Forest Ecology and Management 313 (2014) 340–354

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Immediate and short-term response of understory fuels following mechanical mastication in a pine flatwoods site of Florida, USA

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ARTICLE INFO

Article history:
Received 15 July 2013
Received in revised form 15 October 2013
Accepted 21 October 2013
Available online 21 November 2013

Keywords:
Fire management
Forest management
Fuel models
Fuels treatments

ABSTRACT

Mechanical fuel hazard reduction treatments are widely implemented in fire-prone ecosystems, but research evaluating their effects on fuel dynamics has focused only on woody-dominated post-treatment fuels. In the southeastern US, one of the most fire-prone regions of the world, mechanical fuels reduction is being increasingly used, yet the resulting fuelbeds have yet to be fully characterized for their fire risk. In order to broaden our understanding of the longevity and effectiveness of these treatments, mechanical mastication ("mowing") was examined in a common pine ecosystem of the southeastern US Coastal Plain, where the post-mastication fuel environment was dominated by non-woody fuels. Fuel dynamics differed between recently burned mature stands, mature stands that had not burned for several years, and younger pine plantations. Foliar litter dominated (46–69%) the 17.1–23.1 Mg ha^{-1} of post-mastication surface fuels across these ecosystems, where pre-treatment understories were dominated by palmetto and gallberry shrubs. Although surface fuels compacted over time, the shrub layer recovered quickly, contributing to the result that stand-alone mechanical treatments did not reduce overall fuel loads. Increases in surface fuels followed by rapid shrub recovery may indicate short-term treatment efficacy, with narrow windows of opportunity for post-treatment fuel reduction burns. The fuelbed characteristics and fuel dynamics observed in these treated sites broaden our understanding of mechanical fuels reduction treatments in general, and provide the critical data for fuel model development.

1. Introduction

Altering fuel structure in forest and shrub ecosystems has become a common method aimed at mitigating fire hazard in long-unburned ecosystems. Mechanical mastication (mowing, shredding, chipping, etc.) of the understory rearranges shrubs and small trees into compact surface fuels (Hood and Wu, 2006; Kane et al., 2009; Kobziar et al., 2009) with the intent to reduce subsequent fire behavior. Mastication machinery typically consist of a mastication head, with either rotating blades or a rotating cylinder with fixed or flailing cutters, attached to tracked or rubber-tired ground equipment. The use of such equipment to alter forest fuel structure has become widespread across the USA, with treatments often occurring at large scales.

Recent research describing post-mastication fuel environments has been primarily conducted in the western USA in woody-dominated surface fuels (Hood and Wu, 2006; Kane et al., 2009; Kobziar et al., 2009; Battaglia et al., 2010). Pine flatwoods of the southeastern USA, with understories dominated by saw palmetto (*Serenoa repens* (Bartr.) Small) and gallberry (*Ilex glabra* L. (Gray)) shrubs, are unusual shrub ecosystems considering their foliar-dominated fuel characteristics (McNab and Edwards, 1978). Saw palmetto is a shrub palm that grows from horizontal stems with fronds reaching approximately 2 m tall. Historically, fires were frequent (ca. <5 yrs) in pine flatwoods (Abrahamson and Hartnett, 1991) and understory shrubs typically recover quickly following disturbance (Brose and Wade, 2002). Ample ignition sources (both lightning and anthropogenic) in the southeastern USA contribute to continued high fire frequency fire across the region, compelling managers to use prescribed fire, mechanical treatments, or combinations thereof to mitigate wildfire hazard (Brose and Wade, 2002; Watts and Tanner, 2006). With rapid shrub recovery and palmetto dominant in the understory, mechanical mastication in this fuel complex will likely result in unique post-treatment fuelbeds that may deserve special attention for evaluation of effectiveness in reducing wildfire hazard. Rapid understory recovery also provides an opportunity to evaluate expedited fuel dynamics following fuels

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0378-1127/$ - see front matter
http://dx.doi.org/10.1016/j.foreco.2013.10.034

treatments. In other regions, thoroughly evaluating post-mastication consequences to fuelbeds and wildfire potential may require years to decades, rather than months. Characterizing post-mastication fuelbeds over time in this fuel complex will broaden our understanding of post-treatment fuelbed dynamics, support fuel model development, and provide a range of fuelbed characteristics not likely to occur following mastication in other ecosystems.

Mastication, regionally termed "mowing" and used here throughout, of palmetto/gallberry understories in pine flatwoods is being conducted in large scale applications in northern Florida, USA to reduce fire hazard during post-treatment prescribed burning. Mowing is also being used across the state as a stand-alone treatment where burning is difficult in the wildland–urban interface (WUI), but where altering fuel structure is intended to reduce potential wildfire behavior or enhance suppression efforts (Menges and Gordon, 2010). Treatments are being conducted in mature forests of various ages of "rough", or years since last fire, as well as in pine plantations where understory shrub strata have developed. While many shrub species in this ecosystem, including saw palmetto, sprout or grow new fronds following aboveground damage, the effectiveness of mowing treatments is highly sensitive to time-since-treatment. Increased and continuous surface litter, coupled with a recovered shrub surface fuel load, may result in fuelbeds more conducive to wildfire ignition and spread than untreated stands. In addition, fuel dynamics may differ depending upon the type of stands where treatments are being employed. It is therefore important to evaluate these mowed fuelbeds so that thresholds of fire hazard mitigation effectiveness can be determined. Managers concerned with promoting timber resources can use this information to plan mowing treatments which optimize wildfire risk reduction and minimize the number of entries and total cost.

Evaluating fuel dynamics following mastication treatments will not only provide insight into the post-treatment fire environment, but may serve to provide information useful for other applications. Quantifying biomass change over time can inform our understanding of potential biomass utilization for energy, or how mowing might influence carbon sequestration potential. Post-mowing residues may be left on site or consumed in follow-up prescribed burning treatments. When left on site, extraction for biomass utilization may be feasible. The economic tradeoffs of mowed biomass utilization is dependent on greater understanding of how the biomass changes over time-since-treatment. Also, where mowed residues are left on site, carbon storage potential can be evaluated if we understand the dynamics of surface fuels created from the initial treatment, along with the growth response of shrubs and trees following treatment.

To examine fuel dynamics as a result of mechanically treating understory fuels where rapid vegetation recovery is expected, we evaluated changes to fuel structure and biomass in a pine flatwoods forest in the Osceola National Forest of north-central Florida, The objectives of this *in situ* study were to (1) characterize surface fuels immediately following the mowing of palmetto/gallberry dominated pine flatwoods and (2) quantify changes in fuel/vegetation biomass for up to two years following treatment in three common flatwoods stand types: mature pine, mature/recently burned pine, and pine plantations. Although this study was conducted in one location, we discuss the implications of mowing treatments for fire hazard reduction, as well as biomass utilization or carbon sequestration, in regard to the evidence observed in the sites studied here. Evaluating immediate and longer term changes to fuels in response to mechanical treatments will provide insight into the efficacy of treatment as well as their potential impacts on other ecosystem functions.

2. Methods

2.1. Study site

Fuel characteristics were measured in mechanically treated sites in the Osceola National Forest (Osceola) in north-central (northern peninsular) Florida, USA. The Osceola encompasses 81,000 ha in parts of Columbia, Baker, Bradford, and Hamilton counties. The terrain is generally flat with underlying marine deposited sandy soils. Climate is characterized by hot humid summers, averaging 27–28 °C, with mild winters (12–16 °C) and most precipitation occurring during summer months from thunderstorms (Chen and Gerber, 1990). Dominant vegetation communities in the Osceola include mesic and hydric pine flatwoods and interspersed lesser amounts of cypress–hardwood swamps (Myers and Ewel, 1990).

Mechanical fuels treatments in the Osceola were conducted primarily in pine flatwoods communities that have gone unburned for at least 11 years (Malone et al., 2011), and where fuel accumulations pose a hazard within the wildland urban interface (WUI). Pine flatwoods in this region are dominated by slash pine (*Pinus elliottii* var. *elliottii* (Engelm.)) and/or longleaf pine (*Pinus palustris* Mill.) with an understory comprised primarily of saw palmetto and gallberry. Because these systems recover to preburn fire hazard levels in less than five years (Davis and Cooper, 1963; Brose and Wade, 2002), management goals are to burn pinelands on an average three-year rotation, although many pine flatwoods areas have not burned in over 5+ years. Challenges to management in the Osceola include very large burn units, extensive WUI including a major interstate highway (I-10) transecting the Forest, wilderness areas isolated by wetlands, and a history of fire exclusion or excessively long fire return intervals in many locations. Thus, mechanical mowing treatments are being used to create firebreaks, reduce the height of understory fuels for re-introduction of prescribed fire, and to reduce fire hazard in areas abutting communities, highways, or large private pine plantations.

For this study, fuels were sampled within two extensive mowing treatments in the southwestern portion of the Osceola. One, a large contiguous area (500 ha) adjacent to Interstate 10 is referred to here as the 'areal' treatment site, and the other, a 100 m wide, 6 km long "buffer" treatment site (60 ha) is adjacent to privately owned pine plantations. Mowing treatments were conducted, in both sites, using a rubber-tired skidder and a tracked vehicle (Gyro-Trac Corp., unknown model), both with front-mounted cylindrical masticating heads. Treatment prescriptions included mowing all shrubs and small-diameter trees (<20 cm) and the resulting debris to be left on site. Each treatment occurred within pine flatwoods ecosystems; however, the areal site was in mature pine (ca. 80 yrs old) flatwoods, while the buffer treatment occurred across three different pine flatwoods stand types: mature (ca. 80 yrs old), mature/burned (ca. 80 yrs old, burned 5 yrs prior to mowing), and a younger pine plantation (27 yrs old). Evaluation of treatment effects on fuelbeds over time was conducted in each of these locations and stand types to increase the scope of the study.

2.2. Areal treatment site

To characterize fuelbed properties following mowing in pine flatwoods, fuels and vegetation were sampled from 16 plot locations within the 500 ha areal site (Fig. 1). Plots were allocated using a systematic grid randomly located onto an aerial map of the treatment zone. A grid format was used such that the distance between all grid line intersections was 400 m. Relative plot locations were