The influence of prescribed fire and burn interval on fuel loads in four North Carolina forest ecosystems

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Abstract: Prescribed fire is an important management tool in southern US forests, with more acres burned in the South than any other region of the US. Research from prescribed fire studies shows high temporal and spatial variability in available fuel loads due to physiographic, edaphic, meteorological and biological factors. In an effort to account for parts of this variation and contribute to the expanding southern fuels database, we measured forest fuels on sites in North Carolina's Croatan and Uwharrie National Forests prior to and following prescribed burns. Results confirm previous findings that well-executed prescribed fires are an effective tool to reduce litter and live shrub fuel loads, especially on sites with high understory biomass; however, the increase in dead shrub biomass may contribute to future fireline intensity. Prescribed fire on these sites had almost no detectable influence on dead woody fuels. The use of site-specific shrub biomass equations had a significant impact on estimates of understory fuels.

Introduction

The area burned by wildfire in the US is expected to double by the middle of the 21st century primarily due to projections of future climate change and the buildup of forest fuels following the longstanding 20th century policy of wildfire suppression (Vose *et al*. 2012). Prescribed fire is an ecologically sensitive and economically practical method to reduce fuel loads and mitigate the potential for catastrophic wildfires (Saveland 1987). More acres are burned in the south with prescribed fire than any other region of the US, with over 6.4 million acres burned in 2011 (Andreu and Hermansen-Baez 2008; Waldrop and Goodrick 2012). Despite its prevalent use in the south, prescribed fire and fuels research in the southeastern piedmont, central hardwoods and southern Appalachian Mountains has lagged behind western states and the southeastern coastal plain (Waldrop *et al*. 2006). While the southeastern coastal plain has a long history of studying and employing prescribed fire, research has shown high spatial and temporal variability in available fuel loads (Andreu *et al*. 2012). Estimates of understory biomass, a strong driver of fire behavior, are often included in published research; however, equations to calculate biomass based on measured variables are limited to few studies and sites.

Understory composition and density strongly influence fire behavior and post-fire fuel loads in forest ecosystems. Understory woody stem density has been shown to decrease immediately following prescribed fire, but this reduction is short-lived in fire adapted ecosystems where prolific sprouting typically leads to increased abundance, frequency and density within a year or two (Langdon 1981; Waldrop *et al*. 1987; Arthur *et al*. 1998; Phillips and Waldrop 2008). For example, live shrubs such as inkberry (*Ilex glabra* L.) in the coastal plain and mountain laurel (*kalmia latifolia* L.) in the southern Appalachians are highly flammable, yet decreases in coverage following a burn are often followed by prolific sprouting that can result in greater coverage than was present before the fire (Hughes and Knox 1964; Lewis and Harshbarger 1976; Elliott *et al*. 1999). In southeastern pine stands, Sackett (1975) found that gallberry (*Ilex glabra* L.) and saw-palmetto (*Serenoa repens* Bartr.) heights and weights increased steadily for six to twelve years following prescribed fire before tapering off. A chronic fire regime will, however, reduce the abundance and size of sprouts (Lewis and Harshbarger 1976; Langdon 1981; Waldrop *et al*. 1987). Rapid regrowth of understory species following prescribed burning is an important consideration for fuel managers when determining appropriate burn frequencies.

The forest floor, consisting of dead and decaying plant parts, is an important driver of forest fires due to its quick drying time and contribution to fire ignition and spread. Estimates of forest floor consumption vary widely due to forest type, fire intensity, pre-burn loading and timing of burn. It is well understood that fire reduces litter biomass, and annual burns generally result in a greater reduction than periodic burns (Scowcroft 1965; Kodama and Van Lear 1980; McKee 1982; Brockway and Lewis 1997). Scholl and Waldrop (1999) reported litter mass losses of 47 to 80% following prescribed fire in coastal plain pine stands. Little research has been done on the long-term recovery of forest floor litter following prescribed fire. Stambaugh *et al.* (2006) calculated maximum litter recovery rates of 32, 85 and 97%, one, five and ten years, respectively, following prescribed fire in Ozark oak-hickory forests, but these were theoretical estimates. Parresol *et al*. (2006) found that litter-duff loadings can recover in as little as two to three years on upper coastal plain sites, and Loucks *et al*. (2008) found that litter mass following leaf fall was similar to pre-burn estimates in an Appalachian hardwood forest.

Down deadwood (DDW), dead woody material visible above the litter layer, is another important component of forest fuels that influences fire behavior; however, the high variability in published DDW data from fire studies makes only general observations possible at this time. Both Scholl and Waldrop (1999) and Hartman (2004) reported that DDW fuels ≥0.64 cm but <2.54 cm diameter increased following prescribed fire in coastal plain pine and Ozark hardwood forests, respectively. In the Scholl and Waldrop study increases ranged from 7 to 71% across different fire complexes. Other size classes of DDW responded differently in the two studies. Waldrop *et al*. (2004) reported non-significant decreases in DDW <2.54 cm diameter and a non-significant increase in DDW ≥2.54 cm but <7.62 cm diameter in pine dominated piedmont forests following prescribed fire. In one of the few studies that followed changes in DDW after prescribed fire, Loucks *et al*. (2008) found that all size classes of DDW <7.62 cm diameter decreased following prescribed fire, but returned to pre-burn levels following leaf-off.

CWM (DDW ≥7.62 cm in diameter) is less of a concern to southeastern fire managers since these fuels generally don't contribute to fire ignition and spread, and aren't consumed during prescribed fires (Scholl and Waldrop 1999; Goodrick *et al.* 2010). Waldrop *et al*. (2004) reported non-significant decreases and increases in CWM biomass among different slope positions following prescribed fire in pine-dominated southern piedmont forests. In a study of eight fuel complexes in pine plantations of the upper Atlantic Coastal Plain, Scholl and Waldrop (1999) found no change in CWM biomass in seven of the eight complexes, and a decrease of 8% in the other. Loucks *et al*. (2008) reported a trend toward decreasing CWM biomass following prescribed fire in Appalachian hardwood forests. Following dormant season prescribed burns in the longleaf pine flatwoods of Florida, Hanula *et al.* (2012) reported no significant differences in

CWM volume between sites with different burn frequencies, but found that CWM decayed significantly slower on annually burned sites than unburned sites.

To quantify the impact of prescribed fire on fuel loading and contribute to the southern fuels database, we estimated pre and post fire fuel loading in four North Carolina forest ecosystems with different cover types and burn frequencies. Due to staffing limitation, fuel loads were measured in the summer and not immediately prior to and after the prescribed burns. We hypothesized several post-prescribed fire ecosystem changes including; 1) a reduction in litter and duff; 2) biomass changes in FWM (DDW<7.52 cm diameter) would be difficult to detect and variable among classes; 3) CWM biomass would be unchanged; 4) a reduction in live understory biomass would be offset by an increase in dead understory biomass.

Materials and methods

Study area

This research was conducted in North Carolina's Croatan and Uwharrie National Forests. Croatan National Forest (CNF) is located on the coastal plain in Jones County and is composed primarily of loblolly pine (*Pinus taeda* L.) and longleaf pine (*Pinus palustis* Mill.) stands with a pine-hardwood mix found between the managed pine and unmanaged bottomland hardwoods. The US Forest Service began using prescribed fire on the CNF in the early 1960s. Two longleaf pine stands (i.e., CNF-1 and CNF-3), each with different burn cycles, were selected for this study. Both sites were planted with longleaf pine in the 1930s and managed for sawtimber. Dormant season prescribed fire is employed on these sites to reduce fuel loads and improve habitat. Both these mesic sites have minimal slope, are open-canopied and contain a large volunteer loblolly pine component that likely established before the current fire cycles were introduced. Plots were established on each site (CNF-1 n=20 and CNF-3 n=19) to cover the entire management area.

CNF-1 is an annually burned 6 ha stand with an understory dominated by gallberry (*Ilex coriacea* Pursh), fetterbush (*Lyonia lucida* lam.), waxmyrtle (*Myrica cerifera* L.) and year-old hardwood spouts. Fuel load data was measured in June 2004, approximately four months after the previous annual burn (Fig. 1a). The site was burned again on February 19, 2005 and post-burn fuel loads were measured in June 2005 (Fig. 1b). Fuel moistures prior to the 2005 burn were 4-5% for 1-hr fuels, 11% for 10-hr fuels, 16% for 100-hr fuels, and 70% for live woody fuels. Fire intensity was low to moderate.

CNF-3 is a 27 ha stand burned every three years with an understory dominated by *Vaccinium* species, swamp pepperbush (*Clethra alnifolia* L.), giant cane (*Arundinaria gigantean* Walt.), gallberry, waxmyrtle, and hardwood saplings. Fuel load data was measured in June 2004 (Fig. 2a), approximately three years after the previous burn. The site was burned on January 5, 2005, and post-burn fuel loads were measured in June 2005 (Fig. 2b, c and d). Dead fuel moisture prior to the burn ranged from 11 to 15%, and live fuel moisture was 70%. Fire intensity was moderate and coverage was mosaic (J. Cherry, personal communication, August 8, 2013).

Fig. 1. CNF-1 (i.e. Annual burn site) June 2004 (a), approximately four months following prescribed fire, and June 2005 (b), approximately five month following prescribed fire.

a.

b.

c.

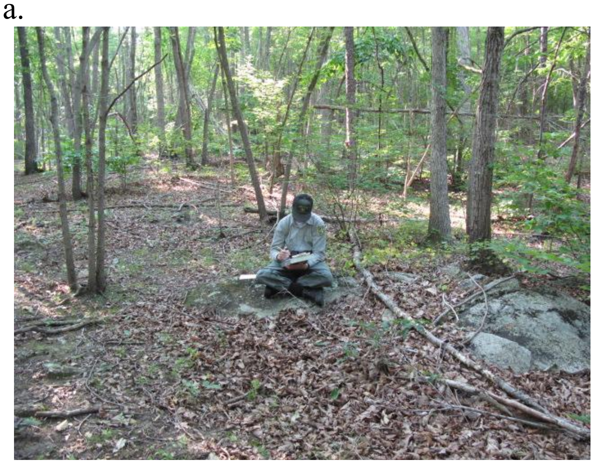
d.

Fig. 2. CNF-3 June 2004 (a), approximately three years following prescribed fire, June 2005 (b), approximately six months following prescribed fire, and one day following prescribed fire (c and d).

Uwharrie National Forest (UNF) is located on the piedmont in Montgomery and Randolph counties. UNF is a highly fragmented forest with numerous privately owned land holdings surrounded by public forestland. This presents unique management challenges, especially when dealing with fire at the wildland-urban interface. The US Forest Service began using prescribed fire on the UNF in the 1980s to reduce fuel loads. Two research sites (i.e., UNF-O and UNF-P) were established in UNF that are representative of typical piedmont forests. Both sites are predominantly mesic with slopes ranging from 0 to 30%. Scattered rock outcroppings are present throughout the sites. Each stand has been treated with prescribed fire on a three to five year cycle to reduce fuel loads. Plots were established on each site (UNF-O n=30 and UNF-P n=30) to cover the entire management area.

UNF-O is a 21 ha oak-hickory stand that grew naturally following clearing in 1916. The sparse understory is composed primarily of hardwood saplings with ferns and giant cane growing in the bottomlands. Fuel load data was measured in July 2004 and the site was burned on March 10, 2005 (Fig.3). Pre-burn fuel moistures were 7-8% for 1-hr fuels and 11-12% for 10-hr fuels. Fire intensity was low to medium, with average flame lengths between 2 and 3 ft and less than 25% crown scorch (Fig 4). Post-burn fuel loads were measured in July 2005.

a.



b.

Fig. 3. UNF-O July 2004 (a) and July 2005 (b), approximately four months following prescribed fire.

UNF-P is a 77 ha loblolly pine stand planted in 1964. While classified as a loblolly pine stand, the overstory is codominant with hardwoods that make up approximately 34% of the total stand basal area calculated from trees $\geq$12.7 cm dbh. The understory is dominated by hardwood saplings, *Vaccinium* species and *Vitis* species. Fuel load data was measured in July 2004 and the site was burned on April 6, 2005 (Fig. 5). Only the southern half of the stand was burned due to rain, resulting in a final sample size of 15 plots. Pre-burn fuel moisture was 5-6% for 1-hr fuels and 9% for 10-hr fuels. Flame length averaged 3-4 ft with spotting up to 6 ft. Most of the area had 25% crown scorch with some pockets larger than 50% (K. Cagle, personal communication, August 10, 2013). Post-burn fuel loads were measured in July 2005.

a. b.

Fig. 4. UNF-O site. Litter was completely consumed in some areas while only partially consumed in others (a and b).

a. b.

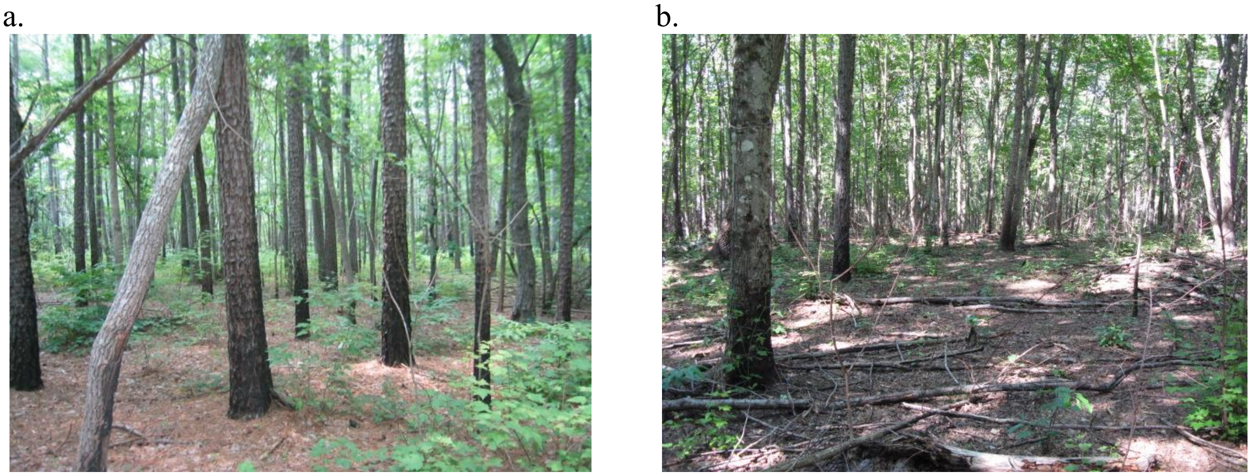


Fig. 5. UNF-P July 2004 (a) and July 2005 (b), approximately three months following prescribed fire.

Methods

Field plots were established to measure fuel loading on each site and included fuelbed height, coarse woody material (CWM), fine woody material (FWM), litter, duff, and understory biomass. Protocols for measuring fuel loading followed those used by the USDA Forest Inventory and Analysis Program to measure down woody debris and fuels (FIA 2004). Under this protocol, plots consisted of four 7.3 m radius subplots with three subplots located 35.6 m and 0, 150 and 270 degrees from the center subplot. Three transects were established in each subplot to measure CWM and FWM. CWM was measured when it intersected a transect and FWM was tallied along the transects in each subplot. Litter and duff depth and fuelbed height were measured at the end of each transect, and a 2.1 m radius microplot was established in each subplot to estimate live and dead shrub and herbaceous biomass. Research plots at CNF-3 and UNF-P consisted of four subplots, but only CWM was measured outside of the central subplot at UNF-P because it was determined through field testing that an acceptable estimate of FWM and microplot data could be calculated from the central subplot when measuring FWM on all three transects (Gavazzi *et al. 'in press'*). A single plot design, without subplots, was employed at CNF-1 and UNF-O to avoid overlapping subplots in these narrow stands.

FWM and CWM biomass were calculated based on line intercept theory whereby values can be summed across transects to estimate per-unit area biomass (Van Wagner 1968; de Vries 1973; Brown 1974). FWM was classified as 1-, 10- and 100-hour fuels equating to less than 0.6 cm, 0.6 to 2.5 cm, and 2.5 to 7.6 cm in diameter at the line intersect, respectively, and tallied by size class when a piece intersected one of the transects. 1- and 10-hour fuels were measured along a 1.8 m length of each transect, and 100-hour fuels were measured along a 3.1 m length of each transect. FWM diameter was measured along one random transect in each plot to determine the mean size class diameter. FWM biomass (Eq. 1) was calculated in tons ac^{-1} as;

$$\mathbf{FWM} = \sum_{i=1}^{n} \frac{u\,\mathrm{dia}_i^2\,\rho\,d\,a\,c}{L} \qquad (1)$$

where n is the total number of pieces of FWM tallied per size class, u is the units conversion factor (11.64); dia is the mean diameter for each class of FWM (in); ρ is the average green specific gravity of species know to exist in each forest type; d is a decay class reduction factor that accounts for biomass loss through decay (assumed to be 0.9 across all samples); a is the correction factor for orientation (assumed to be 1.13); c is a slope correction factor = $\sqrt{1 + (\mathrm{slope}\,\% / 100)^2}$; and L is the transect length (ft). Slope and orientation correction factors from Brown (1974).

CWM was measured when a piece intersected any point along one of the transects. Species, decay class, length, and small and large end diameters were recorded for each piece of CWM. Decay class was categorized on a one to five scale as defined in the FIA protocols, where a decay class of 1 was assigned to recently dead pieces and decay class 5 was assigned to highly decayed pieces. CWM (Eq. 2) was calculated in tons $acre^{-1}$ as:

$$\mathbf{CWM} = \sum_{i=1}^{n} \frac{u\,(\mathrm{d}_s^2 + \mathrm{d}_l^2)\,\rho\,d\,c}{L} \qquad (2)$$

where *n* is the total pieces of CWM sampled along each transect; *u* is the units conversion factor (5.8); d_s and d_l are the small and large end diameters (in) of each piece of CWM measured, respectively; ρ is the green specific gravity of each piece of CWM measured; *d* is a decay class reduction factor for conifers (class 1=1.0, class 2=0.84, class 3=0.71, class 4=0.45, class 5=0.35) and hardwoods (class 1=1.0, class 2=0.78, class 3=0.45, class 4=0.42, class 5=0.35) (Waddell 2002); *c* and *L* are the same as for FWM above.

Litter depth was measured at the end of each transect furthest from plot center and included undecomposed forest floor in the A_e soil horizon. Duff (defined as partially decomposed litter between the A_e horizon and mineral soil surface) was measured separately. Litter and duff depth were also combined into forest floor depth because differentiating between the two classes can be difficult followed prescribed fire. Litter and duff bulk density were estimated by collecting 0.04 m^2 samples from ten random plots in each site prior to prescribed burning. Samples were brought back to the lab, dried at 65°C for two weeks, or until there was no change in mass, and weighed. Litter and duff biomass were calculated by multiplying mean depth measurements from each plot by the mean bulk density estimates for each site. Litter biomass was multiplied by percent litter cover, estimated in each microplot, to better estimate site-level biomass.

Site-specific parameters included litter and duff bulk density, green wood specific gravity (table 1) and mean FWM size class diameter (table 2). Green wood specific gravity values were taken from Markwardt and Wilson (1935) and Jenkins *et al*. (2003). If a piece of CWM was not identifiable to species, it was classified as either hardwood or softwood and assigned a specific gravity value based on the average for species found on the site.

Table 1. Site-specific litter and duff bulk density and green wood specific gravity

Site	Litter bulk density (lb ft^{-3})	Duff bulk density (lb ft^{-3})	FWM specific gravity	CWM specific gravity	
				hardwoods	Softwoods
CNF-1	1.7	4.3	0.53	0.54	0.53
CNF-3	1.4	3.5	0.53	0.54	0.53
UNF-O	0.9	4.6	0.56	0.53	0.47
UNF-P	2.2	3.6	0.50	0.53	0.47

CNF-Croatan National Forest 1- and 3-year burn cycle; *UNF*-Uwharrie National Forest oak (O) and pine (P) sites

Table 2. Pre- and post-burn site-specific fine woody material size class diameter

Site	Treatment	FWM diameter (in)		
		1-hour fuel	10-hour fuel	100-hour fuel
CNF-1	Pre-burn	0.14	0.47	1.68

	Post-burn	0.13	0.51	1.40
CNF-3	Pre-burn	0.13	0.46	1.67
	Post-burn	0.13	0.49	1.47
UNF-O	Pre-burn	0.14	0.44	1.77
	Post-burn	0.14	0.46	1.66
UNF-P	Pre-burn	0.15	0.48	1.55
	Post-burn	0.15	0.46	1.59

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites

Live and dead understory biomass of woody and herbaceous stems less than 2.54 cm diameter were calculated from measurements of height and ocular estimates of percent cover in each microplot. Site-specific biomass equations were developed for the CNF sites by destructively harvesting samples from seven 1 m^2 plots on each site after recording height and percent cover. Only seven plots were established due to time constraints; however, an effort was made to position plots across a wide range of cover percents. Samples were separated into woody and herbaceous components, dried at 65°C for two weeks, or until there was no change in mass, and weighed. Regression equations based on height and/or percent cover were developed using the stepwise modeling function in JMP (Version 9.0) (SAS Institute, Cary, NC). Independent variables with single (e.g., height or percent cover) or paired (e.g., height times percent cover) probability less than 0.05 were included in the regression equations. Prolific sprouting of shrubs and herbs after fire is a typical response in fire adapted ecosystems such as these so site-specific equations with height and percent cover as independent variables were selected for comparison of means to better capture changes in biomass following the prescribed fires.

Live and dead understory shrub and herbaceous biomass at the UNF sites were calculated using equations developed by Brown and Marsden (1976) and Gilliam and Turrill (1993), respectively, since site specific equations were not developed or found in the literature. These shrub equations were also compared to those developed on the CNF sites to assess the difference between using site- and non site-specific equations when estimating understory fuels.

Biomass estimates were calculated using SAS statistical software (Version 9.2) (SAS Institute, Cary, NC). Analysis of means was tested using the Tukey HSD function in JMP to test for statistical differences between pre- and post-burn fuel loads. Results are reported in inches, ft, and t ac^{-1} since these are the standard units used by fire managers to estimate fuel loads.

Results

Croatan National Forest shrub and herbaceous biomass equation comparison

Live shrub biomass equations using only percent cover as the independent variable had higher R^2 and lower P values than equations that used both height and percent cover as independent variables (table 3). There wasn't a significant relationship between the independent variables and dead shrub biomass at CNF-3 and dead herbaceous biomass at CNF-1 so data were combined from both sites to develop best fit equations. Dead shrub and live herbaceous biomass at CNF-1 and live and dead herbaceous biomass at CNF-3 were best modeled with height and percent cover as independent variables.

Table 3. Best fit models for CNF shrub and herbaceous biomass

Site	Fuel Load	*A*	b	*P*	R^2	n
CNF-1	Live Shrub[1]	84.20	0.51	0.043	0.59	7
	Live Shrub[2]	-9.44	3.57	0.002	0.89	7
	Dead Shrub[1]	25.96	1.46	0.019	0.70	7
	Live Herb[1]	-3.78	0.84	0.010	0.84	6
	Dead Herb[1*]	-2.17	1.13	<0.001	0.99	6
CNF-3	Live Shrub[1]	-133.86	0.96	0.033	0.61	7
	Live Shrub[2]	-108.04	7.62	<0.001	0.95	7
	Dead Shrub[1*]	8.76	1.81	<0.001	0.80	10
	Live Herb[1]	-11.31	0.67	0.008	0.93	5
	Dead Herb[1]	-11.90	1.25	0.027	1.00	3

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites
[1]Equation form: biomass (t ac^{-1}) = *a* + (% cover x height (ft) x *b*)
[2]Equation form: biomass (t ac^{-1}) = *a* + (% cover x *b*)
*Site parameters not significant at $P<0.05$ so data combined from both sites

Shrub and herbaceous biomass estimates were influenced by the equations used. Brown and Marsden (1976) equations, using only percent cover as the independent variable, resulted in the highest estimates of live shrub biomass at both sites (table 4). While estimates were not significantly different between the site-specific equations at CNF-1 ($P\geq0.25$), the site-specific equation at CNF-3 using percent cover as the independent variable was significantly larger pre- and post-burn by 0.7 and 0.9 t ac^{-1} ($P<0.01$), respectively, than the equation using percent cover and height. Biomass estimates from the live shrub site-specific equations using only percent cover as the independent variable were significantly smaller ($P<0.01$) than the non-site-specific equation at all sites and treatments except for CNF-3 following the burn ($P=0.52$). There was no significant difference between the two site-specific equations at CNF-1 ($P\geq0.25$). Mean biomass estimates from the two dead shrub equations were significantly different both pre- and post-burn at CNF-3 but not CNF-1 ($P<0.01$ and ≥0.07). The dead shrub biomass estimate from the site-specific equation at CNF-3 was 0.3 t ac^{-1} smaller than the non site-specific equation before the prescribed burn, but 1.0 t ac^{-1} larger after it ($P<0.01$).

Table 4. Live and dead shrub biomass estimates before and after prescribed fire using site- and non site-specific equations

Site	Treatment	Biomass (t ac^{-1})				
		Live shrub[1]	Live shrub[2]	Live shrub[3]	Dead shrub[1]	Dead shrub[3]
CNF-1	Pre-burn	0.7 (0.1)^{AB}	0.4 (0.1)^{B}	0.9 (0.2)^{A}	1.1 (0.2)^{A}	0.7 (0.1)^{A}
	Post-burn	0.8 (0.1)^{AB}	0.6 (0.1)^{B}	1.1 (0.2)^{A}	0.8 (0.2)^{A}	0.5 (0.0)^{A}
CNF-3	Pre-burn	1.6 (0.1)^{A}	2.3 (0.1)^{B}	2.9 (0.1)^{C}	0.2 (0.0)^{A}	0.5 (0.0)^{B}
	Post-burn	0.4 (0.1)^{B}	1.3 (0.1)^{A}	1.5 (0.2)^{A}	1.7 (0.2)^{A}	0.7 (0.1)^{B}
UNF-O	Pre-burn			0.8 (0.1)		0.3 (0.0)
	Post-burn			0.7 (0.1)		0.4 (0.0)
UNF-P	Pre-burn			1.6 (0.3)		0.3 (0.0)
	Post-burn			1.3 (0.2)		0.4 (0.0)

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites
Numbers in parentheses are the standard error of the mean
[1]Equation form: biomass (t ac^{-1}) = a + (% cover x height (ft) x b)
[2]Equation form: biomass (t ac^{-1}) = a + (% cover x b)
[3]Equation from Brown and Marsden (1976)
[ABC]Within site, biomass component and treatment means with the same letter not significantly different, $P<0.05$

Live herbaceous biomass estimates from the two equations were significantly different at CNF-1, but only significantly different at CNF-3 before the burn (table 5). Pre- and post-burn live herbaceous biomass estimates at CNF-1 were 0.4 t ac^{-1} larger using the site-specific equation

Table 5. Live and dead herbaceous biomass estimates before and after prescribed fire using site- and non site-specific equations

Site	Treatment	Biomass (t ac^{-1})			
		Live herb[1]	Live herb[2]	Dead herb[1]	Dead herb[2]
CNF-1	Pre-burn	0.78 (0.10)^{A}	0.40 (0.03)^{B}	0.03 (0.01)^{A}	0.04 (0.01)^{A}
	Post-burn	0.79 (0.08)^{A}	0.40 (0.03)^{B}	0.01 (0.01)^{A}	0.02 (0.01)^{A}
CNF-3	Pre-burn	0.31 (0.03)^{A}	0.21 (0.02)^{B}	0.13 (0.03)^{A}	0.06 (0.01)^{A}
	Post-burn	0.33 (0.03)^{A}	0.27 (0.02)^{A}	0.05 (0.02)^{A}	0.01 (0.01)^{B}
UNF-O	Pre-burn		0.07 (0.03)		0.01 (0.01)
	Post-burn		0.11 (0.03)		0.01 (0.01)
UNF-P	Pre-burn		0.05 (0.04)		0.00 (0.00)
	Post-burn		0.05 (0.03)		0.01 (0.01)

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites

Numbers in parentheses are the standard error of the mean
[1]Equation form: biomass (t ac^{-1}) = *a* + (% cover x height (ft) x *b*)
[2]Equation from Gilliam and Turrill (1993)
[AB]Within site, biomass component and treatment means with the same letter not significantly different, *P*<0.05

compared to the non site-specific equation (*P*<0.01). There was no significant difference between the two equations at CNF-3 post-burn (*P*=0.11), and pre-burn biomass using the site-specific equation was only 0.1 t ac^{-1} larger compared to the non site-specific equation (*P*<0.01). Dead herbaceous biomass was ≤0.1 t ac^{-1} across all sites, treatments and equations. While there was a significant difference between the two equations at CNF-3 post-burn (*P*<0.05), biomass from the site-specific equation was <0.1 t ac^{-1} (*P*<0.05) larger compared to the non site-specific equation.

Croatan National Forest fuel loads

Litter coverage was the only fuel estimate significantly impacted by prescribed fire at the annually burned site (i.e., CNF-1) with a decrease of 28% (*P*<0.01, table 6). Mean 100-hour fuel and dead shrub biomass decreased 0.4 and 0.3 t ac^{-1} (P≥0.23, tables 7 and 8), respectively, and 10-hour fuel biomass increased 0.1 t ac^{-1}(*P*=0.36). Litter biomass decreased 0.4 t ac^{-1} (*P*=0.11), and duff biomass increased 0.5 t ac^{-1} (P=0.50) after the burn. Combining litter and duff resulted in no change in forest floor biomass or depth following prescribed fire (P≥0.93). Live shrub cover increased 10% (*P*=0.19) while height decreased 0.5 ft (*P*=0.56) resulting in a nearly undetectable 0.1 t ac^{-1} increase in biomass (*P*=0.75, table 8). Dead shrub cover and height decreased 5% and 0.1 ft (*P*≥0.29), respectively, resulting in a decrease of 0.3 t ac^{-1} (*P*=0.27, table 8). Mean live herbaceous cover, height and biomass were relatively unchanged as a result of prescribed fire, and a 0.4 ft and 2% decrease (*P*=0.21 and 0.09) in dead herbaceous height and cover, respectively, only reduced biomass <0.1 t ac^{-1} (*P*=0.18, tables 9). Mean CWM biomass increased 1.4 t ac^{-1} (*P*=0.33), and mean live and dead fuelbed height decreased 0.2 and 0.4 ft, respectively, following the prescribed burn (*P*≥0.35, table 7).

Table 6. Litter depth, percent cover, and biomass, and duff and forest floor depth and biomass before and after prescribed fire

Site	Treatment	Litter depth	Litter cover	Litter biomass	Duff depth	Duff biomass	Forest Floor depth[1]	Forest floor biomass[1]
		(in)	(%)	(t ac^{-1})	(in)	(t ac^{-1})	(ft)	(t ac^{-1})
CNF-1	Pre-burn	0.5 (0.1)	79 (4)[a]	1.2 (0.3)	0.3 (0.1)	2.1 (0.4)	0.7 (0.1)	3.3 (0.6)
	Post-burn	0.4 (0.1)	51 (5)[a]	0.8 (0.2)	0.3 (0.1)	2.6 (0.5)	0.7 (0.1)	3.3 (0.6)

CNF-3	Pre-burn	2.0 (0.1)[a]	99 (0)[a]	5.2 (0.3)[a]	0.8 (0.1)[a]	5.1 (0.4)[a]	2.8 (0.1)[a]	10.2 (0.6)[a]
	Post-burn	0.6 (0.0)[a]	75 (3)[a]	1.1 (0.1)[a]	0.5 (0.0)[a]	3.4 (0.2)[a]	1.1 (0.1)[a]	4.5 (0.3)[a]
UNF-O	Pre-burn	1.4 (0.1)[a]	92 (1)[a]	2.0 (0.1)[a]	0.6 (0.0)[a]	5.2 (0.3)[a]	2.0 (0.1)[a]	7.2 (0.4)[a]
	Post-burn	0.4 (0.0)[a]	44 (5)[a]	0.3 (0.1)[a]	0.4 (0.0)[a]	3.2 (0.3)[a]	0.7 (0.1)[a]	3.4 (0.3)[a]
UNF-P	Pre-burn	1.3 (0.1)[a]	96 (1)[a]	5.2 (0.5)[a]	0.6 (0.1)[a]	3.8 (0.7)[a]	1.9 (0.2)[a]	8.9 (1.0)[a]
	Post-burn	0.6 (0.1)[a]	77 (4)[a]	1.8 (0.3)[a]	0.3 (0.0)[a]	2.2 (0.3)[a]	0.9 (0.1)[a]	4.0 (0.5)[a]

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites
Numbers in parentheses are the standard error of the mean
[a]Within site and fuel class treatment means significantly different, *P*<0.05
[1]Sums may differ from reported means due to rounding

There were significant biomass changes at the site that was burned every three years (i.e., CNF-3). Only dead shrub biomass was significantly larger after the burn with an increase of 1.5 t ac^{-1} (*P*<0.01, table 8). Litter cover and depth were both significantly smaller following the burn with decreases of 24% and 1.4 in, respectively (*P*<0.01, table 6). This resulted in a significant

Table 7. Fine and coarse woody material biomass, and live and dead fuelbed height before and after prescribed fire

Site	Treatment	Fine woody material			Coarse woody material	Live fuelbed height	Dead fuelbed height
		1-hour fuel	10-hour fuel	100-hour fuel			
		(t ac^{-1})	(t ac^{-1})	(t ac^{-1})	(t ac^{-1})	(ft)	(ft)
CNF-1	Pre-burn	0.07 (0.02)	0.6 (0.1)	1.1 (0.3)	2.2 (0.9)	2.4 (0.2)	2.0 (0.4)
	Post-burn	0.07 (0.01)	0.7 (0.1)	0.7 (0.2)	3.6 (1.3)	2.2 (0.1)	1.6 (0.3)
CNF-3	Pre-burn	0.11 (0.01)[a]	0.5 (0.1)	0.6 (0.1)	1.6 (0.4)	2.9 (0.1)[a]	1.4 (0.1)[a]
	Post-burn	0.09 (0.01)[a]	0.6 (0.0)	0.6 (0.1)	1.5 (0.4)	2.0 (0.1)[a]	2.2 (0.2)[a]
UNF-O	Pre-burn	0.16 (0.01)[a]	0.7 (0.1)[a]	2.2 (0.3)	4.9 (1.2)	1.0 (0.2)	0.5 (0.1)
	Post-	0.25	1.0 (0.1)[a]	2.0 (0.2)	5.3	0.8 (0.2)	0.8

	burn	(0.02)[a]			(1.3)		(0.2)
UNF-P	Pre-burn	0.11 (0.01)	0.7 (0.1)	2.3 (0.3)	2.6 (0.9)	1.0 (0.2)	0.5 (0.1)[a]
	Post-burn	0.11 (0.01)	0.6 (0.1)	2.6 (0.4)	3.5 (0.5)	0.7 (0.1)	0.1 (0.0) [a]

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites
Numbers in parentheses are the standard error of the mean
[a]Within site and fuel class treatment means significantly different, *P*<0.05

Table 8. Live and dead shrub height, percent cover and biomass before and after prescribed fire

Site	Treatment	Live shrub ht	Live shrub coverage	Live shrub biomass	Dead shrub ht	Dead shrub coverage	Dead shrub biomass
		(ft)	(%)	($t\ ac^{-1}$)	(ft)	(%)	($t\ ac^{-1}$)
CNF-1	Pre-burn	4.4 (0.6)	30 (5)	0.7 (0.1)	5.2 (0.4)	23 (5)	1.1 (0.2)
	Post-burn	3.9 (0.5)	40 (5)	0.8 (0.1)	5.1 (0.6)	18 (3)	0.8 (0.1)
CNF-3	Pre-burn	6.4 (0.4)[a]	80 (2)[a]	1.6 (0.1)[a]	3.0 (0.3)[a]	6 (1)[a]	0.2 (0.0)[a]
	Post-burn	4.1 (0.4)[a]	52 (4)[a]	0.4 (0.1)[a]	6.4 (0.4)[a]	29 (2)[a]	1.7 (0.2)[a]
UNF-O	Pre-burn	5.3 (0.9)[a]	27 (4)	0.8 (0.1)	2.7 (0.5)[a]	5 (1)	0.3 (0.0)
	Post-burn	2.7 (0.5)[a]	27 (4)	0.7 (0.1)	4.6 (0.8)[a]	9 (2)	0.4 (0.0)
UNF-P	Pre-burn	5.7 (1.0)	52 (7)	1.6 (0.3)	3.9 (1.1)	6 (1)[a]	0.3 (0.0)
	Post-burn	4.9 (1.0)	45 (6)	1.3 (0.2)	5.2 (1.3)	11 (2)[a]	0.4 (0.0)

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites
Numbers in parentheses are the standard error of the mean
[a]Within site and fuel class treatment means significantly different, *P*<0.05

decrease in litter biomass of 4.1 $t\ ac^{-1}$ (*P*<0.01). Duff biomass was reduced 1.7 $t\ ac^{-1}$ due to a 0.3 in decrease in depth (*P*<0.01, table 6). 1-hour fuel biomass increased less than 0.1 $t\ ac^{-1}$ (*P*=0.09), 10-hour fuel biomass increased 0.1 $t\ ac^{-1}$ (*P*=0.18), and 100-hour fuel biomass was unchanged following the burn (table 7). The increase in dead shrub biomass was due to a 23% increase in percent cover and a 3.4 ft increase in height (*P*<0.01, table 8). Live shrub biomass decreased 1.2 $t\ ac^{-1}$ as both height and cover decreased 2.3 ft and 28%, respectively (*P*<0.01, table 8). There was very little change in live and dead herbaceous biomass (table 9). Live herbaceous cover increased 9% (*P*=0.02), but height decreased by 0.4 ft (*P*<0.01) resulting in a 0.02 t ac^{-1} decrease in biomass (*P*=0.72). Both dead herbaceous cover and height significantly decreased 8% and 1.7 ft (*P*<0.01), respectively, resulting in a 0.04 t ac^{-1} reduction in biomass (*P*<0.05). The live fuelbed significantly decreased 0.9 ft and the dead fuelbed significantly increased 0.8 ft (*P*<0.01, table 7). CWM biomass was not significantly different after the controlled burn (*P*=0.90, table 7).

Table 9. Live and dead herbaceous height, percent cover and biomass before and after prescribed fire

Site	Treatment	Live herb ht	Live herb coverage	Live herb biomass	Dead herb ht	Dead herb coverage	Dead herb biomass
		(ft)	(%)	(t ac^{-1})	(ft)	(%)	(t ac^{-1})
CNF-1	Pre-burn	3.1 (0.2)	66 (6)	0.78 (0.10)	1.0 (0.2)	4 (1)	0.03 (0.01)
	Post-burn	3.2 (0.2)	65 (5)	0.79 (0.08)	0.6 (0.2)	2 (1)	0.01 (0.01)
CNF-3	Pre-burn	3.1 (0.1)[a]	37 (3)[a]	0.31 (0.03)	2.8 (0.2)[a]	11 (2)[a]	0.13 (0.03)[a]
	Post-burn	2.7 (0.1)[a]	46 (3)[a]	0.33 (0.03)	1.1 (0.3)[a]	3 (1)[a]	0.05 (0.02)[a]
UNF-O	Pre-burn	1.2 (0.4)	12 (4)	0.07 (0.03	0.5 (0.2)	2 (1)	0.01 (0.01)
	Post-burn	1.0 (0.2)	17 (5)	0.11 (0.03)	0.3 (0.2)	2 (2)	0.01 (0.01)
UNF-P	Pre-burn	0.5 (0.2)	8 (6)	0.05 (0.04)	0.2 (0.1)	1 (1)	0.00 (0.00)
	Post-burn	0.5 (0.2)	8 (5)	0.05 (0.03)	0.1 (0.1)	1 (1)	0.01 (0.01)

CNF-Croatan National Forest 1- and 3-year burn cycle, *UNF*-Uwharrie National Forest oak (O) and pine (P) sites
Numbers in parentheses are the standard error of the mean
[a]Within site and fuel class treatment means significantly different, *P*<0.05

Uwharrie National Forest fuel loads

Duff and litter fuel loads were significantly reduced and 1- and 10-hour fuel biomass were significantly increased after prescribed fire on the UNF-O site (tables 6 and 7). Duff depth decreased 0.2 in resulting in a 2.0 t ac^{-1} decrease in duff biomass (*P*<0.01). Litter depth and percent cover decreased 1 in and 48%, respectively, resulting in a 1.7 t ac^{-1} decrease in litter biomass (*P*<0.01). 1- and 10-hour fuel biomass increased 0.1 t ac^{-1} and 0.3 t ac^{-1} (*P*<0.01), respectively, but 100-hour fuel was not significantly different after the burn (*P*=0.53). Live and dead shrub height were the only understory components to be significantly impacted by prescribed fire at UNF-O with decreases of 2.6 ft and 1.9 ft, respectively ($P \leq 0.01$, table 8). Live shrub percent cover was unchanged and mean biomass was 0.1 t ac^{-1} smaller after the burn (*P*=0.74). Dead shrub percent cover increased 4% (*P*=0.05), resulting in a 0.1 t ac^{-1} increase in mean biomass (*P*=0.43). Live and dead herbaceous biomass were relatively unchanged by fire (table 9). Live herbaceous height decreased 0.2 ft, and percent cover increased 5% ($P \geq 0.48$), resulting in a 0.04 t ac^{-1} decrease in biomass (*P*=0.38). Dead herbaceous height decreased 0.2 ft (*P*=0.64) and percent cover and biomass were unchanged. Live fuelbed height decreased 0.2 ft, and dead fuelbed height increased 0.3 ft as a result of prescribed fire ($P \geq 0.21$, table 7). There was no significant change in CWM, but mean biomass increased 0.4 t ac^{-1} (*P*=0.83, table 7).

Duff, litter and dead shrub cover were the only fuels impacted by prescribed fire at UNF-P (tables 6 and 9). Duff depth decreased 0.3 in (*P*=0.02), resulting in a 1.6 t ac^{-1} decrease (*P*=0.03) in duff biomass. Litter depth and percent cover decreased 0.7 in and 19%, respectively, resulting in a 3.4 t ac^{-1} decrease in litter biomass (*P*<0.01). 100-hour fuel biomass increased 0.3 t ac-$^{-1}$ and 10-hr fuel biomass decreased 0.1 t ac^{-1} ($P \geq 0.37$, table 7). Mean live shrub height decreased 0.8 ft and cover decreased 7% resulting in a 0.3 t ac^{-1} decrease in biomass ($P \geq 0.39$, table 8). Dead shrub height increased 1.3 ft and cover increased 5% resulting in a 0.1 t ac^{-1} increase in dead shrub biomass ($P \geq 0.30$, table 8). Live and dead herbaceous biomass were unchanged by prescribed fire, with almost no detectable change in height or percent cover (table 9). Dead herbaceous biomass decreased less than 0.1 t ac^{-1} (P=0.52). Both live and dead fuelbed heights decreased 0.3 ft (*P*=0.09) and 0.4 ft (*P*<0.01), respectively, but only the change in dead fuelbed height was significant (table 7). Mean CWM biomass increased 0.9 t ac^{-1} following prescribed fire (*P*=0.43, table 7).

Forest floor consumption following prescribed fire

Litter and duff (i.e., forest floor) fuel loadings were reduced by prescribed fire on all sites except for the annually burned site (i.e., CNF-1) where there was no change. CNF-3 had the highest reduction in forest floor fuel load following prescribed fire (5.7 t ac^{-1}), and was also the site with the highest pre-burn forest floor biomass. There was a strong relationship across sites between pre-burn forest floor biomass and the loss of forest floor due to prescribed fire (R^2= 0.99, *P*<0.01, Fig. 6). Approximately 53% of the forest floor was consumed by prescribed fire on all sites except for CNF-1.

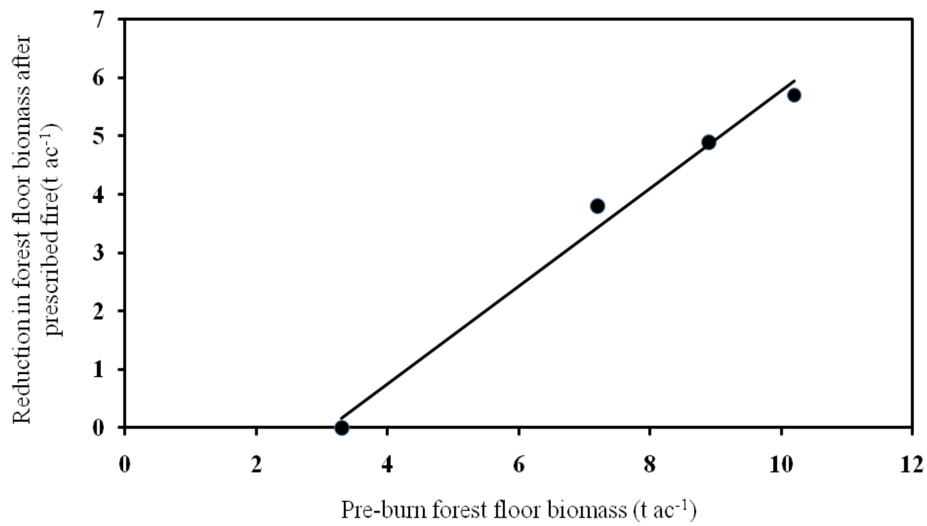


Fig. 6. Change in forest floor biomass following prescribed burning at four research sites in North Carolina's piedmont and coastal plain. (R^2=0.99, P<0.01)

Discussion

Litter and duff biomass were significantly reduced by over 50% and 33%, respectively, on all sites except for the annually burned site at CNF (i.e., CNF-1). This is consistent with findings in the literature, and the expected result that prescribed fire reduces forest floor fuels (Scowcroft 1965; Kodama and Van Lear 1980; Waldrop *et al*. 2004). The use of pre-burn site-specific bulk density values may have resulted in an over- or under-estimation of post-burn litter and duff estimates. Our assumption that weight loss decreases in proportion to volume may be incorrect, but no data was found in the literature to confirm this either way. Sampling post-burn litter and duff may have provided a more accurate estimate of post-burn bulk density. Ottmar and Andreau (2007) estimated litter and duff bulk density across southeastern US forests and found high variability within and between forest types. Our estimates compare favorably with theirs, and the significant reduction in litter depth and cover in this study indicates that our post-burn biomass estimates are reasonable. The strong relationship across sites between pre-burn forest floor biomass and the amount of forest floor consumed by prescribed fire is an interesting finding, although more data points are necessary to test the robustness of this trend.

That forest floor was not impacted by prescribed fire at CNF-1 is not surprising. Although nothing was found in the literature comparing pre- and post-burn fuel loads on annually burned sites, this burn frequency results in the maintenance of low fuel levels. Fuel loads would not be expected to increase significantly in this open canopied ecosystem under an annually burned management regime. Litter coverage was reduced 28%, but litter depth was only reduced 0.1 in from an already low 0.5 in. Waldrop *et al*. (1987) compared southeastern coastal plain loblolly pine sites and found that forest floor biomass was lowest on annually burned sites compared to sites with longer burn intervals. Duff depth increased less than 0.1 in, but this resulted in a 0.5 t ac^{-1} increase in biomass. The increase in duff biomass is likely due to the difficulties encountered when categorizing blackened litter and duff following prescribed fire. Charred litter as well as inputs from burned foliage and woody material can easily be mistaken for unrecognizable litter and misclassified as duff. When litter and duff were combined into forest floor depth and biomass, there was no change in fuel loading. Given that one year of litter fall had occurred between the pre- and post-burn estimates it is likely that most, if not all, of the new litter accumulation was consumed by the burn.

The lack of significant change in FWM, and both live and dead understory fuel loads at CNF-1 suggests that the site either did not burn adequately or that new fuel inputs were equal to those consumed by the fire. The decrease in mean litter, dead shrub and total FWM biomass, and live and dead fuelbed heights, as well as visual observations following the burn, indicate that the site did burn adequately, and that inputs have not kept up with consumed fuels. Since fuel loads were measured in early June, one could expect the live understory biomass to continue increasing, and mean fuel loads to approach pre-burn levels following leaf fall.

Changes in FWM biomass were variable across the sites, and differences that were significant were less than 0.3 t ac^{-1}. This is consistent with other studies across the southeastern US. Scholl and Waldrop (1999) found that 10-hour fuels tended to increase while 1- and 100-hour fuels tended to decrease across different fuel complexes in southeastern coastal plain loblolly pine sites. However, differences were small and the authors did not report levels of significance. Loucks *et al*. (2008) reported non-significant decreases in 1- and 100-hour fuels and a significant decrease in 10-hour fuel immediately following prescribed fire in Appalachian hardwood sites, but differences were small and not significant post-leaf fall the following year. This study found a significant increase in 10-hour fuel at UNF-O, but the increase was only 0.3 t ac^{-1}. Waldrop *et al*. (2004) reported no significant changes in woody fuels following prescribed fire across different landscape ecosystem classification units in southeastern piedmont pine sites.

There were no significant changes in CWM biomass following prescribed fire on our sites, but mean CWM values increased at CNF-1 and both UNF sites. The non-significant increase in CWM following the prescribed fire at CNF-1 can be explained by four large dead stems that fell into the plots and became new CWM following the pre-burn measurements. The increase in CWM biomass at the UNF sites is mostly due to the exposure of pieces that were buried under the forest floor before the burn. These pieces were covered by litter along the measurement transect and, by protocol not counted in the pre-burn inventory. This uncovering of previously buried pieces of CWM also occurred at CNF-3, but the intensity of this fire was such that CWM pieces were observed burning the day after the prescribed fire (Fig. 7). Any additions of new or previously buried pieces of CWM on this site were likely offset by the burning of CWM that resulted in less measureable biomass, either through smaller diameters or shorter lengths. Scholl and Waldrop (1999), Waldrop *et al*. (2004) and Loucks *et al*. (2008) all reported no significant changes in CWM biomass following prescribed fire. These results are not surprising as prescribed fire in the south isn't expected to consume CWM biomass except under very high fire intensity, fuel load and drought conditions.

Fig. 7. CWM still burning one day after prescribed fire was completed on CNF-3.

Prescribed fire had the biggest impact on fuel loads at CNF-3 with more significant differences and the largest reduction in fuel loading compared to the other sites. It was also the only site with significant changes in live and dead fuelbed heights and live and dead shrub biomass. Reductions in live fuelbed height and live shrub biomass were more than offset by increases in dead fuelbed height and dead shrub biomass, with a net decrease of 0.1 ft and a net increase of 0.3 t ac^{-1}, respectively. While the 5.7 t ac^{-1} reduction in forest floor biomass will reduce the wildfire risk in this stand, the significant increase in dead fuelbed and dead shrub biomass may result in a higher than expected post-burn risk; especially if the forest floor recovers quickly, as has been reported in other forest types by Loucks *et al*. (2008) and Parresol *et al*. (2006).

Live and dead understory biomass was not impacted by prescribed fire on CNF-1 and the UNF sites. While there was a significant decrease in live shrub height and a significant increase in dead shrub height at UNF-O, there was no detectable change in biomass for either fuel load. This result at UNF-O is the result of using only percent cover in the biomass equations used, and stresses the importance of including height in shrub biomass equations. Shrub cover has been shown to sprout prolifically following prescribed fire (Lewis and Harshbarger 1976; Arthur *et al* 1998; Waldrop *et al.* 1987). Although live shrub cover was unchanged after prescribed fire at UNF-O, the reduction in height was not included in the regression equation and likely resulted in an overestimation of live shrub biomass.

Including height in site-specific equations had a significant impact on shrub biomass at CNF-3, a site with a dense shrub understory. The non site-specific equation significantly over-estimated both pre- and post-burn live shrub biomass, but more importantly, significantly underestimated post-burn dead biomass by 59%. This difference would result in fuel managers underestimating the biomass of this quickly ignitable fuel by 1.0 t ac^{-1} and could confound efforts to predict fire behavior and intensity. Live herbaceous biomass estimates using site-specific equations were twice as high as estimates from non site-specific equations at CNF-1, but differences were only 0.4 t ac^{-1}. This difference, as well as the low overall biomass of herbaceous shrubs, may not be of concern to fuel managers when planning prescribed fires. Live and dead herbaceous biomass at the UNF sites was less than 0.1 t ac^{-1} due to the nearly closed canopy conditions in the overstory.

This research confirms previous findings that prescribed fire can significantly reduce fuel loads in southeastern US forests. Our hypothesis that forest floor fuels (i.e., litter and duff) would be reduced by prescribed fire was correct for all sites except the annually burned site. It appears that the low intensity annual burns are keeping fuel loads at a steady state, whereby new inputs are being consumed before they can accumulate. There was no consistent trend in the response of FWM to prescribed burning. Few changes were significant, and those that were significant only changed by 0.3 t ac^{-1}. CWM was not impacted by prescribed fire at any of the sites, except that pieces of CWM buried by litter and not measured pre-burn were exposed and included in the post-burn inventory. The increase in dead shrub biomass that was hypothesized to offset reductions in live shrub biomass was not as pronounced as expected, except on the site with the largest pre-burn live shrub biomass. In this case, increased dead shrub biomass more than offset the decrease in live shrub biomass following prescribed fire. This research, while conducted on a limited geographic scale, contributes to our understanding of the impact that prescribed fire has on fuel loads in the southeastern US, and provides valuable site-specific data to the southern fire dataset.

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