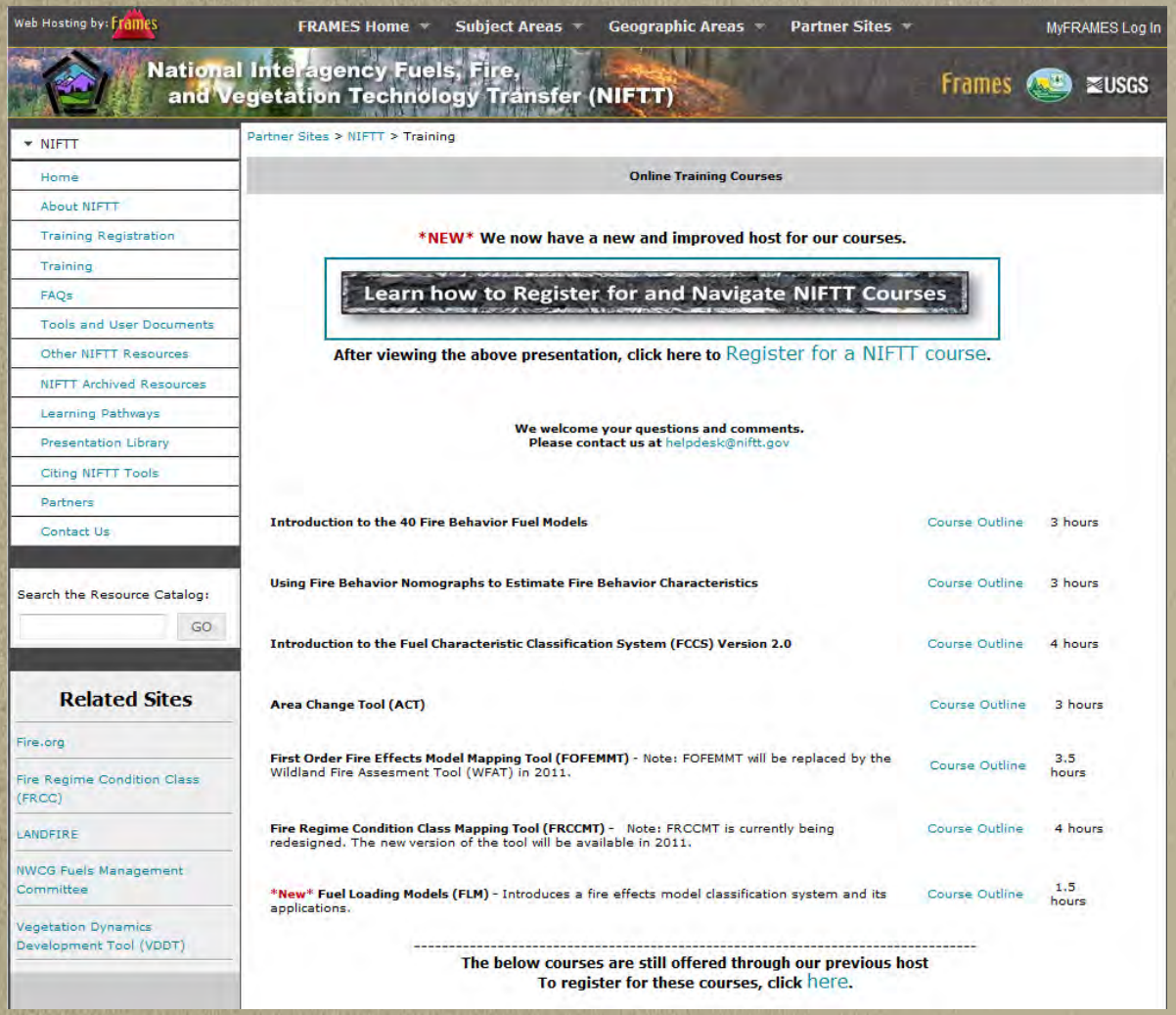
# Unit I
# Introduction to the 40 Fuel Models

# NIFTT

http://www.frames.gov/portal/server.pt/community/niftt/382/training/1659



# What is a model?

- A device used to emulate the real world

# What is a fuel model?

- Set of fuelbed characteristic inputs needed by a fire model

# What is a fuel model?

- Set of fuelbed characteristic inputs needed by a fire model

**Fuelbed inputs:**

- Fuel load by size class
- Bulk density
- Fuel particle size
- Heat content
- Extinction moisture content

**Table 7**—Fuel model parameters.

| Fuel model code | Fuel load (t/ac) | | | | | Fuel model type[a] | SAV ratio (1/ft)[b] | | | Fuel bed depth (ft) | Dead fuel extinction moisture (percent) | Heat content BTU/lb)[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-hr | 10-hr | 100-hr | Live herb | Live woody | | Dead 1-hr | Live herb | Live woody | | | |
| 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.

# What is a fuel model?

- Set of fuelbed characteristic inputs needed by a fire model
  - Fire behavior fuel models
  - NFDRS fuel models
  - Fuel loading models
  - FCCS fuelbed

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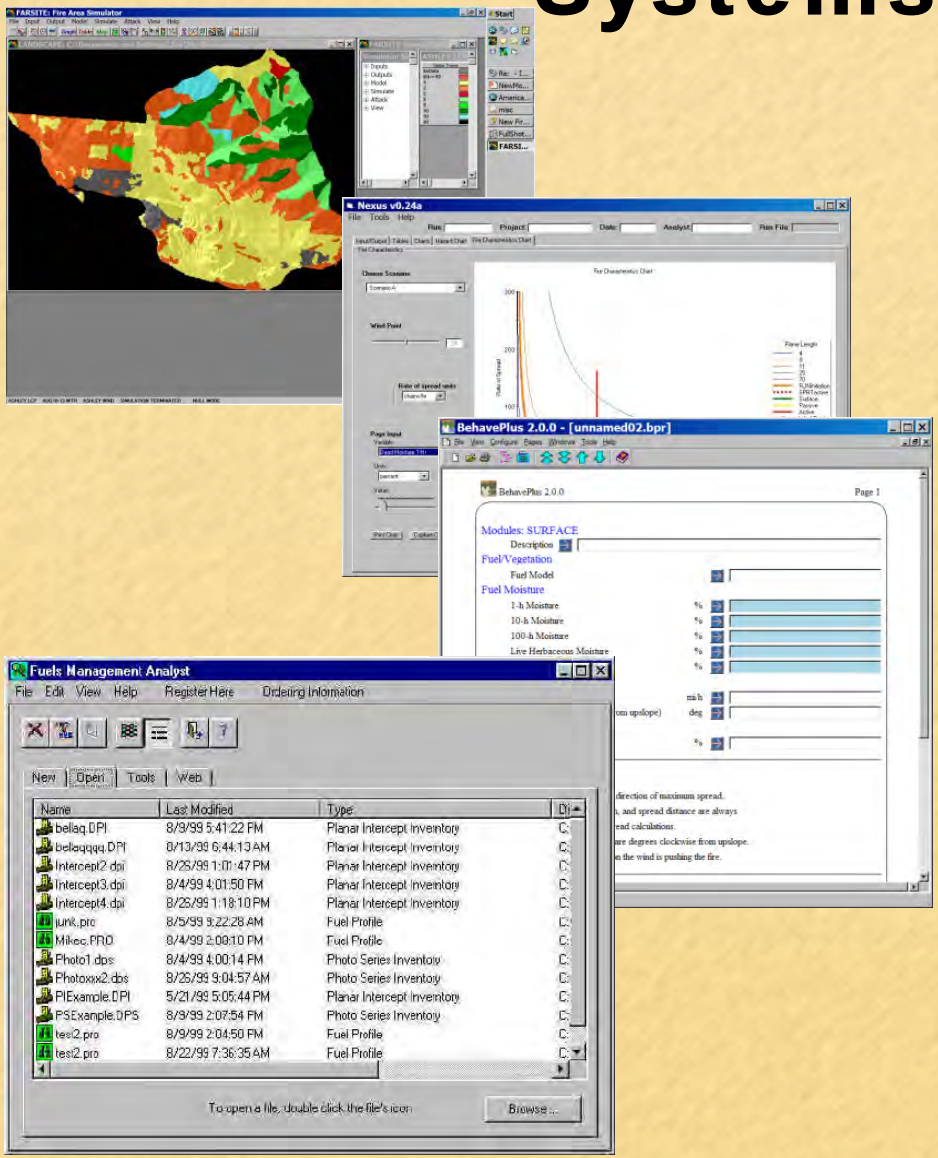
# Why the 40 Fuel Models?

- More Fuel Model Choices
- Less Gaps
- Better Suited for predicting post treatment fire behavior
- Cover a wider range of seasons
- Better drives crown fire initiation models
- Reduced need for custom fuel models

# Systems




- BehavePlus
- FARSITE
- FlamMap
- FSPro
- FFE-FVS
- NEXUS
- BEHAVE by Remsoft
- FMAplus

# History

Table 1.--*Values for input parameters of 11 preliminary fuel models for the National Fire-Danger Rating System*[1]

| Fuel types | Total loading | Dead fuel | | | | | | Living fuel | | Fuel depth |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Fine | | Medium | | Large | | | | |
| | | $\sigma$ | $w_o$ | $\sigma$ | $w_o$ | $\sigma$ | $w_o$ | $\sigma$ | $w_o$ | |
| | *Tons/acre* | *Ft.*$^{-1}$ | *Lb./ ft.*$^2$ | *Ft.*$^{-1}$ | *Lb./ ft.*$^2$ | *Ft.*$^{-1}$ | *Lb./ ft.*$^2$ | *Ft.*$^{-1}$ | *Lb./ ft.*$^2$ | *Ft.* |
| Grass (short) | 0.75 | 3,500 | 0.034 | -- | -- | -- | -- | -- | -- | 1.0 |
| Grass (tall) | 3.0 | 1,500 | .138 | -- | -- | -- | -- | -- | -- | 2.5 |
| Brush (not chaparral) | 6.0 | 2,000 | .046 | 109 | 0.023 | -- | -- | 1,500 | 0.092 | 2.0 |
| Chaparral | 25.0 | 2,000 | .230 | 109 | .184 | 30 | .092 | 1,500 | .230 | 6.0 |
| Timber (grass and understory) | 4.0 | 3,000 | .092 | 109 | .046 | 30 | .023 | 1,500 | .023 | 1.5 |
| Timber (litter) | 15.0 | 2,000 | .069 | 109 | .046 | 30 | .115 | -- | -- | 0.2 |
| Timber (litter and understory) | 30.0 | 2,000 | .138 | 109 | .092 | 30 | .230 | 1,500 | .092 | 1.0 |
| Hardwood (litter) | 15.0 | 2,500 | .134 | 109 | .019 | 30 | .007 | -- | -- | 0.2 |
| Logging slash (light) | 40.0 | 1,500 | .069 | 109 | .207 | 30 | .253 | -- | -- | 1.0 |
| Logging slash (medium) | 120.0 | 1,500 | .184 | 109 | .644 | 30 | .759 | -- | -- | 2.3 |
| Logging slash (heavy) | 200.0 | 1,500 | .322 | 109 | 1.058 | 30 | 1.288 | -- | -- | 3.0 |

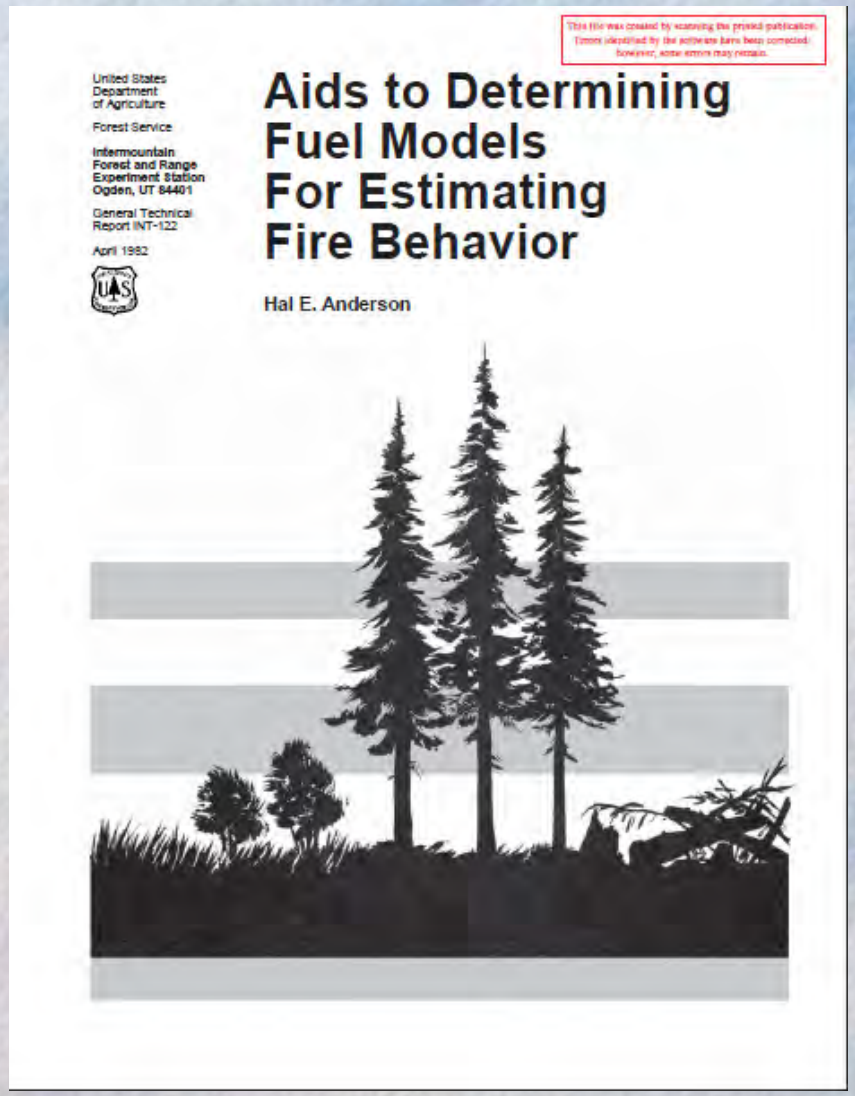
[1] For all models $S_t = 0.0555$, $S_e = 0.010$, h = 8,000 B.t.u./lb., $\rho_b = 32.0$ lb./ft.$^3$, $(M_x)_{dead} = 0.30$, $(M_x)_{living}$ determined by equation 88.

# History

Table 7.--*Description of fuel models used in constructing the nomographs*

| Model | Typical fuel complexes | Surface-to-volume ratio ($ft^{-1}$)/Loading ($lb/ft^2$): Dead fuel 1-h | Dead fuel 10-h | Dead fuel 100-h | Live fuel (Foliage) | Depth (ft) | Moisture of extinction, dead fuel (percent) |
|---|---|---|---|---|---|---|---|
| | | | GRASS AND GRASS-DOMINATED | | | | |
| 1 | Short grass (1 ft) | 3500/.034 | -- | -- | -- | 1.0 | 12.7 |
| 2 | Timber (grass and understory) | 3000/.092 | 109/.046 | 30/.023 | 1500/.023 | 1.0 | 15 |
| 3 | Tall grass (2.5 ft) | 1500/.138 | -- | -- | -- | 2.5 | 25 |
| | | | CHAPARRAL AND SHRUBFIELDS | | | | |
| 4 | Chaparral (6 ft) | 2000/.230 | 109/.184 | 30/.092 | 1500/.230 | 6.0 | 20 |
| 5 | Brush (2 ft) | 2000/.046 | 109/.023 | -- | 1500/.092 | 2.0 | 20 |
| 6 | Dormant brush, hardwood slash | 1750/.069 | 109/.115 | 30/.092 | -- | 2.5 | 25 |
| 7 | Southern rough | 1750/.052 | 109/.086 | 30/.069 | 1550/.017 | 2.5 | 40 |
| | | | TIMBER LITTER | | | | |
| 8 | Closed timber litter | 2000/.069 | 109/.046 | 30/.115 | -- | 0.2 | 30 |
| 9 | Hardwood litter | 2500/.134 | 109/.019 | 30/.007 | -- | .2 | 25 |
| 10 | Timber (litter and understory) | 2000/.138 | 109/.092 | 30/.230 | 1500/.092 | 1.0 | 25 |
| | | | LOGGING SLASH | | | | |
| 11 | Light logging slash | 1500/.069 | 109/.207 | 30/.253 | -- | 1.0 | 15 |
| 12 | Medium logging slash | 1500/.184 | 109/.644 | 30/.759 | -- | 2.3 | 20 |
| 13 | Heavy logging slash | 1500/.322 | 109/1.058 | 30/1.288 | -- | 3.0 | 25 |

# History



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Forest Service

Intermountain Forest and Range Experiment Station Ogden, UT 84401

General Technical Report INT-122

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## Aids to Determining Fuel Models For Estimating Fire Behavior

Hal E. Anderson

# History

- Many fuel inputs have always been constant for all fuel models
  - 10-h and 100-h dead fuel SAV ratio
  - Total and effective mineral fraction
  - Ovendry fuel particle density

- Designed to stand alone

- Designed to stand alone
- Original 13 still available

- Designed to stand alone
- Original 13 still available
- Specifies fuelbeds not vegetation

- Three-part naming convention

- Three-part naming convention
  - Fuel model code

- Three-part naming convention
  - Fuel model code
  - Fuel model number

| fuel type | fuel model number block | used in original or new set | reserved for future standard fuel models | available for custom fuel models |
|---|---|---|---|---|
| | 1-13 | 1-13 | | |
| | 14-89 | | | 14-89 |
| NB | 90-99 | 91-93, 98-99 | 94-95 | 90, 96-97 |
| GR | 100-119 | 101-109 | 110-112 | 100, 113-119 |
| GS | 120-139 | 121-124 | 125-130 | 120, 131-139 |
| SH | 140-159 | 141-149 | 150-152 | 140, 153-159 |
| TU | 160-179 | 161-165 | 166-170 | 160, 171-179 |
| TL | 180-199 | 181-189 | 190-192 | 180, 193-199 |
| SB | 200-219 | 201-204 | 205-210 | 200, 211-219 |
| | 220-256 | | | 220-256 |

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| GS | 120-139 | 121-124 | 125-130 | 120, 131-139 |
| SH | 140-159 | 141-149 | 150-152 | 140, 153-159 |
| TU | 160-179 | 161-165 | 166-170 | 160, 171-179 |
| TL | 180-199 | 181-189 | 190-192 | 180, 193-199 |
| SB | 200-219 | 201-204 | 205-210 | 200, 211-219 |
| | 220-256 | | | 220-256 |

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| GS | 120-139 | 121-124 | 125-130 | 120, 131-139 |
| SH | 140-159 | 141-149 | 150-152 | 140, 153-159 |
| TU | 160-179 | 161-165 | 166-170 | 160, 171-179 |
| TL | 180-199 | 181-189 | 190-192 | 180, 193-199 |
| SB | 200-219 | 201-204 | 205-210 | 200, 211-219 |
| | 220-256 | | | 220-256 |

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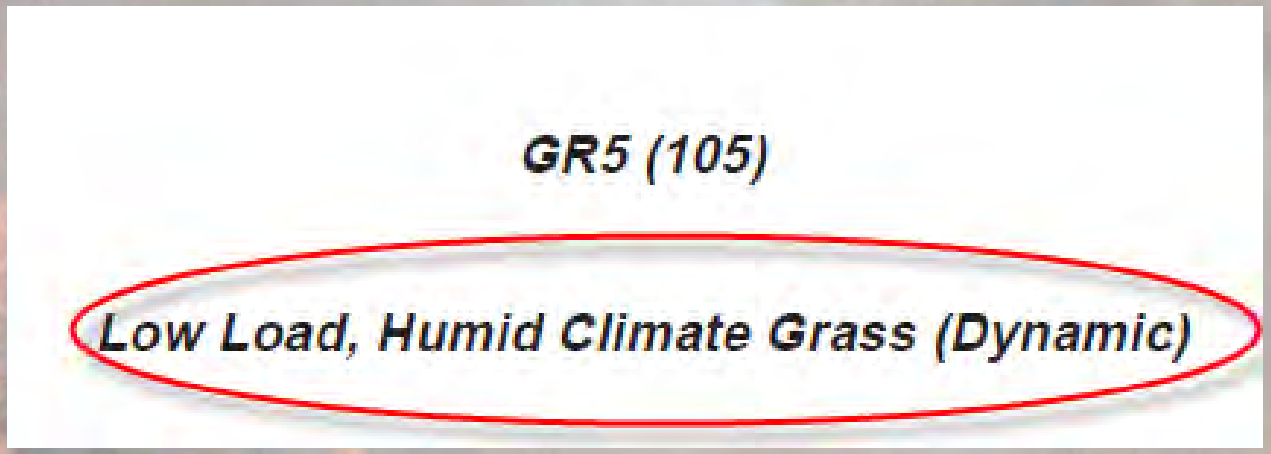
| SB | 200-219 | 201-204 | 205-210 | 200, 211-219 |
| | 220-256 | | | 220-256 |

# Naming

Three Part Naming Convention

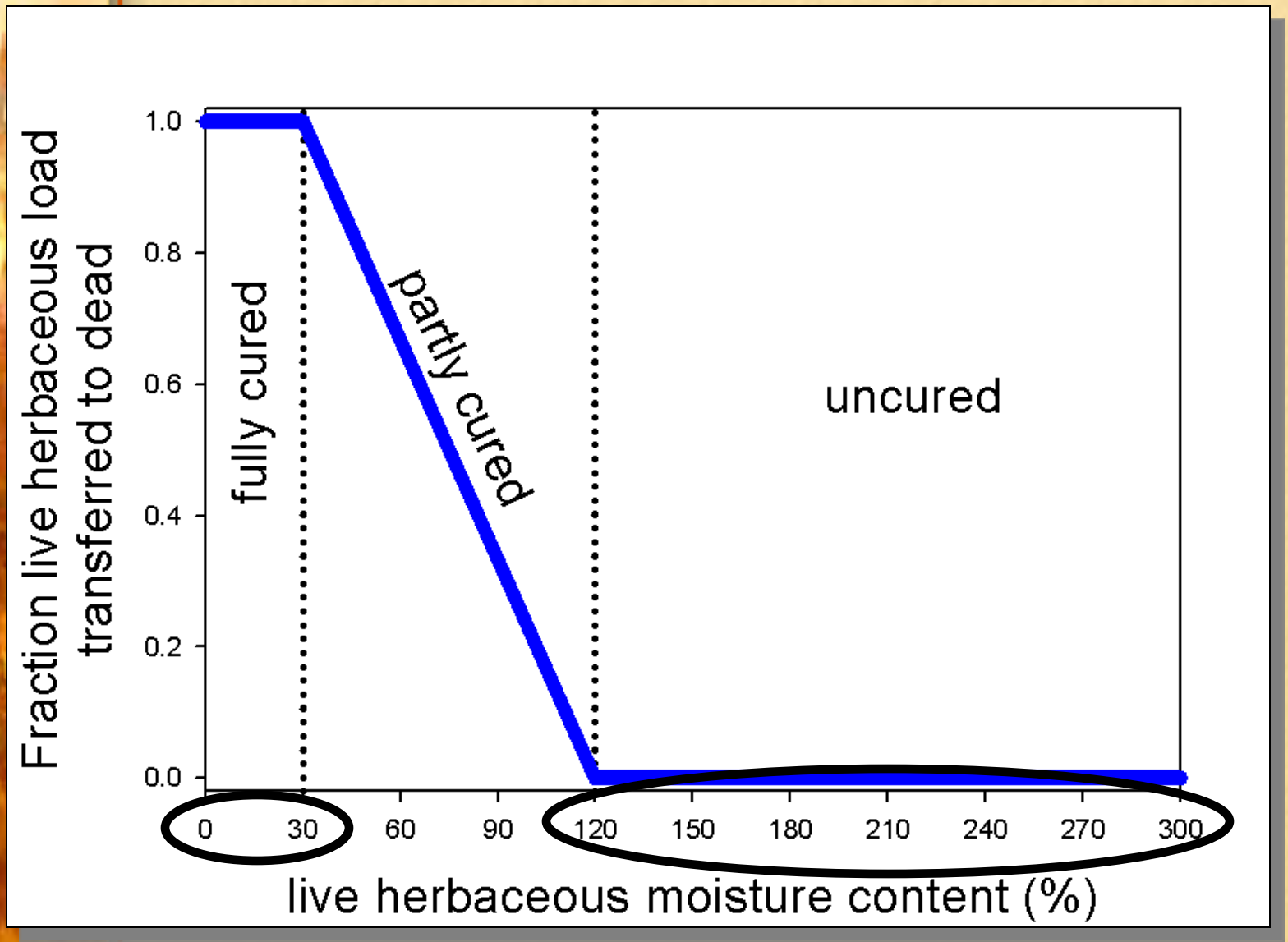
1) Fire Model Code
2) Fuel Model Number
3) Fuel Model Name



# Dynamic

- Allocation of herbaceous load to live and dead

# Dynamic fuel models



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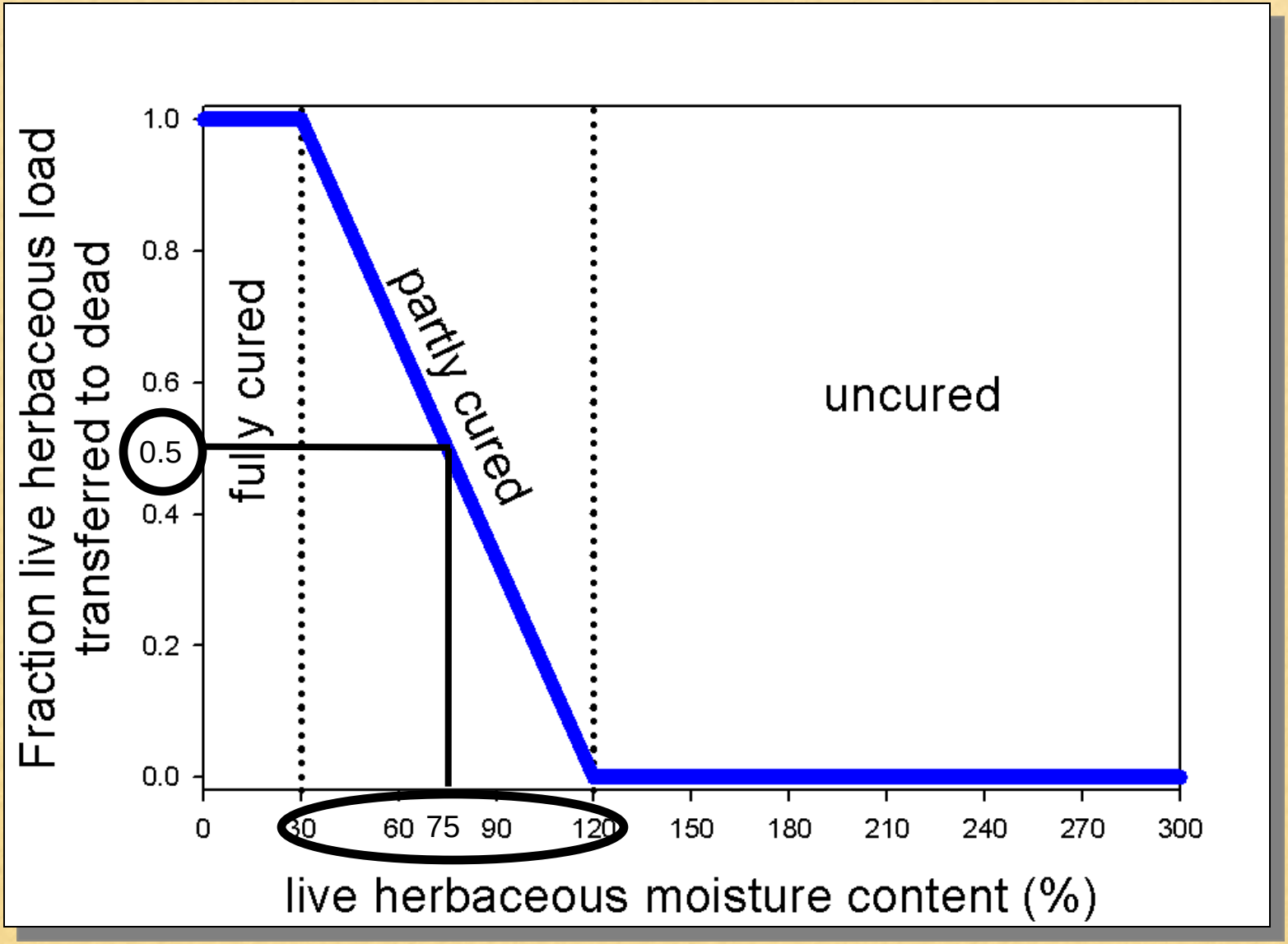
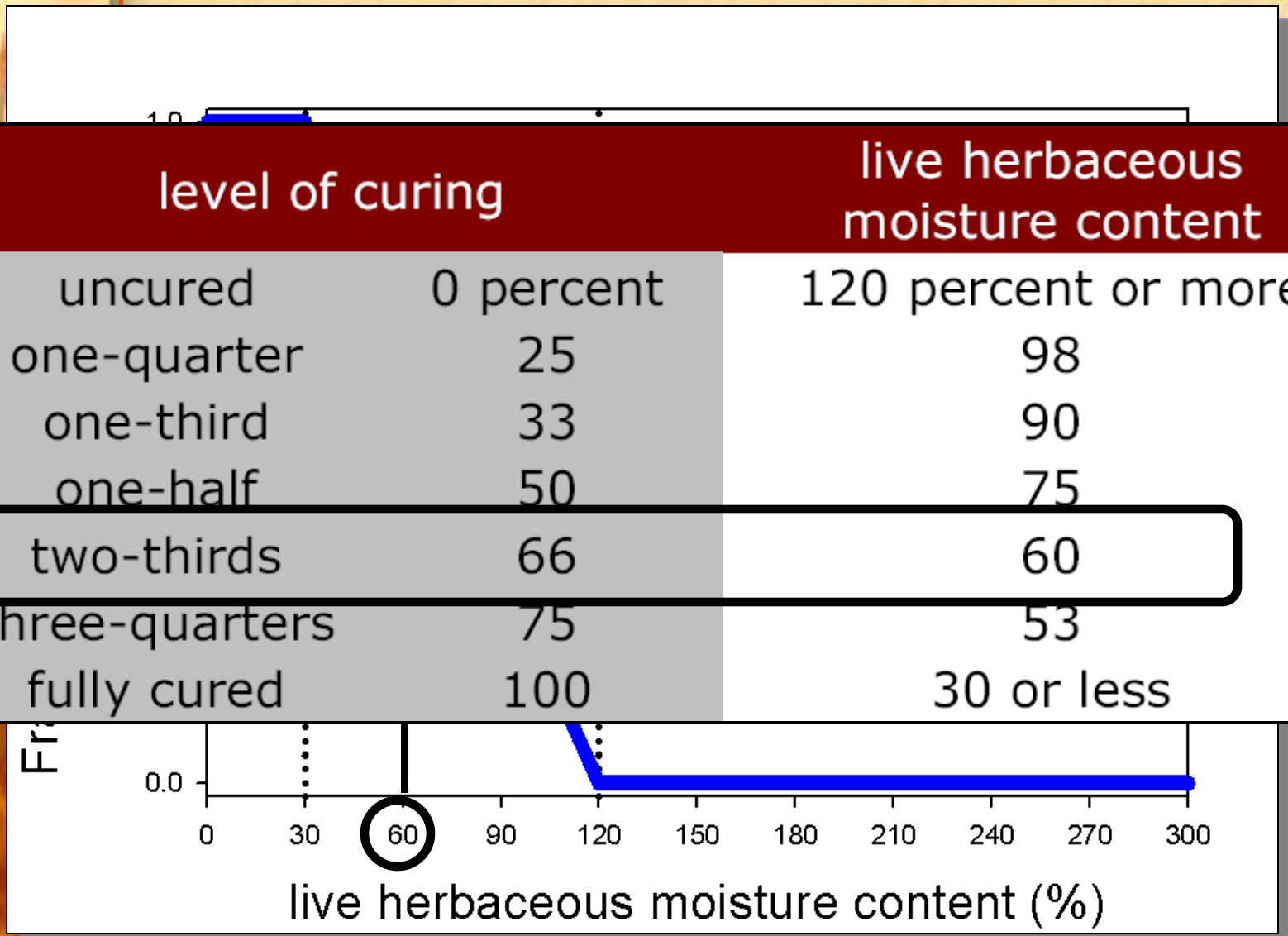


# Dynamic fuel models

| level of curing | | live herbaceous moisture content |
|---|---|---|
| uncured | 0 percent | 120 percent or more |
| one-quarter | 25 | 98 |
| one-third | 33 | 90 |
| one-half | 50 | 75 |
| two-thirds | 66 | 60 |
| three-quarters | 75 | 53 |
| fully cured | 100 | 30 or less |



# Dynamic fuel models

- Allocation of herbaceous load to live and dead

# Dynamic fuel models

- Allocation of herbaceous load to live and dead
- Dead herbaceous load takes on dead 1-hr MC

# Dynamic fuel models

- Allocation of herbaceous load to live and dead
- Dead herbaceous load takes on dead 1-hr MC
- Dead herbaceous load is given the live herbaceous SAV ratio

# Dynamic fuel models

- Allocation of herbaceous load to live and dead
- Dead herbaceous load takes on dead 1-hr MC
- Dead herbaceous load is given the live herbaceous SAV ratio
- Increases ability (and difficulty)