RESEARCH BRIEF

Vegetation response to canopy disturbance and season of burn during oak woodland and savanna restoration in Tennessee

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The objective of this study was to assess the relative effectiveness of different forest canopy reduction levels (woodland vs. savanna) and season of burn (spring vs. fall) towards meeting restoration objectives for oak woodlands and savannas. These ecosystems are usually dominated by fire-tolerant tree species and have high levels of herbaceous diversity (exceeding those of prairies or closed-canopy forests), but are rapidly disappearing due to succession associated with 20th century fire exclusion practices.

The study occurred at Catoosa Wildlife Management Area, managed by the Tennessee Wildlife Resources Agency, and located within the Cumberland Plateau and Mountains physiographic region. Oak woodland and savanna restoration began in 2002, first with salvage logging of pine bark beetle-killed shortleaf pine trees from a1999-2000 outbreak, followed by prescribed fire and additional canopy-opening commercial harvests in response to the rapid development of common prairie and savanna flora.

At the time of pre-treatment data collection in 2008, the study site consisted of a mixed pine-hardwood closed-canopy forest (>85% canopy closure) dominated by white, southern red, black, and scarlet oaks, and also red maple, sourwood, and hickories. Dense mid-story vegetation was dominated by blackgum, downy serviceberry, red maple, sourwood, and sassafras. Very little herbaceous vegetation was present in the ground-layers, which instead were dominated by blueberry, tree seedlings, and leaf litter.

Within a 300-ha (~741 acres) area, ten stands were delineated into 20-hectare (~49 acres) experimental units. Two replications of five different treatments were assigned to the stands. Treatments were: **spring fire / woodland residual basal area of 14 m²/ha** (~61 ft²/acre); **fall fire / woodland residual basal area**; **spring fire / savanna residual basal area of 7 m²/ha** (~30 ft²/acre); **fall fire / savanna residual basal area**; and **no-treatment** (control). Basal area reduction was accomplished through commercial timber harvests, which targeted fire-intolerant (pyrophobic) tree species such as maples, sweet gum, and yellow poplar, and resulted in overstories dominated by fire-tolerant (pyrophyllic) trees such as shortleaf pine, oaks, and hickories.

Fall burns occurred in October 2010 prior to leaf abscission, and spring burns

MANAGEMENT IMPLICATIONS

- Herbaceous cover, richness, and diversity increased with increasing canopy disturbance, and these increases accelerated as residual basal area was reduced below 15 m^2 / ha (65 ft^2 / acre)
- Fire, regardless of season, enhanced herbaceous response; however, lower-intensity growing-season fire had similar effects as higher-intensity dormant-season fire
- Reductions in dense layers of red maple and other fire-intolerant saplings were short-lived, leading to a two-year fire interval recommendation during the initial oak woodland/savanna restoration phases

Salvage logging, commercial thinning, and recurring prescribed fire have led to oak/pine woodland conditions, promoting herbaceous abundance and diversity at Catoosa Wildlife Management Area near Crossville, Tennessee. (Photo: Clarence Coffey)

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Response to canopy disturbance and season of burn

occurred in March 2011 prior to leaf emergence. Pre- and post-data were collected in 2008 and then post-canopy disturbance data were collected in 2009 and 2010, and for two consecutive years post-fire in 2011 and 2012. Woody vegetation data included stem density by different size/form classes (shrubs, seedlings, small and large saplings, overstory trees) with species partitioned by pyrogenicity. Herbaceous groundcover was identified and categorized as graminoid, legume, other forb, or fern, and plot-level herbaceous richness and diversity were calculated (via Shannon-Wiener's Index).

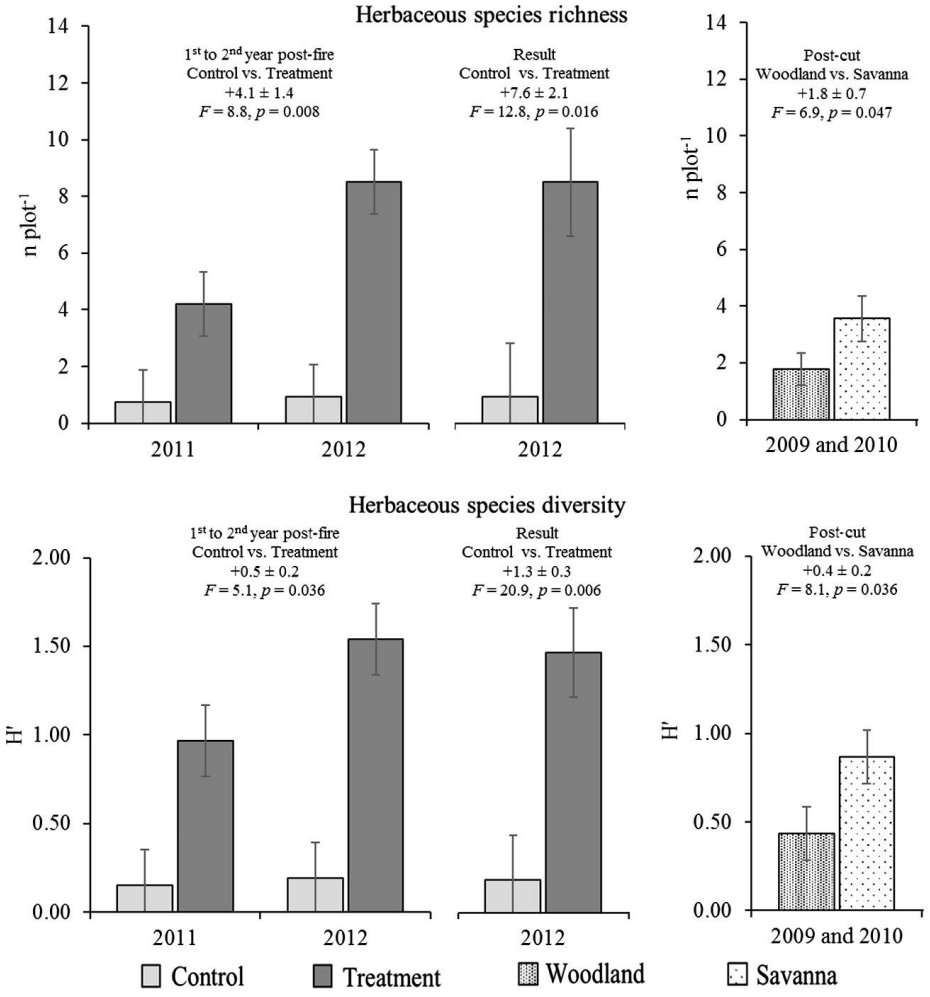
For each year of data collection, trends in the vegetation community were characterized, including density of woody stems by size/form class and pyrogenenicity. The percent groundcover by herbaceous class, herbaceous richness and diversity, and their respective relationships to treatments were tracked through time. Fire intensity was assessed using scorch height, which was proven to be a suitable surrogate.

The effect of canopy disturbance and fire on woody vegetation density varied by size class and pyrogenicity. All size classes of woody vegetation, except for large saplings (≥ 1 m tall, and ≥ 7.6 but < 12 cm DBH), increased in density as canopy openness increased. Small sapling (≥ 1.4 m tall and < 7.6 cm DBH) density was temporarily decreased by fire, though quickly rebounded to equal or exceeding pre-fire levels within two years. Pyrophyllic seedling and small-sapling density increased post-treatment, while pyrophobic tree species density decreased as canopy closure decreased.

Despite occurring >65 years after the fire-suppression induced closure of tree canopies at the site, management stimulated a robust response of prairie and savanna associated grasses and wildflowers. Herbaceous groundcover increased with increasing levels of canopy disturbance. Graminoid and forb groundcover, herbaceous richness, and herbaceous diversity were 8 to 24 times greater in treatments compared to controls two years post-treatment.

The study authors conclude 1) that these findings demonstrate the utility of pairing canopy disturbance with fire when restoring oak woodlands and savannas from closed-canopy forests, and 2) that commonly used restoration success metrics (e.g., herbaceous richness/diversity) were positively related to lower levels of canopy cover. Decreases in understory woody vegetation after fire were short-lived due to the prolific resprouting of hardwoods, and the authors recommend that managers consider a two-year fire return interval during the initial phases of restoration. This return interval is sufficient in length to allow fine fuels to reaccumulate in support of adequate fire behavior, but short enough to prevent woody vegetation from replenishing below-ground energy reserves.

Late-growing season fires achieved similar fire effects as dormant-season fires, including hardwood density reductions and herbaceous layer enhancement, despite being consistently less intense. The authors conclude that late-growing season fire can benefit oak woodland and savanna restoration through 1) potentially increasing the efficacy of fire management in achieving related goals, 2) the increased fire-control associated with lower-intensity fire, and 3) increased opportunities for restoration burning per year.



All significant (α = 0.05) contrasts for herbaceous species richness (n plot−1) and diversity (Shannon-Wiener Index, H') during an oak woodland and savanna restoration experiment (2008–2012) at Catoosa Wildlife Management Area, Cumberland County, TN. (Click HERE for full caption)

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