Impacts of prescribed fires and ecological land types on the structure and dynamics of woody species of the Ozark Highland forest ecosystems, Missouri

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Introduction

The historical woodland-savanna-glade mosaic in the Ozark Highlands of Missouri has been replaced by a large contiguous block of high-density oak-hickory forest (Figure 1) due to extensive fire suppression and widespread application of other management practices that have promoted development of forests. In 1996, the Nature Conservancy initiated a long-term prescribed burning project at the Chilton Creek Preserve of about 2300 ha to study response of forest ecosystems to restoration of "natural" fire disturbance regimes that are characterized by frequent fire. Five prescribed burning units (1012 ha in total, Table 1) including annual burn and burns with return intervals 1 to 4 years selected randomly were established to monitor long-term fire effects on vegetation structure and dynamics on different ecological land types (ELT) (Hartman and Heumann 2003, Dey and Hartman 2005).

The objective of this study is to evaluate how different burning treatments affect woody species abundance in terms of stem density and basal area in over-, mid- and understory and ground flora after four-years of burning treatments.

Data and Methods

• The data for this study came from the 250 0.2-ha permanent plots established in the five burning units.

• Woody stems in four size (dbh) classes: >11 cm (over-story), 4-11 cm (mid-story), < 4cm but over 1.5 m tall (under-story) and <1.5 m tall (seedlings), and herbaceous species were monitored in the 250 0.2-ha permanent plots in 1997 and 2001. Variables measured included species, crown class, dbh, status (live or dead) for woody stems and coverage and life form for herbaceous.

• Data were pooled together by two ecological land type groups (dry and mesic ELTs) instead of individual ELTs because there were no or few plots within certain ELTs. The "Chilton East" burning unit was not included in the data analysis because the terrain and vegetation features were different from the other four units.

• Multivariate analysis of variance (MANOVA) was employed to analyze the paired (prior to and post burning) woody vegetation data and study the effects of fire and ELT on woody species stem density and basal area changes in different size classes at the plot level and by separate species groups in the plot.

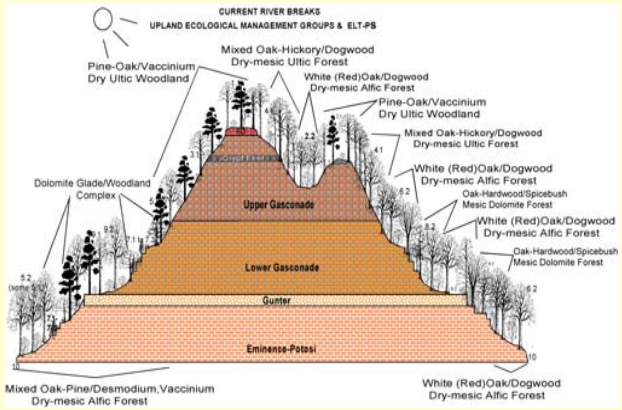

Figure 1. High density oak-hickory stands growing on different ecological land types in the Chilton Creek Preserve, southeast Missouri Ozark Highlands.

Prescribed Burning Unit	1998	1999	2000	2001
Chilton East	X			
Chilton North	X			
Chilton South	X	X	X	
Kelly North (annual burn)	X	X	X	X
Kelly South	X		X	X

Table 1. Burn schedule on the Chilton Creek Preserve study site, 1998-2001 (X-- burning event).

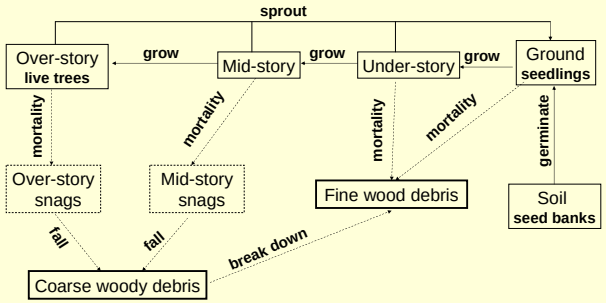

Figure 2. Diagram of woody vegetation structure and dynamics.

Results and Discussion

MANOVA showed that both fire and ELT had significant effects on stem density of woody species (Wilks' Lamda <0.0001 and =0.0376, respectively) as a whole. Specifically, fire reduced stem density in the mid- and under-story (from 1.5 m over to dbh < 11cm), with stem density being halved by multiple fires compared to one fire (Chilton North). Fire increased ground seedling density (p=0.0039) but have had little effect on over-stroy (dbh>11 cm) tree density (Figure3). Ground seedling density on dry ELTs is three times that on mesic ELTs. There were no significant differences in other size classes between dry and mesic ELTs (Figure 4). With basal area change in over-, mid- and under-story, only fire was shown to be important (Wilks' Lamda<0.0001). Multiple fires significantly reduced stem basal area in the mid- and under-story compared to the "one fire" treatment , but had no effect on over-story stem density (Figure 3).

Woody species (or groups) responded differently to prescribed fires in terms of stem density change within different size classes (Table 2). Red oak was the only species group with decreasing stem density for all size classes. Flowing dogwood stem density also decreased in all size classes except that there were no seedlings on the ground. White oak stem density increased in the over-story, but decreased in the mid- and under-story. There were no white oak seedlings found on the ground. Hickories, shortleaf pine and other species had an increasing stem density in the over-story and on the ground, but a decreasing density in the mid- and under-story (Table 2).

These results imply that prescribed burns gradually change not only forest size structure but species composition. Because the burn period is relatively short, no apparent change was observed with the over-story because large trees usually resist low intensity surface fires for a relatively longer time of period. As the prescribed burn treatments continue on the study sites, it is expected that over-story responses may occur.

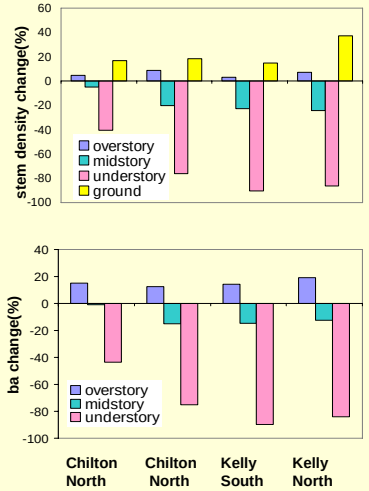

Figure 3. Least square means of overall stem density and basal area (ba) change (100%*[year01-year97]/year97) in different burning units.

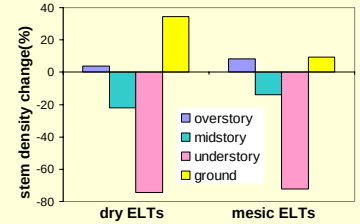

Figure 4. Least square means of overall stem density change (100%*[year01-year97]/ year97) by ELT groups (dry ELTs: 1,2,3,5; mesic ELTs: 4,6,7,8,9. see Figure1).

	Over-story	Mid-story	Under-story	Ground
White oaks	up	down	down	none
Red oaks	down	down	down	down
Hickories	up	down	down	up
Shortleaf pine	up	down	down	up
Flowing dogwood	down	down	down	none
Other species	up	down	down	up

Table 2. Effect of fires on stem density change (year01-year97) by species group.

On-going/future work

Since the last measurement in 2001, Ozark highland forest ecosystem characteristics on the study sites continue to change with additional prescribed burning. Field measurements will be conducted in this year (2007) and new data will be combined with previous data to further analyze forest changes under different burn treatments and to infer how burn affects the dynamics and transition between different components.

Major references

Dey, D. C., and G. Hartman. 2005. Returning fire to Ozark Highland forest ecosystems: Effects on advance regeneration. For. Eco. Manag. 217:37-53.

Hartman, G., and B. Heumann 2003. Prescribed fire effects in the Ozarks of Missouri: The Chilton Creek Project 1996-2001.