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Effect of long-term understory prescribed burning on standing and down dead woody material in dry upland oak forests

John A. Polo [a], Stephen W. Hallgren [a,*], David M. Leslie Jr. [b]

[a] Oklahoma State University, Department of Natural Resource Ecology and Management, 008C Ag Hall, Stillwater, OK 74078, USA
[b] U.S. Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078, USA

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ABSTRACT

Dead woody material, long ignored or viewed as a nuisance for forest management, has gained appreciation for its many roles in the forest including wildlife habitat, nutrient storage and cycling, energy for trophic webs, protection of soil, fuel for fire and carbon storage. The growing interest in managing dead woody material has created strong demand for greater understanding of factors controlling amounts and turnover. Prescribed burning, an important management tool, may have strong effects of dead woody material given fire's capacity to create and consume dead woody material. We determined effects of long-term understory prescribed burning on standing and down woody material in upland oak forests in south-central North America. We hypothesized that as frequency of fire increased in these stands the amount of deadwood would decrease and the fine woody material would decrease more rapidly than coarse woody material. The study was conducted in forests dominated by post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) in wildlife management areas where understory prescribed burning had been practiced for over 20 years and the range of burn frequencies was 0 (unburned) fires per decade (FPD) to 4.6 FPD. The amount of deadwood was low compared with more productive forests in southeastern North America. The biomass (24.7 Mg ha^{-1}) and carbon stocks (11.7 Mg ha^{-1}) were distributed among standing dead (22%), coarse woody debris (CWD, dia. > 7.5 cm., 12%), fine woody debris (FWD, dia. ⩽ 7.5 cm., 23%), and forest floor (43%). There was no evidence that understory prescribed burning influenced the amount and size distribution of standing and down dead woody material. There were two explanations for the lack of a detectable effect. First, a high incidence of severe weather including ice storms and strong winds that produce large amounts of deadwood intermittently in an irregular pattern across the landscape may preclude detecting a strong effect of understory prescribed burning. Second, fire suppression during the first one-half of the 20th Century may have led to encroachment of woody plants into forest gaps and savannas creating a patchwork of young and old stands that produced deadwood of different sizes and at different rates.

1. Introduction

Dead woody material in forests consists of dead standing and down trees, branches, stumps and roots. It has numerous roles in ecosystem functions including wildlife and plant habitat, energy and mineral nutrient supply for the detritus trophic web, fuel for fire, storage of organic matter and nutrients, and regulation of surface runoff (Brown et al., 2003; Harmon et al., 1986; Harmon, 2002; Loeb, 1996). Prior to the sea change in forest conservation that took place around the middle 20th Century that recognized the importance of all parts of an ecosystem, deadwood was considered a nuisance and removed at earliest convenience (Thomas, 2002). Now, its value is recognized, and it is the focus of expanded research. Increased knowledge about the types, distribution, and turnover of dead woody material is important to understanding its role in the ecosystem and how to manage it while conserving other ecosystem attributes.

Quantity of deadwood depends on the balance between inputs and outputs (Goodburn and Lorimer, 1998; Harmon et al., 1986). Inputs are determined by site productivity, stand age and density, successional stage, and disturbance regime. Outputs are determined by rates of microbial decomposition, fragmentation, leaching and fire regime. Effects of fire are particularly interesting because the fire regime throughout much of North America was strongly altered following Euro-American settlement and fire was completely suppressed in many places (Guyette et al., 2002; Nowacki and Abrams, 2008; Pyne et al., 1996). Prescribed burning has become an important management tool to restore ecosystems to

* Corresponding author. Tel.: +1 405 744 6805; fax: +1 405 744 3530.
E-mail address: steve.hallgren@okstate.edu (S.W. Hallgren).

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historic conditions (Pyne et al., 1996). Benefits of prescribed burning include control of invasive species, preservation of biological diversity, improved wildlife habitat and management of wildland fuels. Although prescribed fire is often used to reduce the amount of hazardous fine fuel (Mitchell et al., 2009; Stephens and Moghaddas, 2005; Stephens et al., 2009), its effects on the quantity of deadwood are problematic in some ecosystems (Waldrop et al., 2010) because fire has the potential to produce as well as consume deadwood.

Fire has been a major disturbance in the upland oak forests in the ecotone between the eastern deciduous forest and the southern Great Plains of the United States for thousands of years (Albert, 1981; Clark et al., 2007; DeSantis et al., 2010a, 2010b; Stambaugh et al., 2009). Fires were often of anthropogenic origin because Native Americans used fire for many purposes (Guyette et al., 2002; Moore, 1972), and the fire regime was most likely low severity fires every 0–10 years (Brown, 2000). Burning probably increased shortly after Euro-American settlement as the settlers learned to use fire for the same purposes as the Native Americans (Guyette et al., 2002). Eventually the increase in human population resulted in the need for fire suppression to protect life and property including forest timber resources. Fire suppression in oak forests can lead to increased stand density to the detriment of herbaceous vegetation (Burton et al., 2010; Burton et al., 2011), increased mesophytic tree species, reduced oak dominance and increased encroachment of eastern redcedar (DeSantis et al., 2010b). Use of prescribed burning to reverse changes in forest vegetation composition and structure has been increasing, but there is a dearth of background information on effects of prescribed burning on various ecosystem attributes.

We studied effects of prescribed burning on quantities of standing dead trees and down dead woody material in upland oak forests in south-central North America. Research has shown low intensity dormant season burns can significantly reduce understory shrubs and saplings and increase herbaceous vegetation (Burton et al., 2010, 2011) but they have little effect on the trees larger than 5 cm diameter at breast height (DBH). Forest ecologists have speculated frequent low-intensity fires before Euro-American settlement reduced dead woody material because periodic fires consumed down wood and reduced stand density (Spetich et al., 1999). Prescribed burning mesic forests of mixed oak and pine reduced shrubs and saplings and litter but the effect did not last long due to resprouting and new litter inputs. Overstory mortality was minor and replaced by growth of remaining trees (Waldrop et al., 2008, 2010). Most research on effects of fire on dead woody material has been based on short-term study of one or two burns (Graham and McCarthy, 2006; Hubbard et al., 2004; Uzoh and Skinner, 2009; Liljaa et al., 2005; Chiang et al., 2008; Waldrop et al., 2008, 2010; Kolaks et al., 2004); few have studied long-term effects of repeated burning (Neill et al., 2007). We hypothesized long-term understory prescribed burning would reduce dead woody material, especially small material, and the effect would be directly related to the frequency of burning. The study was conducted in three Wildlife Management Areas (WMA) managed by the Oklahoma Department of Wildlife Conservation where dormant season prescribed fire had been used at frequencies ranging from 0 to 5 fires per decade for over 20 years to improve wildlife habitat.

2. Methods

2.1. Study sites

The study was conducted on three WMAs in the upland oak forests of eastern and central Oklahoma: Okmulgee WMA (OWMA), Lexington WMA (LWMA), and Cherokee WMA (CWMA) (Fig. 1). The WMAs were managed by the Oklahoma Division of Wildlife Conservation. The forests were dominated by post oak (*Qurecus stellata*) and blackjack oak (*Quercus marilandica*) (Duck and Fletcher, 1943; Rice and Penfound, 1959; Küchler, 1964) and were relatively free from harvesting and human disturbance due to shallow soils and low productivity (Therrell and Stahle, 1998). The elevation ranged from 180 to 370 m. Soils at OWMA were of the Hector complex: excessively drained stony sandy loam to 15 cm and fine sandy loam 15–33 cm on slopes 5–30%. These soils did not have potential for commercial timber production (Sparwasser et al., 1968). Soils at LWMA were of the Stephenville-Darsil-Newalla and Stephenville-Darsil complexes. The predominant Stephenville soil was well drained, fine sandy loam and loamy fine sand to 25 cm and sandy clay loam 25–70 cm on

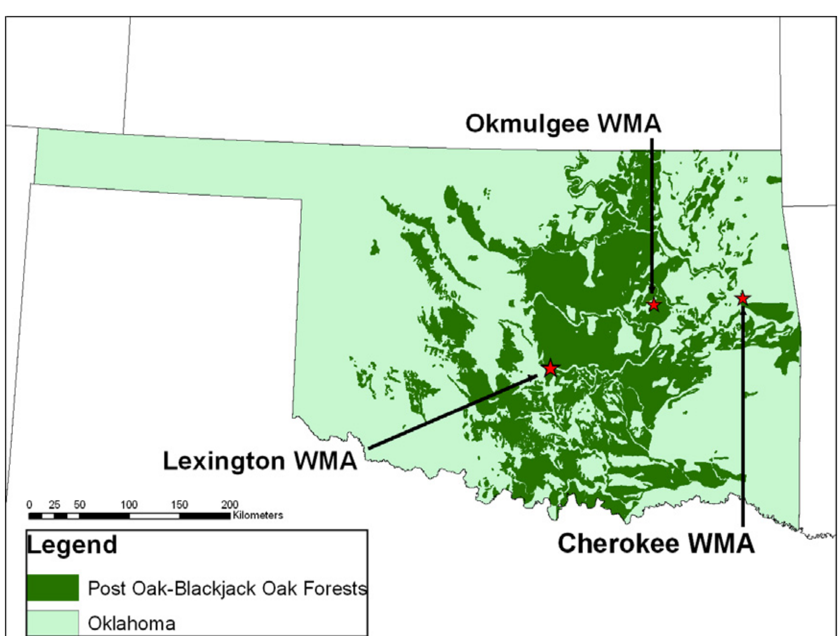

Fig. 1. Locations of the three wildlife management areas (WMA) in the post oak-blackjack oak forests of Oklahoma (Duck and Fletcher, 1943; Küchler, 1964).