RESEARCH BRIEF

Frequency of prescribed burning in an upland oak forest determines soil and litter properties and alters the soil microbial community

Ryan J. Williams, Stephen W. Hallgren, and Gail W.T. Wilson. Forest Ecology and Management, 265(2012): 241-247.

MANAGEMENT IMPLICATIONS

- Frequent prescribed fire (5 fires per decade) may reduce soil organic matter and carbon thus increasing bulk density and reducing soil porosity and water holding capacity
- Burning frequencies of 2.5 fires per decade or greater reduced the nitrogen content of leaf litter
- Fire frequencies less than 2.5 fires per decade had little measureable effect on the soil physical characteristics

Fire occurred frequently on landscapes in south-central North America for millennia. Fire suppression associated with Euro-American settlement has caused an increased prevalence of fire-intolerant, non-oak species and closed forest canopies. In recent years prescribed fire has been increasingly employed to reverse these changes, increase plant diversity of these forests, and reduce fuel levels. Fire may affect forest litter and soil microbial communities. Long-term effects of repeated fires on soils have rarely been examined, though previous studies have shown that certain physical properties can be altered after burning (see Chapter 2 in DeBano et al. 2005). Due to the heterogeneous distribution of fuels and soil water content, studies often report mixed results regarding physical soil properties. After a fire, it is known that many nutrients, including some forms of nitrogen, become available to plants through ash. Soil microbial community dynamics can fluctuate depending on fire severity, soil water content, and fuel loading. In a study of an oak savanna that assessed short-term effects of prescribed fire, gram-positive and -negative bacteria were unaffected while fungi decreased (see Ponder et al. 2009).

This study examined the effects of long-term periodic prescribed burning on the litter characteristics, physical soil properties, and soil microbial community in xeric oak forests of the Okmulgee Wildlife Management Area in eastern Oklahoma. Soil and litter measurements were made in areas that were subjected to prescribed burning at frequencies of 0 (unburned), 2.5, and 5 fires per decade (FPD) over the prior 20 years using low intensity dormant-season prescribed fires. Litter samples and soil cores were taken from five plots in each treatment type.

A decrease in litter nitrogen (N) by 20-21% was found in treatments of 2.5 and 5 FPD, with no changes in litter carbon (C) or lignin. Ratios of nitrogen to carbon and lignin were increased due to lower nitrogen levels in the litter.

Soil pH, N, C:N, nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), potassium (K),

Photos by Jesse Burton, National Park Service

Soils in sites at the Okmulgee Wildlife Management Area, OK that were exposed to five fires per decade (FPD) contained fewer gram-negative bacteria, less soil organic matter and organic carbon, and increased bulk density.

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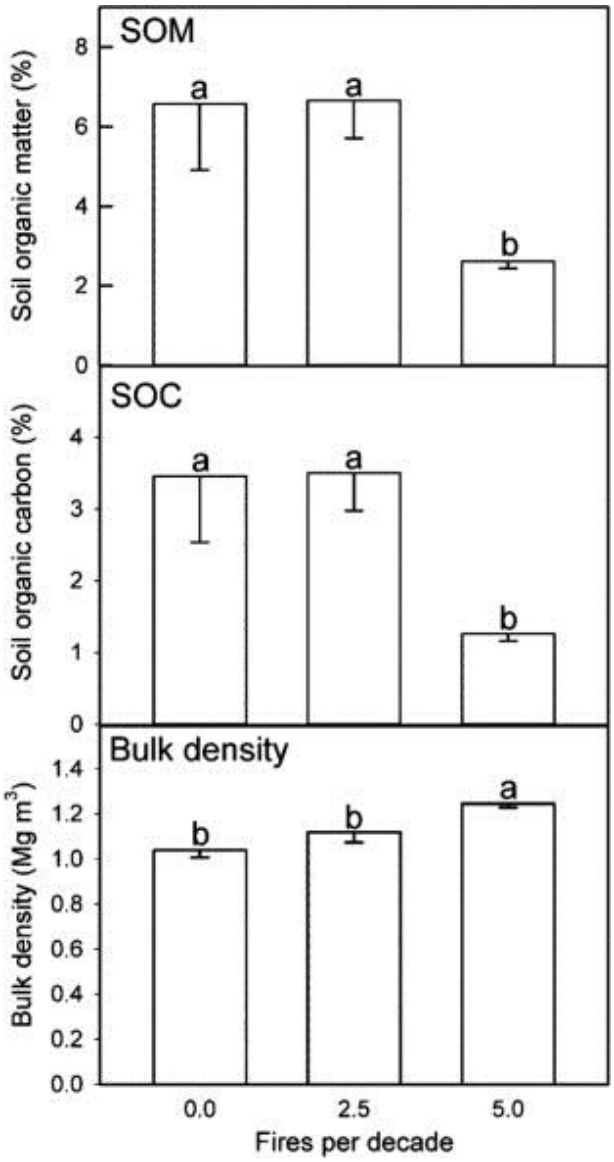
Fire frequency and soil and litter properties

phosphorous (P), and soil water content did not differ between burned and unburned plots. In the 5 FPD treatment, soil organic matter decreased by 60%, organic carbon decreased by 65%, and bulk density increased by 20%. Mycorrhizal and saprophytic fungi, non-specific microbes, and gram-positive bacteria did not differ between burned and unburned plots. Gram-negative bacteria decreased 20% in the 5 FPD treatment.

The authors stated that the observed reduction in litter N was likely due to oxidation loss from the litter and that this may lower decomposition rates and plant tissue quality. Similar to other studies, changes in litter N occurred independently of total soil N, which showed no change in burned areas. Soil organic matter (decaying biotic materials) and organic carbon (carbon stored in the soil) were significantly reduced in the 5 FPD treatment, adding to the varying results in the literature. Soil organic carbon levels are known to be reduced by fire in some studies but unchanged in others. Soil organic matter, in a study by Phillips et al. (2000), did not change with 2 fires per decade, yet it was reduced 31-41% with annual burning. The same study reported higher soil bulk densities when exposed to annual and biennial low-intensity prescribed fires. Diminution of soil organic matter and carbon leads to a collapse in soil structure, which results in decreased soil porosity and water holding capacity, and a higher risk of erosion.

Soil microbial communities were affected by frequent burning but with no clear mechanism identified. The authors suggested that the decrease in gram-negative bacteria are a product of indirect effects of prescribed burning. Burning increased plant cover in treatment areas of 5 FPD and this may, in turn, affect nutrient and substrate availability for microbes.

The authors advised resource managers to consider these results and the potential consequences on the soil ecosystem when applying frequent fire. They indicated that xeric forests can sustain prescribed burning frequencies of up to 2.5 FPD without major changes in the soil properties they considered. They also suggest that future research should examine annual net primary production resulting from plant community changes and the subsequent effects on soil organic matter, organic carbon, and microbial communities.



Soil organic matter (SOM) and carbon (SOC) decreased and bulk density increased after five fires per decade in upland oak forests of Oklahoma.

FOR FURTHER READING

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Phillips, D.H., J.E. Foss, E.R. Buckner, R.M. Evans, and E.A. FitzPatrick 2000. Response of surface horizons in an oak forest to prescribed burning. Soil Science Society America Journal., 64(2000):754–760.

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