Mechanical Methods for Restoration and Fuels Reduction in Longleaf Pine Flatwoods

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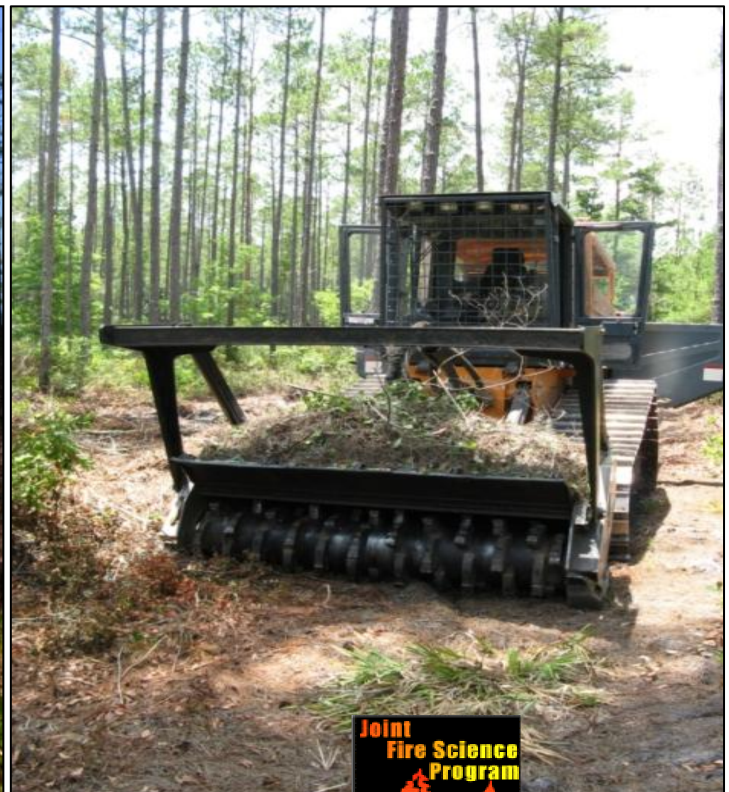
SOUTHERN Fire Exchange



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FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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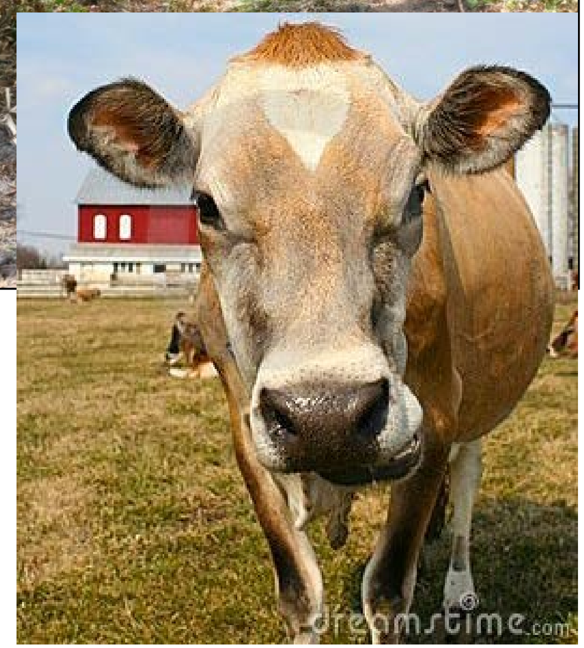
Joint Fire Science Program

New?

- Mowing has been used to create fuel breaks and buffers for as long as machines existed
- Before that, the original “mastication” machines…



- Both nationally and regionally, the scale and extent of their use is increasing greatly, which changes the scale and extent of their effects
- New quantification of mechanical treatment effects on fuelbeds and whether they mitigate wildfire risk

Mechanical in lieu of / before fire

Increasing Populations = Increasing WUI

Liability concerns

Rx Fire and Smoke Issues

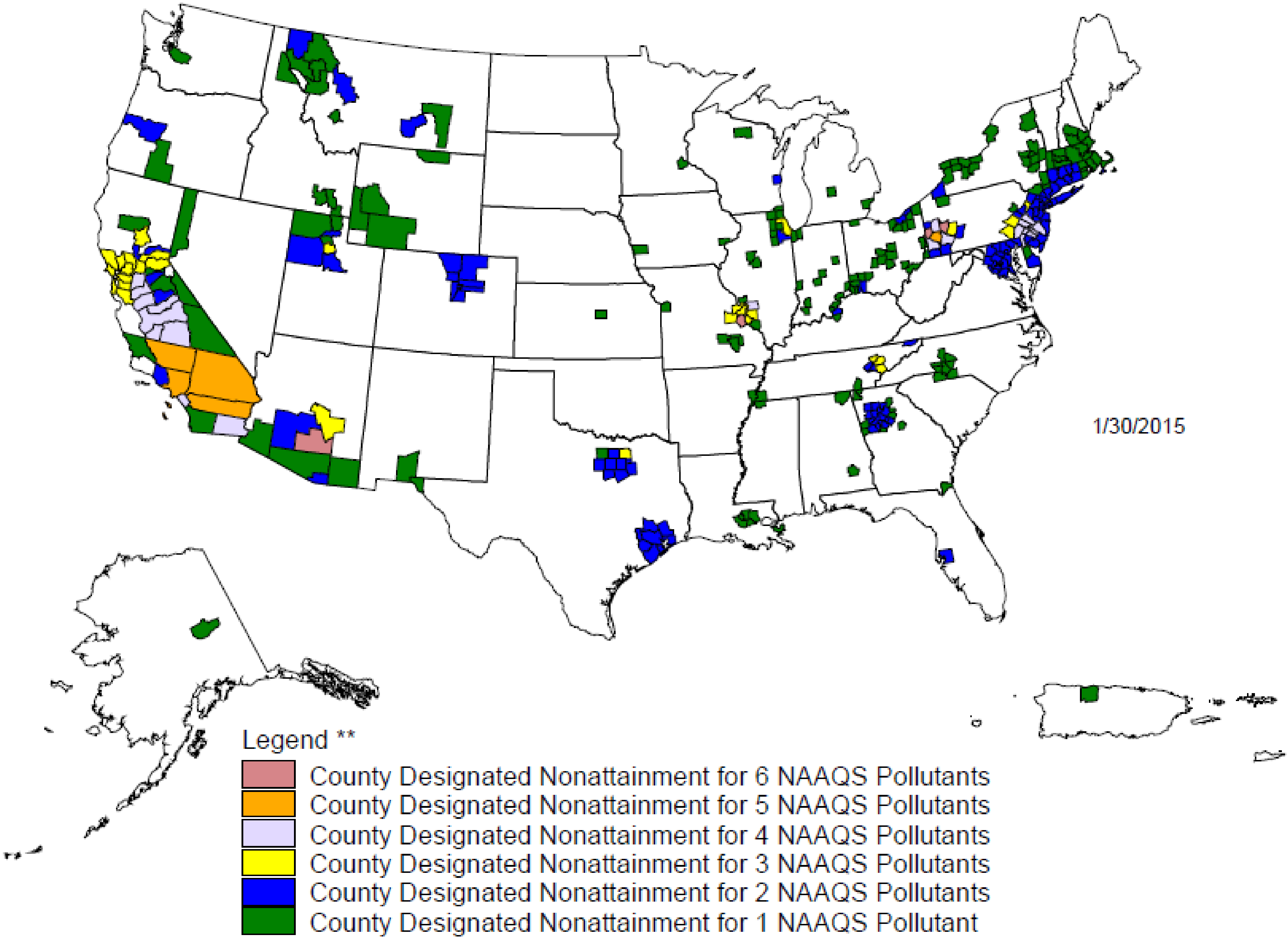
Initial stage of restoration pursuits (long unburned areas)

Ideally, followed by fire

Increasingly conducted in Florida's National Forests and private lands in the future?

Counties Designated "Nonattainment"

for Clean Air Act's National Ambient Air Quality Standards (NAAQS) *



* The National Ambient Air Quality Standards (NAAQS) are health standards for Carbon Monoxide,Lead (1978 and 2008), Nitrogen Dioxide, 8-hour Ozone (1997 and 2008), Particulate Matter (PM-10 and PM-2.5 (1997 and 2006)), and Sulfur Dioxide.(1971 and 2010)

Mechanical Treatment Objectives

- Reduce vertical fuel continuity and height
  - Convert into horizontal fuelbeds
  - Reduce small diameter trees
- Reduce wildfire risk and mitigate behavior
- Initiate restoration in long unburned locations
  - Reduce fire behavior when reintroduced

What we already know

- Lack of or infrequent (>4 yr FRI) fire will lead to litter and duff fuel build-up (*Osceola Long-Term Rx Fire Demonstration Plots, Outcalt and Wade, 2004)*

- Mechanical methods vary greatly, but most cost between \$150-\$350/acre, vs. prescribed fire ~\$15-\$100/ acre

- Restoration of native ground cover (e.g. forbs, grasses) requires successive treatments, or additive treatments (mech. + fire; *Rummer, Outcalt, Brockway 2002)*

- Regrowth following mech. treatments can double understory cover (e.g. oaks, vines, shrubs) if not re-treated within 2 growing seasons in longleaf pine stands (*Brockway et al. 2009*) (? True elsewhere?)

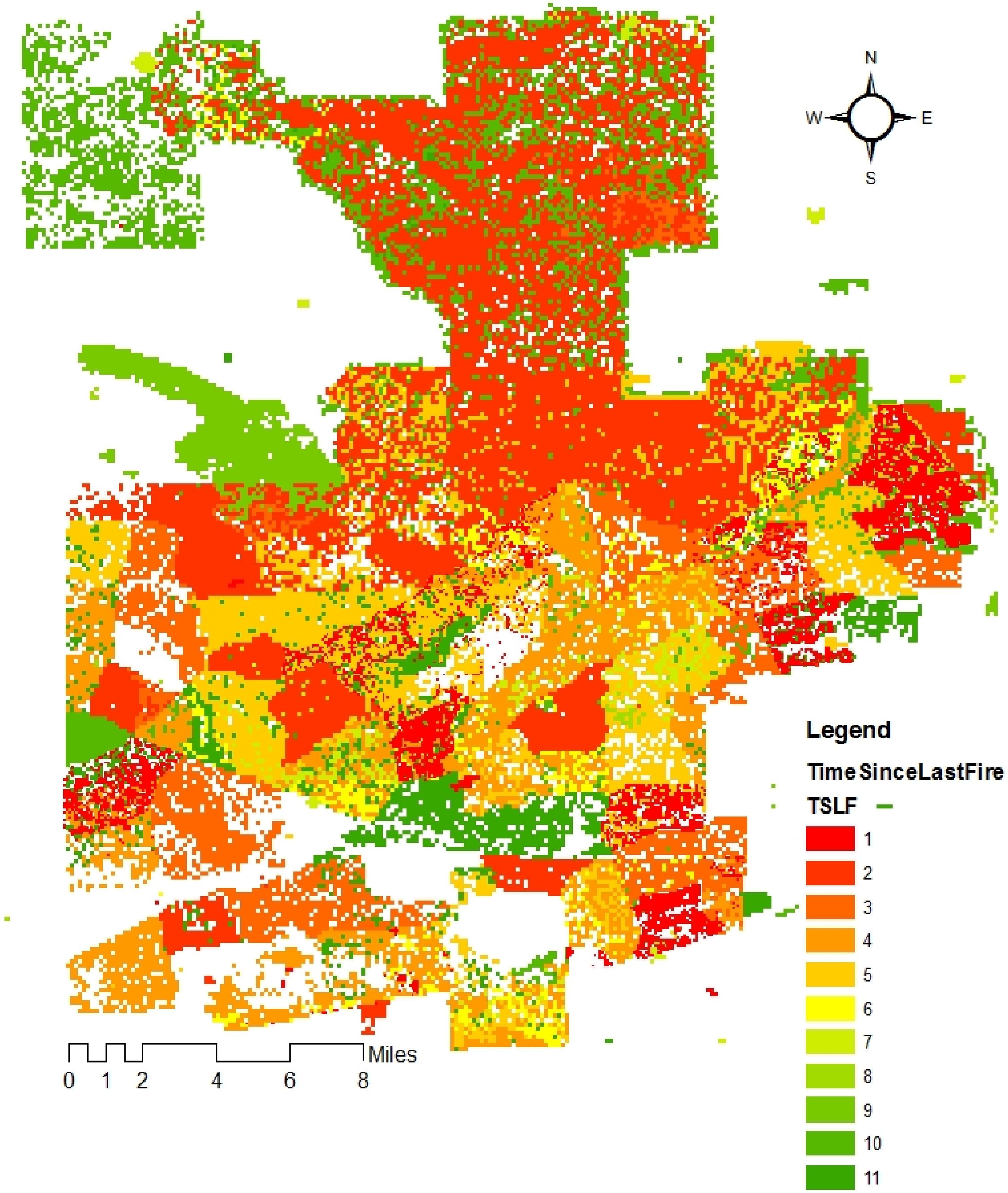
Persisting Research & Management Questions

- How can mechanical and fire treatments be used to meet management objectives?
- Do treatments reduce wildfire risk?
  - Potential (predicted) and actual (prescribed) fire behavior
  - Are combined treatments most effective?
  - **How long do effects last?**
- Other effects of mechanical and combined treatments
  - **Reductions in tree mortality where fire is being reintroduced?**
  - **Impacts on understory composition (restoration)?**
  - Impacts on growth rates of remaining trees (2015)
  - C budget/ soil nutrients, fertility
  - Spread of invasive species from WUI into forest

Osceola National Forest

Repeat photos taken before (left) and after (right) mechanical mastication in pine flatwoods.

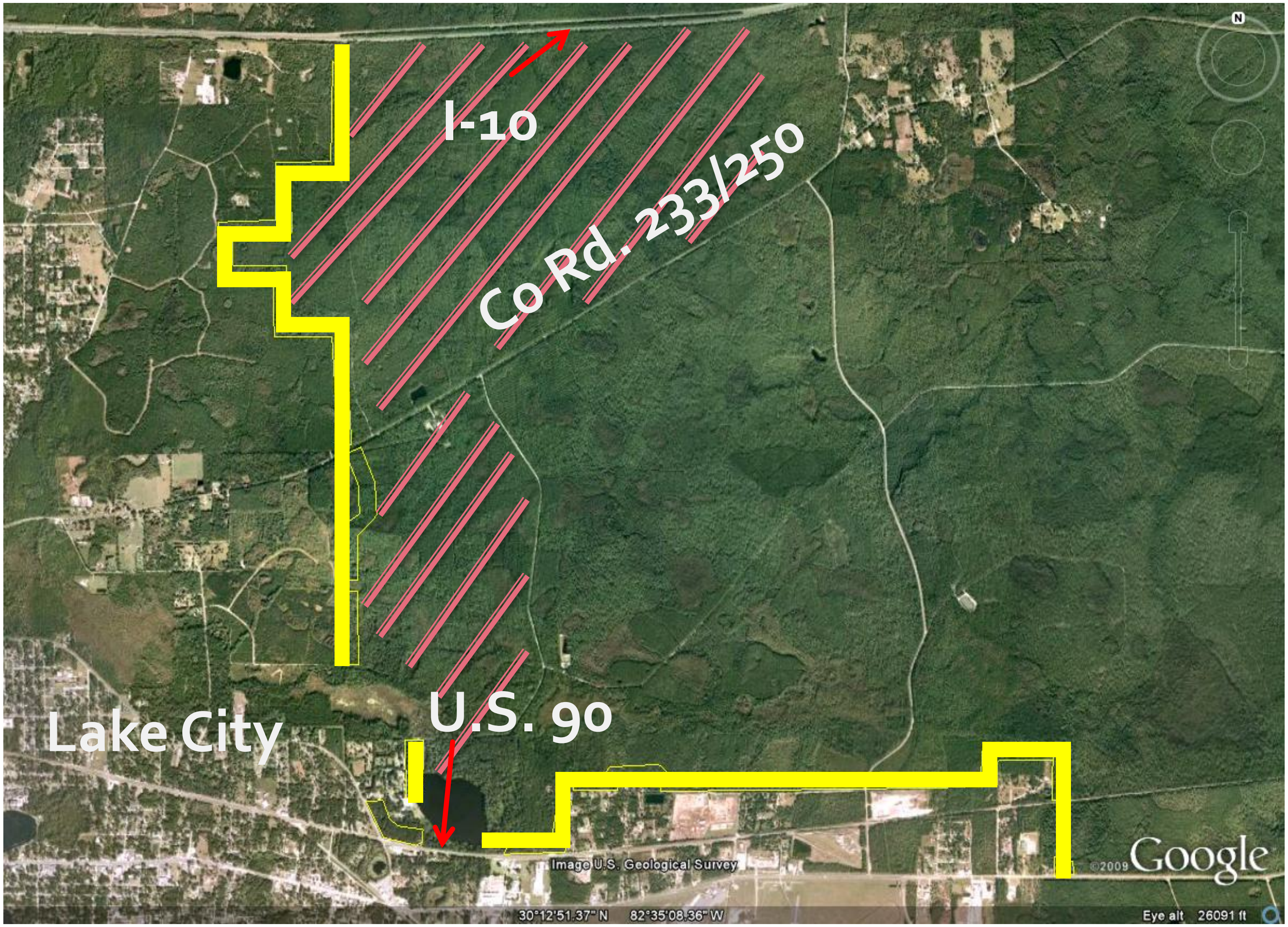
Time Since Last Fire
Osceola National Forest (2009)



Study locations- three areas

113 Total plots

Buffer (2009), Areal Treatment (2010)



Split block demonstration sites

- 2 ha units
- 3 replicates per treatment, 3 plots per rep. = 9 per treatment
- Soil Respiration study sites (D. Godwin)
- Long term monitoring
- Remeasuring 2014-2015

Key issues addressed

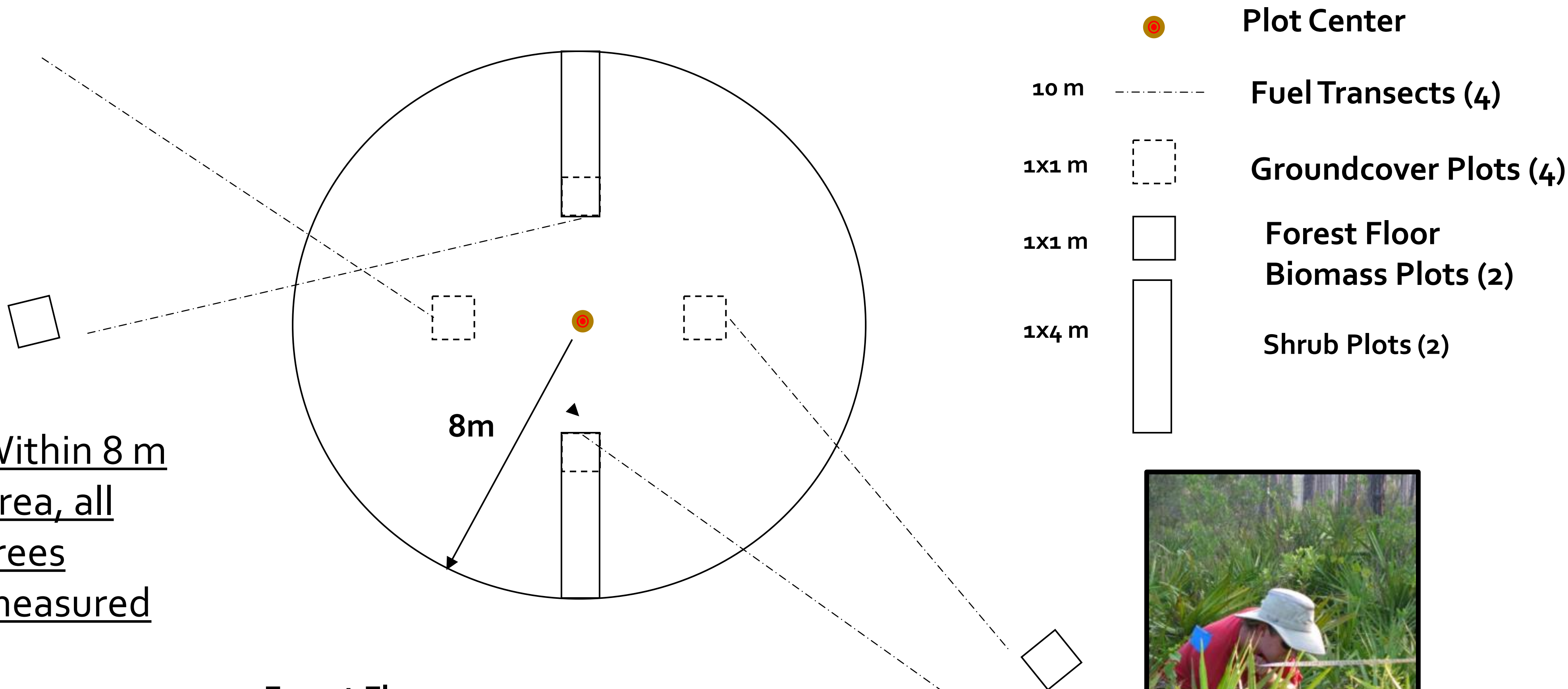
- **Efficacy of Treatments**
  - Fire hazard reduction
    - Longevity
  - Restoration
    - Reducing palmetto/increasing grasses
    - **Restoring frequent fire without damaging overstory**
    - Soil impacts?
  - Understanding what drives treatment effects
    - Shrubs? Downed woody debris? Litter?

Pre-Treatment

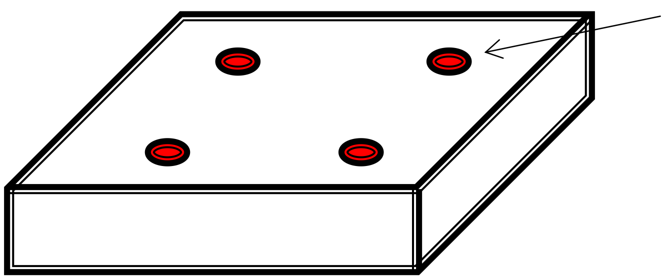
Post-Treatment

Repeat photos taken before (left) and after (right) mechanical mastication in pine flatwoods.

Treatment prescriptions included mowing all shrubs and small-diameter trees (<20 cm) and the resulting debris to be left on site.



Forest Floor Biomass Plots



Measurements

Litter depth

Duff depth

Woody debris, litter, and duff collected oven-dried and weighed
DECOMPOSITION plots


Immediately Post-mow

Immediate Effects of Mowing on trees, shrubs, fuels

Overstory, understory, and surface fuel characteristics of a 500 ha mowing treatment in palmetto/gallberry pine flatwoods of north-central Florida, USA. Surface fuels sampled non-destructively (planar intercept method). Values in parentheses are standard errors.

	Trees					Shrubs[a]		
	Density (trees ha^{-1})	BA[d] (m^2 ha^{-1})	QMD[d] (cm)	Height (m)	CBH[d] (m)	Density (ind m^{-2})	Height (m)	Biomass (Mg ha^{-1})
Pre-treatment	358 (39)^A	18.8 (2.3)^A	25.8 (1.0)^A	16.7 (0.9)^A	12.0 (0.8)^A	4.2 (0.5)^A	1.12 (0.02)^A	3.68 (0.49)^A
Post-treatment[b]	277 (38)^A	18.6 (2.4)^A	29.8 (1.2)^B	20.7 (0.9)^B	14.7 (0.7)^B	0.6 (0.2)^B	0.75 (0.14)^B	0.24 (0.08)^B

	Surface fuel loading						
	1 h	10 h	100 h	1000 h-S	1000 h-R	Litter	Duff
		(Mg ha^{-1})					
Pre-treatment	1.7 (0.3)^A	1.4 (0.1)^A	0.3 (0.1)^A	0.3 (0.3)^A	0.2 (0.2)^A	9.0 (0.9)^A	42.0 (3.6)^A
Post-treatment[b]	2.7 (0.5)^B	3.1 (0.5)^B	0.6 (0.3)^A	0.4 (0.2)^A	0.3 (0.2)^A	13.4 (1.2)^B	42.0 (4.3)^A

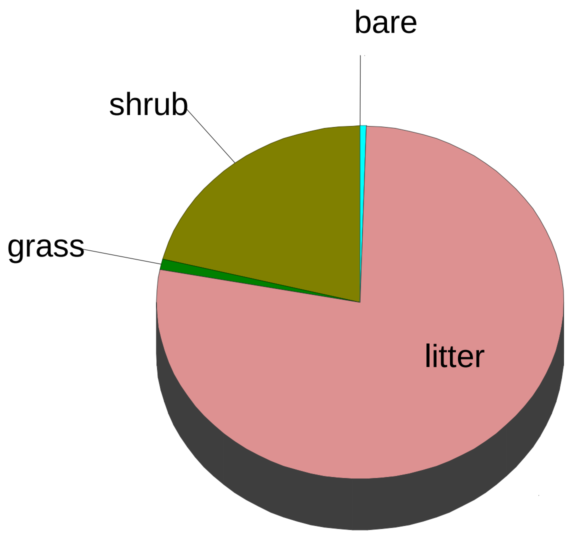
	Fuel depth		
	FWD[c]	Litter	Duff
	(cm)		
Pre-treatment	7.2 (1.7)^A	7.8 (0.8)^A	5.8 (0.5)^A
Post-treatment[b]	7.3 (0.9)^A	6.0 (0.5)^B	3.8 (0.4)^B

Note: Values sharing letters (superscripts A and B) within columns are not statistically different ($\alpha = 0.05$).

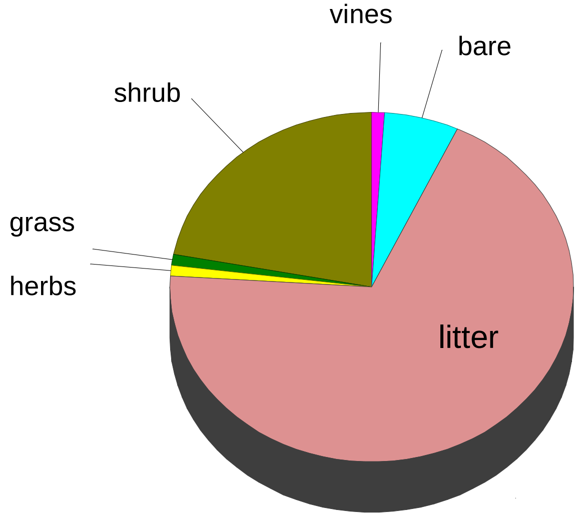
[a] Shrubs >0.5 m in height.
[b] ca. 2 mos following treatment.
[c] Fine woody debris (1 h, 10 h, and 100 h fuels).
[d] Basal area (BA), quadratic mean diameter (QMD), crown base height (CBH).

Kreye, Kobziar, and Camp. Immediate and short-term response of understory fuels following mechanical mastication in a pine flatwoods site. Forest Ecology and Management 313 (2014) 340–354

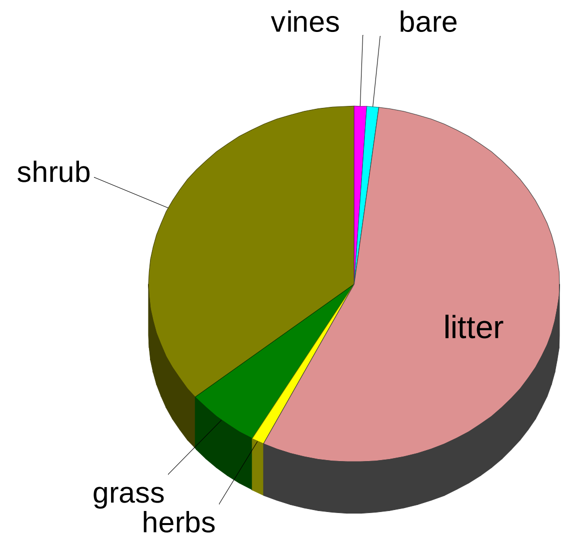
Post- Mowing: Percent Ground Cover: Major functional groups



Pre Treatment



Post Treatment



1Yr Post Treatment

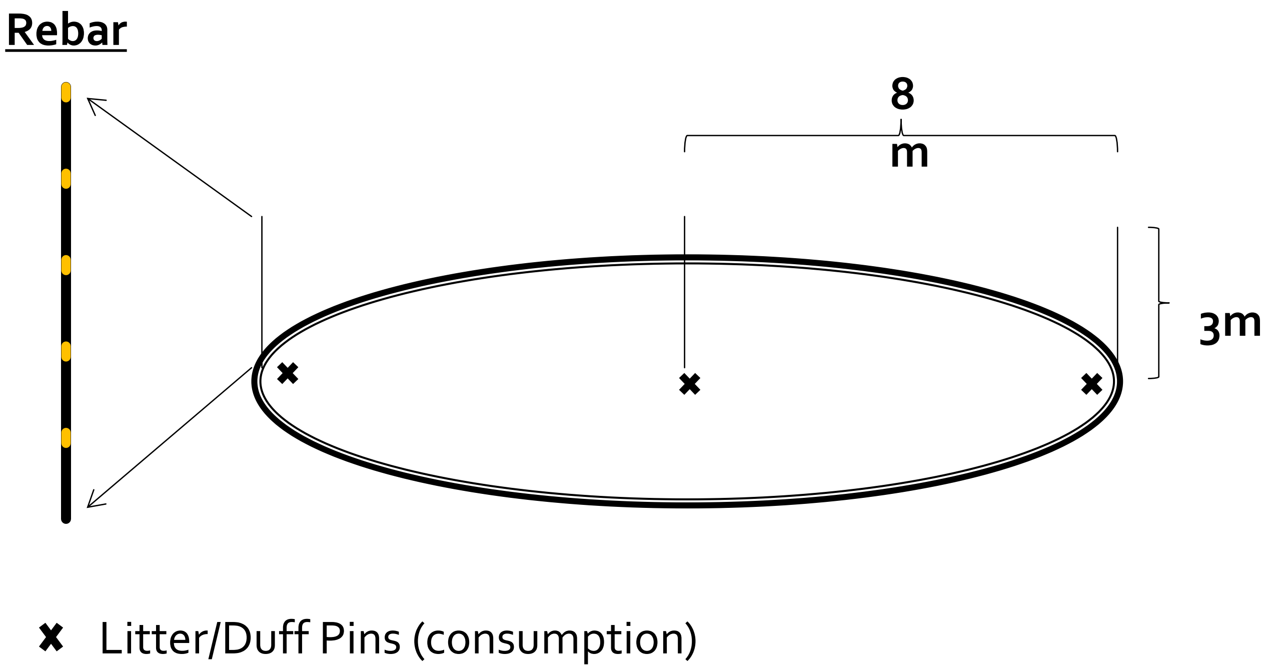
Burned Feb 23, 2011
(Unmowed)

2 Days Post-Burn

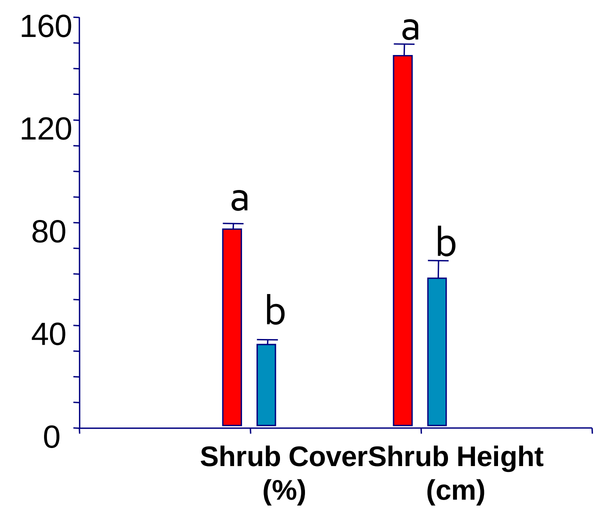
Burn Only

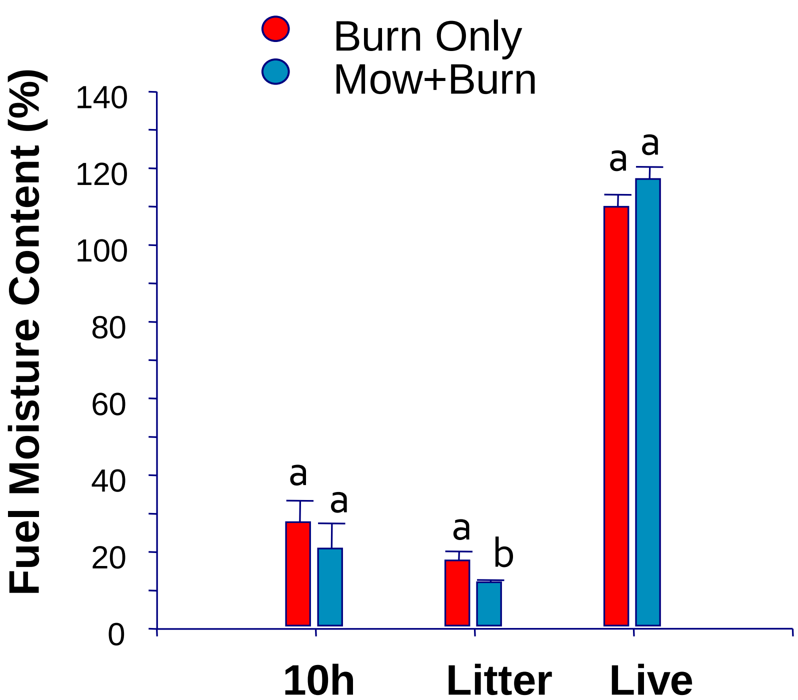
(6 Months Post-Mowing)

Mow + Burn



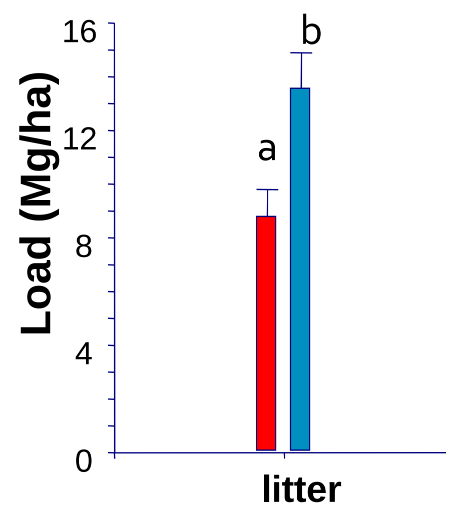
Pre burn characteristics
Winter Burn: Feb 23, 2011
(6 mos post-mastication)
Wind: 1-5 km·h^{-1}
RH: 47-62%
Temp: 17-24 ˚C (63-75˚F)





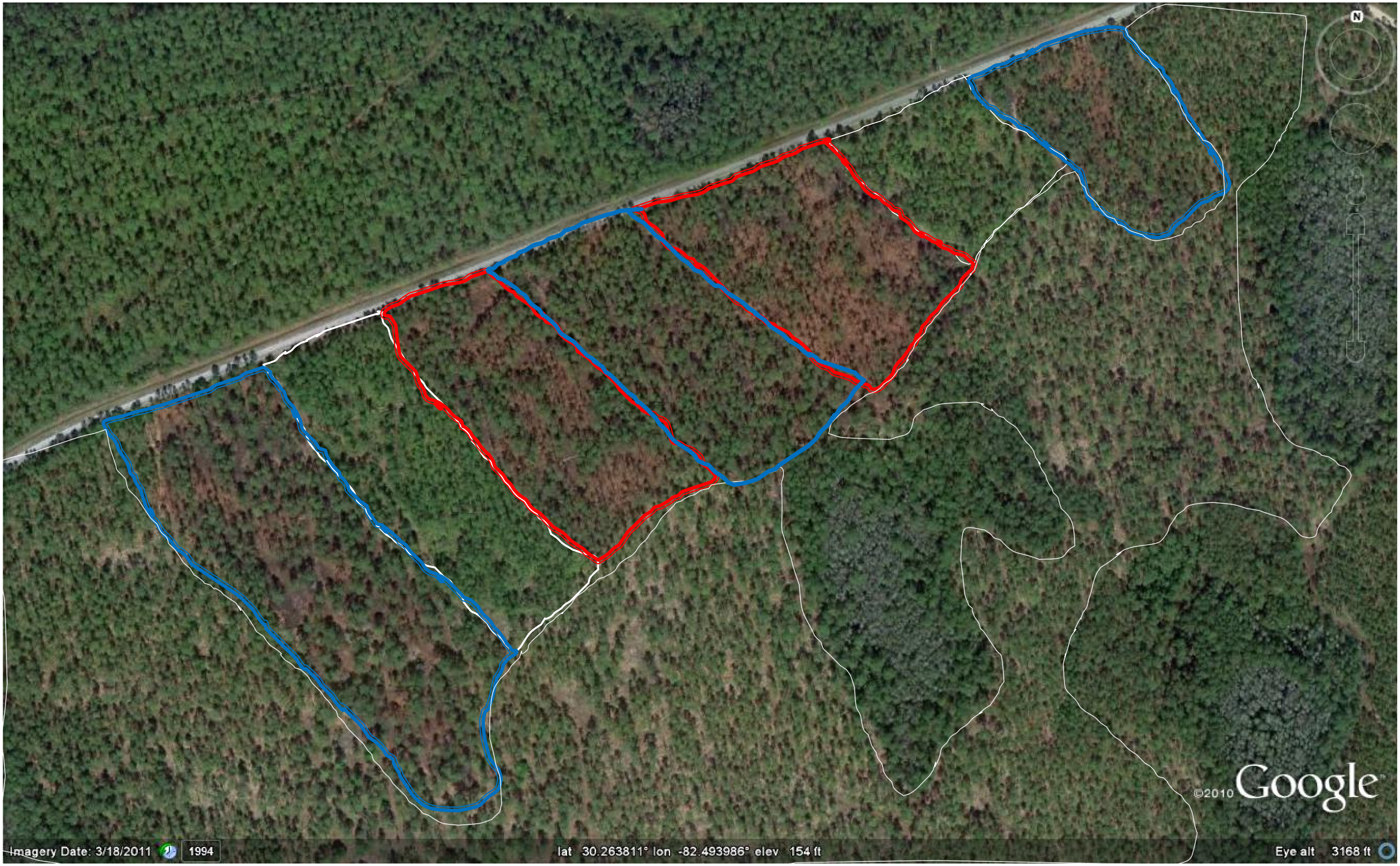
Fuel Moisture

10h:
Burn 28 (6)%
Mow + Burn 21 (7)%
Litter (1h):
Burn 18 (2)%
Mow + Burn 12 (1)%
Live:
Burn 110 (3) %
Mow + Burn 117 (3)%



Demonstration Site Burning

Burn only vs. mow + burn



Burned Feb 23, 2011
(Unmowed)

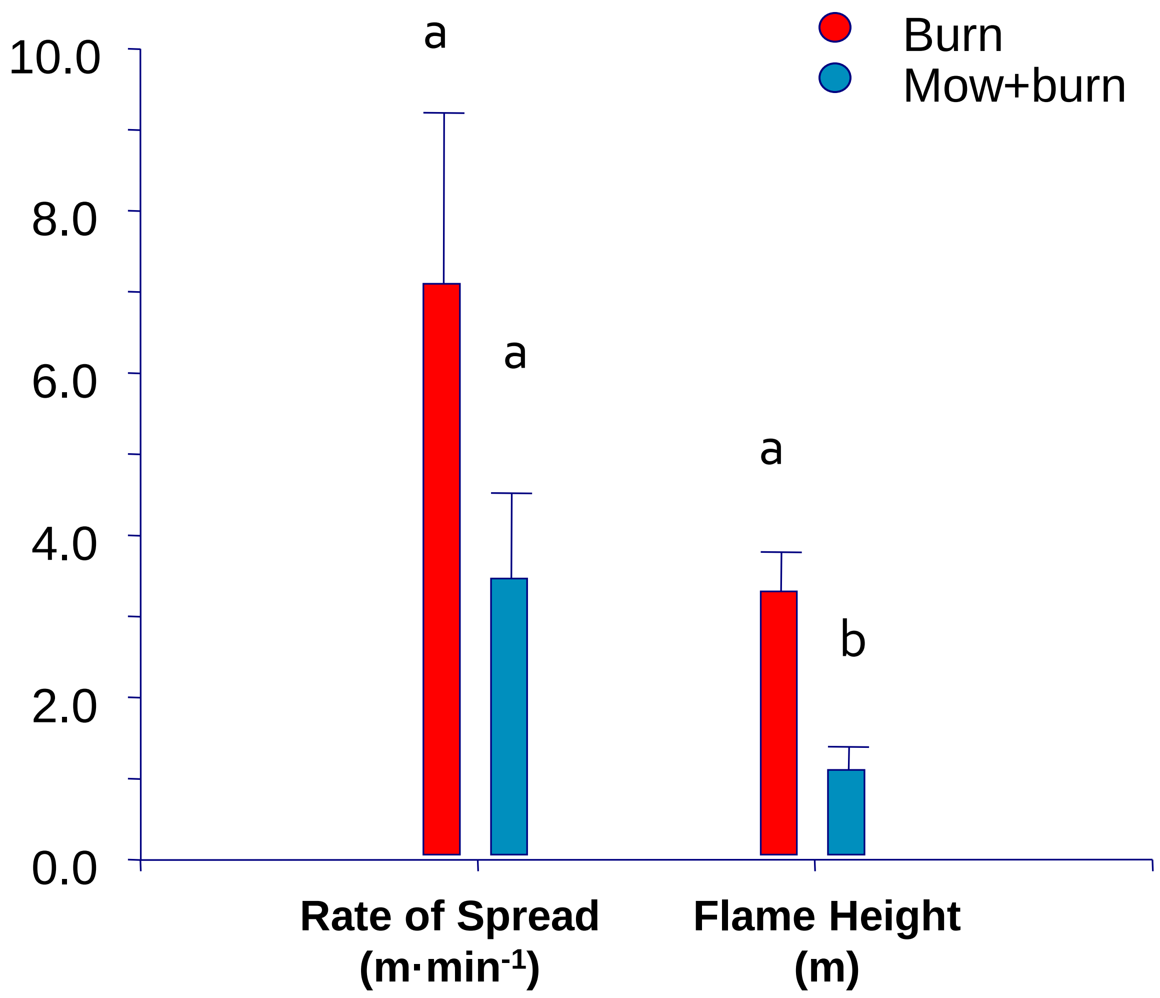
2 Days Post-Burn

Burn Only

(6 Months Post-Mowing)

Mow + Burn

Fire Behavior



Rate of Spread

Burn	7.1 (2.1) $m \cdot min^{-1}$
Mow+burn	3.5 (1.1) $m \cdot min^{-1}$

Flame Height

Burn	3.3 (0.5) m
Mow+burn	1.1 (0.3) m

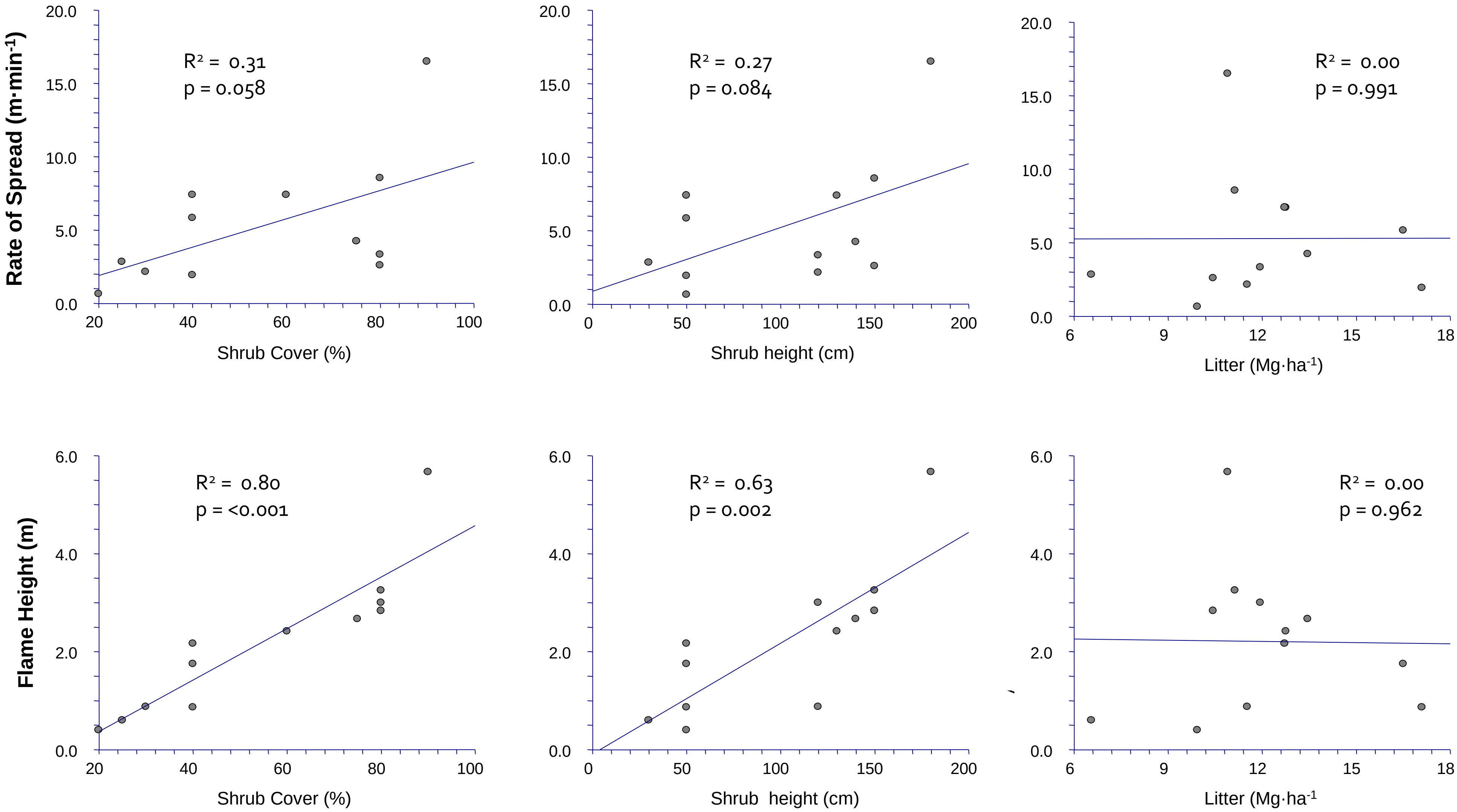
Litter Consumption

Burn	86 (8)%
Mow+burn	83 (4)%

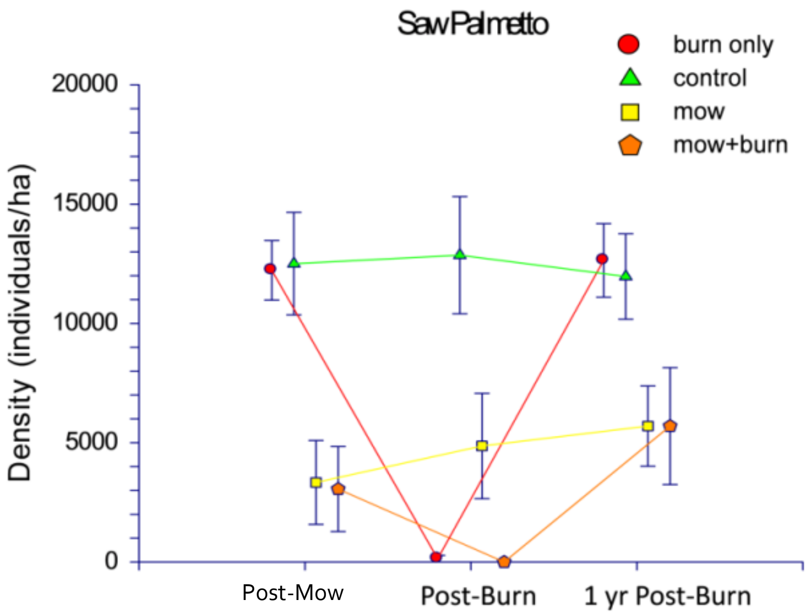
Duff Consumption

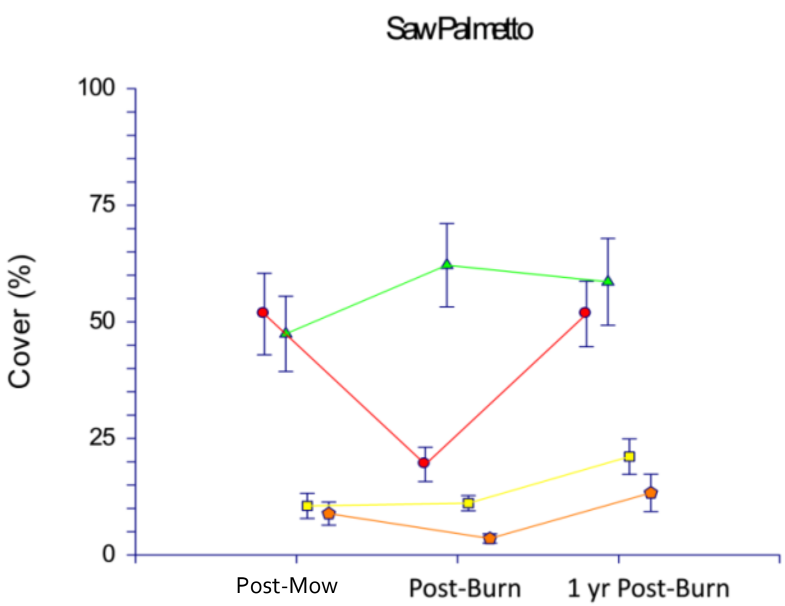
Burn	3 (3)%
Mow+burn	0 (0)%

Drivers of Fire Behavior: it's all about shrubs



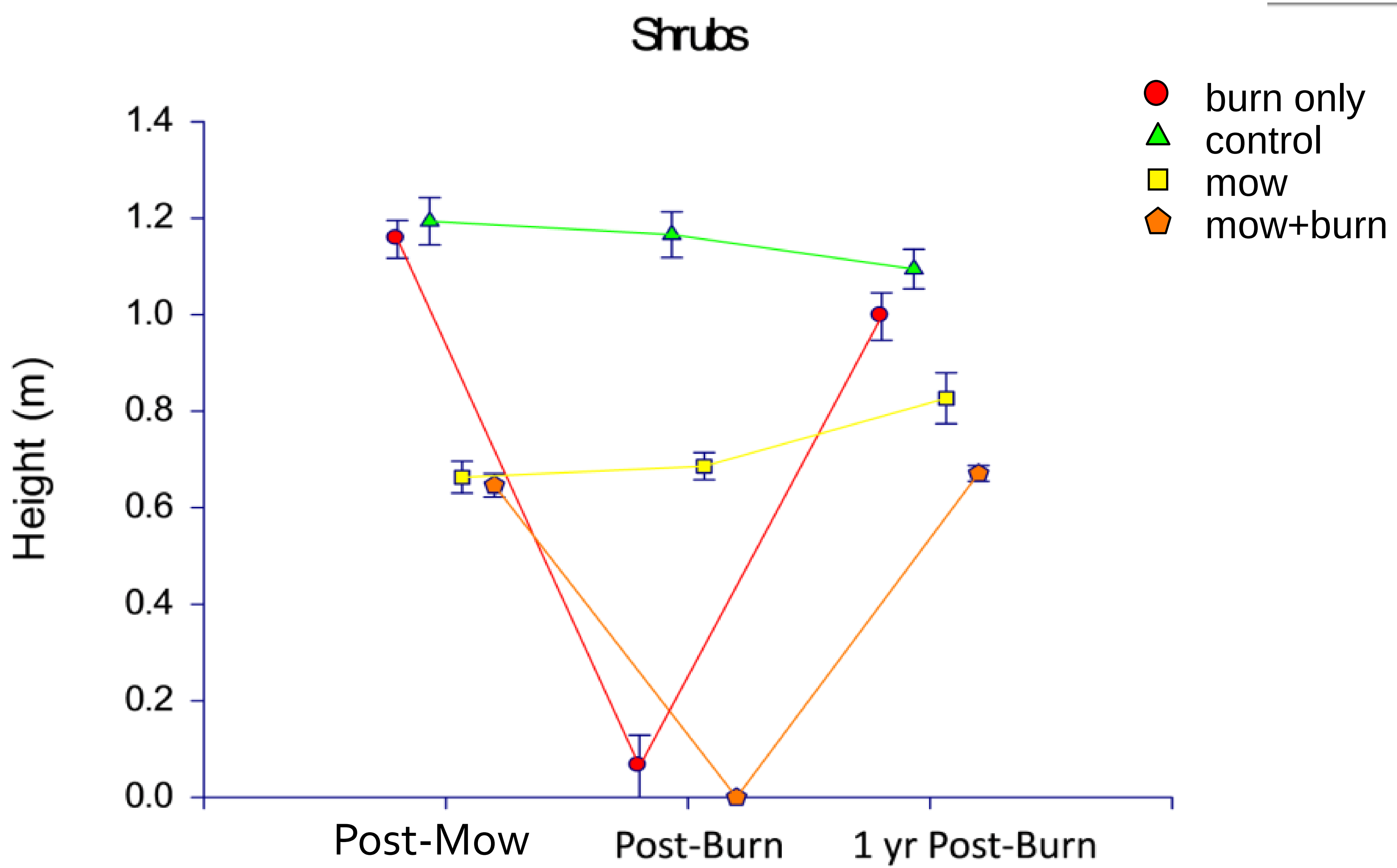
Palmetto recovery post burn vs. mow + burn





% Cover= driver of fire behavior

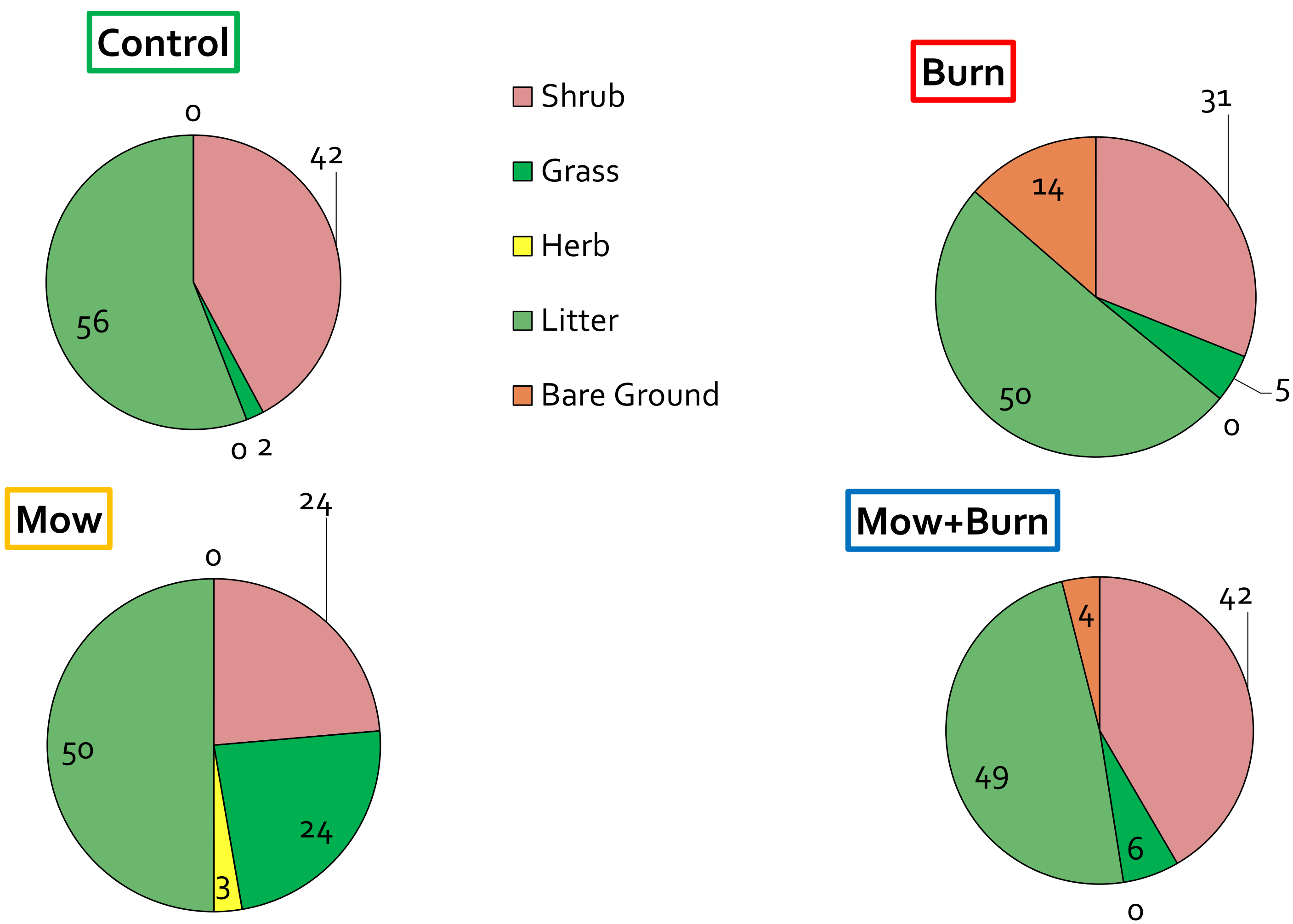
Overall shrub height- driver of fire behavior



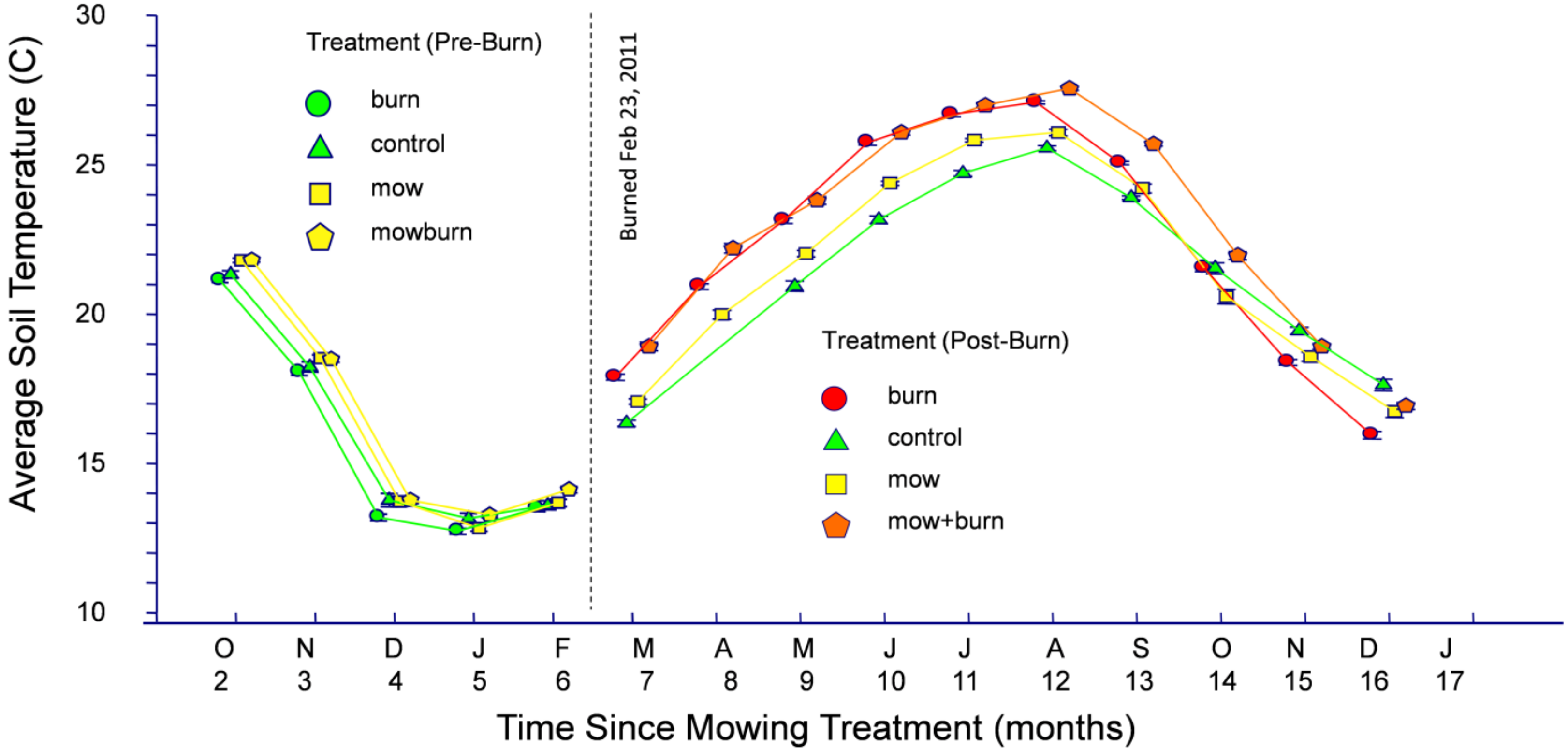
Groundcover- functional groups

7 months post-burn & 1 year post-mowing

Percent Cover of Groundcover, Litter, and Bare Ground (shrubs <0.5m)



Soils

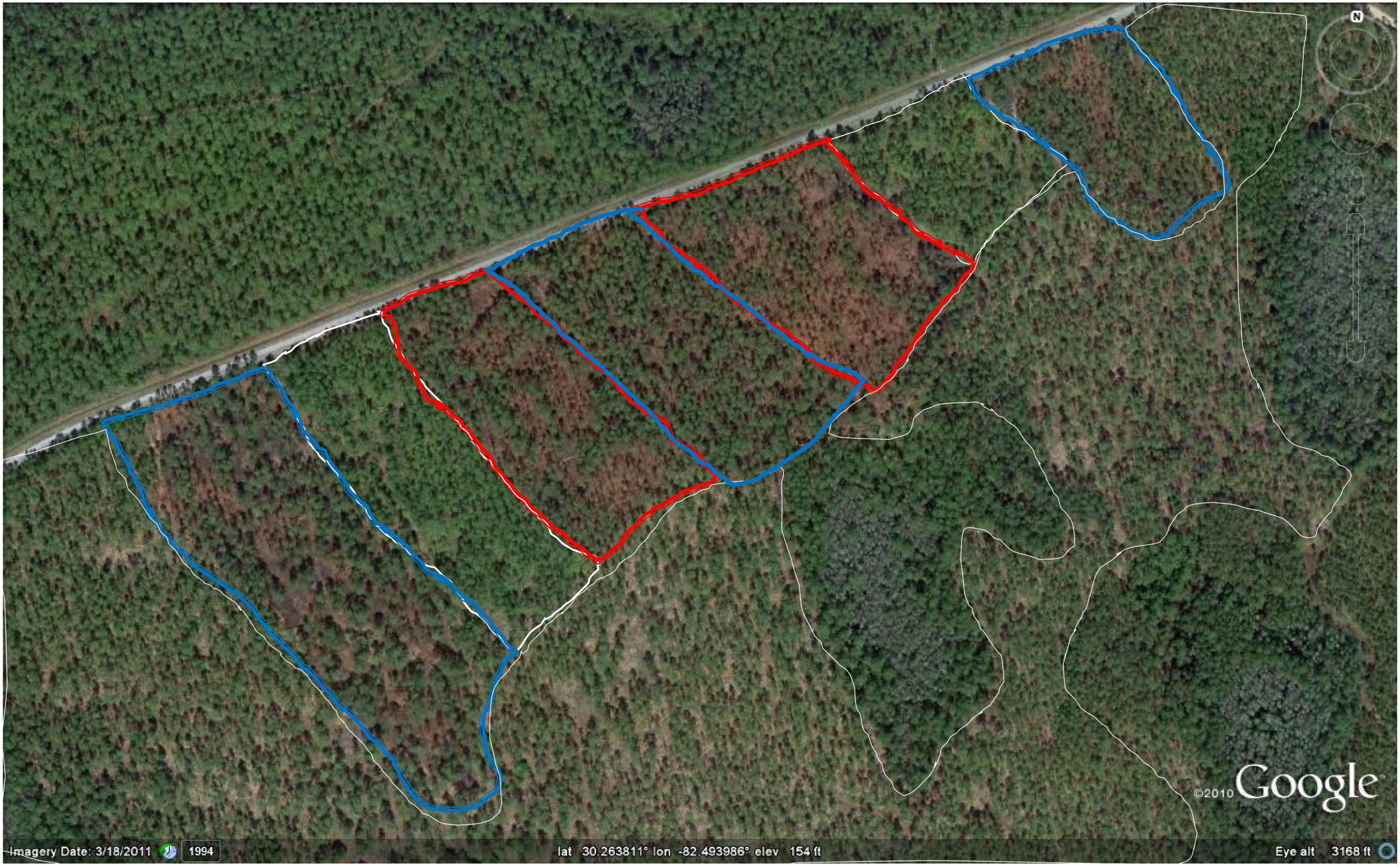


<u>Soil Nutrients</u> (pre-burn & 1 yr post-burn)

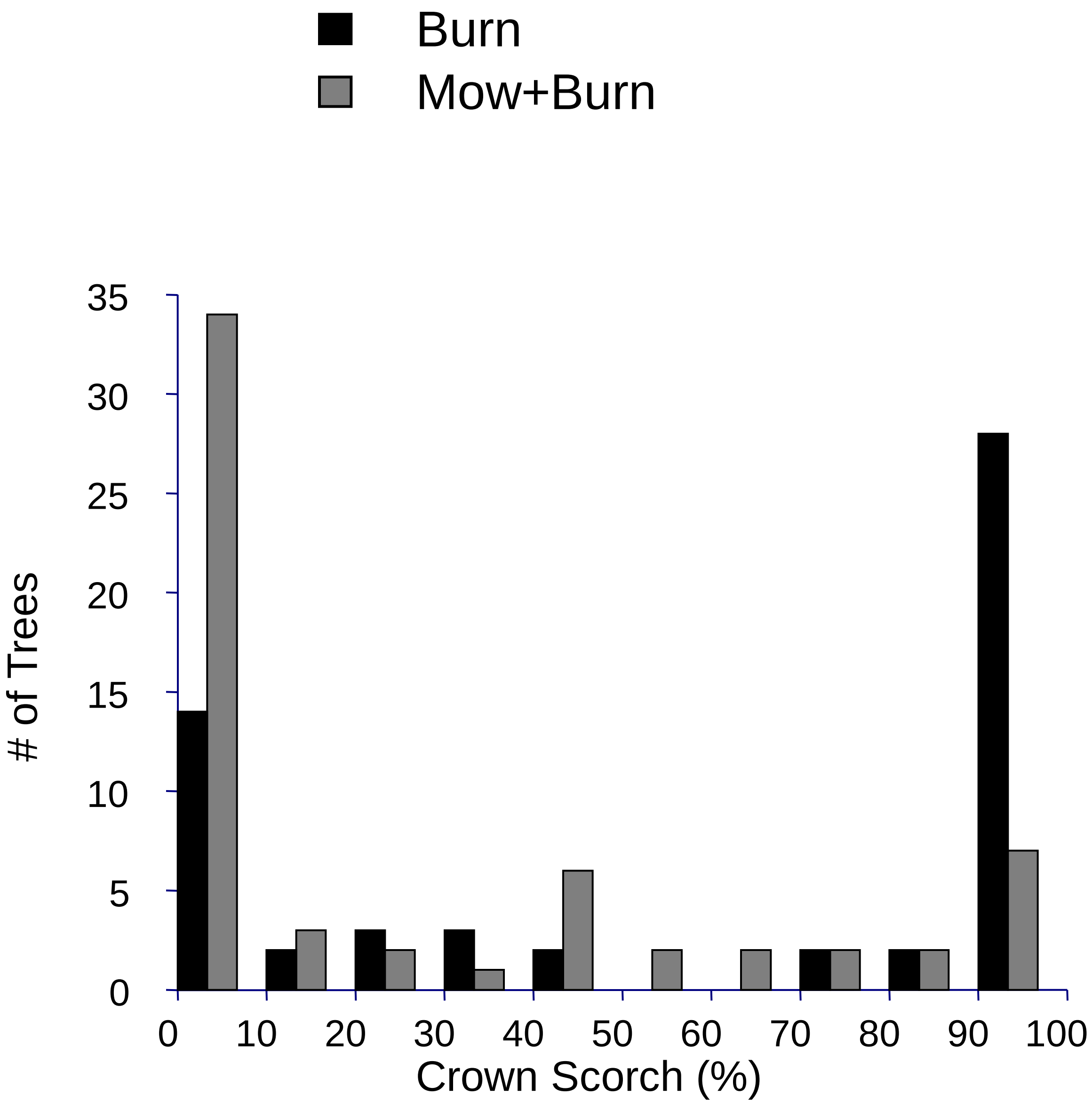
- BD, pH, CEC
- Exchangeable K, Mg, Ca
- Base Saturation of K, Mg, Ca
- Available P
- Total C, P, N
- Organic Matter

<u>*No Treatment Effects</u>

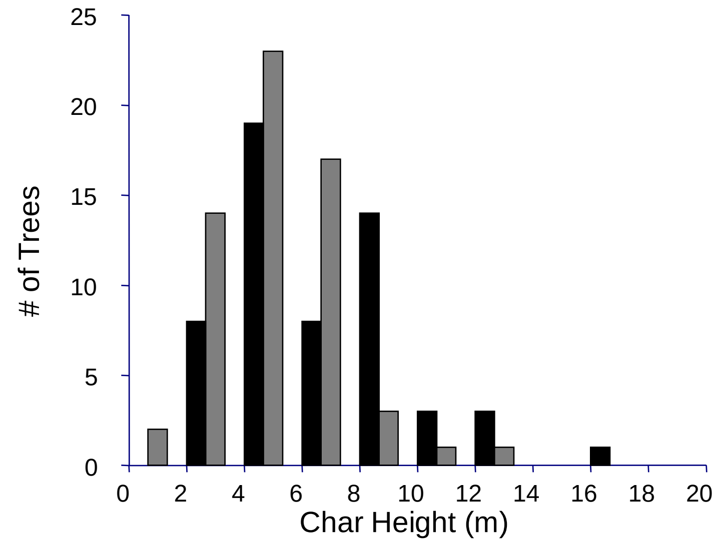
Burn only vs. mow + burn



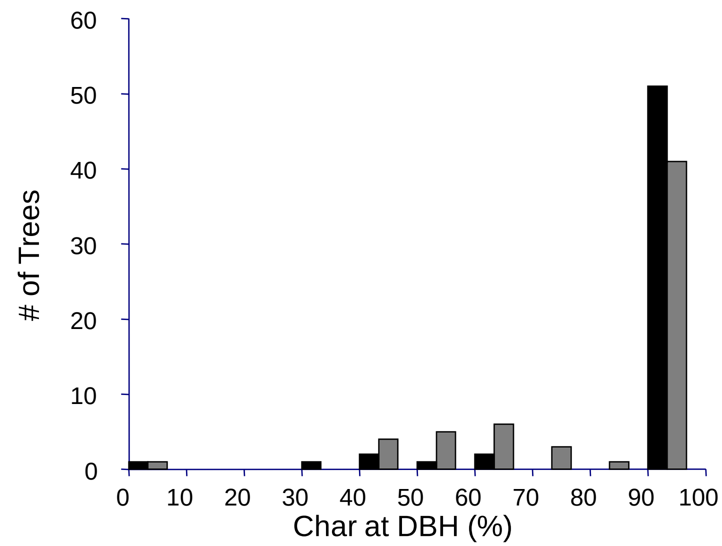
Tree Damage



Burn
Mow+Burn
# of Trees
0
5
10
15
20
25
30
35
0 10 20 30 40 50 60 70 80 90 100
Crown Scorch (%)



# of Trees
0
5
10
15
20
25
0 2 4 6 8 10 12 14 16 18 20
Char Height (m)



# of Trees
0
10
20
30
40
50
60
0 10 20 30 40 50 60 70 80 90 100
Char at DBH (%)

Summer Burns: vs winter conditions

Table 4-3 Comparison of burning conditions (weather, overstory, and fuels) between a summer and winter burn in masticated palmetto/gallberry pine flatwoods of northern Florida, USA.

Burning Conditions

	Burn Date	Temp °C	RH %	Windspeed $km \cdot hr^{-1}$	Litter Moisture %	KBDI
Summer	28 Jul 2010	31-34	61-76	1.6-7.2	14.7 (1.1)[a]	425
Winter	23 Feb 2011	23-24	47-49	1.6-2.7	12.1 (0.6)[a‡]	107

Overstory

	Tree Density *tph*	Basal Area m^2	QMD *cm*	Height *m*	CBH *m*
Summer	290 (27)[a]	23.1 (3.0)[a]	32.0 (2.6)[a]	23.3 (0.9)[a]	15.8 (0.8)[a]
Winter	307 (64)[a]	18.9 (4.4)[a]	27.8 (1.6)[a]	21.0 (0.7)[a‡]	14.7 (0.9)[a]

Understory Fuels

	Shrub Height[1] *cm*	Shrubs $Mg \cdot ha^{-1}$	Shrub Foliage $Mg \cdot ha^{-1}$
Summer	69 (7)[a]	0.9 (0.5)[a]	0.5 (0.2)[a]
Winter	58 (13)[a]	0.6 (0.3)[a]	0.4 (0.2)[a]

Surface Fuels

	Litter Depth *cm*	Duff Depth *cm*	Litter $Mg \cdot ha^{-1}$	Duff $Mg \cdot ha^{-1}$	1 h $Mg \cdot ha^{-1}$	10 h $Mg \cdot ha^{-1}$	100 h $Mg \cdot ha^{-1}$
Summer	4.9 (0.7)[a]	5.3 (0.8)[a]	10.9 (1.6)[a]	58.8 (9.4)[a]	4.1 (1.0)[a]	6.6 (0.6)[a]	2.5 (1.1)[a]
Winter	6.0 (0.4)[a]	3.5 (0.6)[a]	13.4 (0.9)[a]	38.8 (6.5)[a]	1.1 (0.2)[b]	2.1 (0.3)[b]	1.1 (0.6)[a]

Note: Values sharing letters within columns are not statistically different (Tukey-Kramer Test, α=0.05), [‡] indicates marginal differences (p<0.10)

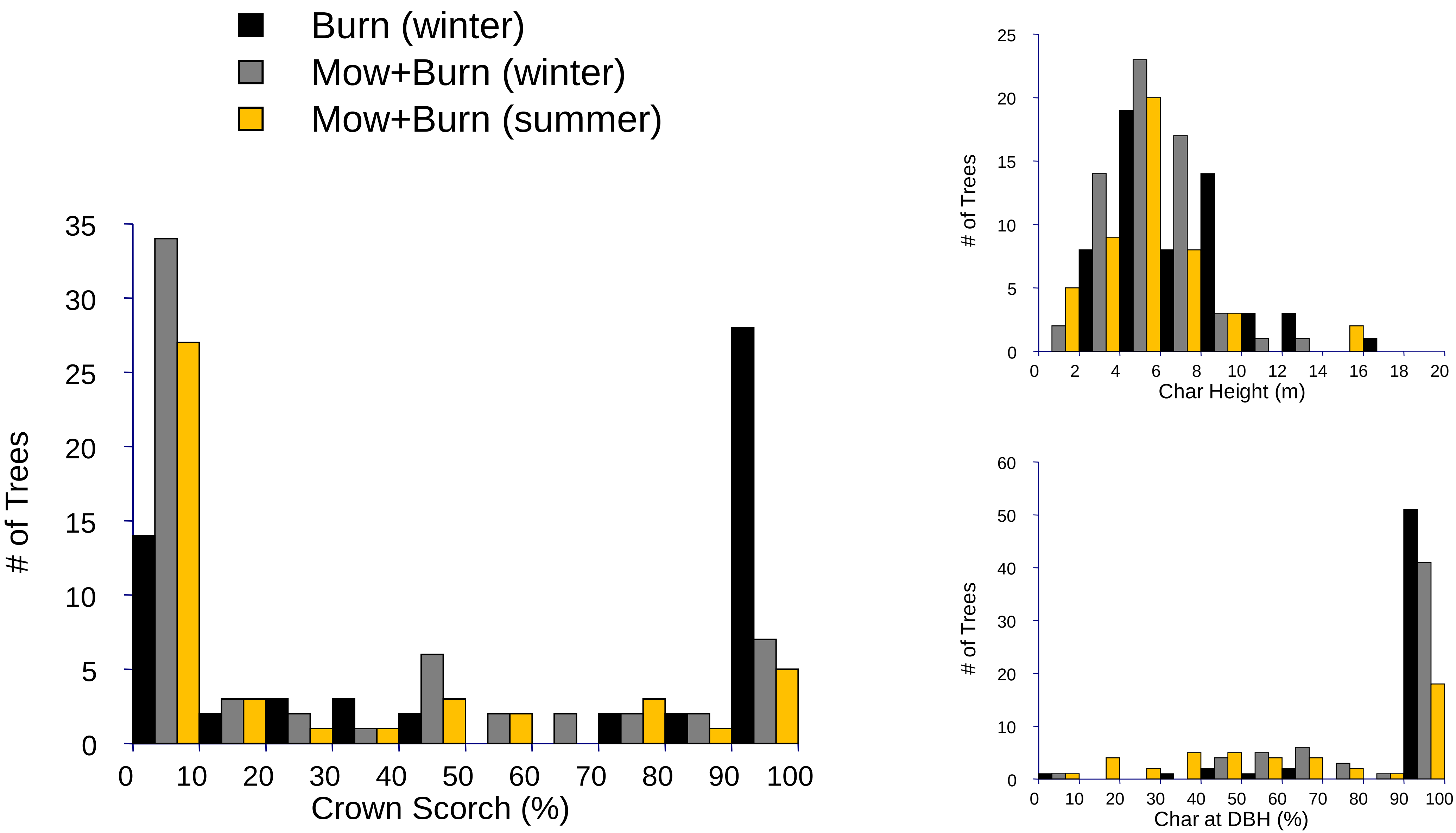
Fire Behavior/Effects: winter vs. summer

Table 4-4 Fire behavior and effects between summer (July) and winter (Feb) burning of masticated palmetto/gallberry pine flatwoods.

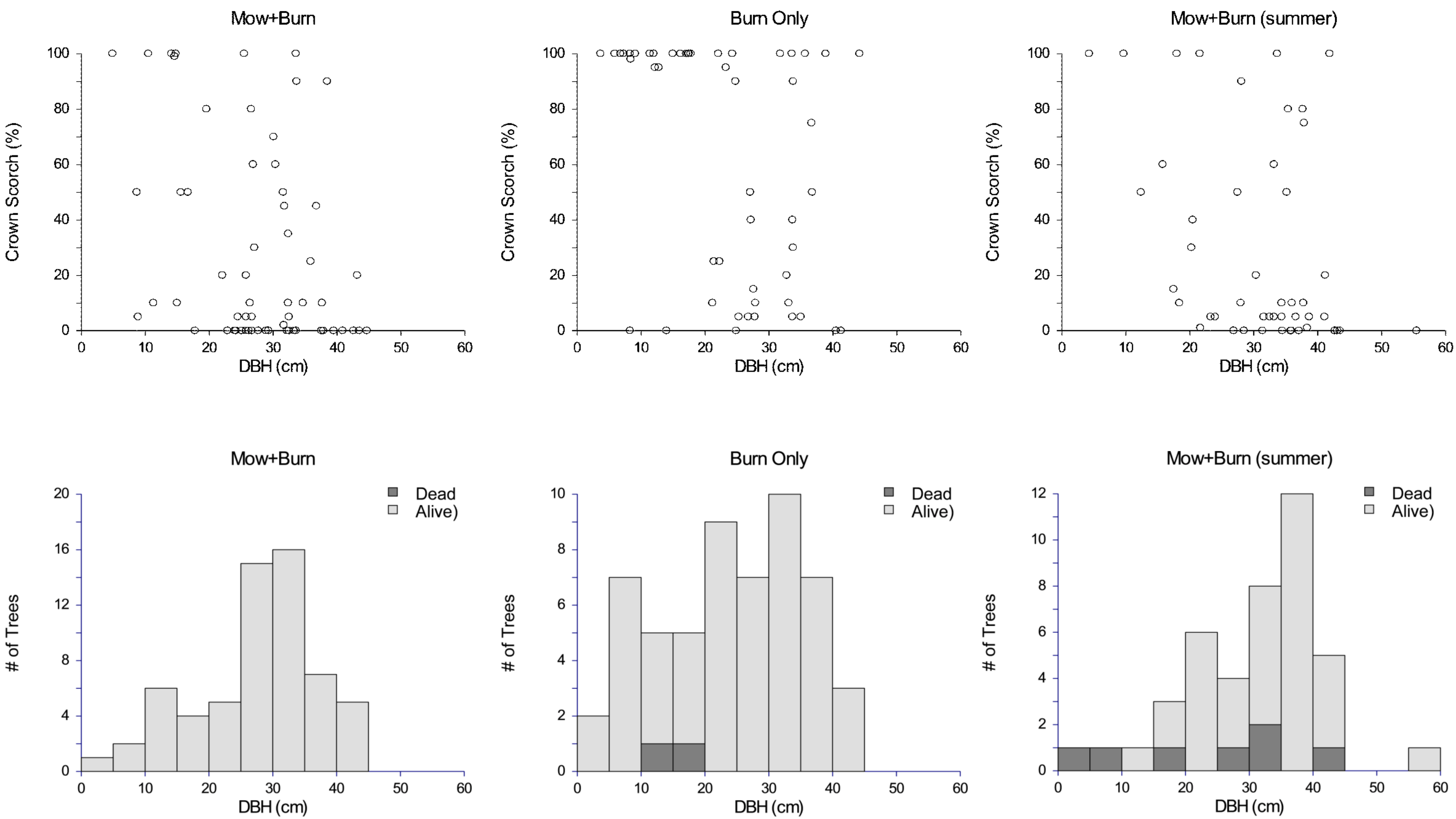
	Fire Behavior		Consumption				Overstory Fire Effects		
	Flame Ht	ROS	Litter	Duff	Litter	Duff	Scorch	Char	Char Height
	m	*m·min*$^{-1}$	--------*Mg·ha*$^{-1}$--------		--------%--------		%	%	*m*
Summer	1.5 (0.1)[a]	5.9 (1.8)[a]	5.5 (1.3)[a]	23.1 (10.1)[a‡]	48 (7)[a]	32 (11)[a‡]	25 (11)[a]	64 (9)[a‡]	4.7 (0.6)[a]
Winter	1.1 (0.3)[a]	3.4 (1.0)[a]	9.6 (0.9)[b]	2.6 (1.9)[a]	71 (4)[b]	5 (3)[a]	37 (8)[a]	86 (6)[a]	5.5 (0.6)[a]

Note: Values sharing letters within columns are not statistically different (Tukey-Kramer Test, α=0.05), ‡ indicates marginal differences (p<0.10)

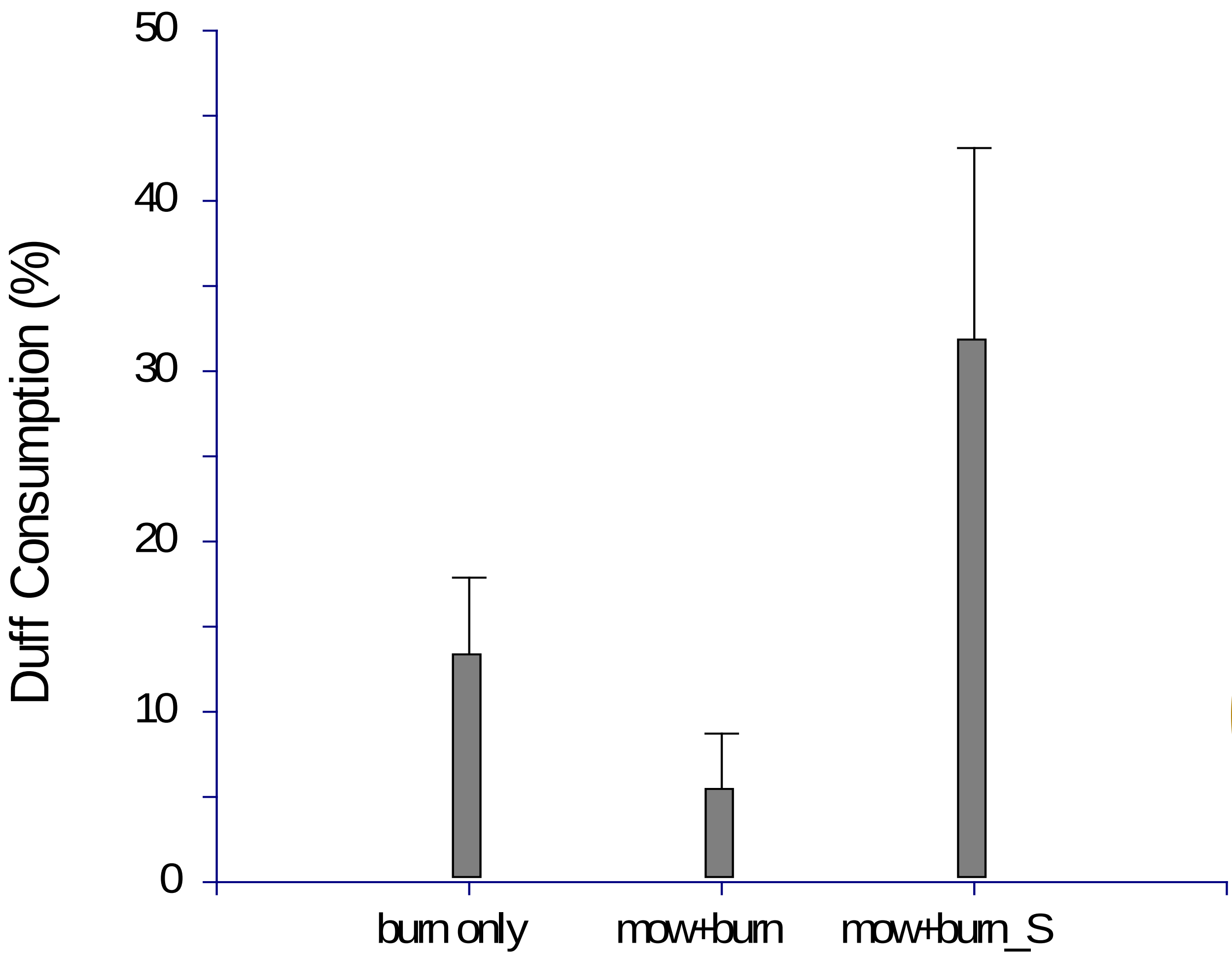
Summer (July 2010) vs. winter (Feb. 2011) Burns



Resulting Tree Mortality



Duff Consumption



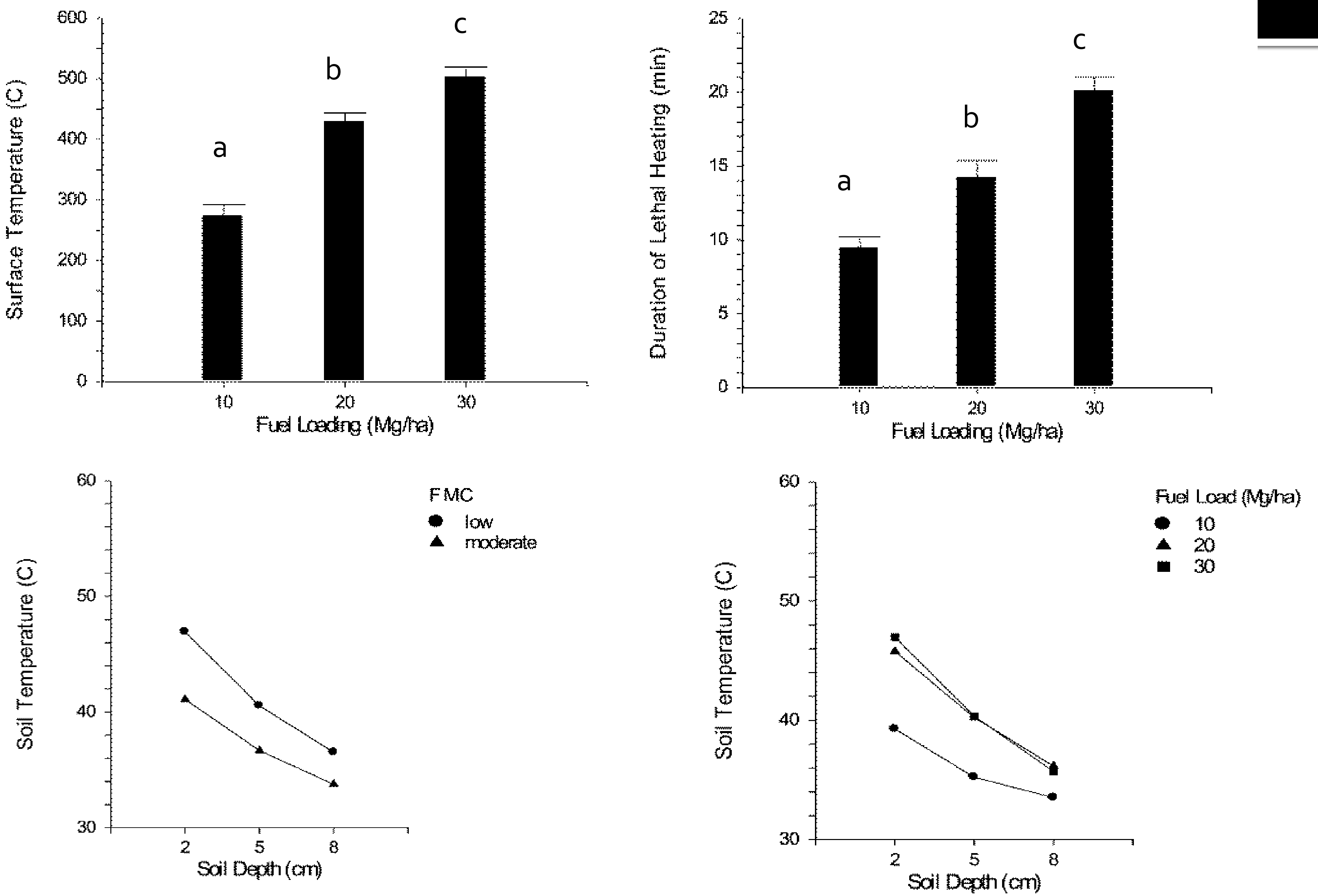
Pre-Burn Duff (Mg·ha^{-1})

Burn Only	53.3 (9.5)
Mow+Burn	38.8 (6.5)
Mow+Burn (S)	58.8 (9.4)

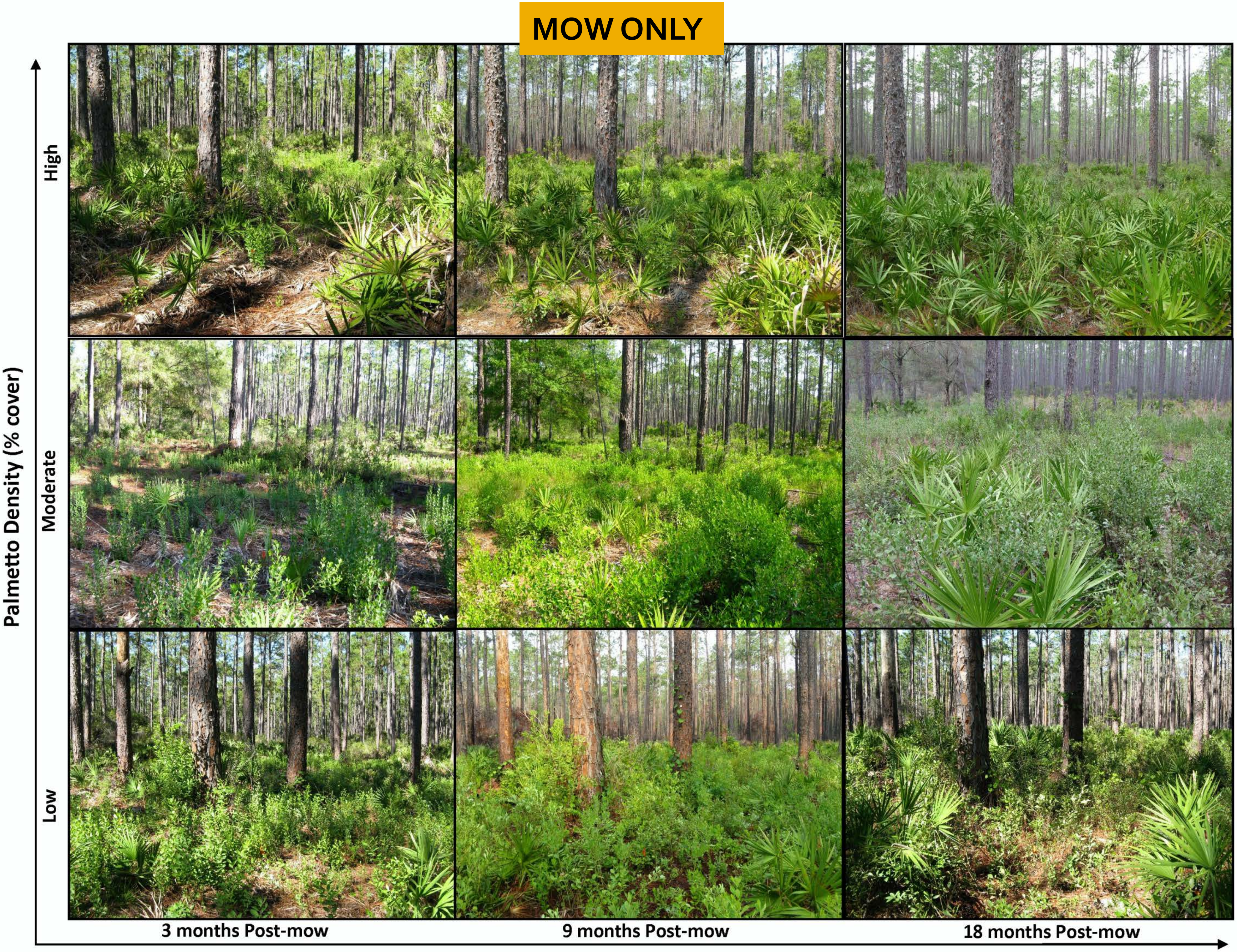
KBDI
Winter: 107
Summer: 425

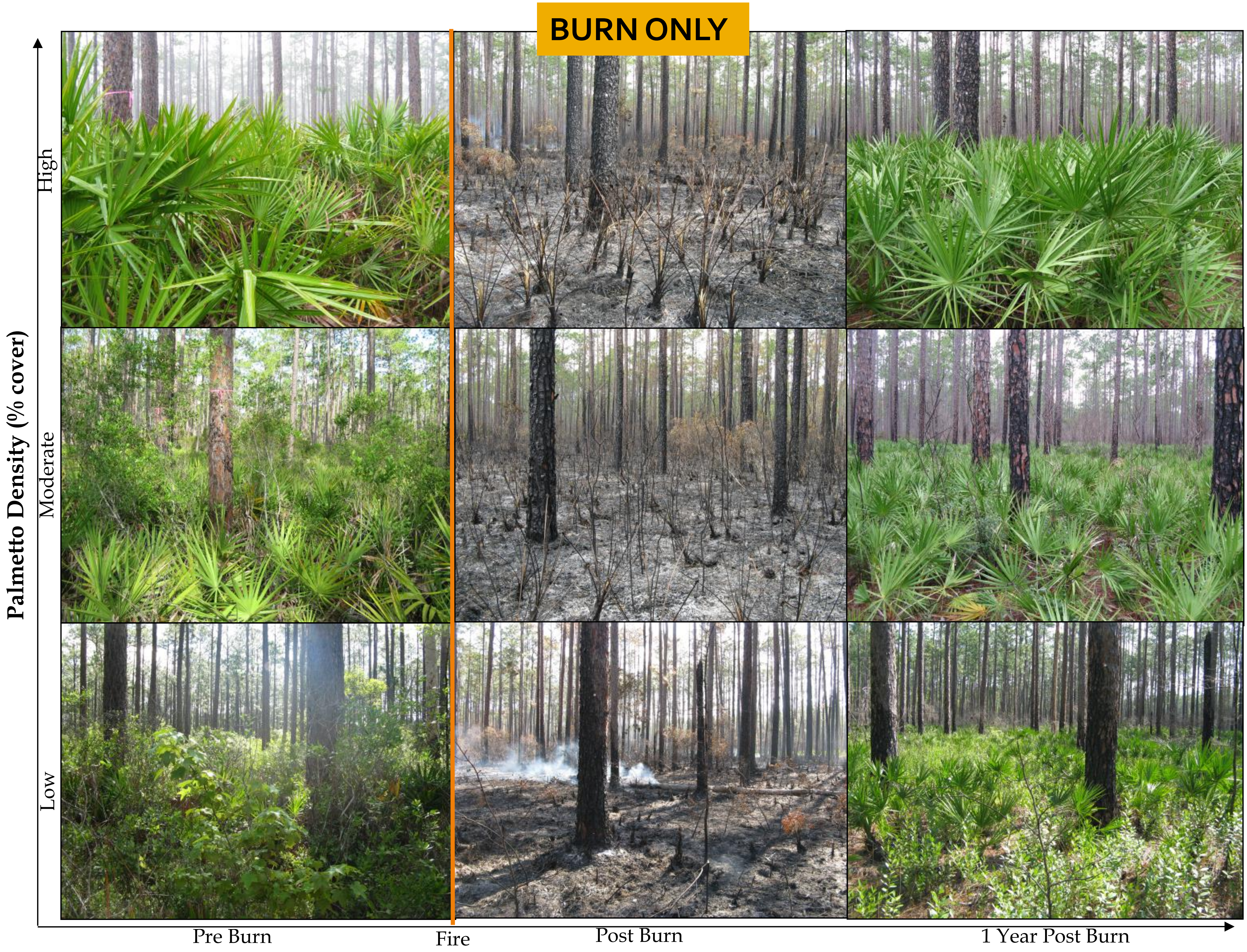
(index range: 0-800)

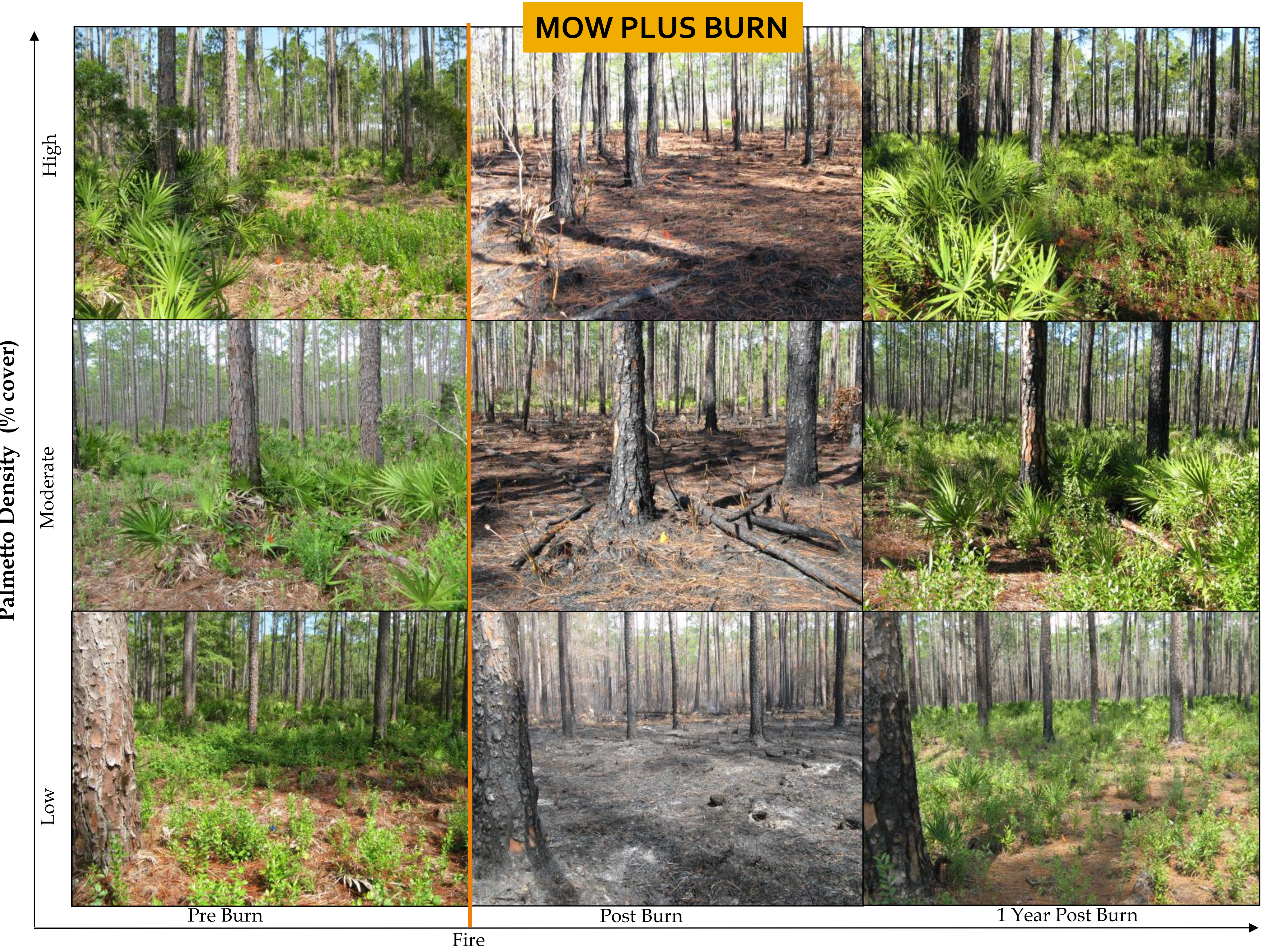
Surface and Soil Heating



Longevity of treatments


MOW ONLY
Palmetto Density (% cover)
High
Moderate
Low
3 months Post-mow
9 months Post-mow
18 months Post-mow


BURN ONLY
Palmetto Density (% cover)
High
Moderate
Low
Pre Burn
Fire
Post Burn
1 Year Post Burn


MOW PLUS BURN
Palmetto Density (% cover)
High
Moderate
Low
Pre Burn
Post Burn
1 Year Post Burn
Fire

Take Home Messages

- Mowed plus burned sites recover more slowly than burn only sites
- Mowing prior to burning reduces fire behavior (flame length, rate of spread), but shrub recovery is nearly 100% within 2 years
- Summer burns following mowing may cause more overstory mortality likely due to fine root or basal cambium damage if burns are conducted during drier conditions
- Soil heating is unlikely to reach biological mortality thresholds, even under heavy fuel loads
  - Soil nutrients, C, CEC are not significantly impacted by treatments
- Mowing may increase proportion of herbaceous ground cover, if only temporarily.
- More information is available!

Fuel Treatments in Pine Flatwoods:
A Photo Series Guide

For Estimating Vegetation and Fuel Biomass Change over Time Following Mowing and Burning in Southern Pine Flatwoods Forests

Mow 1: High Pre-Treatment Palmetto Density

Site Information	
Location	Osceola National Forest, Columbia County, Florida
Stand type	Mature pine flatwoods (slash and longleaf pine)
Stand history	More than 12 years since last burned
Overstory metrics	Tree density (per acre): 100.6 Average height (ft): 78.2

Fuel Characteristics	Post Mow	9 mos	1.5 yr	2.5 yr
1-hour (tons/acre)	0.2	0.2	0.3	0.1
10-hour (tons/acre)	1.2	0.3	1.4	1.3
100-hour (tons/acre)	1.1	0.5	1.1	0.0
1,000-hour S (tons/acre)	0.0	0.0	0.0	0.0
1,000-hour R (tons/acre)	0.0	0.0	0.0	0.0
Duff (tons/acre)	24.7	24.4	23.0	31.0
Duff depth (in)	1.9	1.6	1.9	2.0
Litter (tons/acre)	6.2	5.7	5.1	6.0
Litter Depth (in)	2.4	1.9	2.5	2.0
Palmetto Cover (%)	**25**	**10**	**50**	**75**
Palmetto Height (ft)	**2.9**	**2.6**	**3.1**	**3.9**
Total Shrub Biomass (tons/acre)	0.6	0.9	2.6	2.9

Mow and Burn 1: High Palmetto Density

Site Information	
Location	Osceola National Forest, Columbia County, Florida
Stand type	Mature pine flatwoods (Slash pine and Longleaf pine)
Stand history	More than 12 years since last burned
Overstory Metrics	Tree density (per acre): 120.7 Average height (ft): 66.7 Basal area (ft^2/acre): 56.4

Fuel Characteristics	Pre burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.3	0.1	0.1	0.1	0.2
10-hour (tons/acre)	1.4	0.6	0.6	0.6	1.4
100-hour (tons/acre)	0.0	0.0	0.0	0.0	0.0
1,000-hour S (tons/acre)	2.1	0.0	0.0	1.3	1.5
1,000-hour R (tons/acre)	0.0	0.0	0.0	0.5	0.0
Duff (tons/acre)	24.0	20.9	20.9	12.6	15.6
Duff depth (in)	1.3	1.4	1.4	0.8	1.1
Litter (tons/acre)	5.9	0.8	0.8	1.2	0.8
Litter Depth (in)	2.3	0.6	0.6	0.9	0.7
Palmetto Cover (%)	**15**	**5**	**5**	**20**	**25**
Palmetto Height (ft)	**2.3**	**0.6**	**0.6**	**2.7**	**2.9**
Total Shrub Biomass (tons/acre)	0.0	0.0	0.0	0.2	0.6

Osceola NF Fuels Treatment Effects

Photo Guide- CONTROL

Treatment: Control

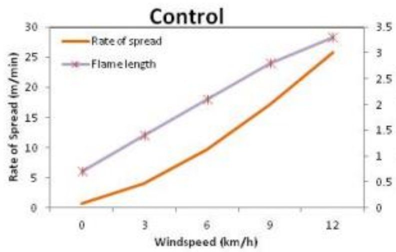
Photo Date: May 2011

Location: Osceola National Forest Columbia County, Florida

30.2657, -82.4919

Fuel Loading

Treatment	Control	
N	7	
	mean	sd
1h (Mg·ha^{-1})	0.39	0.51
10h (Mg·ha^{-1})	1.60	1.24
100h (Mg·ha^{-1})	0	0
1000h S (Mg·ha^{-1})	0.25	0.65
1000h R (Mg·ha^{-1})	0	0
Litter (Mg·ha^{-1})	9.49	2.42
Duff (Mg·ha^{-1})	14.60	3.39
Shrub H-A (Mg·ha^{-1})	9.6	
Litter Depth (cm)	8.2	2.1
Duff Depth (cm)	5.7	1.8
Palmetto Cover (%)	62	24
Palmetto Height (m)	1.0	0.2
BA (m^2·ha^{-1})	19.4	6.0



Osceola NF Fuels Treatment Effects

Photo Guide- MOW TREATMENT

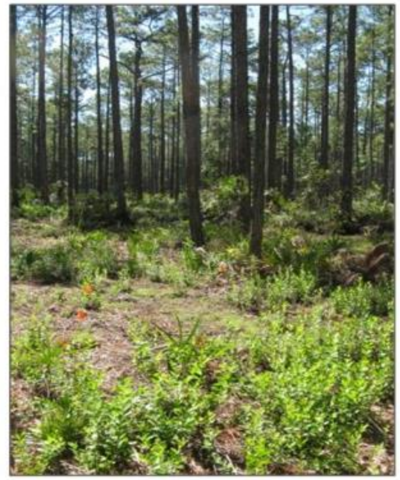
Treatment: Mow Only

Treatment Date: August 2010

Photo Date: October 2010

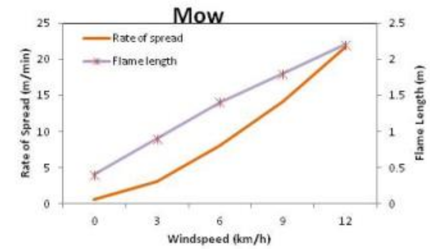
Location: Osceola National Forest Columbia County, Florida

30.2642, -82.4920



Fuel Loading

Treatment	Mow	
N	9	
	mean	sd
1h (Mg·ha^{-1})	0.97	0.45
10h (Mg·ha^{-1})	2.29	1.97
100h (Mg·ha^{-1})	1.16	1.63
1000h S (Mg·ha^{-1})	0.43	0.84
1000h R (Mg·ha^{-1})	0	0
Litter (Mg·ha^{-1})	12.88	2.40
Duff (Mg·ha^{-1})	12.06	2.08
Shrub H-A (Mg·ha^{-1})	1.2	
Litter Depth (cm)	5.3	1.2
Duff Depth (cm)	4.4	1.1
Palmetto Cover (%)	11	8
Palmetto Height (m)	0.7	0.3
BA (m^2·ha^{-1})	20.0	7.3



Osceola NF Fuels Treatment Effects

Photo Guide- BURN TREATMENT

Treatment: Burn Only

Treatment Date: February 2011

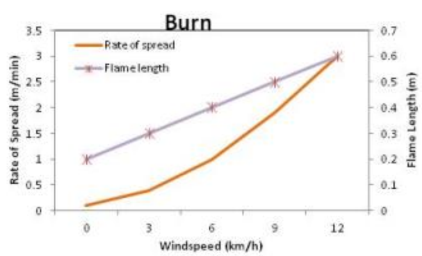
Photo Date: March 2011

Location: Osceola National Forest Columbia County, Florida

30.2653, -82.4929

Fuel Loading

Treatment	Burn	
N	11	
	mean	sd
1h (Mg·ha^{-1})	0.09	0.11
10h (Mg·ha^{-1})	1.56	1.64
100h (Mg·ha^{-1})	0.27	0.60
1000h S (Mg·ha^{-1})	4.89	11.82
1000h R (Mg·ha^{-1})	0	0
Litter (Mg·ha^{-1})	2.22	0.62
Duff (Mg·ha^{-1})	11.15	2.51
Shrub H-A (Mg·ha^{-1})	0.30	
Litter Depth (cm)	1.9	0.5
Duff Depth (cm)	4.0	1.3
Palmetto Cover (%)	18	11
Palmetto Height (m)	0.5	0.1
BA (m^2·ha^{-1})	18.6	8.3



Osceola NF Fuels Treatment Effects

Photo Guide- MOW + BURN TREATMENT

Treatment: Mow & Burn

Date: Mow: August 2010

Burn: February 2011

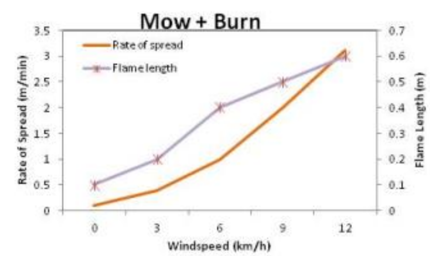
Photo Date: March 2011

Location: Osceola National Forest Columbia County, Florida

30.2660, -82.4909

Fuel Loading

Treatment	Mow+burn	
N	9	
	mean	sd
1h (Mg·ha^{-1})	0.21	0.11
10h (Mg·ha^{-1})	1.35	0.66
100h (Mg·ha^{-1})	0.17	0.50
1000h S (Mg·ha^{-1})	0.80	1.60
1000h R (Mg·ha^{-1})	0.06	0.18
Litter (Mg·ha^{-1})	1.74	0.58
Duff (Mg·ha^{-1})	10.67	3.29
Shrub H-A (Mg·ha^{-1})	0.0	
Litter Depth (cm)	1.5	0.5
Duff Depth (cm)	3.7	1.7
Palmetto Cover (%)	4	3
Palmetto Height (m)	0.3	0.2
BA (m^2·ha^{-1})	22.5	10.3



SFE Fact Sheet 2015-1

Mechanical Treatments in Pine Flatwoods: A Temporary Rearrangement of Fuel Structure

Jesse Kreye, David Godwin, and Leda Kobziar

SUMMARY

Mechanical "mowing" treatments can alter the structure and arrangement of understory and midstory fuels in pine flatwoods thereby reducing post-treatment flame lengths and rates of fire spread. Shrubs, however, can quickly recover following treatment and reduce the longevity of this effectiveness. Surface fuels resulting from the mowing of small trees and shrubs may present challenges given that long-duration combustion can occur in these compact fuels. The timing of subsequent mechanical or prescribed fire treatments may be very important for achieving management objectives.

MECHANICAL FUEL TREATMENTS

Prescribed burning is a dominant forest management tool used across the Southeastern U.S., yet burning is often limited due to various social, ecological, or economic factors. The use of mechanical methods as a fire surrogate or as a means to treat overgrown fuels prior to reintroducing fire has become increasingly used in the region, especially in the wildland-urban-interface (WUI) and other areas with significant smoke concerns. Mechanical treatments can include thinning of the overstory, treating understory shrubs and small trees, or a combination of both. Understory treatments commonly used in the South include "mowing", "mulching", "masticating" or "chipping" (depending on the equipment used) of shrubs and small trees. While different terms are used, each treatment is aimed at transforming aerial fuels to surface fuels to reduce fire behavior. Treatments are often employed as a stand-alone option in the WUI, or are followed-up with prescribed burning where possible. While specific treatment objectives may vary, reduction of potential fire behavior attributes including flame lengths, rate of spread, and crown fire potential, are emphasized. Reducing these fire behavior factors is important to both follow-up prescribed burning and potential wildfire.

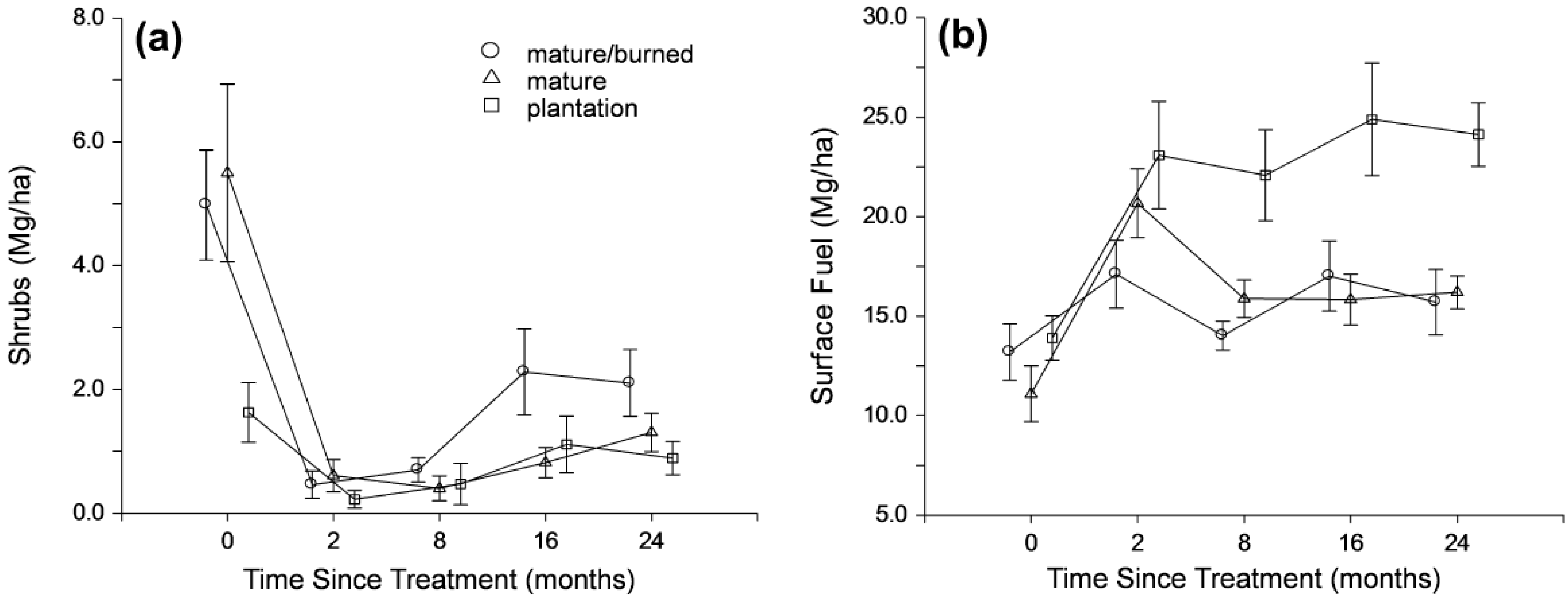
TREATMENT OF FUELS IN PINE FLATWOODS

Mowing is a common mechanical fuels treatment method especially in long-unburned pine flatwoods (ca. >10 yr. old rough) of the Southeastern Coastal Plain, where understories are dominated by saw palmetto (*Serenoa repens*) and gallberry (*Ilex glabra*) shrubs. Although understory shrubs in these stands can be very dense, mature longleaf pine (*Pinus palustris*) and slash pine (*P. elliottii*) in the overstory are often

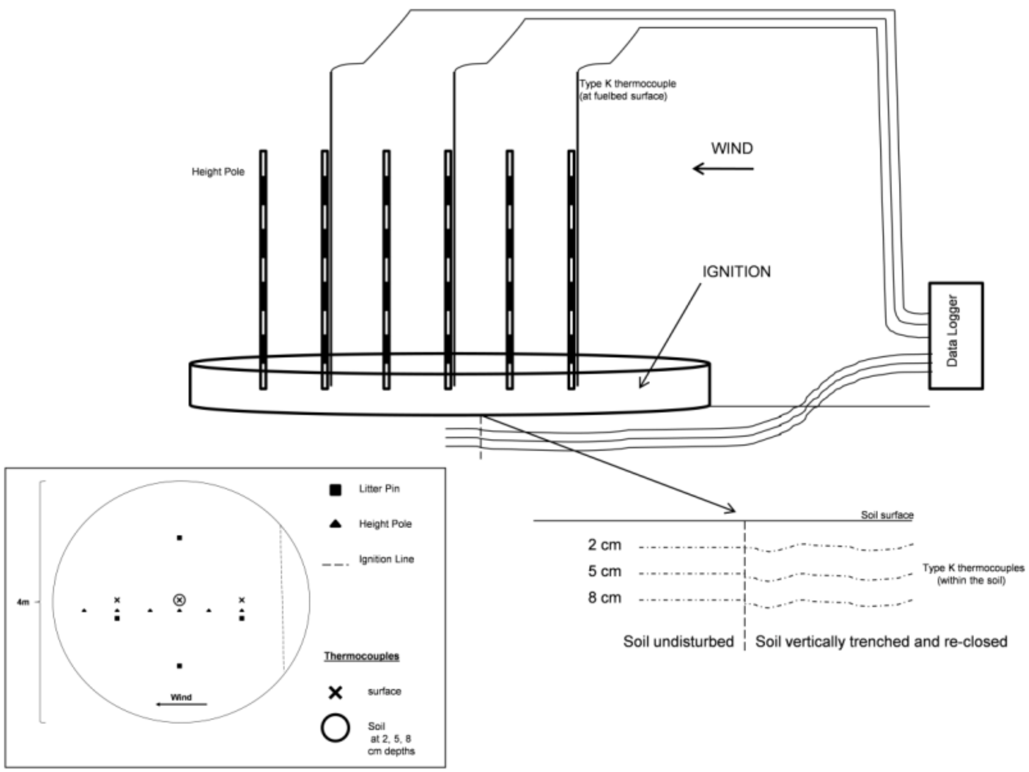
Following treatment, fuel bed height is greatly reduced while fuel bed bulk density is substantially increased, both of which can influence fire behavior[1]. Fuel beds created from mowing are mixtures of small-diameter woody fuels composed of broken sticks from shrub stems, or fractured (shredded) woody debris from larger shrub or tree stems. In pine flatwoods, the bulk of the post-mowing forest floor material is often composed of shredded saw palmetto foliar material[2]. These pine flatwoods post-treatment fuel beds can be somewhat "fluffy" or aerated compared to mowed debris generated in forests where woody shrubs or trees dominate the understory[3]. Although the surface of such fuel beds may initially appear "fluffy," the lower strata of mowed fuels remain relatively dense and may become more compact over time.

Thank you- questions?

Longevity of mowing effects: Shrubs and Surface Fuels



Small-Scale Fire Behavior Experiment



- Flame Length
- Rate of Spread
- Fuel consumption (%)
- Heating
  - Surface temperatures
  - soil temperatures
- Fireline Intensity ($kJ \cdot m^{-1} \cdot s^{-1}$)

$I = h \cdot w \cdot r$

I Fireline Intensity
h heat content ($kJ \cdot kg^{-1}$)
w mass of fuel consumed ($kg \cdot m^{-2}$)
r rate of spread ($m \cdot s^{-1}$)

May 2010
Temp: 28-34˚C
RH: 46-63%
Wind: 0.3-1.8 $m \cdot s^{-1}$

Kreye et al. 2011. *International Journal of Wildland Fire*

Winter and Summer Burn Conditions

Table 4-3 Comparison of burning conditions (weather, overstory, and fuels) between a summer and winter burn in masticated palmetto/gallberry pine flatwoods of northern Florida, USA.

Burning Conditions

	Burn Date	Temp	RH	Windspeed	Litter Moisture	KBDI
		°C	%	$km \cdot hr^{-1}$	%	
Summer	28 Jul 2010	31-34	61-76	1.6-7.2	14.7 (1.1)[a]	425
Winter	23 Feb 2011	23-24	47-49	1.6-2.7	12.1 (0.6)[a‡]	107

Overstory

	Tree Density	Basal Area	QMD	Height	CBH
	tph	m^2	cm	m	m
Summer	290 (27)[a]	23.1 (3.0)[a]	32.0 (2.6)[a]	23.3 (0.9)[a]	15.8 (0.8)[a]
Winter	307 (64)[a]	18.9 (4.4)[a]	27.8 (1.6)[a]	21.0 (0.7)[a‡]	14.7 (0.9)[a]

Understory Fuels

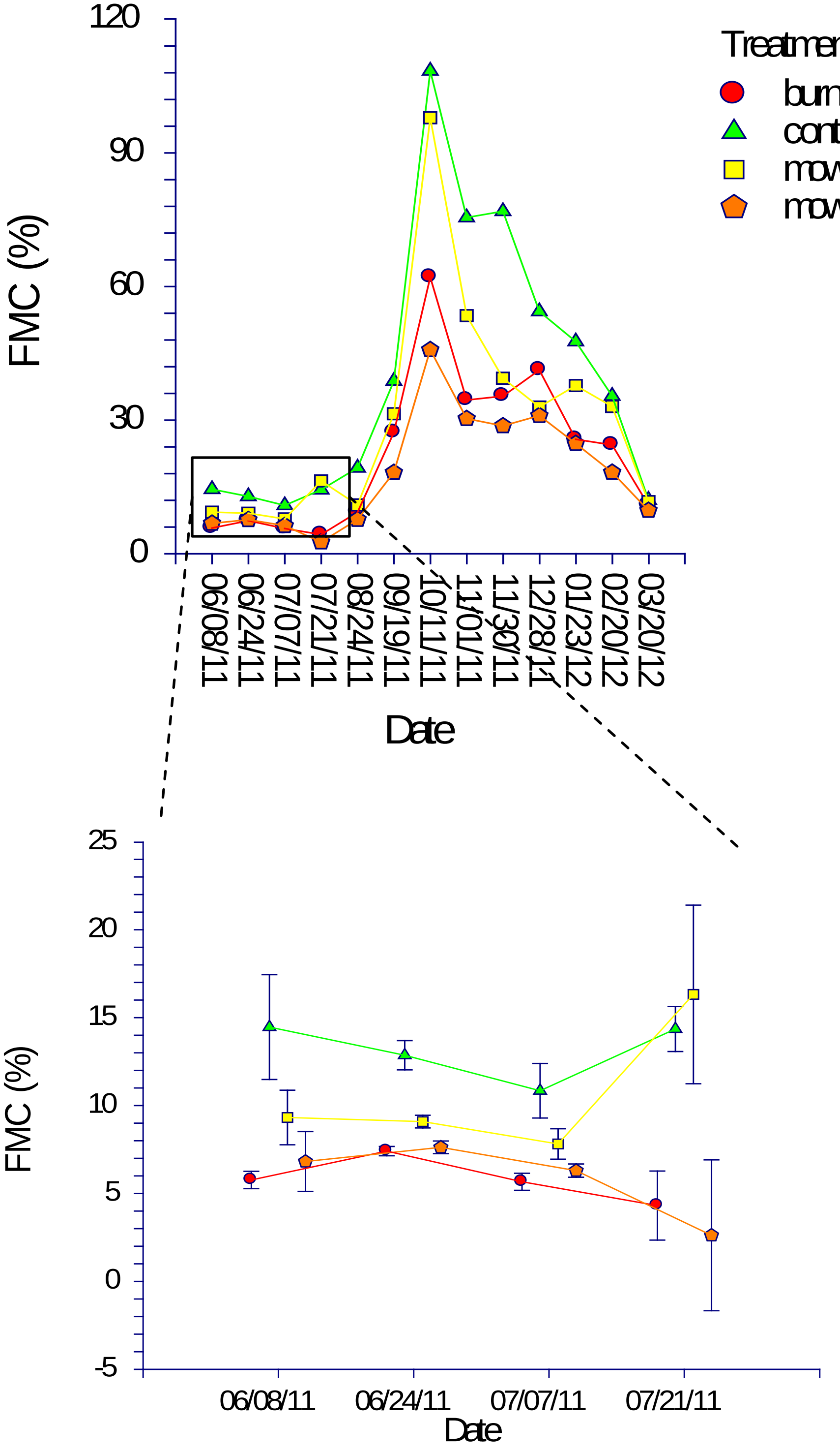
	Shrub Height[1]	Shrubs	Shrub Foliage
	cm	------------$Mg \cdot ha^{-1}$------------	
Summer	69 (7)[a]	0.9 (0.5)[a]	0.5 (0.2)[a]
Winter	58 (13)[a]	0.6 (0.3)[a]	0.4 (0.2)[a]

Surface Fuels

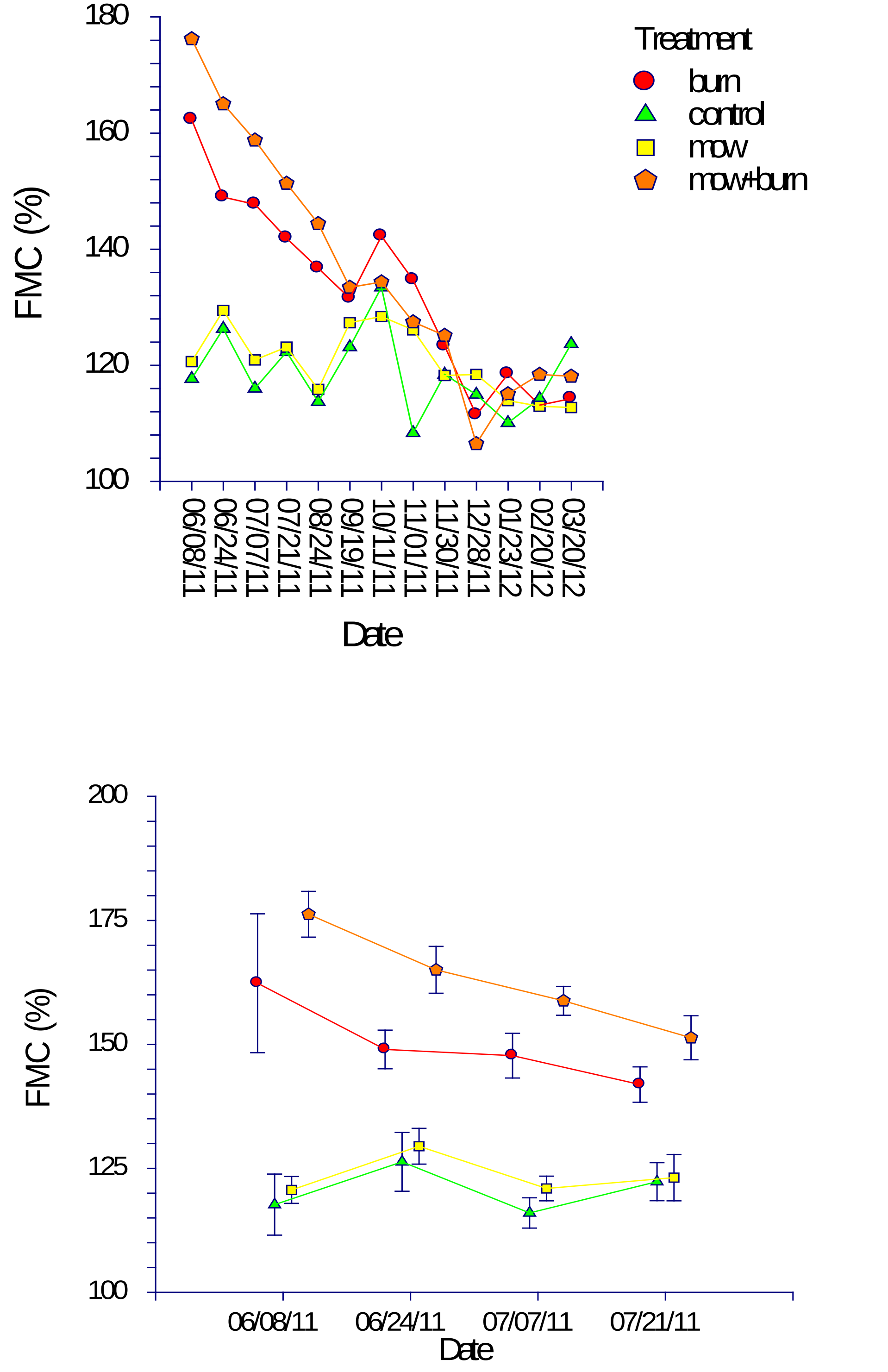
	Litter Depth	Duff Depth	Litter	Duff	1 h	10 h	100 h
	------cm------		------------------$Mg \cdot ha^{-1}$------------------				
Summer	4.9 (0.7)[a]	5.3 (0.8)[a]	10.9 (1.6)[a]	58.8 (9.4)[a]	4.1 (1.0)[a]	6.6 (0.6)[a]	2.5 (1.1)[a]
Winter	6.0 (0.4)[a]	3.5 (0.6)[a]	13.4 (0.9)[a]	38.8 (6.5)[a]	1.1 (0.2)[b]	2.1 (0.3)[b]	1.1 (0.6)[a]

Note: Values sharing letters within columns are not statistically different (Tukey-Kramer Test, α=0.05), ‡ indicates marginal differences (p<0.10)

Post treatment Litter Moisture Content



Live (shrubs) Moisture Content



Mowing → Shrubs/Small Trees