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Fire behavior in masticated fuels: A review

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ABSTRACT

Mastication is an increasingly common fuels treatment that redistributes "ladder" fuels to the forest floor to reduce vertical fuel continuity, crown fire potential, and fireline intensity, but fuel models do not exist for predicting fire behavior in these fuel types. Recent fires burning in masticated fuels have behaved in unexpected and contradictory ways, likely because the shredded, compact fuel created when trees and shrubs are masticated contains irregularly shaped pieces in mixtures quite different from other woody fuels. We review fuels characteristics and fire behavior in masticated fuels across the United States. With insights from the few laboratory and field burning experiments conducted, we highlight the variation likely to occur across different ecosystems in which these treatments are being widely implemented. Masticated debris has a propensity to flame and smolder for long durations. Fuel variability and vegetation response will likely influence whether or not treatments reduce long-term fire hazard. We identify key science needs that will better elucidate fire behavior and effects in these treatments. With mastication widely applied in an expanding wildland–urban interface it is crucial to understand how such fuels burn. What we learn about combustion in these fuels will inform effective fuels management in these and other mixed fuels.

1. Introduction

Managing landscapes dependent on fire as an ecological process, while also mitigating the negative impacts of wildfire to people and property is challenging. In many fire-prone forest and shrubland ecosystems, vegetation structure and composition have changed, often increasing the threat of catastrophic wildfires (Agee and Skinner, 2005). Changing climate exacerbates vegetation change (Chapin et al., 2004; Linder et al., 2010; Chmura et al., 2011), potentially leading to increases in severity, frequency, intensity, and size of fires (Westerling et al., 2006; Goetz et al., 2007; IPCC, 2007; Lannom et al., in press). To protect people and property within the expanding wildland–urban interface (Stewart et al., 2007) from wildfire, fuel treatments are widely used to reduce crown fire hazard and extreme fire behavior (Agee and Skinner, 2005; McIver et al., 2008).

Mastication is an increasingly common fuel treatment primarily used in forest or shrub ecosystems. Understory trees and shrubs are "mulched", "chipped", "shredded", or "mowed" creating irregularly shaped fuel particles that effectively relocates vertical "ladder" fuels onto the ground to reduce fire hazard and improve resilience to future fires (Fig. 1a) (Kane et al., 2009; Vitorelo et al., 2009). Mastication can be used as a stand-alone treatment (Battaglia et al., 2010; Reiner et al., 2009), but may also be applied following understory thinning (Kane et al., 2009; Stephens and Moghaddas, 2005), or prior to prescribed burning (Kane et al., 2010; Knapp et al., 2011; Kreye et al., 2013a). Mastication and other fire surrogate treatments for fuels are commonly used where prescribed or wildfires would damage residual trees or other ecosystem attributes, and where prescribed burning is difficult, lacks community support, and carries high risk of exposing public to excessive smoke (Stephens and Moghaddas, 2005). Tightening restrictions as part of smoke management regulations, the expanding wildland–urban interface (WUI), and continued need for fuels management to promote healthy ecosystems all point to increased use of mastication and similar fuel treatments designed to alter fire behavior.

Unfortunately, probability of ignition, fire behavior, and duration of long-term smoldering in masticated fuels and the resultant

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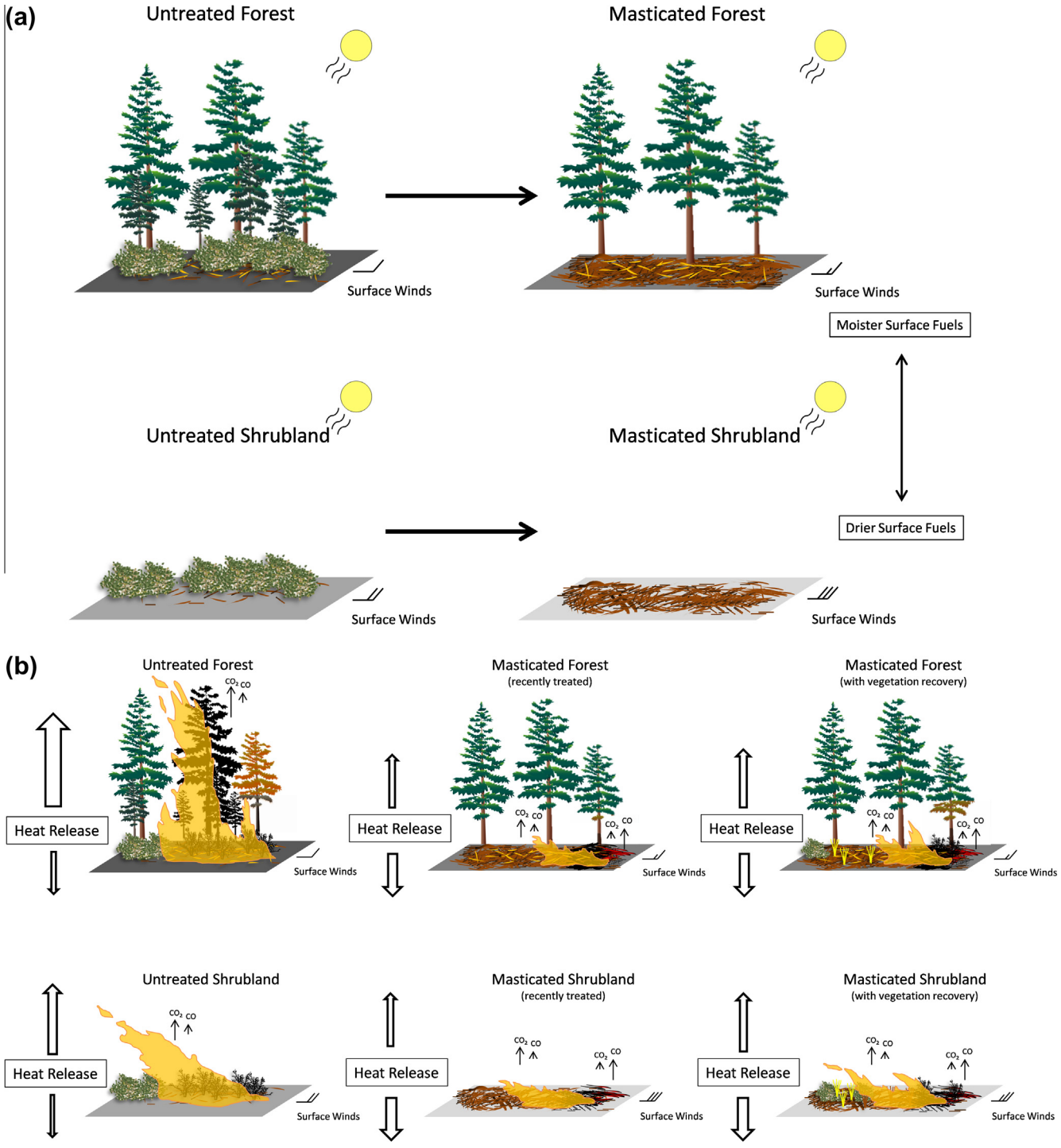

Fig. 1. Conceptual diagram of the changes in fuel conditions (a), and expected fire behavior soon after treatment and following some vegetation recovery after mastication of forests and shrublands (b). Vertical fuels (shrubs/small trees) are masticated and converted into compact surface fuels. Changes to fire behavior may be immediately dramatic, however long-term effectiveness will depend on the ability of treated vegetation to recover. The proportion of smoldering combustion relative to flaming combustion changes with mastication, as does the related heat release. The size of the heat release arrows refer to the relative proportion of heat release above and below; these are equal in all figures except for the untreated forest to indicate that a greater total heat release occurs due to crown ignition. In untreated shrublands, it is likely that only the surface fuels, and live foliage (and some live woody) are contributing to total heat release, while in the masticated shrubland, if most of the surface debris is consumed, there should be a greater total heat release because the masticated woody (now dead) will also contribute to energy output. The relative amounts of shading, surface winds, and CO and CO_2 emissions are also indicated.

effects on ecosystems are not well understood (Knapp et al., 2011; Kreye, 2012; Brewer et al., 2013; Kreye et al., 2013a). Mastication may not always reduce fire intensity and severity as is commonly assumed. Understanding the fuel characteristics of masticated sites and evaluating their effects on actual fire behavior will be important for fire prediction and evaluating treatment effectiveness. We have some understanding of how large downed woody fuels burn (Smith and Hudak, 2005; Hyde et al., 2011, 2012), but masticated fuel beds are likely a unique, compact mix of small and large fractured woody pieces (Fig. 1a, Fig. 2). Mastication is generally