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

SOUTHERN Fire Exchange

JOINT FIRE SCIENCE PROGRAM

UF IFAS UNIVERSITY of FLORIDA

SFRC SCHOOL OF FOREST RESOURCES & CONSERVATION

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Overview

Time-interval photographs are arranged in chronological order to illustrate fuel loading in longleaf pine (*Pinus palustris*) flatwoods forests as a function of understory fuels and vegetation recovery after mechanical and fire fuels treatments. Examples of vegetation and fuels recovery in stands with contrasting pre-treatment conditions are provided for each treatment type, along with observed fire behavior characteristics. The Guide is designed to assist land managers in estimating the recovery and growth of characteristic understory conditions in flatwoods forests of the Southern Coastal Plain.

Acknowledgements

This Guide is a result of collaboration and support from the Joint Fire Science Program (project JFSP 10-1-01-16, PI Kobziar), the University of Florida School of Forest Resources and Conservation, the USDA Forest Service, the Southern Fire Exchange, and the American Recovery and Reinvestment Act. We thank the Osceola National Forest personnel for conducting fuel treatments and providing support for research activities, W. Zipperer of the USDA Forest Service Interface South Center, and research technicians L. Ramirez, N. Bowman, S. McGee, E. Carvalho, D. McKinstry, and A. Kattan.

Authors

Michelle L. Budny, Jesse K. Kreye, Leda N. Kobziar, James M. Camp**:** University of Florida, School of Forest Resources and Conservation, Kobziar Fire Science Lab (www.http://www.sfrc.ufl.edu/fire); Southern Fire Exchange: www.SouthernFireExchange.org.

References

Brown JK (1971) A planar intersect method for sampling fuel volume and surface area. Forest Science 17, 96-102.

Kreye, JK, Kobziar, LN, Zipperer, WC (2013) Effects of fuel load and moisture content on fire behaviour and soil heating in masticated litter-dominated fuels. International Journal of Wildland Fire 22 (4), 440 - 445.

Kreye, JK (2012) Efficacy and ecological effects of mechanical fuel treatments in pine flatwoods ecosystems of Florida, USA. PhD Dissertation, University of Florida.

Smith, WB, Brand, GJ (1983) Allometric biomass equations for 96 species of herb, shrubs and small trees. Research Note NC-299. USDA Forest Service, North Central Forest Experimental Station, St. Paul, MN, USA.

Table of Contents

Introduction

Purpose of this Photo Guide

Photo guides are a common reference tool for informing forest management decisions. They are often used to estimate fuel loading and to predict potential fire behavior. However, few guides show understory succession after mechanical fuels treatments and prescribed burns. This guide illustrates three fuel manipulation treatments (**Mow**, **Burn**, and **Mow and Burn**) compared to untreated conditions, and captures the succession of post treatment understory and fuels recovery in southern pine flatwoods forests. It can be used to estimate fuels recovery, biomass, relative cover of different understory functional groups, and time since treatment if treatment date is unknown.

Photo Guide Development

The guide was developed to assist land managers in estimating fire behavior and effects by quantifying fuel characteristics following treatments in southern pine flatwoods. A University of Florida Fire Science Lab study conducted in the USDA Osceola National Forest (near 30°15'58"N, 82° 29'57'W) in north-central Florida documented fire behavior and effects in four different treatments: unburned for 11+ years, a single implementation of mechanical mowing, burning without prior treatments, and mowing followed by burning. The photographs for this series were collected before and for 1-2 years after fuel treatments were implemented between 2009 and 2013. Sections of the forest, containing replicated treatment plots, were either left untreated, or randomly subjected to one of the fuels reduction treatments. Within these blocks, permanent monitoring plots were established to chronicle vegetation, fuel characteristics, fire behavior, microclimate, and weather data. Photographs were taken at the center of each plot before and at regular time intervals after treatment implementation.

Photograph and Data Arrangement

The Guide is arranged by treatment type. For each treatment, information is presented in three sections:

- The first section describes the fuel treatment methods and the initial forest conditions.
- The second section includes a collage of succession for plots with varying pre-treatment understory composition coupled with average data values.
- The third section displays examples of plots with different densities of saw palmetto cover and associated fuels and vegetation data. For these examples, photographs from each plot are arranged in chronological order on the left-hand page. The facing page contains tables of information with the site description and fuel characteristics.

Using the Photo Series

Forest managers can use the photos and accompanying data to compare with observed conditions in pine flatwoods forests across the Southern Coastal Plain. This data can be used to support management decision-making regarding prescribed fire or fuels treatment implementation, timing, and consequences for potential wildfire activity.

Sampling Description

At each plot location, all trees were measured within a 26.2 ft radius circular plot. Tree diameter at breast height (DBH: measured at 4.5 ft above the ground) and tree height were measured for all trees ≥1 in DBH, and classified by species and by tree status (live or dead) (Figure 1). Shrubs ≥1.6 ft in height were sub-sampled within two 43 ft^2 rectangular belt transects (3.3 × 13.1 ft) located at 13.1 ft north and south of plot center, respectively, each extending to the 26.2 ft plot radius. Height and basal diameter were measured for all shrubs. For individual saw palmetto shrubs (*Serenoa repens*), fronds were tallied for each individual and an average-sized frond was selected for measurement of basal rachis diameter and frond (palm blade and rachis) length. Biomass of shrub woody stems and foliage were estimated, separately, for the dominant shrub species using published allometric equations (Smith and Brand 1983), except for saw palmetto. Saw palmetto biomass was estimated using methods described in Kreye (2012). Percent groundcover (shrubs < 1.6 ft., grass, forb (or herbs), litter, bare ground) was estimated in four 3.3 × 3.3 ft quadrats. Surface fuels (1, 10, 100, 1000 (S: sound, R: rotten) -hour downed woody debris, litter, and duff) were estimated along four 33 ft transects using the planar intersect method (Brown 1971). All plots were measured before*, after, and for 6-24 months after each treatment.

*Mow and Mow & Burn plots were first sampled after mowing treatment and before burning.

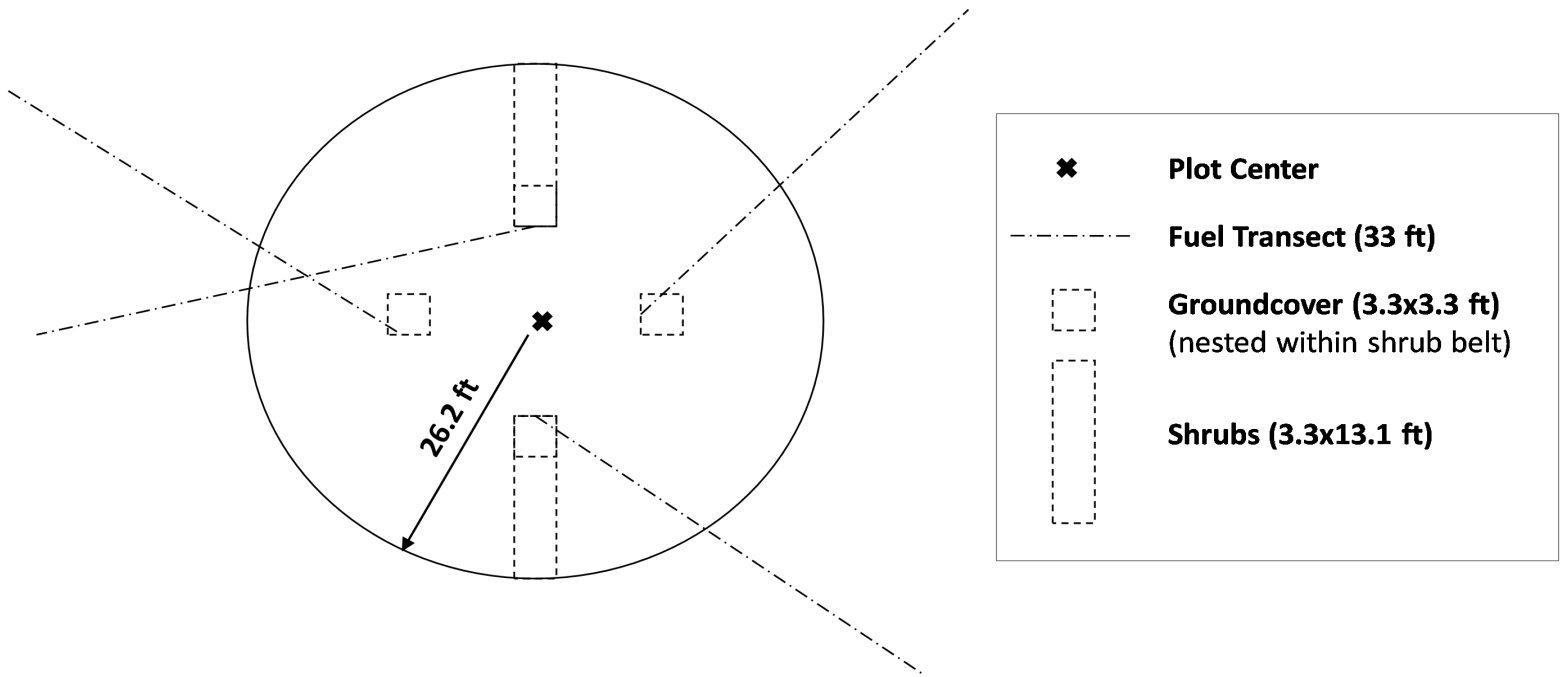
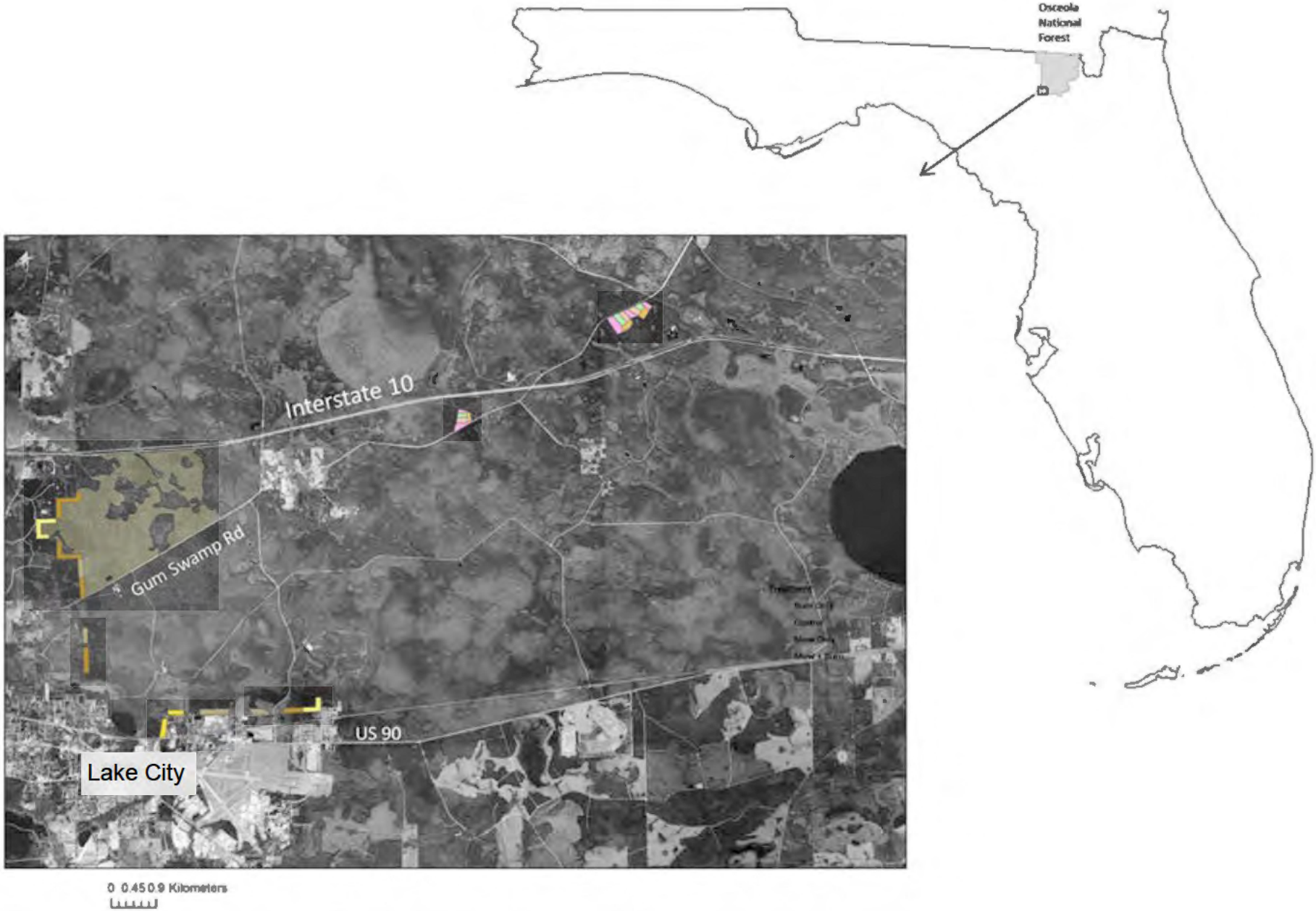


Figure 1. Diagram of vegetation and surface fuels sampling plot.

Study Locations in the Osceola National Forest, Florida



Shrub and Tree Species

SHRUBS		TREES	
Scientific Name	**Common Name**	**Scientific Name**	**Common Name**
Andropogon capillipes	Chalky bluestem	*Acer rubrum*	Red Maple
Aristida sp.	Treeawn	*Albizia julibrissin*	Mimosa/ Silktree
Asimina tetramera	Paw paw	*Cinnamomum camphora*	Camphor
Befaria racemosa	Tar flower	*Gordonia lasianthus*	Loblolly bay
Callicarpa americana	Beauty berry	*Myrica cerifera*	Wax myrtle
Diospyros virginiana	Persimmon	*Pinus elliottii*	Slash pine
Dichanthelium sp.	Rosette grass	*Pinus palustris*	Longleaf pine
Eupatorium capillifolium	Dog fennel	*Prunus serotina*	Black cherry
Gaylussacia dumosa	Dwarf huckleberry	*Rhus copallinum*	Winged sumac
Hamamelis Virginiana	Witch hazel	*Sapium sebiferum*	Chinese tallow
Ilex glabra	Gallberry	*Magnolia virginiana*	Sweet bay
Lyonia ferruginea	Rusty staggerbush		
Lyonia lucida	Fetterbush lyonia		
Melia azedarach	Chinaberry		
Pterocaulon pycnostachyum	Rabbit tobacco / Black root		
Rubus sp.	Black berry		
Serenoa repens	Saw palmetto		
Vaccinium arboreum	Sparkleberry		
Vaccinium corymbosum	High bush blueberry		
Vaccinium myrsinites	Shiny blueberry		
Vaccinium stamineum	Deer berry		

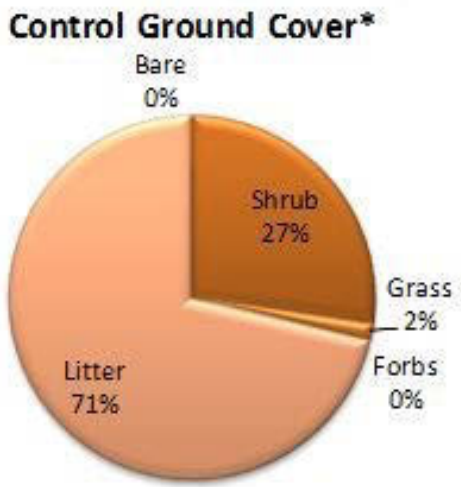

Control

Control

Representing Pre-treatment Conditions for All Treatments

Fuels treatments were conducted across the Osceola National Forest (ONF) in pine flatwoods communities that had gone unburned for more than a decade (exact number of years undocumented), and where fuel accumulations posed a hazard within the wildland-urban interface. Pine flatwoods on the ONF are dominated by slash pine (*Pinus elliottii* var. *elliottii* (Engelm.) and longleaf pine (*Pinus palustris* Mill.) in the overstory, and by saw palmetto (*Serenoa repens* (Bartr.) Small) and gallberry (*Ilex glabra* L. (Gray) shrubs in the understory. In each block assessed in this study, plots were left untreated to serve as experimental controls.

Site Information (n=9)	
Location	Osceola National Forest, Columbia County, Florida
Stand type	Slash pine and Longleaf pine
Stand history	More than 12 years since last burned
Overstory metrics	Tree density (per acre): 178.9
	Average height (ft): 73.9
	Basal area (ft^2/acre): 89.9



* Ground cover includes shrubs < 1.64 ft

Fuel Characteristics (pre-treatment)	Control
1-hour (tons/acre)	0.3
10-hour (tons/acre)	0.6
100-hour (tons/acre)	0.1
1,000-hour S (tons/acre)	0.1
1,000-hour R (tons/acre)	0.2
Duff (tons/acre)	17.8
Duff depth (in)	2.1
Litter (tons/acre)	4.7
Litter depth (in)	3.5
Palmetto cover (%)	**44.6**
Palmetto height (ft)	**3.5**
Total shrub biomass (tons/acre)	1.8


Immediately Post-mow

Mowing Treatment Description

Mechanical mowing (roller chopping) was used to reduce the height of surface understory fuels for the re-introduction of prescribed fire, and to reduce fire hazard in areas near communities, highways, and private pine plantations. Treatments occurred in mature pine flatwoods (ca. 80 yrs old) lacking a mid-story and where the primary fuel strata affected by mowing was understory shrubs, including saw palmetto.

Live understory fuels (shrubs and small trees <8 in diameter) were chopped or cut using boom-mounted or front-end rotating equipment with flailing cutters which sever branches and limbs. This vegetation was not removed from the site, but scattered across the ground, adding foliar-dominated litter to the fuelbed.

Boom-mounted equipment

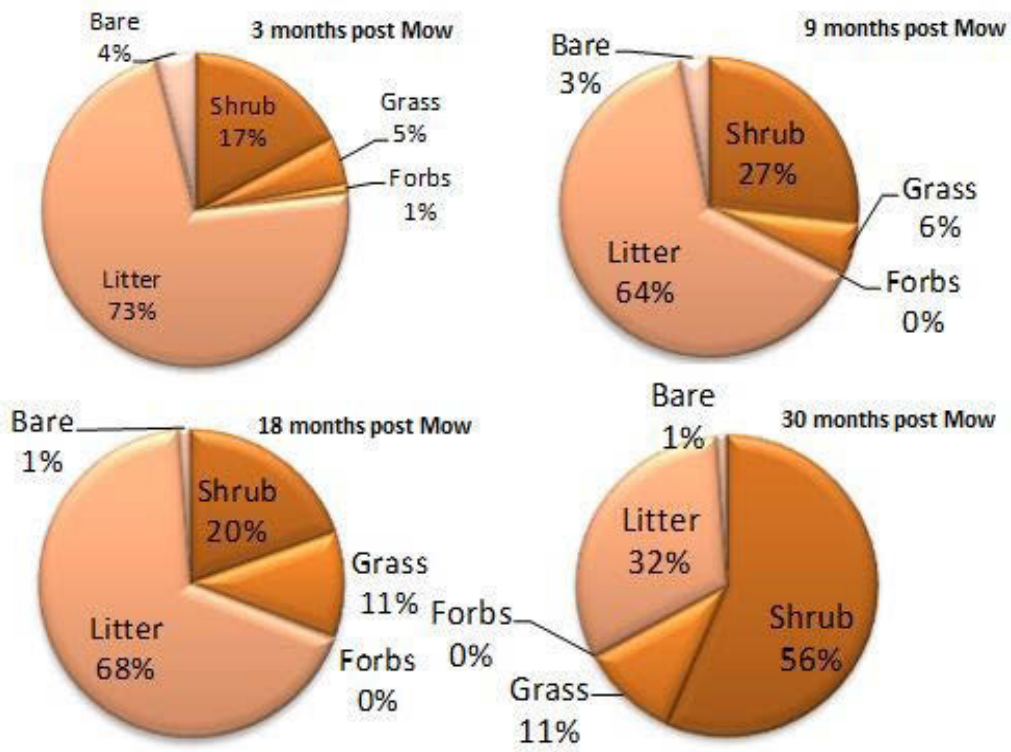
Front-end mowing equipment


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

Average Metrics for Mowing Treatment

Site Information (n=9)	
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): 79.2
	Average height (ft): 74.4
	Basal area (ft^2/acre): 83.7

Percent Ground Cover* of Mowed Sites



*Ground Cover includes shrubs < 1.64 ft

Fuel Characteristics (post Mow)

	3 mos	9 mos	1.5 yr	2.5 yr
1-hour (tons/acre)	0.4	0.1	0.4	0.2
10-hour (tons/acre)	0.9	0.9	1.5	1.4
100-hour (tons/acre)	0.4	0.2	0.6	0.3
1,000-hour S (tons/acre)	0.1	0.5	0.1	0.1
1,000-hour R (tons/acre)	0.0	0.0	0.1	0.4
Duff (tons/acre)	21.8	25.4	21.2	27.2
Duff depth (in)	1.7	1.7	1.4	1.8
Litter (tons/acre)	5.3	5.2	5.7	6.3
Litter Depth (in)	2.1	1.8	1.9	2.1
Palmetto Cover (%)	**10.5**	**11.1**	**21.1**	**25.5**
Palmetto Height (ft)	**2.2**	**2.7**	**2.8**	**2.9**
Total Shrub Biomass (tons/acre)	0.2	0.3	0.8	1.1


2 months post mow


9 months post mow


18 months post mow


30 months post mow

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


2 months post mow
9 months post mow
18 months post mow
30 months post mow

Mow 2: Moderate 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): 40.2 Average height (ft): 70.3

Fuel Characteristics	Post mow	9 mos	1.5 yr	2.5 yr
1-hour (tons/acre)	0.7	0.6	1.0	0.4
10-hour (tons/acre)	0.7	1.1	2.1	2.6
100-hour (tons/acre)	0.5	0.0	0.5	1.1
1,000-hour S (tons/acre)	0.0	1.9	0.5	0.5
1,000-hour R (tons/acre)	0.0	0.0	0.9	1.1
Duff (tons/acre)	19.2	21.7	23.0	31.3
Duff depth (in)	1.5	1.4	1.5	2.1
Litter (tons/acre)	4.5	4.1	5.1	4.3
Litter Depth (in)	1.7	1.4	1.7	1.5
Palmetto Cover (%)	**5**	**10**	**15**	**20**
Palmetto Height (ft)	**2.3**	**2.6**	**2.9**	**3.2**
Total Shrub Biomass (tons/acre)	0.1	0.3	0.9	1.8


2 months post mow
9 months post mow
18 months post mow
30 months post mow

Mow 3: Low 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): 120.7 Average height (ft): 75.9

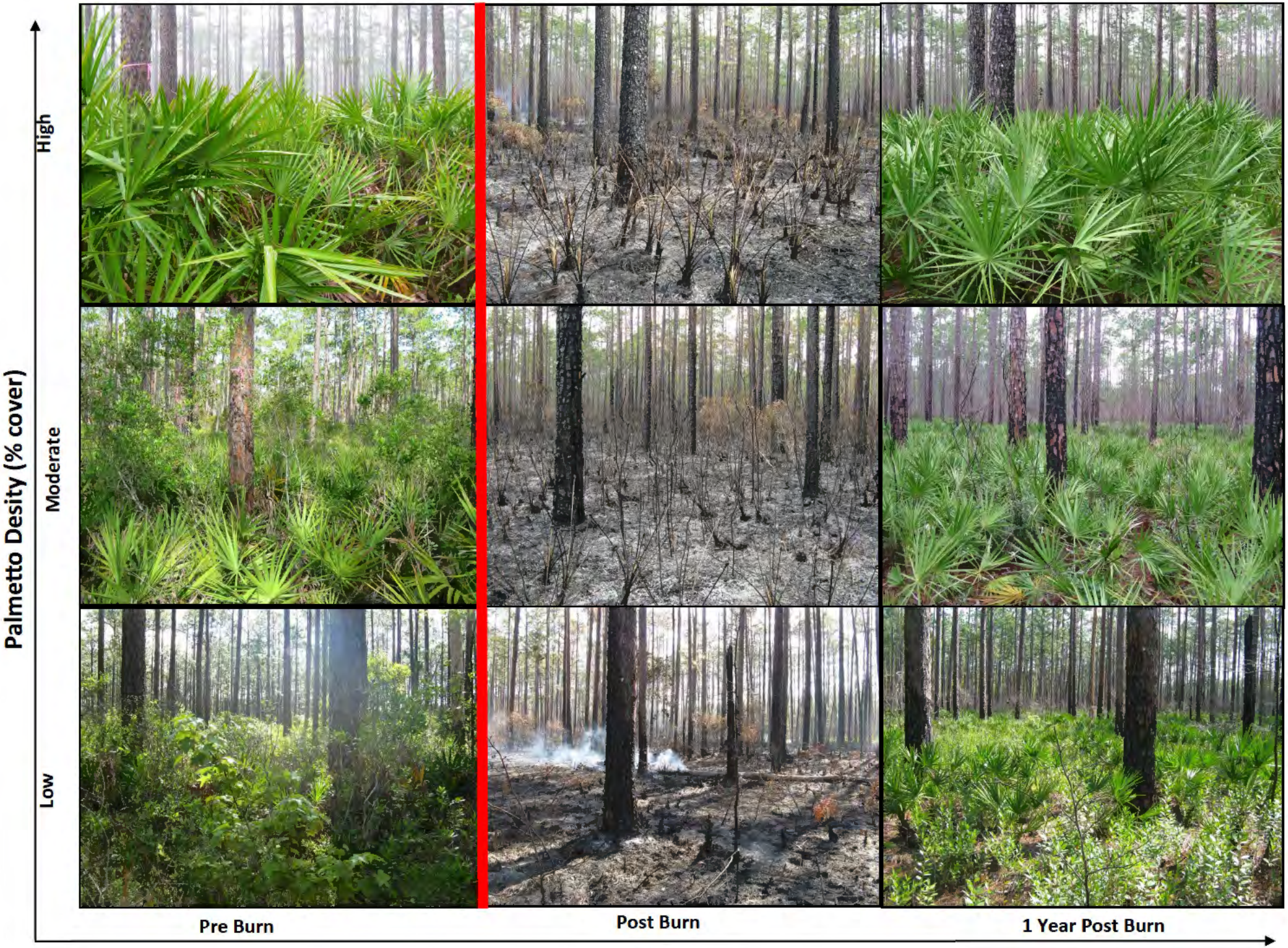
Fuel Characteristics	Post Mow	9 mos	1.5 yr	2.5 yr
1-hour (tons/acre)	0.3	0.2	0.1	0.1
10-hour (tons/acre)	0.8	0.7	0.8	1.8
100-hour (tons/acre)	0.0	0.0	0.0	0.0
1,000-hour S (tons/acre)	0.0	3.1	0.0	0.4
1,000-hour R (tons/acre)	0.0	0.0	0.0	2.0
Duff (tons/acre)	27.2	26.1	19.1	23.1
Duff depth (in)	2.1	1.7	1.2	1.5
Litter (tons/acre)	5.5	5.5	5.1	6.0
Litter Depth (in)	2.1	1.9	1.7	2.1
Palmetto Cover (%)	**5**	**5**	**20**	**70**
Palmetto Height (ft)	**1.9**	**3.2**	**3.2**	**3.9**
Total Shrub Biomass (tons/acre)	0.1	0.0	0.4	0.3


Prescribed Burn

Burning Treatment Description

Burning operations were conducted by the Osceola National Forest fire management staff using strip head firing techniques. Ignitions were lit 50-65 ft upwind of each plot location so that fire would burn through the plots at a steady rate of spread. Observations of fire behavior included ocular assessments of flame height using pre-marked rebar poles, and ocular estimations of rates of spread using timing devices and pre-marked locations (data in table below).

Weather, Fire Behavior, and Fire Effects	
Treatment dates	Burn—23 Feb 2011
Air temperature (°F)	63-75
Relative humidity (%)	47-62
Wind speed (mph)	1-3
Rate of spread (ft/min)	23.2
Flame height (ft)	10.8
Crown scorch (%)	53
Basal circumference charred (%)	97
Max. bole char height (ft)	24.3

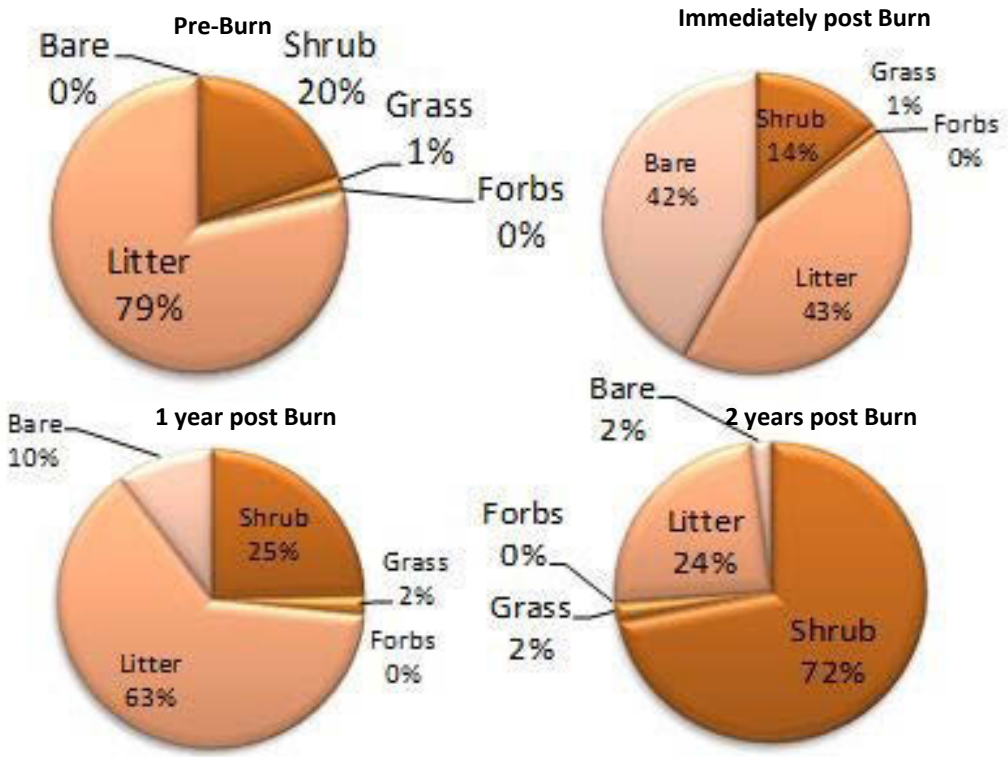

Palmetto Desity (% cover)
High
Moderate
Low
Pre Burn
Post Burn
1 Year Post Burn

Average Metrics for Burn Treatment

Site Information (n= 9)

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
	Tree density (per acre): 145.3
Overstory metrics	Average height (ft): 69.3
	Basal area (ft^2/acre): 72.5

Percent Ground Cover* of Burned Plots



* Ground Cover includes shrubs < 1.64 ft

Fuel Characteristics

	Pre burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.3	0.1	0.1	0.1	0.1
10-hour (tons/acre)	0.8	0.7	0.6	1.1	1.1
100-hour (tons/acre)	0.2	0.1	0.1	0.2	0.2
1,000-hour S (tons/acre)	1.1	2.6	2.6	1.6	0.6
1,000-hour R (tons/acre)	0.0	0.0	0.0	0.6	1.7
Duff (tons/acre)	17.9	13.9	13.9	8.7	10.7
Duff depth (in)	2.1	1.6	1.6	1.1	1.3
Litter (tons/acre)	4.1	0.9	0.9	1.0	1.5
Litter Depth (in)	3.1	0.7	0.7	0.7	1.1
Palmetto Cover (%)	**51.6**	**19.4**	**19.4**	**51.6**	**53.3**
Palmetto Height (ft)	**3.5**	**1.6**	**1.6**	**3.0**	**3.1**
Total Shrub Biomass (tons/acre)	2.0	0.0	0.0	1.6	2.7


Pre burn
Immediately post burn
1 month post burn
1 year post burn

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
	Tree density (per acre): 117.1
Overstory metrics	Average height (ft): 81.3
	Basal area (ft^2/acre): 88.4

Fuel Characteristics	Pre Burn	Post Burn	1 mo	1 yr	2 yr
1-hour (tons/acre)	0.1	0.0	0.0	0.0	0.1
10-hour (tons/acre)	0.1	0.1	0.1	0.2	0.5
100-hour (tons/acre)	0.5	0.0	0.0	0.0	0.0
1,000-hour S (tons/acre)	0.0	5.9	5.9	6.6	0.0
1,000-hour R (tons/acre)	0.0	0.0	0.0	0.0	4.1
Duff (tons/acre)	25.8	18.9	18.9	12.9	21.2
Duff depth (in)	3.1	2.3	2.3	1.5	2.5
Litter (tons/acre)	4.4	1.2	1.2	1.3	4.4
Litter Depth (in)	3.3	0.9	0.9	1.1	1.7
Palmetto Cover (%)	**80**	**20**	**20**	**75**	**80**
Palmetto Height (ft)	**3.2**	**1.9**	**1.9**	**3.9**	**3.9**
Total Shrub Biomass (tons/acre)	1.8	0.0	0.0	2.7	2.5


Pre burn


Immediately post burn


1 month post burn


1 year post burn

Burn 2: Moderate 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
	Tree density (per acre): 140.9
Overstory metrics	Average height (ft): 77.8
	Basal area (ft^2/acre): 75.5

Fuel Characteristics	Pre burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.3	0.0	0.2	0.1	0.0
10-hour (tons/acre)	0.9	2.3	2.1	2.4	2.2
100-hour (tons/acre)	0.0	0.6	0.5	0.0	0.5
1,000-hour S (tons/acre)	0.0	0.0	0.0	0.0	0.0
1,000 hour R (tons/acre)	0.0	0.0	0.0	0.0	0.0
Duff (tons/acre)	11.8	11.8	11.8	7.1	13.9
Duff depth (in)	1.4	1.4	1.4	0.8	1.6
Litter (tons/acre)	3.9	0.6	0.6	0.8	3.9
Litter Depth (in)	3.1	0.5	0.5	0.6	1.2
Palmetto Cover (%)	**35**	**15**	**15**	**70**	**40**
Palmetto Height (ft)	**3.6**	**1.9**	**1.9**	**3.6**	**2.6**
Total Shrub Biomass (tons/acre)	1.0	0.0	0.0	0.8	5.4


Pre burn
Immediately post burn
1 month post burn
1 year post burn

Burn 3: Low 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
	Tree density (per acre): 100.6
Overstory metrics	Average height (ft): 77.3
	Basal area (ft^2/acre): 97.4

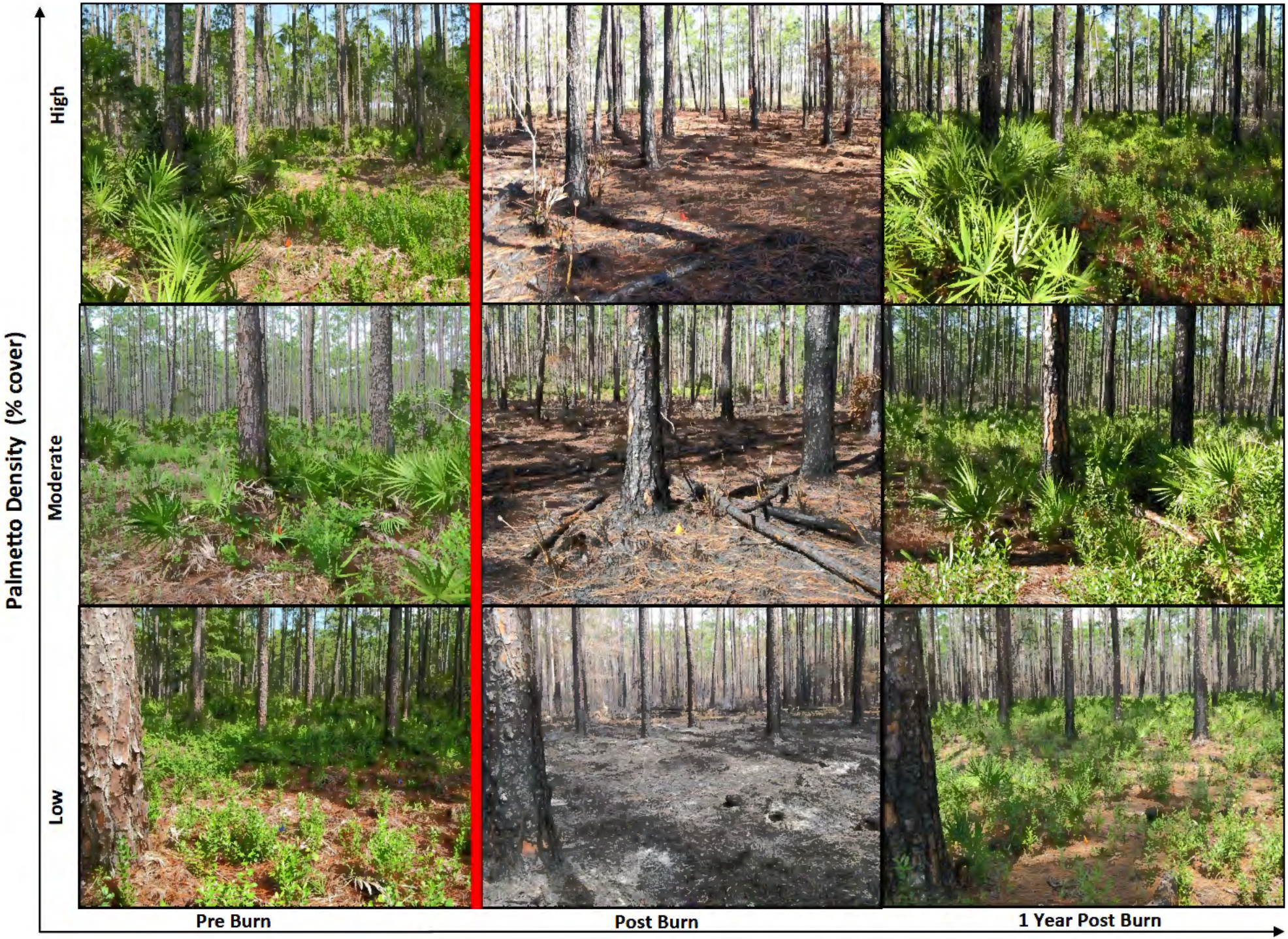
Fuel Characteristics	Pre Burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.1	0.0	0.0	0.0	0.1
10-hour (tons/acre)	0.5	0.2	0.1	0.5	0.6
100-hour (tons/acre)	0.0	0.0	0.0	0.0	0.0
1,000-hour S (tons/acre)	0.0	0.4	0.4	0.0	0.0
1,000 hour R (tons/acre)	0.0	0.0	0.0	0.0	0.0
Duff (tons/acre)	20.6	17.8	17.8	10.3	9.9
Duff depth (in)	2.5	2.1	2.1	1.2	1.2
Litter (tons/acre)	4.1	0.9	0.9	1.4	4.1
Litter Depth (in)	3.1	0.7	0.7	1.1	1.5
Palmetto Cover (%)	**45**	**5**	**5**	**25**	**20**
Palmetto Height (ft)	**3.2**	**0.9**	**0.9**	**2.3**	**0.6**
Total Shrub Biomass (tons/acre)	1.6	0.0	0.0	0.9	1.6


Mow and Burn

Mow and Burn Treatment Description

Several plots were mowed at the same time as the Mow Only treatment plots using the same methods and equipment. Six months later, they were burned at the same time as the Burn Only treatment plots. Burning operations were conducted by the Osceola National Forest fire management staff using strip head firing techniques. Ignitions were lit 50-65 ft upwind of each plot location so that they would burn through the plots at steady rates of spread. Observations of fire behavior included ocular assessments of flame height using pre-marked rebar poles, and ocular estimations of rates of spread using timing devices and pre-marked locations (data in table below).

Weather, Fire Behavior, and Fire Effects	
Treatment Dates	Mow—1 July 2010 Burn—23 Feb 2011
Air temperature (°F)	63-75
Relative humidity (%)	47-62
Wind Speed (mph)	1-3
Rate of spread (ft/min)	11.1
Flame Height (ft)	3.6
Crown Scorch (%)	37
Basal Circumference charred (%)	86
Char Height (ft)	18.0

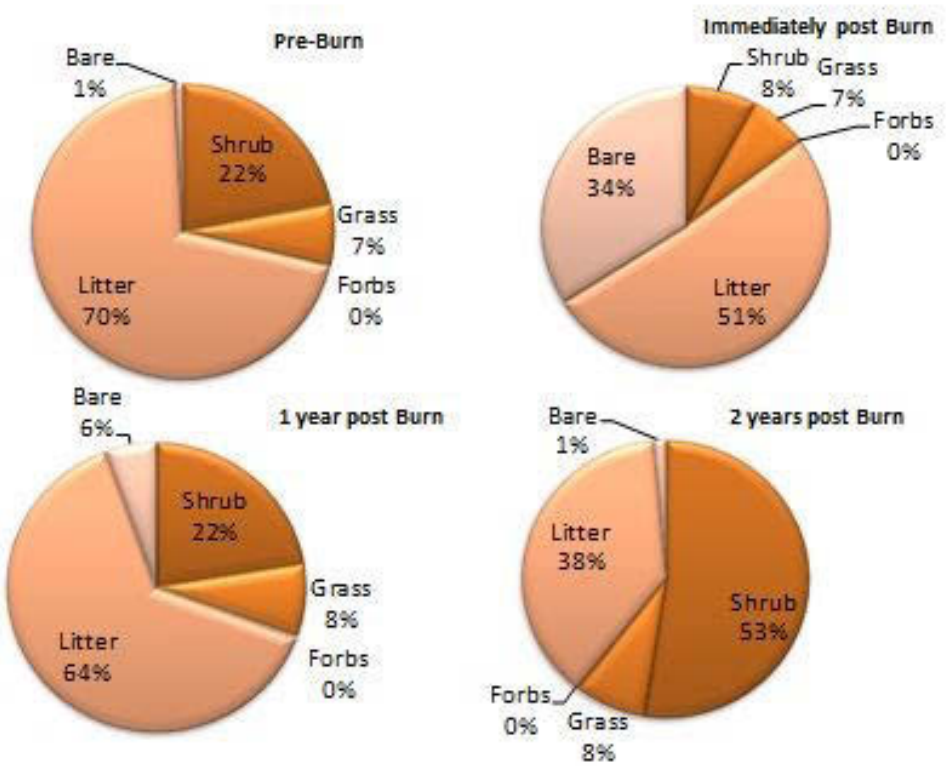

Palmetto Density (% cover)
High
Moderate
Low
Pre Burn
Post Burn
1 Year Post Burn

Average Metrics for Mow and Burn Treatment

Site Information (n = 9)

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
	Tree density (per acre): 136.4
Overstory metrics	Average height (ft): 73.1
	Basal area (ft^2/acre): 97.1

Percent Ground Cover* of Mowed and Burned Plots



* Ground Cover includes shrubs < 1.64 ft

Fuel Characteristics

	Pre-burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.4	0.1	0.1	0.1	0.1
10-hour (tons/acre)	0.9	0.6	0.5	0.7	1.2
100-hour (tons/acre)	0.4	0.1	0.1	0.3	0.4
1,000-hour S (tons/acre)	0.4	0.3	0.3	3.5	3.0
1,000 hour R (tons/acre)	0.0	0.0	0.0	0.1	0.1
Duff (tons/acre)	24.0	21.7	21.7	16.7	20.1
Duff depth (in)	1.9	1.4	1.4	1.1	1.3
Litter (tons/acre)	5.9	0.7	0.7	1.6	1.8
Litter Depth (in)	2.3	0.5	0.5	1.2	1.3
Palmetto Cover (%)	**8.8**	**3.5**	**3.5**	**13.3**	**16.1**
Palmetto Height (ft)	**2.2**	**0.9**	**0.9**	**2.3**	**2.9**
Total Shrub Biomass (tons/acre)	0.2	0.0	0.0	0.4	0.8


Pre Burn


Immediately post burn


1 year post burn


2 years post burn

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


Pre Burn
Immediately post burn
1 year post burn
2 years post burn

Mow and Burn 2: Moderate 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
	Tree density (per acre): 221.4
Overstory Metrics	Average height (ft): 68.9
	Basal area (ft^2/acre): 155.4

Fuel Characteristics

	Pre burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.4	0.0	0.0	0.1	0.1
10-hour (tons/acre)	0.7	0.1	0.1	0.7	0.6
100-hour (tons/acre)	1.7	0.6	0.5	1.2	0.0
1,000-hour S (tons/acre)	0.0	0.0	0.0	0.2	0.0
1,000-hour R (tons/acre)	0.0	0.0	0.0	0.0	0.2
Duff (tons/acre)	21.8	29.2	29.2	19.5	25.0
Duff depth (in)	1.7	1.9	1.9	1.3	1.6
Litter (tons/acre)	4.7	1.1	1.1	2.0	1.7
Litter Depth (in)	1.8	0.8	0.8	1.5	1.3
Palmetto Cover (%)	**5**	**1**	**1**	**15**	**10**
Palmetto Height (ft)	**3.2**	**0.9**	**0.3**	**2.7**	**3.6**
Total Shrub Biomass (tons/acre)	0.2	0.0	0.0	0.4	1.0


Pre Burn


Immediately post burn


1 month post burn


1 year post burn

Mow and Burn 3: Low 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
	Tree density (pervacre): 120.7
Overstory metrics	Average height (ft): 93.4
	Basal area (ft^2/acre): 128.2

Fuel Characteristics	Pre burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.2	0.1	0.1	0.1	0.1
10-hour (tons/acre)	0.9	0.1	0.1	0.6	2.7
100-hour (tons/acre)	0.5	0.0	0.0	0.0	0.0
1,000-hour S (tons/acre)	0.0	1.5	1.5	0.8	0.0
1,000-hour R (tons/acre)	0.0	0.0	0.0	0.0	0.0
Duff (tons/acre)	26.2	22.1	22.1	11.8	21.4
Duff depth (in)	2.1	1.4	1.4	0.7	1..4
Litter (tons/acre)	6.3	0.4	0.4	1.2	1.8
Litter Depth (in)	2.4	0.3	0.3	0.9	1.4
Palmetto Cover (%)	**5**	**5**	**5**	**15**	**20**
Palmetto Height (ft)	**2.6**	**0.9**	**0.9**	**2.7**	**2.6**
Total Shrub Biomass (tons/acre)	0.1	0.0	0.0	0.3	0.8


Pre Burn


Immediately post burn


1 month post burn


1 year post burn

Mow and Burn 4: Grass Understory

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
	Tree density (trees/acre): 81.5
Overstory metrics	Average height (ft): 62.6
	Basal area (ft^2/acre): 60.3

Fuel Characteristics	Pre burn	Post burn	1 mo	1 yr	2 yrs
1-hour (tons/acre)	0.3	0.1	0.1	0.0	0.2
10-hour (tons/acre)	0.6	0.8	0.7	0.7	1.0
100-hour (tons/acre)	0.0	0.0	0.0	0.0	0.0
1,000-hour S (tons/acre)	0.0	0.0	0.0	0.0	1.2
1,000-hour R (tons/acre)	0.0	0.2	0.2	0.2	0.2
Duff (tons/acre)	10.7	11.3	11.3	15.6	19.9
Duff depth (in)	1.1	0.7	0.7	1.1	1.3
Litter (tons/acre)	5.5	0.7	0.7	2.7	2.1
Litter Depth (in)	2.1	0.5	0.5	2.1	1.5
Palmetto Cover (%)	**5**	**1**	**1**	**5**	**15**
Palmetto Height (ft)	**2.6**	**0.9**	**0.9**	**2.3**	**3.2**
Total Shrub Biomass (tons/acre)	0.1	0.0	0.0	0.0	1.1

Additional Research Findings

This Photo Guide was developed as part of the Joint Fire Science Program project, "Characterization of Masticated Fuelbeds and Fuel Treatment Effectiveness in Southeastern US Pine Ecosystems". In addition to characterizing fuels, fire behavior and ecological repercussions were investigated. Some of our major findings for this work are listed below.

⇒ While the shrub fuel stratum is significantly reduced following mowing, expedient regrowth suggests the fire behavior reduction effectiveness is short-lived. **Follow-up prescribed burning within one year of mowing is recommended for fuels control**; but caution should be administered with regards to potential impacts of burning stands with higher litter loads.

⇒ Experimental burning of mowed pine flatwoods fuelbeds showed that the duration of temperatures exceeding 60ºC at the fuelbed surface increases by about 5 minutes for each 10 Mg ha^{-1} increase in fuel load. **High temperatures and long-duration heating at the fuelbed surface could cause basal cambial damage to overstory trees.**

⇒ Species richness of all groundcover plants did not differ among treatments after one year. Vines, herbs, and grasses were rare across treatments, but **there was some evidence of increased grass cover in mowed and mowed and burned sites.**

⇒ The impacts of mowing in longleaf pine flatwoods forests on microclimate were minor, but **treatment influences on fuel moisture indicated that loss of shrub cover may have enhanced drying of surface fuels.** While increased fuel bulk density should provide a mulching effect, drier surface fuels in mowed sites may actually increase ignition probability.

⇒ Surface fuelbeds following mowing in palmetto/gallberry pine flatwoods were dominated by foliar litter, with a lower component of fine woody fuels. This is in contrast to many other post-mowed/masticated sites that have been studied, where fine woody fuels dominate.

⇒ Empirical models developed to predict maximum soil temperatures from fuelbed depth, soil moisture, and soil depth, (ranging from 43 to 318 degrees C predicted), drastically overestimate soil heating in mowed saw palmetto fuelbeds of longleaf pine flatwoods forests. **Soil temperatures did not reach 60ºC even as shallow as 2 cm beneath the soil surface under replicated experimental burns of low, moderate, and high fuel loads.**

⇒ **Soil nutrients were generally unaffected by mowing treatments, combined mowing and burning, or burning alone.** The only differences detected in soil properties or nutrient content was that exchangeable K within 0-5 cm was lower in pre-burn mowed sites compared to controls.

⇒ **Decomposition rates of mowed debris did not differ when located within mowed and control sites.** 74% of litter and 82% of 1h woody fuels remained after one year of decomposition, while 81% of 10h woody fuels remained after 10 months of decomposition.