ENERGY CONTENT IN DRIED LEAF LITTER OF SOME OAKS AND MIXED MESOPHYTIC SPECIES THAT REPLACE OAKS

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Abstract—Mixed-mesophytic hardwood tree species are replacing upland oaks in vast areas of the Eastern United States deciduous forest. Some researchers have suggested that the leaf litter of mixed-mesophytic, oak replacement species renders forests less flammable where forest managers wish to restore a natural fire regime. We performed chemical analyses on dried leaf litter from select oak and oak replacement tree species. The litter of oak replacement species was lower in calorific value and higher in mineral ash content than that of oaks. These results support a feedback theory that the flammability of oak litter favors the perpetuation of oaks over fire-sensitive species. Incorporating this information into fuel and fire behavior models will assist forest managers in planning prescribed burning operations in areas where mixed mesophytic hardwood tree species are replacing oaks.

INTRODUCTION

Prescribed fire is an important silvicultural tool in the management of oak (*Quercus* spp.)-dominated forests in the eastern United States (Brose and Van Lear 1998). However, some researchers have suggested that the replacement of upland oaks by mixed-mesophytic hardwood tree species changes the fire regime in eastern deciduous forests. Specifically, the litter of oak replacement species is suggested to be less flammable than that of oaks (Abrams 2005), although differences in leaf litter quality among eastern deciduous tree species have not been documented. The objective of this study was to determine if there were differences in chemical properties of the litter of select oaks and oak replacement species.

METHODS

Leaf Litter Collection and Sample Preparation

We collected freshly fallen leaf litter of three oaks and two species suggested to replace oaks in two to three different stands in the Clemson University Experimental Forest, Clemson, SC. Oak tree species included scarlet oak (*Q. coccinea* Muenchh.), southern red oak (*Q. falcata* Michx.), and post oak (*Q. stellata* Wangenh.). Oak replacement tree species included red maple (*Acer rubrum* L.) and American beech (*Fagus grandifolia* Ehrh.). Dried leaf litter was milled to 60-mesh in a Wiley mill and pressed into 0.5 g pellets for calorimetry and remained in powder form for mineral ash content analysis.

Calorimetry and Mineral Ash Content Analysis

Fuel chemistry is concerned with the total amount of chemical energy in a fuel and its availability to the combustion process (Mutch 1970). Calorific value is a measure of the thermal energy released when a fuel is burned (Dickinson and Kirkpatrick 1985) and was measured using an IKA® C200 oxygen bomb calorimeter using four subsamples per litter species per stand. Mineral ash content affects combustible fuel mass, gas evolution, and ignitability (Broido and Nelson 1964) and was measured as the percent of dry mass remaining after complete combustion of three subsamples per litter species per stand in a muffle furnace (at 600 °C for 2 hours). Calorific values and mineral ash contents of the litter of the oak species and oak replacement tree species were averaged and compared using one-way analysis of variance.

RESULTS AND DISCUSSION

The calorific value of the leaf litter of oak replacement tree species (17,977 ± 248.49 J g^{-1}) was less than that of oak litter (18,676 ± 242.95 J g^{-1}) ($P = 0.0322$). Further, the mineral ash content of the leaf litter of oak replacement tree species (7.27 ± 0.74 percent) was greater than that of oak litter (3.93 ± 0.73 percent) ($P = 0.0028$).

The results of this study suggest sites dominated by mixed-mesophytic hardwood tree species may exhibit lower fire intensities than those dominated by oaks because calorific value greatly influences heat output (Dickinson and Kirkpatrick 1985). Additionally, sites dominated by mixed-mesophytic species may be less flammable and/or burn more heterogeneously than those dominated by oaks because increasing mineral ash content decreases ignitability (Broido and Nelson 1964).

CONCLUSION

In our study, the leaf litter of oak replacement tree species had lower calorific value and higher mineral ash content than that of oak species. These results support a feedback theory that the flammability of oak fuel complexes favors the perpetuation of oaks over mixed-mesophytic, fire-sensitive tree species. Oak replacement might be expected to make it increasingly difficult to accomplish silvicultural objectives with prescribed fire. However, incorporating information regarding fuel quality into fuel and fire behavior models should assist forest managers in modeling and manipulating prescribed fire in areas where mixed-mesophytic hardwood tree species are replacing oaks.

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