RESEARCH BRIEF

Management and climate variability effects on understory productivity of forest and savanna ecosystems in Oklahoma, USA

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In this study, authors assessed the relative influence of management treatments (tree harvest, prescribed fire) and climate variability on understory aboveground net primary productivity (ANPP) in grassland, savanna, and mature forest ecosystems in southeastern Oklahoma, USA.

The study took place within the Pushmataha Wildlife Management Area, located in the Kiamichi Mountains, owned and managed by the Oklahoma Department of Wildlife Conservation. Prior to management treatments, the closed-canopy forest overstories within the study area were dominated by post oak (*Quercus stellata*), shortleaf pine (*Pinus echinata*), blackjack oak (*Q. marilandica*), and hickory (*Carya spp.*). Forest understories were dominated by woody vegetation including sparkleberry (*Vaccinium arboretum*), winged sumac (*Rhus copallinum*), poison ivy (*Toxicodendron radicans*), greenbriers (*Smilax* spp.), and seedlings of the overstory tree species. The forest ground cover primarily consisted of leaf litter with little herbaceous growth.

During 1983-84, a randomized experimental design was implemented with a total of 28 management units (approximately 2-4 acres in size) established. Treatments consisted of commercial harvesting of the overstory pine component, thinning of hardwoods (except for one treatment), followed by prescribed fire at varied return intervals (1-4 years; treatment codes: HT1, HT2, HT3, HT4). For one treatment (code: HNT1), the hardwood component was not thinned, pine was harvested, and the fire interval was one year. No thinning or

MANAGEMENT IMPLICATIONS

- Fire maintains highly productive understories through limiting tree basal area and litter accumulations.
- Fire return intervals greater than three years result in forest redevelopment and loss of savanna or woodland structure.
- Timing of precipitation (particularly mid-growing season) is more important than total precipitation for herbaceous aboveground net primary productivity.

Different vegetation structures and levels of understory productivity resulted from 31 years of prescribed fire applied at varied return intervals (A= no fire, B= 4-yr, C= 3-yr, D= 1-yr). Pushmataha Wildlife Management Area, southeast Oklahoma, USA.

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Effects on understory productivity

burning occurred in the control treatment. Prescribed fires were implemented during the dormant season (January-April) and the established fire return intervals were maintained throughout the experiment, resulting in a 31-year period between initial treatment and sampling for this study.

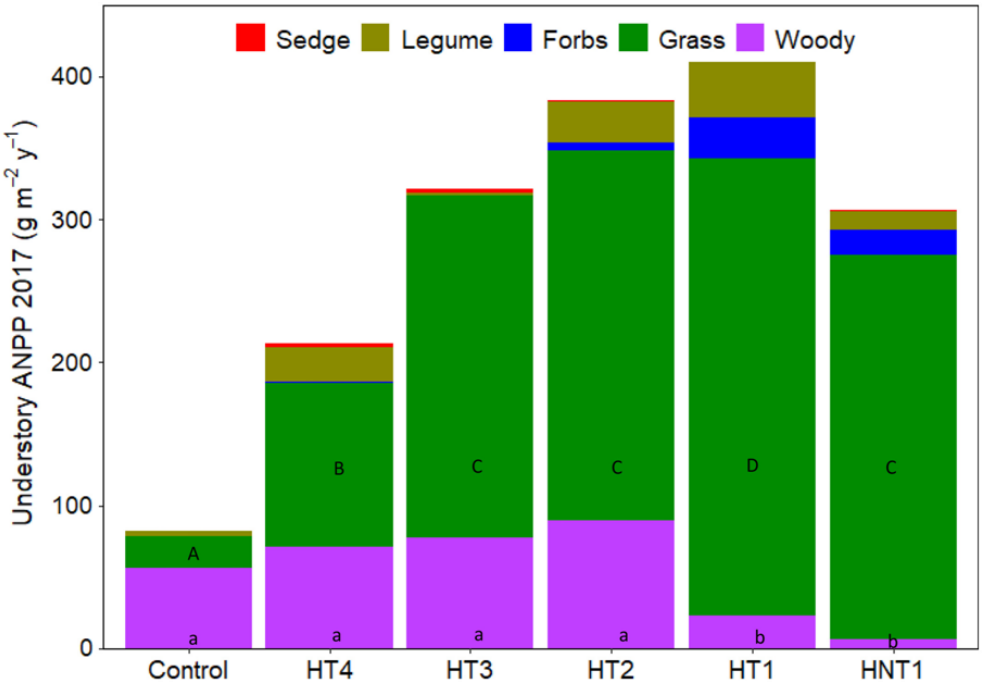
Permanent plots were established in 1987. Aboveground net primary productivity (ANPP) was quantified by clipping, drying, and weighing aboveground vegetation. ANPP was calculated separately for different functional groups (understory woody, grass, forb (non-legume), sedge, and legume). At each plot, overstory tree dominance and density was characterized (basal area and canopy cover) and litter accumulation was measured (including all plant material, bark, leaves, and small branches). Statistical models were developed between understory ANPP (herbaceous ANPP + understory woody ANPP) and tree basal area, litter accumulation, fire return intervals, and weather variables.

Study results showed that fire, through its negative influence on tree basal area and litter accumulation (both inversely related to understory ANPP), was critical to maintaining highly productive understories. Total understory ANPP was highest (by a factor of 7) in the thinned (pine and hardwood) + annual fire treatment (HT1) and lowest in the control. Understory ANPP was dominated by grasses, ranging from 27 grams per m^2 per year ($g \cdot m^{-2} \cdot yr^{-1}$) in mature forests (control) to 374 $g \cdot m^{-2} \cdot yr^{-1}$ for annually burned treatments. Grass ANPP (mean) in the control was significantly lower than in all treatments, lowest in the 4-yr fire interval among all burn treatments, and greatest in the thin and annual burning treatment. Herbaceous ANPP was positively associated with June precipitation, and negatively related to early and late growing season temperature maximums, overstory tree basal area, and litter accumulation. Understory woody ANPP was significantly lower in the annual burn treatment, positively associated with tree basal area and precipitation, and was negatively influenced by summer soil moisture deficits.

Herbaceous ANPP increased with shorter fire return intervals, due to reduced basal area, tree canopy cover, and leaf litter, and was most sensitive to June precipitation. Mean understory ANPP was consistently low in the control treatments, and herbaceous plant contribution to total understory ANPP increased along with fire frequency, e.g., 54% in control, 70% in 4-yr fire interval, and 92% and 93% in annual fire treatments. Herbaceous ANPP was highly variable over time in all treatments, and showed a decreasing trend in the 4-yr fire return interval treatment as the uneven-aged woodland developed over time.

Precipitation timing (especially mid-growing season) was more important than total annual precipitation for herbaceous ANPP. Higher temperatures which occurred during this experiment did not have a significant negative effect on understory woody ANPP, suggesting that expected changes to climate may have variable effects on different functional groups.

Burning every 1-3 years post-thinning resulted in smaller increases in canopy cover over time, which was mostly due to residual tree canopy expansion, and resulted in maintained grassland, savanna, or woodland structures. Burning every four years (HT4) for 31 years, however, resulted in an uneven-aged woodland in which residual tree canopies expanded and periodic recruitment of new trees occurred. In this treatment, canopy cover increased from 7.3% (one year after thinning and initial fire treatments) to 52.4%. Consequently, a fire return interval threshold of three years was identified, beyond which forest redevelopment and loss of woodland or savanna characteristics is expected to occur.



Average aboveground net primary productivity (ANPP) of different plant functional groups in different treatments measured in 2017. Different uppercase letters (Grass ANPP) and lowercase letters (Woody ANPP) represent significantly different mean ANPP values.

This research brief was funded by The Joint Fire Science Program. ***www.firescience.gov***