THE IMPACT OF PRESCRIBED FIRE ON HERBIVORY LEVELS OF UNDERSTORY WHITE OAK

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Abstract—Historical data and the presence of fire-resistant characteristics support the role of fire in the establishment and maintenance of the mixed-oak (*Quercus* spp.) forests of eastern North America. Following the clear cutting of eastern forests in the 1800's, fire suppression became a dominant forest management technique. Age and species mosaics declined and forest stand composition shifted, allowing more vigorous and shade tolerant species to dominate. As a result, seedlings in oak-dominated forests became suppressed by vegetative competition, and today oaks are virtually non-existent in the midstory. This shift in species composition has resulted in the economic loss of an extremely valuable hardwood group, and may also impact forest succession rate, wildlife composition and distribution, and watershed characteristics.

The use of prescribed fire as a management tool to enhance oak regeneration has recently been met with renewed interest. Fire enhances oak growth by reducing vegetative competition, increasing sunlight penetration, and increasing nutrient composition in the soil.

Traditionally research has focused on environmental factors and vegetative competition influencing oak regeneration. However, acorns, seedlings, and mature oaks are constantly exposed to insect herbivory. Prescribed fire may serve to manipulate insect composition and abundance, which could effect seedling establishment and sprout success. Fire may impact herbivore populations directly by habitat alteration and disruption of the life cycle, or it may have indirect impacts caused by alterations in food quality and availability.

OBJECTIVES

This study is identifying biotic factors attributing to the lack of oak regeneration in eastern Kentucky forests, and will assess the effects of prescribed fire on the herbivore complex associated with oak regeneration. The specific objectives of this research are to characterize the effects of single year and multiple year burns on: 1) oak seedling growth, 2) phytochemistry, and 3) herbivory levels.

MATERIALS AND METHODS

Study sites were established in the Daniel Boone National Forest (DBNF) on oak-dominated ridgetops under the following burn regimes: 1) single year burn - areas burned in late winter of 1998, 2) multiple year burn - areas burned in late winter of 1998 and 1996, following the prescribed fire management program established by the DBNF, and 3) unburned controls - areas with no recent history of fire activity.

Within each site, subplots consisting of a series of herbivore exclusion treatments were established to assess herbivory levels in each burn regime. Each subplot consists of seedling fencing/insecticide treatments designed to: 1) exclude arthropod herbivory(- fence/ + insecticide), 2) exclude mammalian herbivory(+ fence/ - insecticide), 3) exclude both mammalian and arthropod herbivory (+ fence/ + insecticide), and 4) no herbivore exclusion (- fence/ - insecticide). The split plot design involves seedling treatments (+/- fence, +/- insecticide) replicated 3 times within site treatments (1x-burn, 2x-burn, non-burned), which are also replicated three times.

To assess the effects of prescribed fire on oak growth, measurements of seedling performance (shoot elongation, height, diameter) were taken at 4 equal intervals throughout the growing season. Twenty five adjacent seedlings were flagged for periodical destructive sampling for phytochemical analysis. Foliar samples were collected to analyze for total non-structural carbohydrates, nutrients, protein, and phenolics.

Herbivory was visually assessed by measuring the area affected by mammalian and arthropod feeding on each tree at 14 d intervals throughout the season. Levels of herbivory in each of the 4 seedling (subplot) treatments were compared under the different burn regimes. Herbivory levels will be correlated with seedling growth (Objective 1) and phytochemistry (Objective 2).

To augment the relatively low (0-30 percent) natural herbivory levels, fall webworm (FWW) larvae were caged on additional seedlings. Paired seedlings were caged with and without larvae in each burn regime and allowed to feed for 6 days. After caging, leaf tissue was flash frozen for future phytochemical analysis.

RESULTS

Results of the augmented herbivory experiment are presented here. Final herbivory levels across burn treatments averaged 50 percent. Since there was no significant difference between the once and twice burned sites pre- or post-FWW challenge, results for the burn treatments were pooled. Prior to the FWW caging

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Citation for proceedings: Stringer, Jeffrey W.; Loftis, David L., eds. 1999. Proceedings, 12th central hardwood forest conference; 1999 February 28-March 1-2; Lexington, KY. Gen. Tech. Rep. SRS-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 293 p. [Poster abstract].

experiment, mean defoliation levels of seedlings on non-burned sites exceeded that of burned sites (Table 1). This trend was reversed for the post-challenge sample date, when defoliation on seedlings from burned sites exceeded that of non-burned sites. FWW defoliation increased by greater than 90 percent on burned sites, but only 75 percent on non-burned sites.

The overall herbivory rate of FWW challenged oak seedlings on burned sites significantly exceeded that of non-burned control sites (Fig. 1, $P = 0.0442$).

DISCUSSION

By FWW Herbivory

The lower herbivory levels in pre-challenged, burned plots may reflect enhanced production of inducible defenses such as phenolics due to site (burn) treatment. The increase in herbivory on burned sites for the post-FWW challenge may be attributable to an induced defensive response which has been compromised by the stresses of site treatment combined with herbivory levels. Future research will concentrate on analysis of phytochemical compounds within each treatment.

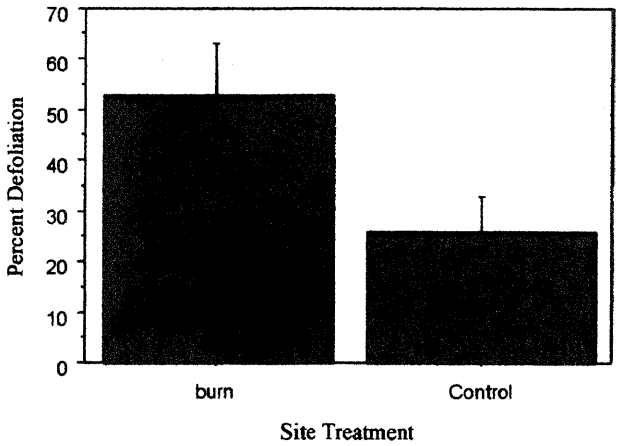

Fig. 1—Defoliation of white oak seedlings challenged.

Table 1—Mean percent defoliation (s.e.) of white oak seedlings challenged by fall webworm herbivory on burned and non-burned sites

White oak seedlings	Burned	Non-burned control
	------- *Percent defoliation* ------	
Pre-FWW challenged	6.46 (1.89)	9.66 (2.10)
Post-FWW challenged	59.29 (10.27)	35.68 (5.27)

This study will elucidate some of the complex interactions between fire, oak seedling growth, phytochemistry and herbivory. Knowledge of these interactions may alleviate some of the difficulties associated with the oak regeneration issue. As natural oak regeneration and human management techniques fail to produce the desired results, prescribed burning offers some hope.