Fire Behavior and Fire Effects of Mastication and Prescribed Fire in a Ponderosa Pine Plantation

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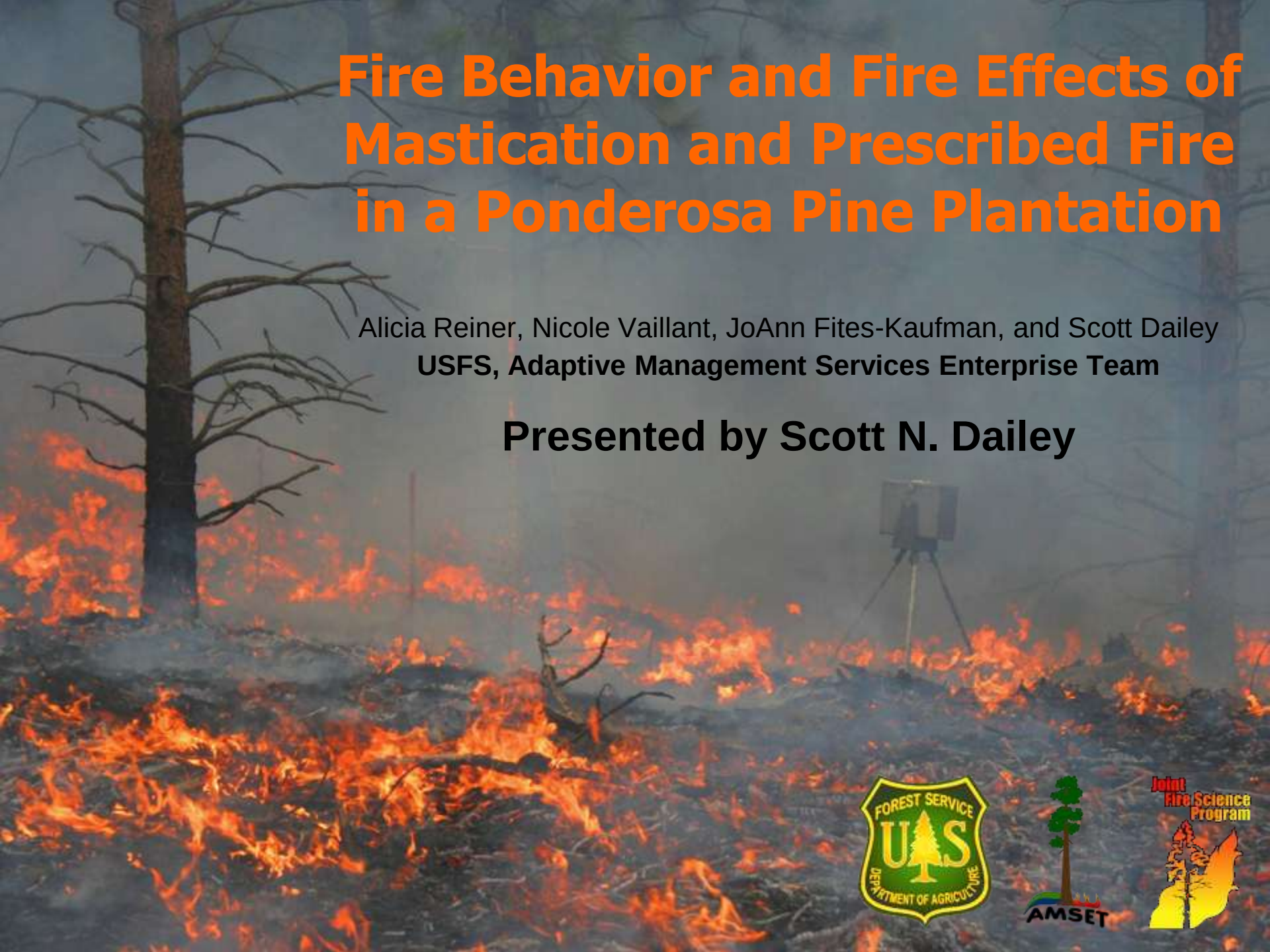
Presented by Scott N. Dailey



What is mastication?

- Mechanical fuel treatment alternative
- Shreds fuel into small chunks

What is mastication?

- Removes ladder fuels (shrubs & small trees)
- Canopy fuels reduced… transferred to the surface layer

Treatment objectives?

- Reduce the risk of crown fire
- Improve suppression effectiveness
- Reduce undesirable fire effects

Why mastication?

- Mechanical treatment alternative where tree removal is not feasible
- More cost effective than hand-treating
- Avoids air quality issues associated with prescribed burning
- Pre-treatment necessary to safely apply a prescribed underburn

Concerns over mastication?

Surface fuels increased

- Undesirable fire behavior?
- Undesirable fire effects?

Are managers concerned?

Sequoia NF ready to implement mastication treatment in 25year old ponderosa pine plantation

Sequoia NF concerns

- What about surface fuel increases?
- If prescribed fire used post-mastication, what about tree mortality?

Time for a study!

- USFS Adaptive Management Services Enterprise Team collaborated with the Sequoia National Forest
- Received JFSP funding to begin study in 2005

Project objectives

Determine the results of applying:

- Mastication alone
- Mastication followed by prescribed underburn
- Mastication with material pulled back from trees, then underburn

Project objectives

Information needed in key areas:

- ✓ Fuel characteristics of masticated material
- ✓ Prescribed fire characteristics
- ✓ Prescribed fire effects… tree mortality
- ✓ Predicted wildfire behavior (90^{th} & 97^{th} percentile weather)
- ✓ Predicted fire effects

Study site
Red Mountain Project

- Southern Sierra Nevada
- Greenhorn Ranger District on the Sequoia National Forest
  - Burned in 1970
  - Planted with ponderosa pine
- Elevation: 1600 to 2000 m
- South facing slopes, typically < 30%

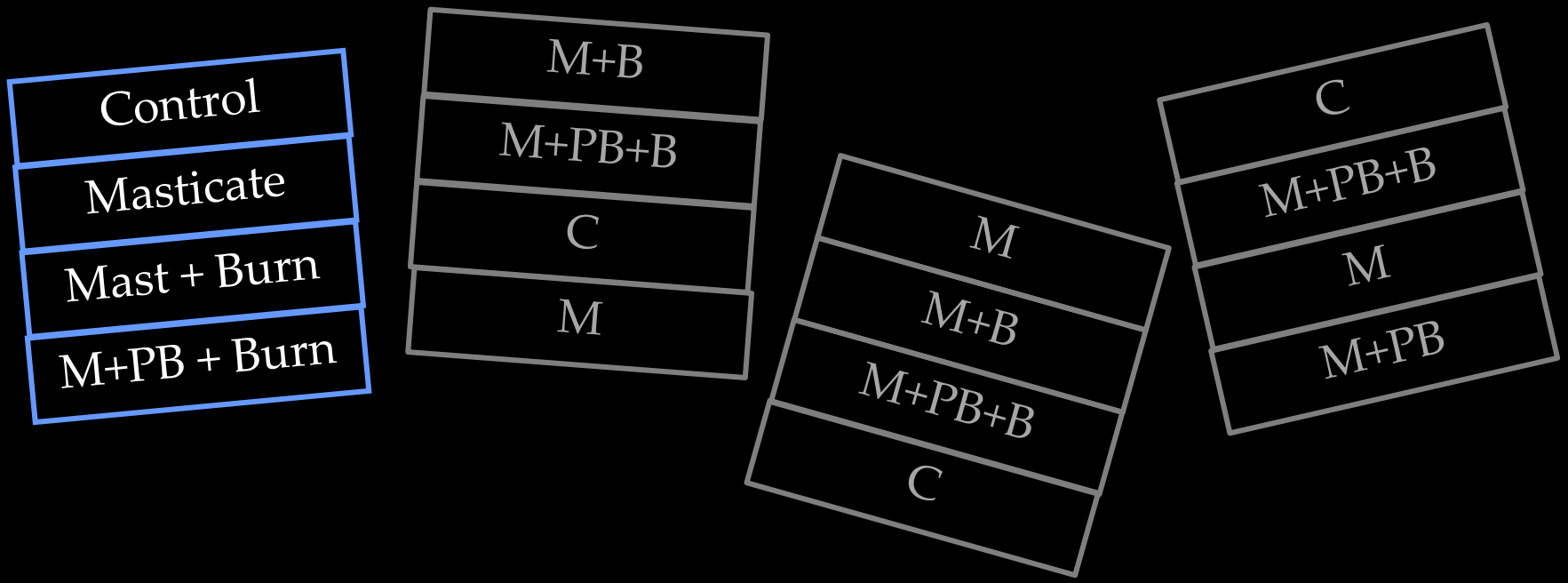
Study design

- Random block design
- 4 blocks randomly divided into 1 control + 3 treatments , with 4 plots each
- Total 16 plots/treatment

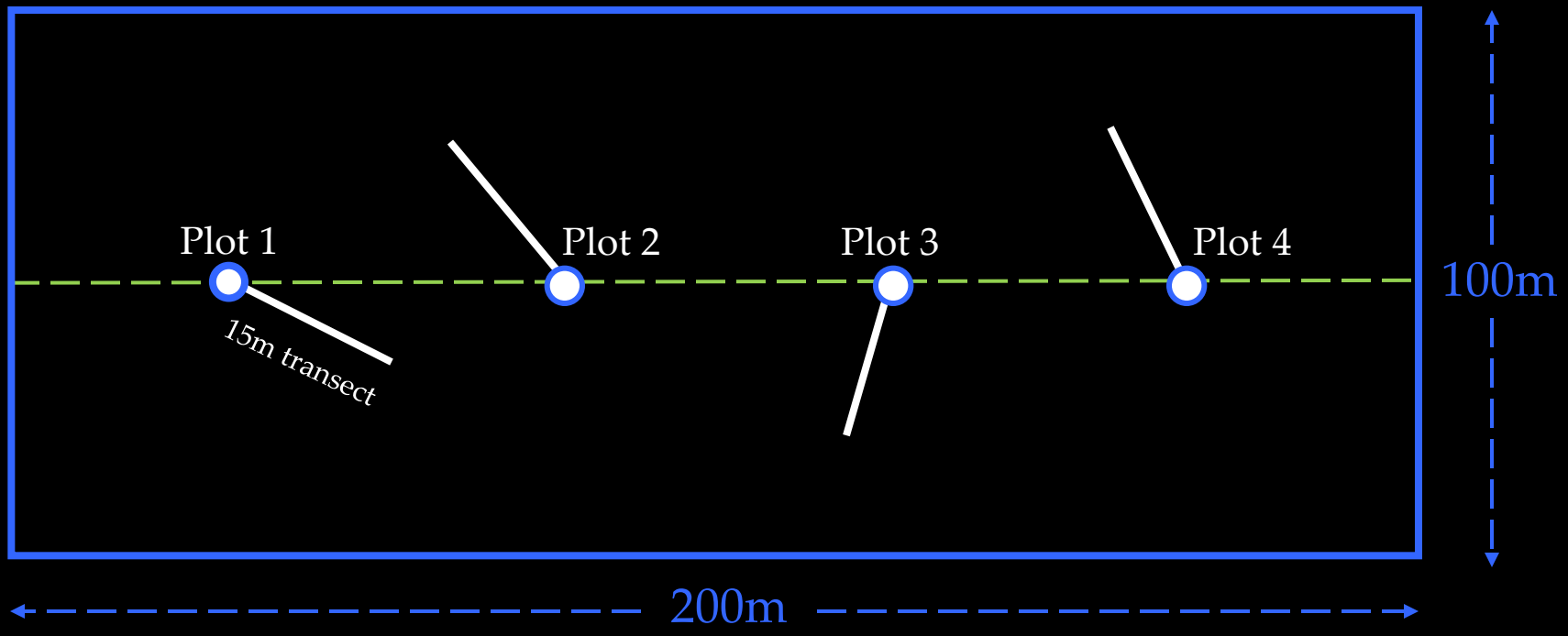
1) Control (no treatment)
2) Masticate
3) Masticate + Prescribed Underburn
4) Masticate w/pull back + Underburn

Study design

- Random block design
- 4 blocks, 8 ha each, randomly divided into 3 treatments + control
- Each treatment site = 2 ha

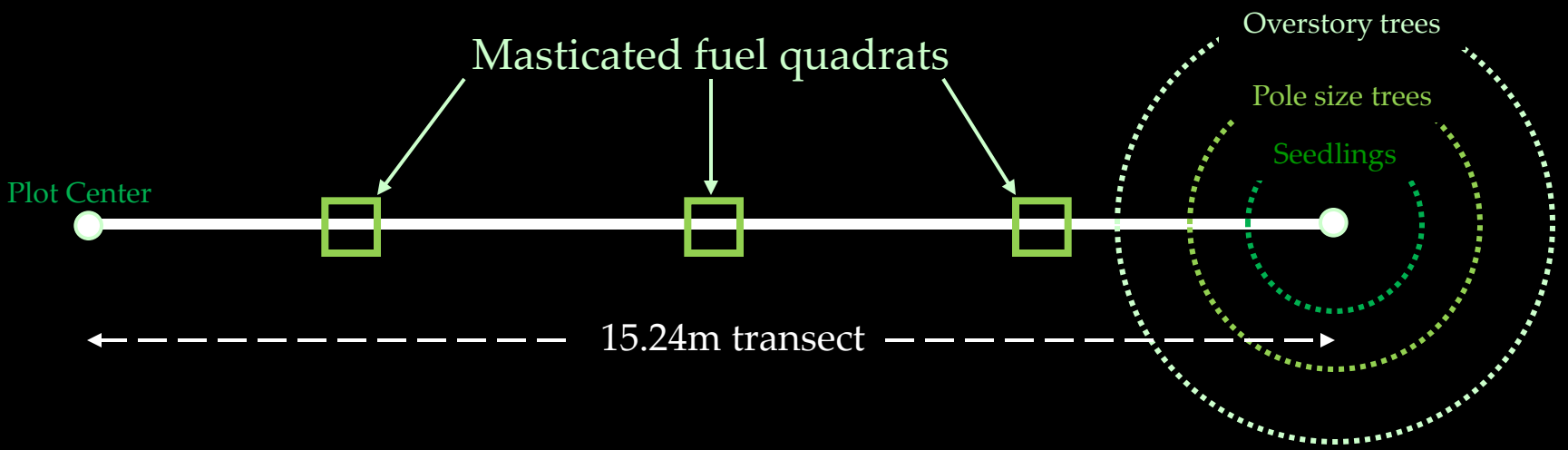


Plot Layout

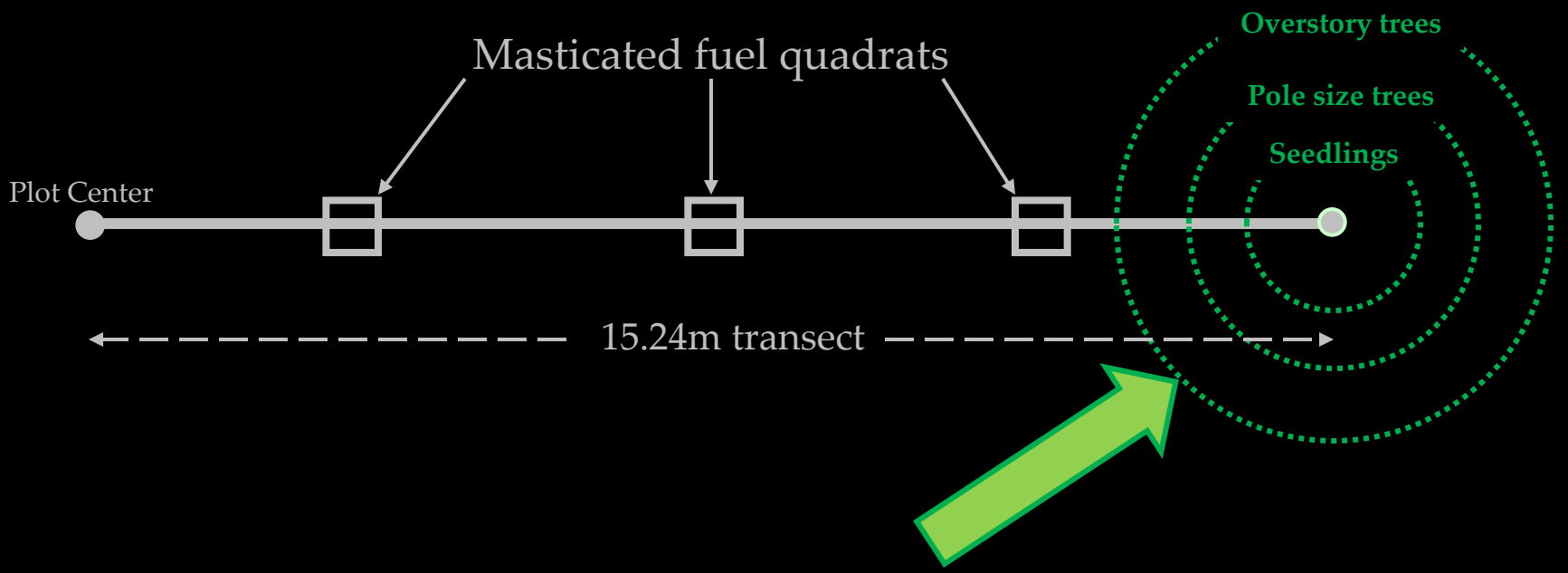


(Each treatment site = 2 ha)

Plot detail


Masticated fuel quadrats
Overstory trees
Pole size trees
Seedlings
Plot Center
15.24m transect

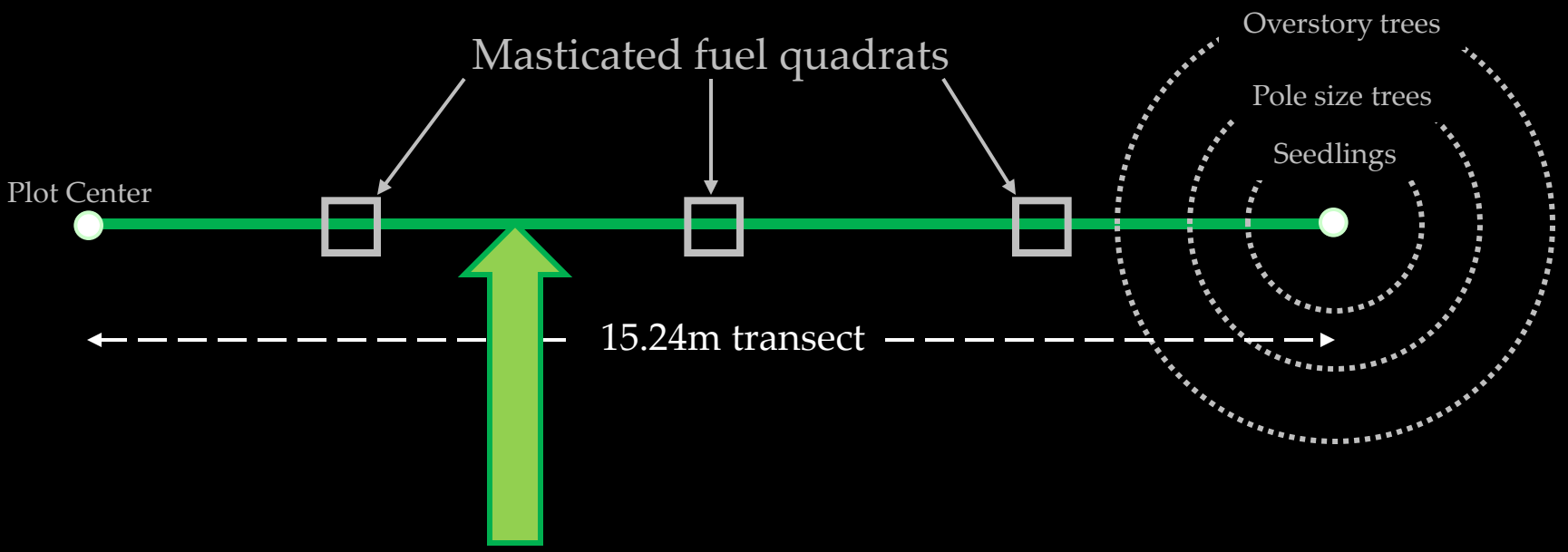
Plot detail



Tree data: Nested circular plots

Tree species, tree#, DBH, canopy base height, tree height, crown position

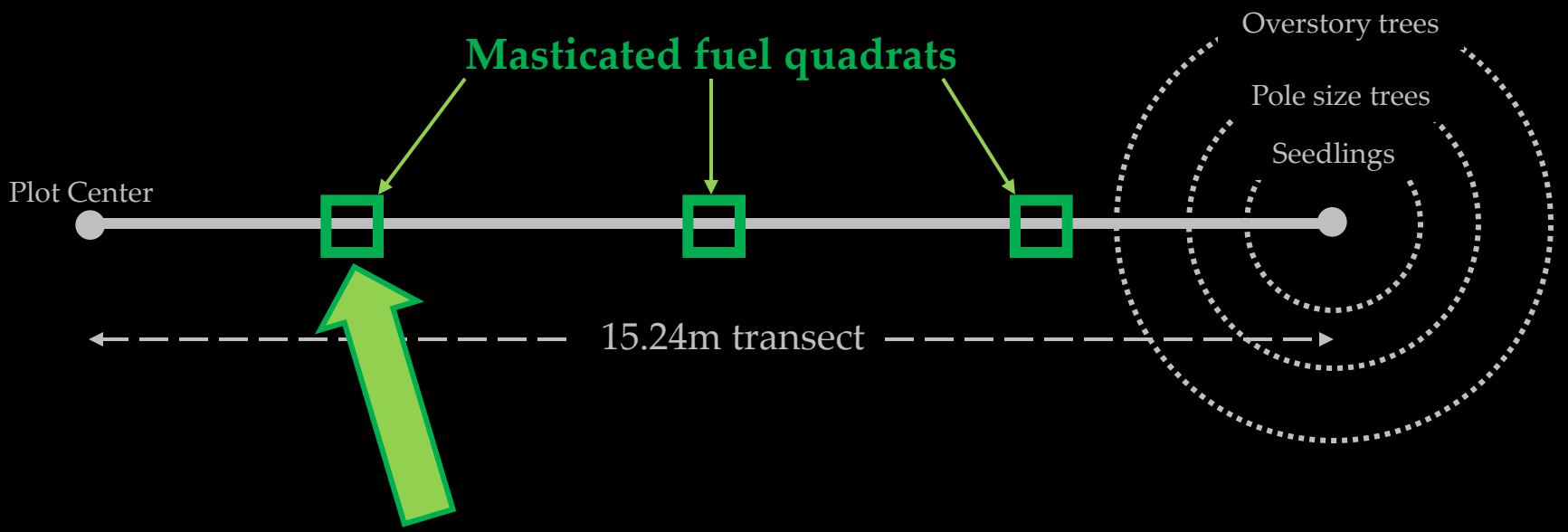
Plot detail



Surface Fuel and understory vegetation

- Fuel load and depth (natural & masticated fuels)
- Understory vegetation (1 m belt) Burgan & Rothermel method

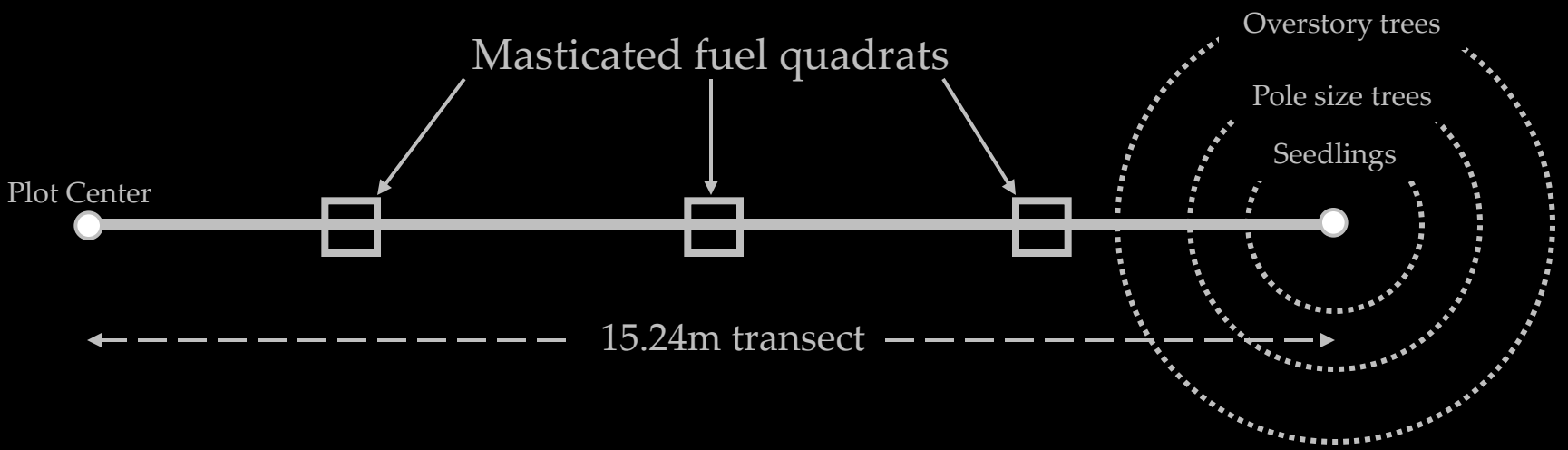
Plot detail



3 Masticated quadrats (1x1m)

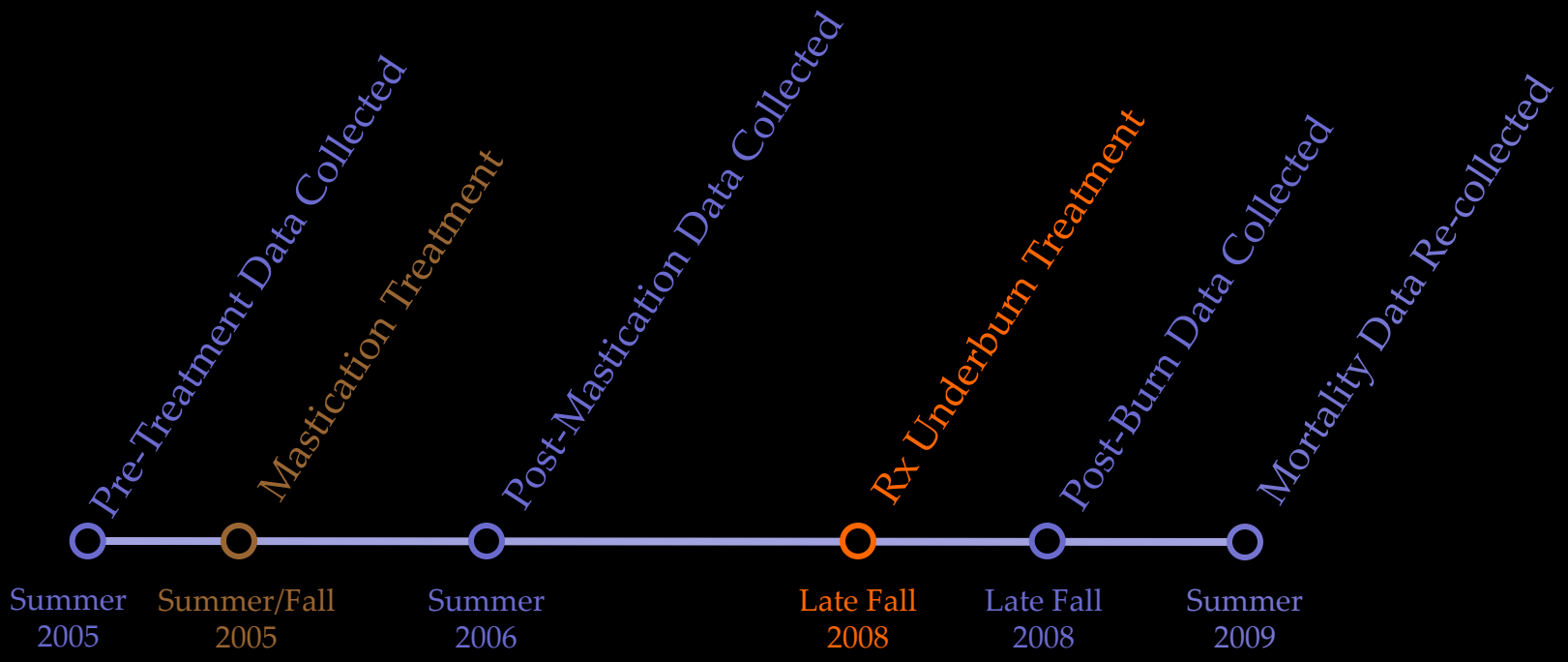
- Estimate of masticated material cover%
- 5 depth measurements each, (Hood and Wu)

Plot detail



Masticated samples collected
(1 random 30x30 cm frame per plot)

Timeline


Pre-Treatment Data Collected
Mastication Treatment
Post-Mastication Data Collected
Rx Underburn Treatment
Post-Burn Data Collected
Mortality Data Re-collected
Summer 2005
Summer/Fall 2005
Summer 2006
Late Fall 2008
Late Fall 2008
Summer 2009

Mastication

Implemented Late Summer/Fall 2005

Pre-Mastication

Post-Mastication

Mastication

Implemented Late Summer/Fall 2005

Pre-Mastication

Post-Mastication

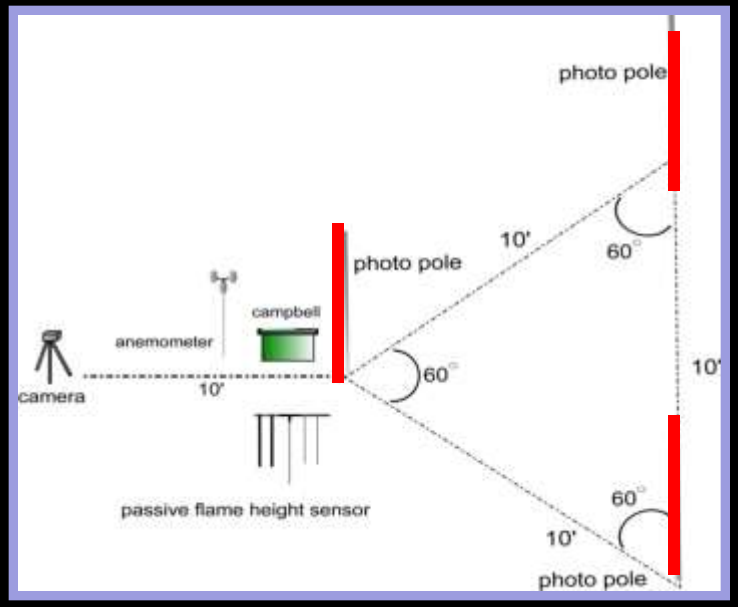
Mastication

- Masticated material samples collected
- Samples cleaned, dried, and weighed for dry weight

Prescribed Burn

- Implemented Dec. 5 and 6, 2008
- Temp. 5 – 15 C
- RH: 30 to 100%
- Rain/snow during burning of last unit
- Wind: 5 – 13 km/hour
- Gusts: 21km/hour

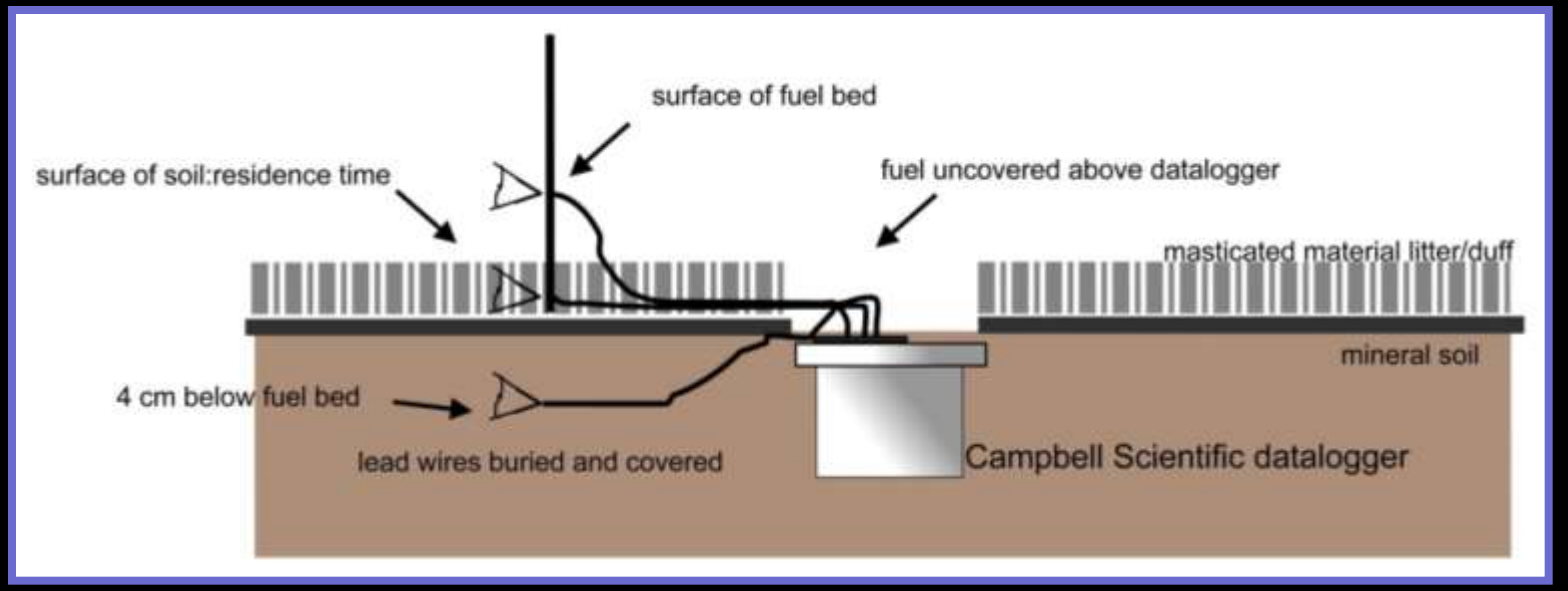
Fire Behavior Measurements



- Video
- Flame length
- Rate of spread
- Temperature
- Wind Speed

Fire Behavior Measurement

Temperature measurements



Prescribed underburn

Implemented December 2008

Prescribed underburn

Implemented December 2008

Prescribed underburn

Implemented December 2008

Pre-Burn

Post-Burn

Prescribed underburn

Implemented December 2008

Pre-Burn

Post-Burn

Data analysis

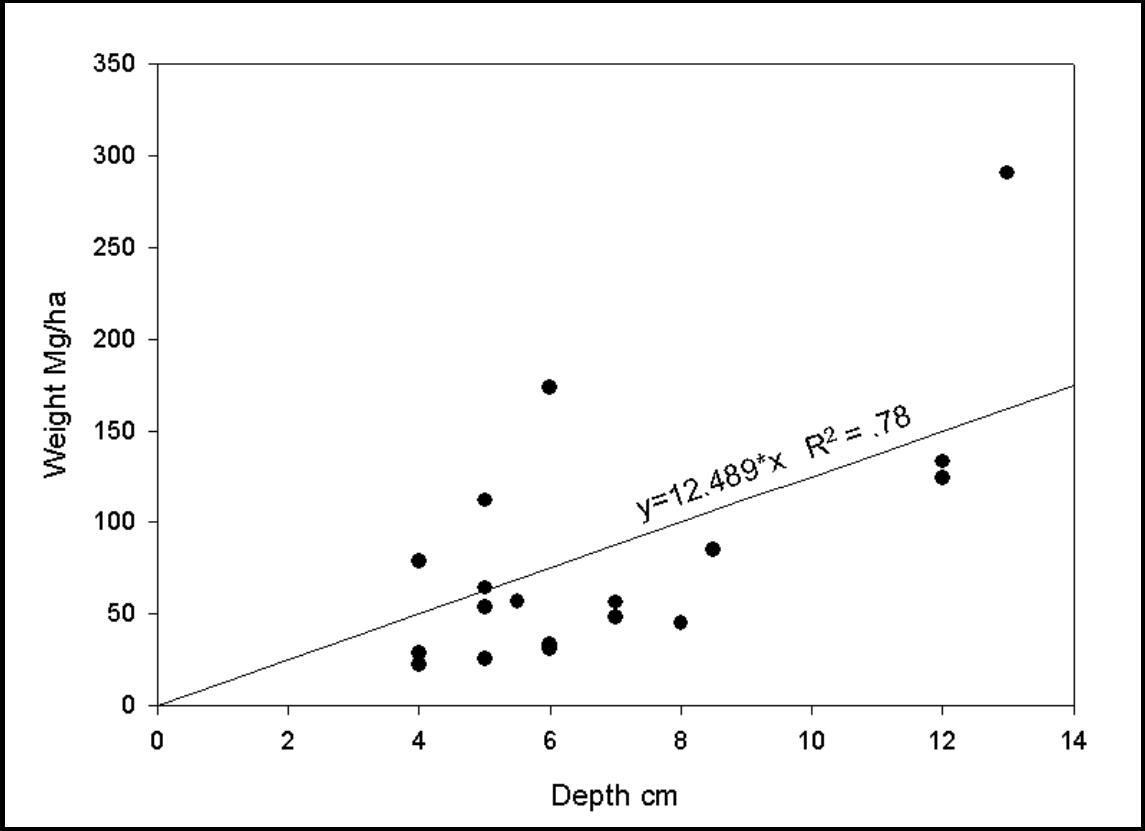
- Site specific regression created for litter, duff, and masticated fuel loads
- Biomass of live understory fuels calculated with BEHAVE
- Canopy characteristics and potential fire behavior calculated with Fuels Management Analyst (FMA Plus)

Results

Surface and Canopy Fuels

Results

Surface and Canopy Fuels



Depth to weight relationship of masticated fuel bed

Results

Surface Fuels

Status (Year)	Treatment	1-hr (Mg ha^{-1})	10-hr (Mg ha^{-1})	100-hr (Mg ha^{-1})	1000-hr (Mg ha^{-1})	Total (Mg ha^{-1})	Masticated (Mg ha^{-1})
Post-mastication (2006)	Masticate	0.19 (0.07)	0.79 (0.28)	0 (0)	17.4 (6.0)	18.4	**42.9 (12.5)**
	Masticate/burn	0.04 (0.02)	1.44 (0.99)	1.5 (0.67)	14.1 (7.2)	17.1	**25.9 (5.3)**
	Masticate/pull-back/burn	0.05 (0.02)	0.43 (0.18)	1.02 (0.71)	13.9 (9.8)	15.4	**35.0 (6.3)**
	Control	0.02 (0.01)	1.08 (0.35)	2.08 (1.24)	52.1 (19.5)	55.3	n/a
Post-burn (2008)	Masticate	0.22 (0.11)	1.38 (0.75)	0 (0)	57.4 (21.0)	59.0	48.0 (15.4)
	Masticate/burn	0.05 (0.03)	0.06 (0.04)	0.26 (0.25)	3.4 (1.7)	3.8	5.3 (1.5)
	Masticate/pull-back/burn	0.02 (0.01)	0.43 (0.13)	0 (0)	0 (0)	0.5	2.6 (1.1)
	Control	0.05 (0.02)	1.35 (0.33)	1.22 (0.61)	21.2 (7.3)	23.8	n/a

Surface fuel load (standard error)

Results

Canopy Fuels

Status (Year)	Treatment	Trees (ha^{-1})	Canopy base height (m)	Canopy bulk density ($kg\ m^{-3}$)
Pre-treatment (2005)	Masticate	956 (20)a	0.6 (0.1)c	0.092 (0.009)a
	Masticate/Burn	937 (9)a	1.0 (0.2)c	0.120 (0.013)a
	Masticate/Pull-back/Burn	911 (12)a	1.1 (0.2)c	0.124 (0.011)a
	Control	833 (11)a	0.9 (0.2)c	0.110 (0.019)a
Post-burn (2008)	Masticate	270 (32)b	1.8 (0.3)bc	0.057 (0.006)a
	Masticate/Burn	208 (71)b	6.5 (0.6)a	0.055 (0.009)a
	Masticate/Pull-back/Fire	229 (84)b	5.5 (0.8)ab	0.062 (0.01)a
	Control	828 (108)a	1.0 (0.2)c	0.111 (0.012)a
	Year*treatment p-value	<0.001	0.003	0.048

Results

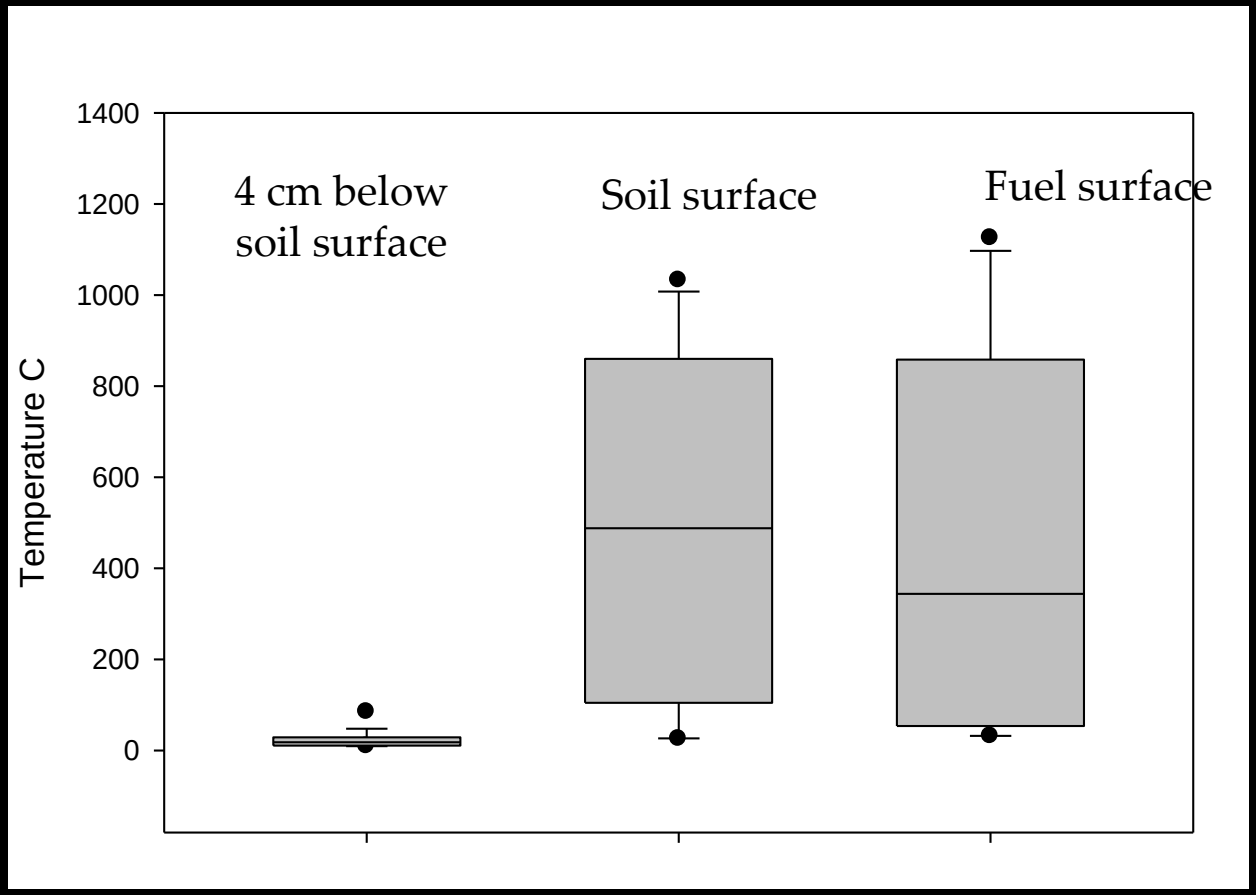
Prescribed Fire Behavior Measurements

Results
Prescribed Fire Behavior Measurements

Mean Flame Height

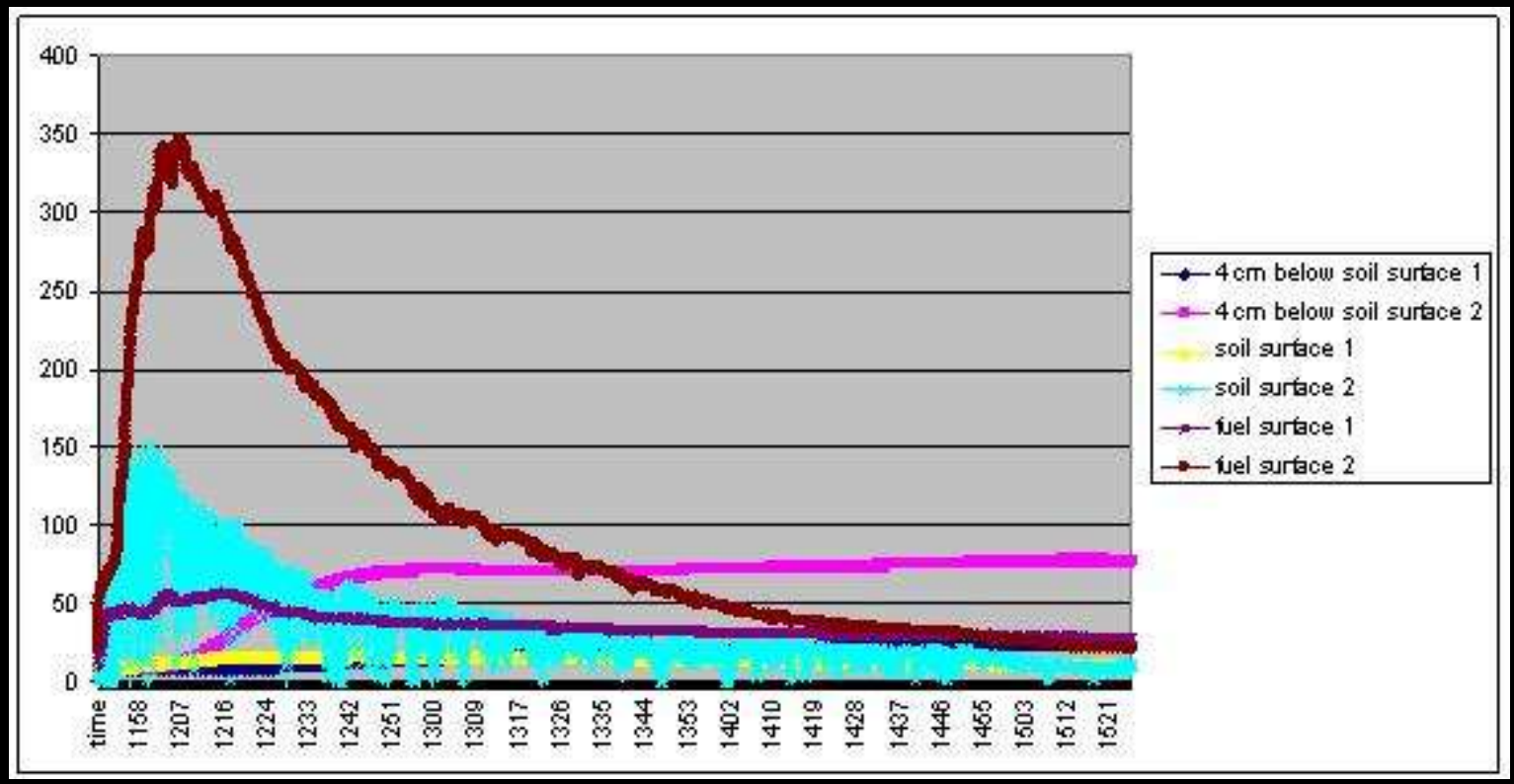
Treatment	Mean Flame height (m)	Standard error	n
Masticate/burn	1.06	14	14
Masticate/pull-back/burn	0.97	17	11

Results
Prescribed Fire Behavior Measurements



Maximum Temperature

Results
Prescribed Fire Behavior Measurements



Temperature (C) change over time

Results
Post-underburn fire effects

Results
Post-underburn fire effects

Tree scorch, torch, and mortality first growing season post-treatment

Treatment	% Scorch (SE)	% Torch (SE)	% Mortality (SE)
Masticate	0 (0)	0 (0)	1 (1)
Masticate/burn	74 (4)	15 (3)	38 (8)
Masticate/pull-back/burn	75 (3)	8 (3)	28 (10)
Control	0 (0)	0 (0)	0 (0)

Results
Predicted Wildfire Fire Behavior

Results
Predicted Wildfire Fire Behavior

Flame length and rate of spread, predicted for post-treatment fuel conditions and extreme weather

Treatment	Weather scenario	Flame length (m)	Rate of spread (ch/h)
Masticate	90	1.3 (0.2)	10.2 (2.1)
Masticate	97	1.6 (0.3)	16.1 (3.4)
Masticate/burn	90	0.4 (0.2)	2.5 (1.6)
Masticate/burn	97	0.5 (0.2)	4.2 (2.8)
Masticate/pull-back/burn	90	0.2 (0)	0.9 (0)
Masticate/pull-back/burn	97	0.2 (0)	1.3 (0.1)
Control	90	0.5 (0)	3.1 (0.4)
Control	97	0.6 (0.1)	4.7 (0.6)

Results
Predicted Wildfire Fire Behavior

Predicted torching and crowning indices for post-treatment fuel conditions, under 97th percentile weather

Treatment	Torching index (SE)	Crowning index (SE)
Masticated	22 (10)	34 (2)
Masticated/burned	73 (7)	38 (4)
Masticated/pull-back/burned	80 (0)	36 (7)
Control	31 (8)	22 (2)

Results
Predicted Wildfire Fire Effects

- 87% Masticate only
- 57% Control
- 28% Masticate/burn
- 30% Masticate/pull-back/burn

Management Implications

- Take care when using mastication!

- Prescribed burning in masticated fuels can yield undesirable fire effects
- Succeeds at reducing canopy fire potential
- With increased flame length and rate of spread, may not meet objectives for improving fire suppression capabilities
- May not meet objectives to reduce fire effects

What's next?

- Will summarize longer-term mortality associated with treatments
- Looking for opportunities to measure free-burning fire behavior in masticated fuel beds in order to customize/calibrate fuel models

Acknowledgements

- Joint Fire Science
- Sequoia National Forest

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http://www.fs.fed.us/adaptivemanagement/projects/