Pre

Post 1

Post 2

Post 8

Region 5 Fuel Treatment Effectiveness and Effects Study 2001 - 2011

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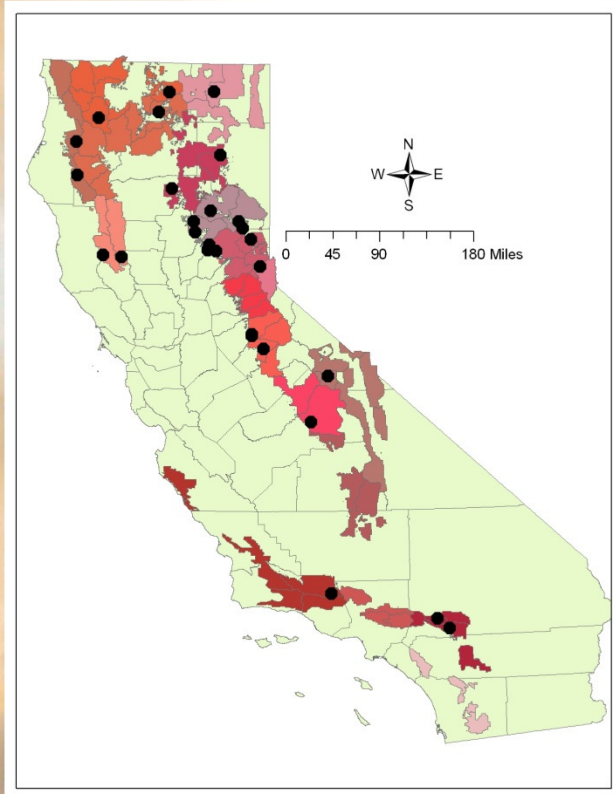
ARE CUSTOM FUEL MODELS BETTER?

The Efficacy and Limitations of Custom Fuel Modeling using FFE-FVS

BACKGROUND

- Region-wide, long-term monitoring program encompassing 14 National Forests in California, from 2001 to 2011 (and 2012).
- Pre and Post-treatment measurements of surface and crown fuels; vegetation structure and composition; and wildlife habitat.
- Fuel treatments: prescribed fire only, thinning only, mechanical understory treatments (mastication), and thinning followed by a surface fuel reduction.
- Dominant overstory: Yellow Pine (Ponderosa, Jeffrey), Mixed Conifer, Red fir, and Douglas-fir
- Measurement intervals include: Pre, Post1, Post2, Post5, Post8, and Post10.



OBJECTIVES

- Evaluate predicted fire behavior & fuels between 3 methods used to compute fuel models
  - Custom Fuel Models using calculated values of bulk density from field measurements
  - Custom Fuel Models using default values of bulk density from FFE-FVS (Appendix B)
  - Standardized Fuel Models chosen from FFE-FVS (Appendix B)

FIRE MODELS

The Fire Spread Model

$$R = \frac{I_r \xi (1 + \phi_w + \phi_s)}{\rho_b \varepsilon Q_{ig}}$$

Surface Fire Rate of Spread

served 6.1-m (20-ft) windspeed. In simple form, the Rothermel (1991a) correlation for average crown fire spread rate is

$$R_{active} = 3.34(R_{10})_{40\%} \qquad (7)$$

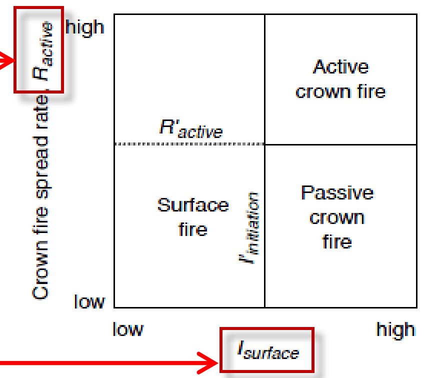
Crown Fire Rate of Spread

Byram (1959) defines fireline intensity, I, as

$$I = \frac{H W_f R}{60}$$

Fireline Intensity

Transition to Passive & Active Crown Fire



Byram also showed how the flame length could be calculated from the fireline intensity with the model:

$L = 0.45 I^{0.46}$ flame length, ft

Flame Length

BACKGROUND

Parameters for a fuel model

Table B.1.2 - Fuel model parameters, their standard English units, and how each is mapped to a fuel pool quantity, a default value, or a calculation.

Fuel model parameter	units	Description
1-h load	t/a	The litter load plus the 1-h timelag dead fuel load as described in Table 1.
10-h load	t/a	The 10-h timelag dead fuel load as described in Table 1.
100-h load	t/a	The 100-h timelag dead fuel load as described in Table 1.
Live herbaceous load	t/a	The herbaceous fuel load as described in Table 1.
Live woody load	t/a	The live woody fuel load as described in Table 1.
1-h SAV	1/ft	User-specified SAV ratio of the 1-h timelag class. Default = 2000 1/ft. (See FireCalc keyword.)
Herbaceous SAV	1/ft	User-specified SAV ratio of the herbaceous fuel class. Default = 1800 1/ft. (See FireCalc keyword.)
Live woody SAV	1/ft	User-specified SAV ratio of the live woody fuel class. Default = 1500 1/ft. (See FireCalc keyword.)
Fuel bed depth	Ft	Calculation described below.
Dead fuel extinction moisture	Percent	Calculation described below.
Heat content	BTU/lb	Heat content of the fuel. All but one of the 53 standard fuel models uses a value of 8000 BTU/lb. Default = 8000 BTU/lb. (See FireCalc keyword.)

WHAT DOES FFE-FVS DO THAT IS DIFFERENT?

Obtain a value for **Bulk Density (Fuel Bed Depth)** that is representative of the measured fuel complex.

$$FuelBedDepth = \frac{TFL}{BD} * 0.04591$$

where:

TFL = total fuel load (t/ac)

BD = fuelbed bulk density (lb/ft^3)

Bulk Density = TFL/Fuel Bed Depth

Bulk density is a function of both live and dead fuels, weighted by the proportion of each that compose the fuel bed.

$$BD = BD_{live} + [WF * (BD_{dead} - BD_{live})]$$

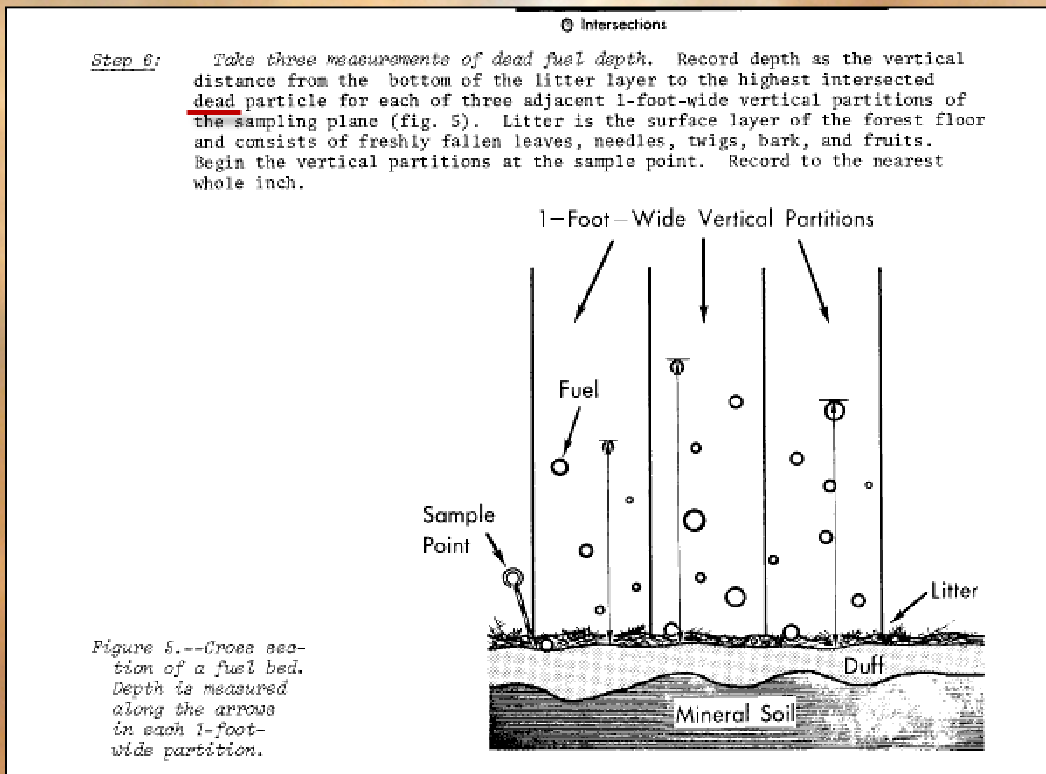
where:

BD_{live} = bulk density of the live fuel component of the fuelbed

BD_{dead} = bulk density of the dead fuel component of the fuelbed

Rebain et al. 2012. The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation, pg. .366

BACKGROUND



⊙ Intersections

Step 6: *Take three measurements of dead fuel depth.* Record depth as the vertical distance from the bottom of the litter layer to the highest intersected dead particle for each of three adjacent 1-foot-wide vertical partitions of the sampling plane (fig. 5). Litter is the surface layer of the forest floor and consists of freshly fallen leaves, needles, twigs, bark, and fruits. Begin the vertical partitions at the sample point. Record to the nearest whole inch.

Figure 5.--Cross section of a fuel bed. Depth is measured along the arrows in each 1-foot-wide partition.

Brown, J.K. 1974. Handbook for Inventorying Downed Woody Material. pg. 7.

Fuel Bed Depth:
“Record depth as the vertical distance from the bottom of the litter layer to the highest intersected dead particle…”

Does not take live fuels into account

METHODS

- Calculated Bulk Density
  - Measured Fuel loads and heights were used to compute bulk density.
    - BD_{live} = Live H + Live W / Live fuel Ht (weighted)
    - BD_{dead} = Fine Dead Fuel Loading/Fuel Height (measured in the field)
    - WF = scales between Bd_{live} & Bd_{dead} using measured dead fuel loads and modeled live fuels.

$$BD = BD_{live} + [WF * (BD_{dead} - BD_{live})]$$

where:

BD_{live} = bulk density of the live fuel component of the fuelbed

BD_{dead} = bulk density of the dead fuel component of the fuelbed

METHODS

- FFE-FVS Calculated Bulk Density
  - Default Bulk Density Values were used.
    - BD_{live} = 0.10 lb/ft^3
    - BD_{dead} = 0.75 lb/ft^3
    - WF = scales between Bd_{live} & Bd_{dead} using measured dead fuels and modeled live fuels.

$$BD = BD_{live} + [WF * (BD_{dead} - BD_{live})]$$

where:

BD_{live} = bulk density of the live fuel component of the fuelbed

BD_{dead} = bulk density of the dead fuel component of the fuelbed

METHODS

- FFE-FVS Selects a Fuel Model:

  A Standardized Fuel model is chosen based on:

  - Major fuel carrying the fire – grass, grass/shrub, litter/slash, or shrub/timber understory
  - Climate type and how that affects the moisture value whereby the fuel will no longer burn (moisture of extinction) – Arid to semi-arid or humid to semi-humid.
  - Whether to use Anderson's 13 fuels models; Scott and Burgan 40 fuel models or both.

$$DI = 0.25 * \left(\frac{SAV_{fuelbed} - SAV_{fm}}{405.2} \right)^2 + 0.25 * \left(\frac{BD_{fuelbed} - BD_{fm}}{0.3992} \right)^2 + 0.50 * \left(\frac{FFL_{fuelbed} - FFL_{fm}}{3.051} \right)^2$$

where:

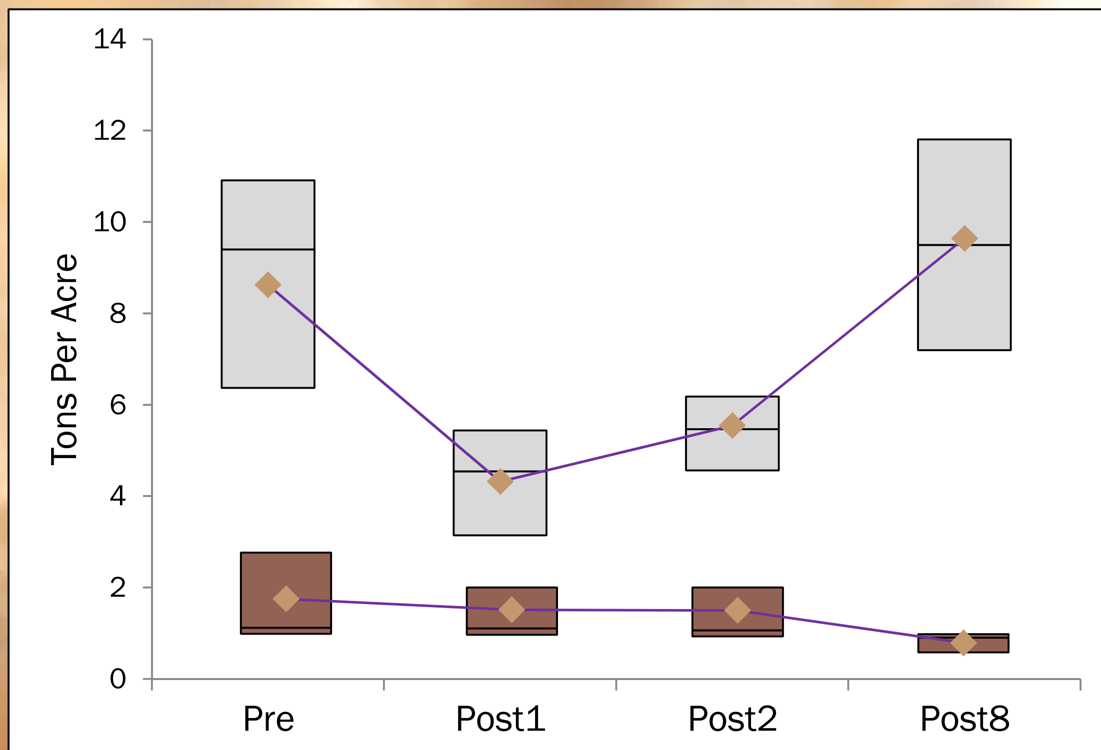
$SAV_{fuelbed}$	=	surface area to volume ratio of the subject fuelbed
SAV_{fm}	=	surface area to volume ratio of the subject standard fuel model
405.2	=	standard deviation of SAV of the 53 standard fuel models
$BD_{fuelbed}$	=	bulk density (lb/ft^3) of the subject fuelbed
BD_{fm}	=	bulk density (lb/ft^3) of the subject standard fuel model
0.3992	=	standard deviation of BD of the 53 standard fuel models
$FFL_{fuelbed}$	=	fine fuel load (t/a) of the subject fuelbed
FFL_{fm}	=	fine fuel load (t/a) of the subject standard fuel model
3.051	=	standard deviation of FFL of the 53 standard fuel models

RESULTS

Mixed Conifer, Surface Fire Only, Live & Dead Surface Fuels

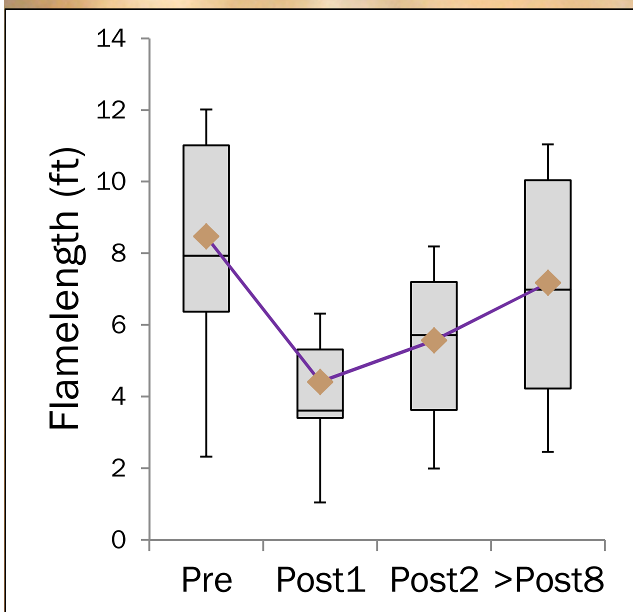
Measured Downed Fuels

FFE Simulated Live Fuels

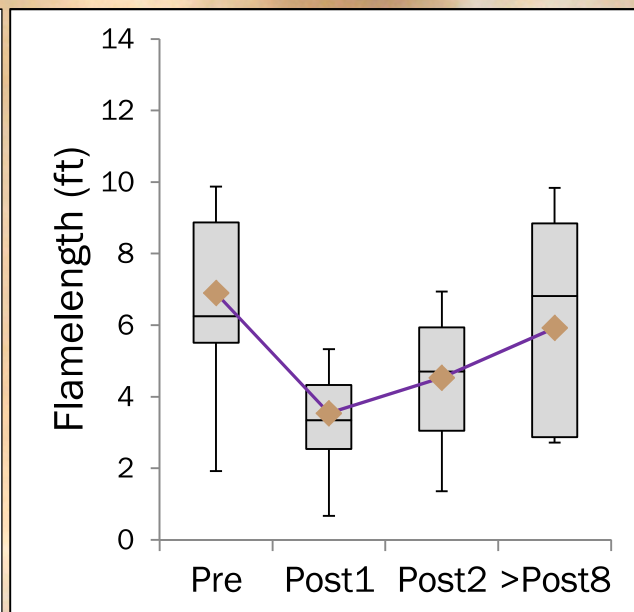


RESULTS

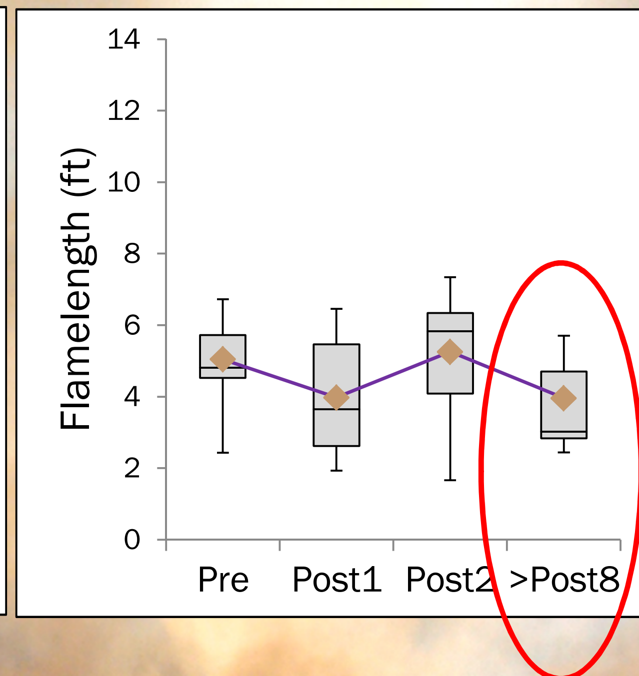
Predicted Surface Flame Length (ft) modeled under a Severe Scenario



Calculated Bulk Density



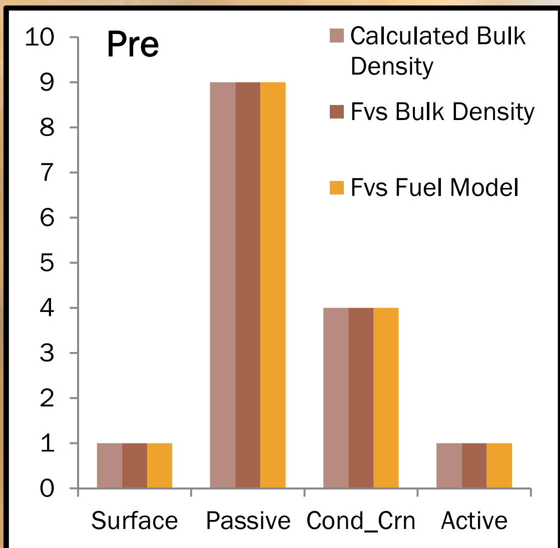
FVS Bulk Density

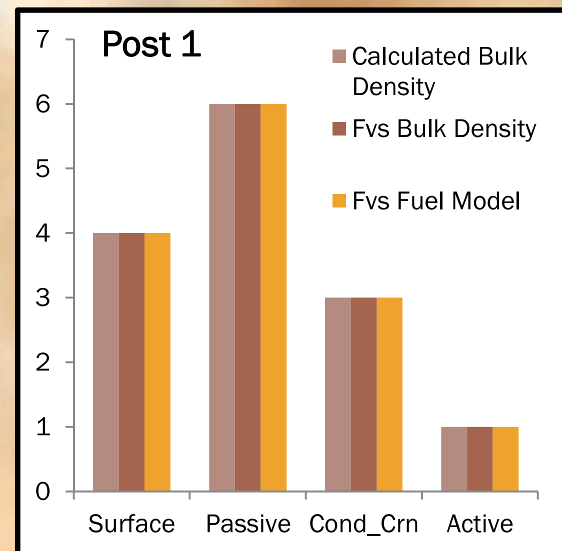


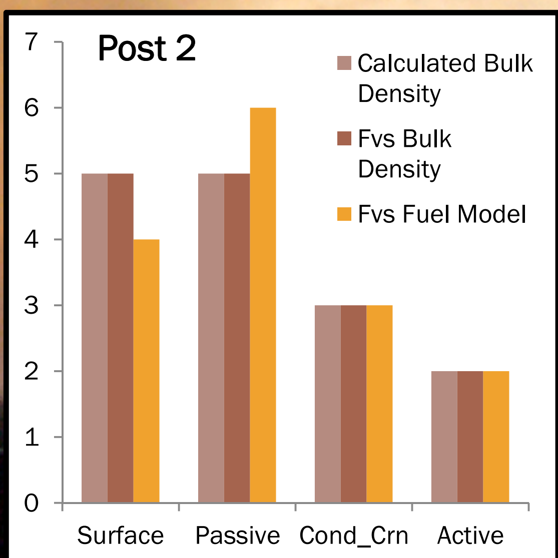
FVS Fuel Model

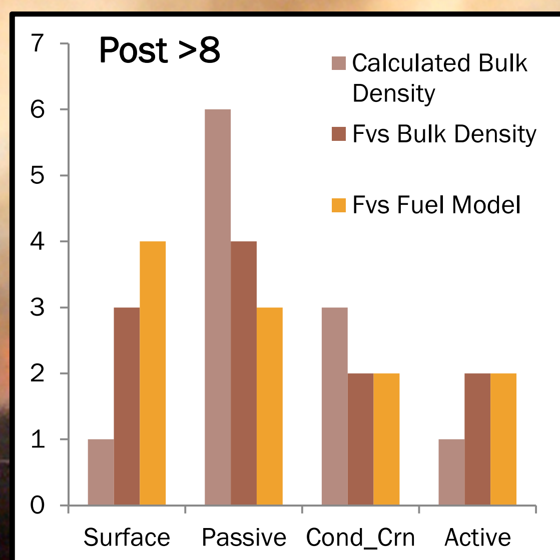
RESULTS

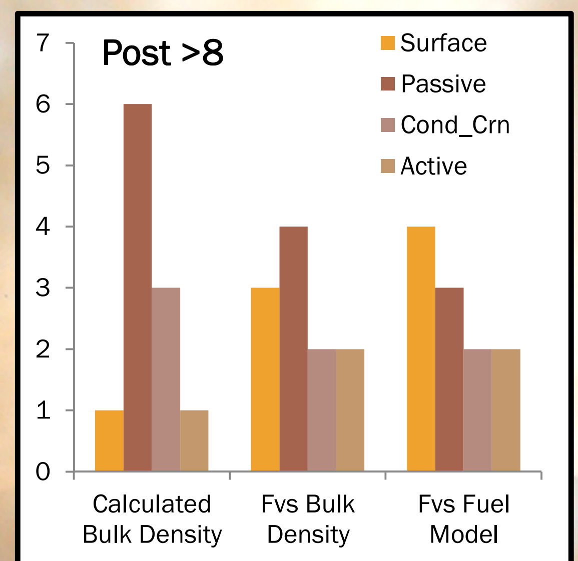
Predicted Fire Type modeled under a Severe Scenario



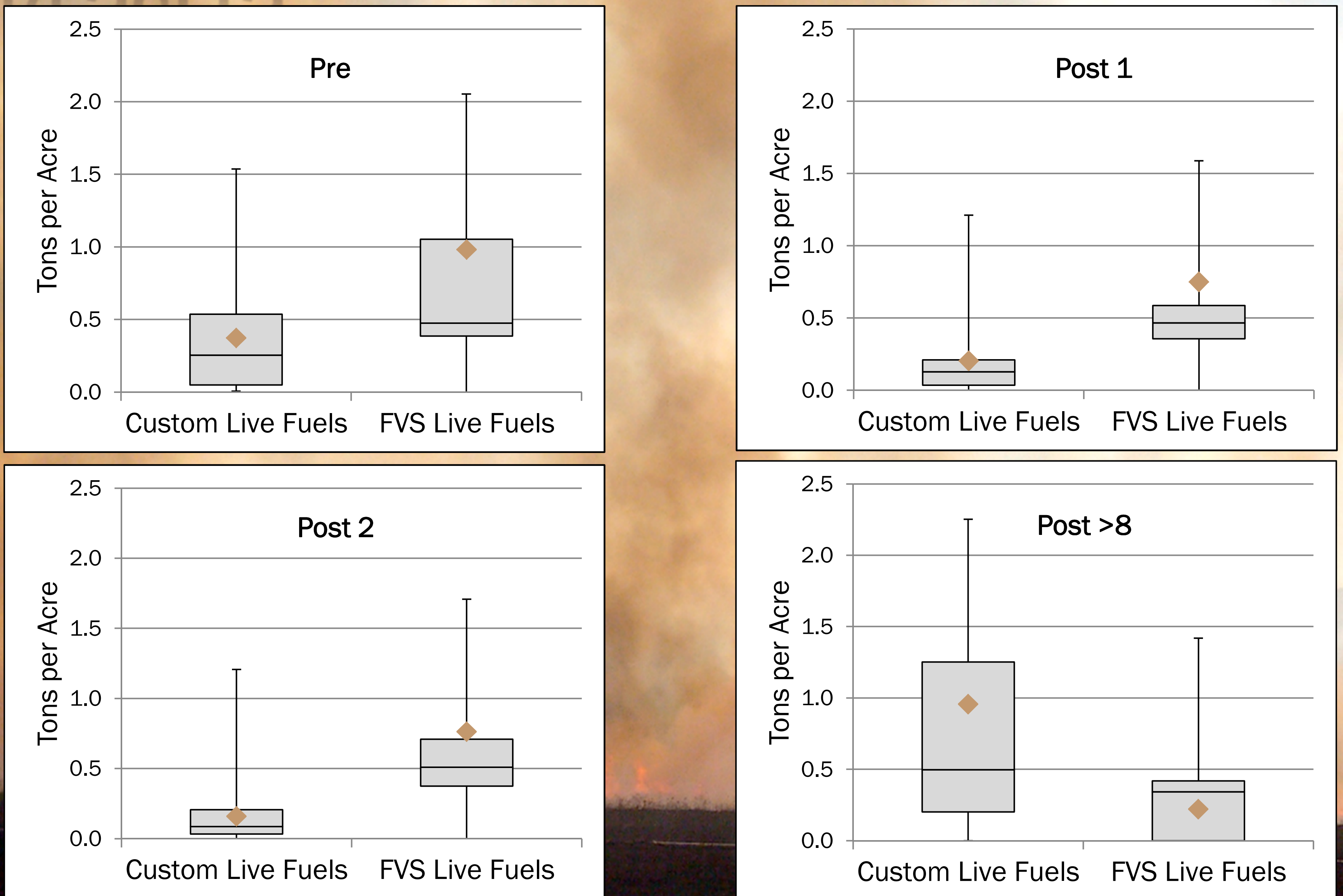








RESULTS


Pre
Post 1
Post 2
Post >8
Tons per Acre
2.5
2.0
1.5
1.0
0.5
0.0
Custom Live Fuels
FVS Live Fuels

EFFICACY

- A modeling system to provide an objective approach to calculate bulk density for both live & dead fuels.
- Using FFE-FVS defaults is easy

LIMITATIONS

- FFE-FVS calculates its own values of Live Woody and Live Herbaceous fuel loads
  - For a majority of Region 5 variants, based on tree canopy cover and dominant overstory species.
- What makes FFE-FVS so useful is also what makes it hard to obtain fuel models based on your data alone.
  - The Fire behavior calculations are done AFTER fuel accumulation from snags and decay, but before litter fall and crown breakage.
  - Keywords available to control these processes.

ARE CUSTOM FUEL MODELS BETTER?

- Not an automatic “YES”
- Greater variability of fuels mean greater variability for the results
- Do custom fuel models produce realistic values of fire behavior?
- Does the relative difference between time since treatment make sense given the change of fuels (both live & dead)?

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