PRELIMINARY VEGETATIONAL CHANGES IN FREQUENTLY BURNED AND UNBURNED UPLAND PINE-HARDWOOD FORESTS AT COOK'S BRANCH CONSERVANCY IN MONTGOMERY COUNTY, TEXAS, U.S.A.

Eric Keith
Raven Environmental Services, Inc.
P.O. Box 6482
Huntsville, Texas 77342, U.S.A.
keith@ravenenvironmental.com

Jesse Blum
Raven Environmental Services Inc.
P.O. Box 6482
Huntsville, Texas 77342, U.S.A.
exum@ravenenvironmental.com

Sarah Mitchell
Cook's Branch Conservancy
2630 Exposition, Suite 214
Austin, Texas 78703, U.S.A.
smitchell@cgmf.org

ABSTRACT

Vegetational changes over a 6-year period (2012 to 2017) were recorded in upland pine-hardwood forests on Cook's Branch Conservancy (CBC) in Montgomery County, Texas, using permanent vegetation monitoring plots as a basis for following future vegetational changes. Cook's Branch Conservancy is a 2,160-hectare preserve purchased by George and Cynthia Mitchell in 1964 and is now part of a conservation program operated by the Cynthia and George Mitchell Foundation. Plots sampled for this study include eight Fire Monitoring Handbook vegetation plots located in upland forests over sandy soils including four plots located in frequently burned stands (11 times since 2002) and four plots located in stands that have not been burned in decades (20+ years). Data collected confirm significant changes to vegetational structure in frequently burned forests compared to similar habitats that are unburned. Prior to initiation of prescribed burning in 2001, habitat conditions and species composition was similar in stands surrounding all eight plots sampled. The overstory tree structure of all eight plots sampled is similar in basal area, canopy cover, and in species composition. The number of midstory trees is less in frequently burned plots, however, frequently burned plots possess a much greater number of seedlings. At the shrub level, *Callicarpa americana* and *Ilex vomitoria* represented 97.7% of total stems in the frequently burned plots, with *Callicarpa americana* stems count increasing in frequently burned plots, suggesting the species is pyrophytic. Additionally, diversity of herbaceous species was higher in frequently burned plots vs unburned plots. Visually, the frequently burned forest is open in the understory, while the unburned forest is dense with woody understory vegetation making it difficult to traverse on foot.

RESUMEN

Se registró el cambio de la vegetación durante un periodo de 6 años (2012 hasta 2017) en los bosques de pinos y árboles de madera dura de las tierras elevadas de Cook's Branch Conservancy (CBC) en el condado de Montgomery, estado de Texas, utilizando los parcelas de seguimiento permanente como base para seguir las variaciones futuras de la vegetación. Cook's Branch Conservancy es una reserva de 2,160 hectáreas adquirido por George y Cynthia Mitchell en 1964 y forma parte, en la actualidad, de un programa de conservación administrado por la Fundación de Cynthia y George Mitchell. Las parcelas muestreadas en este estudio contienen ocho tipos de vegetación según "Fire Monitoring Handbook" y se ubican en los bosques de tierra elevada por encima de la tierra arenosa, incluyendo cuatro parcelas ubicadas en un agrupación de árboles quemados frecuentemente (11 veces desde 2002) y cuatro ubicados en agrupaciones que no se han quemado durante algunas décadas (más de 20 años). Los datos recopilados confirman cambios significativos en la estructura de la vegetación en bosques que se queman con frecuencia en comparación con hábitats similares que no se queman. Con antelación al inicio de los incendios controlados ordenado en el año 2001, las condiciones de los hábitats y la composición de especies era similar al de las agrupaciones que estaban alrededor de las ocho parcelas muestreadas. La estructura de los árboles de las ocho parcelas estudiadas es similar en el sotobosque, en la cobertura y en la composición de especies. El número de árboles del sotobosque es menor en las parcelas que se queman con frecuencia, sin embargo, poseen un número mucho mayor de plántulas. A nivel de arbustos, *Callicarpa americana* e *Ilex vomitoria* representaron el 97,7% del total de tallos en las parcelas que se quemaban con frecuencia, y el número de tallos de *Callicarpa americana* aumentó en estas parcelas, lo que sugiere que la especie es pirófita. Además, la diversidad de especies herbáceas fue mayor en las parcelas quemadas con frecuencia frente a las parcelas no quemadas. Visualmente, el bosque que se quema con frecuencia está abierto en el sotobosque, mientras que el bosque no quemado es denso con vegetación leñosa en el sotobosque, lo que dificulta el tránsito a pie.

INTRODUCTION

The primary objective of this study was to analyze the effects of frequent prescribed fires on vegetation in upland pine-hardwood forests compared to similar forests that have not been burned in at least twenty years, and potentially several decades, using Fire Monitoring Handbook (FMH) permanent vegetation plots on

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Cook's Branch Conservancy (CBC) in Montgomery County, Texas. The eight permanent plots, including four in frequently burned habitats and four in unburned habitats, were initially installed in 2012 and sampled every year through 2017. Sampling of this subset of eight plots and analysis is part of a broader effort to gather baseline data and conduct long-term vegetation monitoring throughout the property using 37 plots. Information gathered from this effort is being utilized for characterizing vegetation communities, documenting vegetational changes, and developing management plans to enhance and restore pre-European settlement habitats. Data collection for this study follows guidelines by TPWD (2010) for quantitative vegetational studies on Texas state parks.

Cook's Branch Conservancy totals 2160 hectares and is located in Montgomery County, Texas, approximately 11 kilometers south of the town of Montgomery. The property boundary is located entirely within the USGS, 7.5 Minute, Keenan Quadrangle map and the approximate geographic center is Latitude 30°17'0"N and Longitude 95°39'30"W. The property was purchased by George and Cynthia Mitchell in 1964 and is now operated as part of the Cynthia and George Mitchell Foundation. In 1999, the Mitchell family began a long-term habitat restoration project utilizing management tools including prescribed burning, selective timber harvests, mechanical and manual midstory control, invasive species eradication, and replanting of native species. In 2003, CBC entered into an agreement with Texas Parks and Wildlife Department (TPWD) and Texas Forest Service by enrolling in the Regional Habitat Conservation Plan for the Red-cockaded Woodpecker on Private Lands in East Texas. There are currently 25 active clusters of the federally endangered red-cockaded woodpecker (*Leuconotopicus borealis* Vieillot) on the property.

Cook's Branch Conservancy is particularly susceptible to encroaching development since, according to U.S. Census data; Montgomery County was one of the fastest growing counties in the state from 2010 to 2015 (+17%) (Ura & Flannery 2016) with Conroe, the county seat, being the fastest growing city in the U.S. from July 2015 to July 2016 increasing from 76,362 to 82,286 residents (+7.8%) during that period (Ura & Daniel 2017). FM Highway 149, connecting the towns of Montgomery and Magnolia, intersects the northeastern boundary of the property, and subdivision development is rapidly progressing adjacent to CBC property (Fig. 1). CBC owners recognize both the need and opportunity to manage and conserve this property as an island-refuge of critical habitat. As the surrounding area becomes increasingly urbanized, CBC will become one of the last remaining large contiguous blocks of privately owned natural forest in the region. It is the goal of CBC to restore forested portions of the property to an ecological condition that is representative of the old-growth forest that existed prior to European settlement.

Study area description.—Ecologically, CBC is located in a transition zone at the convergence of the Gulf Coastal Prairie, the Pineywoods, and the Blackland Prairie ecoregions (Diamond et al. 1987) which contributes to the properties overall ecological diversity. The presettlement vegetation in the western portion of the Pineywoods (where CBC is located) was predominantly a mosaic of mixed stands of shortleaf pine (*Pinus echinata*) and variety of dry-site oaks and hickories (Diggs et al. 2006). Henri Joutel, a member of LaSalle's expedition from 1684–1687, described the area just east of the Trinity River in Houston County approximately 120 km north of CBC, as a "country of valleys and hills of medium height on which there were many trees, mostly oak and walnut … where we saw tall pine groves. The pine trees are quite lovely and very straight, but their cones are very small" (Foster 1998). The Marques dé Rubí describes the same area in 1767 with "thick growths of pine, castaño (translated to chestnut, probably chinquapin and/or hickories), oak, and walnuts draped with grapevines (Foster 1995). The earliest account of the vegetation of Montgomery County is by William Bollaert, who travelled through the area in 1843 (Hollon & Butler 1956). He wrote on his initial entry after crossing Lake Creek, which is the southern boundary of CBC, "There are great trees in the country, particularly the cypress, sycamore, walnut, peccan (sic), and they must be of great age. The pine grows in this country to a great height, say 150 to 200 feet" (Hollon & Butler 1956). He also described his friend Robert Robson Esq's. estate near the town of Montgomery as being situated in one of the "numberless pine barrens," which he later describes as "lands partaking of the forest and prairie" (Hollon & Butler 1956). CBC is located

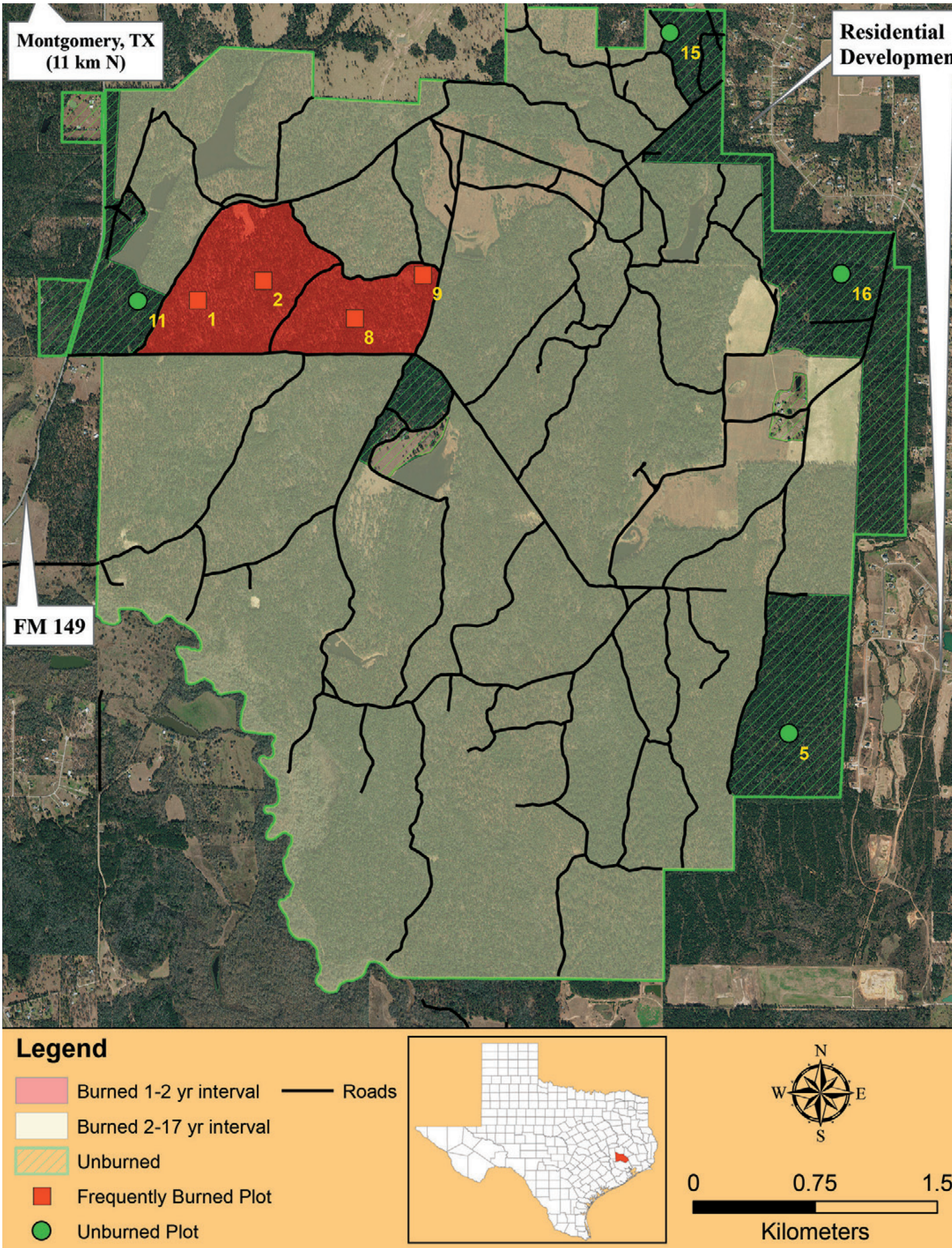

Fig. 1. Fire Monitoring Handbook (FMH) vegetation monitoring plot locations (numbered) including burn management history on Cook's Branch Conservancy, Montgomery County, Texas. Aerial imagery is 2015 Texas Orthoimagery Project (TOP) Natural Color.

approximately 80 km west of the known historical and current range of longleaf pine (*Pinus palustris* Mill.) (Bridges & Orzell 1989; Diggs et al. 2006).

The current vegetative cover is predominately shortleaf pine, loblolly pine (*Pinus taeda*), and various oak species (*Quercus* L. spp.), creating a matrix of mixed pine-hardwood and hardwood-pine forest types, with an understory composed primarily of yaupon holly (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), and a diverse assemblage of other woody species and herbaceous species in habitats receiving prescribed burn treatments. A complete forest inventory of the property in 2001 recorded the average age of each mature forest stand to be 81 years, with very few older than 90 years, indicating the property was essentially clear-cut in approximately 1920. The forest habitat in the study area is a mosaic of the Loblolly Pine-Oak Series and Shortleaf Pine-Oak Series (Diamond et al. 1987; Texas Natural Heritage Program 1993) and more narrowly defined by three intergrading forest plant associations including the: Loblolly Pine-(Shortleaf Pine)-Southern Red Oak (*Quercus falcata*)-Black Hickory (*Carya texana*) / Farkleberry (*Vaccinium arboreum*) Forest; Shortleaf Pine-(Loblolly Pine)-Southern Red Oak/Round-fruit Witchgrass (*Dichanthelium sphaerocarpon*) Forest; and Shortleaf Pine-(Loblolly Pine)-(Sand Post Oak (*Quercus margarettiae*), Southern Red Oak)-Black Hickory Woodland (NatureServe 2018; USNVC 2019) (Table 1). The latter community type is ranked as a G2 community, meaning that it is considered "imperiled globally because of a high risk of extinction due to a very restricted range, very few populations (<20), steep declines, or other factors" (NatureServe 2018). The property lies within the San Jacinto River Basin and is bounded along the south by Lake Creek, which originates in Grimes County to the northwest near the town of Shiro and empties into the West Fork San Jacinto River southwest of the city of Conroe. Five perennial streams transect the property and flow in a southerly direction where they join Lake Creek including Cook's Branch for which the property is named. In addition, there are eight man-made lakes on the property, and an eight-foot tall net-wire fence bounds the property. The terrain is gently rolling to flat and the most prevalent soils are Conroe Loamy Fine Sands (CoC) and Boy Fine Sands (Bo) (McClintock et al. 1972). The parent geology is Pliocene aged clay, silt, sand, and siliceous granule to pebble gravel deposits of the Willis Formation (Bureau of Economic Geology 1992; McClintock 1972).

Montgomery County, where CBC is located, lies within the humid, subtropical belt that extends northward from the Gulf of Mexico during spring, summer, and fall (McClintock et al. 1972). Average annual rainfall of 120 centimeters occurs along a gradient from higher precipitation to the east and lower precipitation to the west (NESDIS 2018). The following climatic information is from Montgomery County weather station (Montgomery) for the years 1980–2010, unless otherwise noted. The mean annual temperature is 19.7°C. Winters are generally mild with temperatures for January ranging from a mean daily low of 4.4°C to a mean daily high of 16.3°C. Summers are hot and humid, with mean daily extremes for August of 22°C and 34.5°C. The growing season averages 270 days, and typically runs from early March to mid-November (McClintock et al. 1972). Average monthly rainfall varies from 6.9 cm in July to 13.9 cm in October with an average of 9.9 cm monthly. Rainfall is somewhat evenly distributed throughout the year; however, temperature and precipitation vary greatly from year to year with significant short-term precipitation and cold weather events as well as heat waves and prolonged droughts (McClintock et al. 1972; NESDIS 2018). For the duration of this study, the average monthly rainfall of 11.7 cm was slightly above average with a high of 15 cm per month in 2017 and low of 9.1 cm per month in 2013 (NESDIS 2018).

While it is widely acknowledged that natural and anthropogenic ignition fires played a significant role in shaping the pre-European settlement landscape, some land managers continue to debate the frequency and intensity of fire and the utility of prescribed fire to mimic the pre-European settlement fire regime (Frost 1998; Stambaugh et al. 2011; Stambaugh et al. 2014). This paper presents an initial analysis of CBC data spanning six years to begin to determine the effects to vegetation in frequently burned upland pine-hardwood forests. Continued monitoring of these plots and others on the property are ongoing.

TABLE 1. Total (standard error = S.E.) basal area (m^2/ha) of all overstory species as recorded in eight 50 m × 20 m plots from 2012 to 2017.

Species	Unburned (BA=m^2/ha)						Frequently Burned (BA=m^2/ha)					
	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
Carya texana	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Liquidambar styraciflua	0.8	0.8	0.8	0.9	0.9	0.9	0.4	0.4	0.5	0.5	0.5	0.6
Nyssa sylvatica	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Pinus echinata	1.0	1.0	1.1	1.1	1.1	1.2	5.8	5.3	5.1	5.3	5.4	5.5
Pinus taeda	11.5	11.6	12.2	12.7	13.5	13.2	11.8	11.9	12.0	12.5	12.8	12.9
Quercus alba	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2
Quercus falcata	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.2	0.2	0.2	0.2	0.2
Quercus margarettiae	1.1	1.1	1.1	1.2	1.2	1.2	0.5	0.5	0.5	0.6	0.6	0.6
Quercus nigra	0.8	0.8	0.9	1.0	1.0	1.0	0.9	0.9	1.0	1.0	0.6	0.6
Quercus pagoda	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.7	0.8	0.8	0.8
Ulmus alata	1.2	1.2	1.3	1.3	1.3	1.4	0.5	0.5	0.5	0.5	0.6	0.6
Total BA	17.5	17.7	18.5	19.2	20.1	20.0	21.7	21.1	21.2	22.2	22.2	22.4
S.E.	10.4	10.6	9.9	10.6	11.7	10.9	7.1	8.0	9.2	8.0	9.4	9.1
Species Richness (Avg./plot)	6.0	6.0	6.0	6.0	6.3	6.3	7.0	7.0	7.3	7.3	7.0	7.0
S.E.	1.1	1.1	1.1	1.1	0.9	0.9	0.6	0.6	0.8	0.8	0.7	0.7

METHODS

The objective of this project was to compare vegetational changes in frequently burned and unburned upland pine-hardwood forests over a six year period by resampling eight forest FMH vegetation monitoring plots originally established and sampled in 2012 (USDI 2003) (Fig. 1). All eight plots are located in a mosaic of the three intergrading upland pine-hardwood forest communities described in the Introduction, and all eight plots occur on gently undulating uplands over Conroe loamy fine sands (McClintock 1972). The four burn plots were selected because they were the only four plots on the property receiving nearly annual prescribed burn treatments while the four unburned plots were selected because they were the only four not burned. Most of the remaining upland areas on the property are burned on two to four year rotations (Fig. 1). Data collected during this study will continue to be used to monitor long term vegetational changes throughout CBC that occur from management activities such as prescribed burning, mechanical mulching, herbicide treatments, and selective harvests. In the frequently burned plots and prior to initial sampling, the plots had received fire in different seasons and on seven occasions including 2003, 2005, 2006, 2007, 2009, 2010, and 2011.Subsequently, these plots were burned in February 2012, February 2013, August 2014, February 2016, and March 2017 (Fig. 2). In November 2014, a native seed mix, comprised primarily of little bluestem (*Schizachyrium scoparium*), was planted in 2 m wide rows with a no-till seed drill. These plantings occurred near (± 20 m), but not within one of the frequently burned plots. With the exception of one plot (#16) that had some very old burn scars at the base of some trees, the unburned plots have not received prescribed burn treatments or experienced any wildfires in more than twenty years (Figs.1 & 3). One of the plots (#15) with no evidence of recent burning suffered substantial wind-throw damage from Hurricane Ike that made landfall in October 2008 and was salvaged for merchantable timber (Fig. 1). No other management activities have occurred in the remaining three plots since the late 1990s.

Plot sampling for this study was conducted once during the growing season from June to October in each year from 2012 to 2017. While it would have been ideal to sample vegetation during the same month in each year, sampling efforts were often adjusted to record vegetation during peak recovery following fires or accelerated because of planned burns during the growing season. All plants growing in plots during sampling were recorded including those in a vegetative condition and spring annual species that had withered. Stem counts rather than individual plants were recorded for shrub, vine, and herbaceous species in order to more accurately detect changes from resprouting individuals following prescribed burns. Many of the perennial species

Fig. 2. Frequently burned plot: 18 October 2012 and 25 July 2017. Notice increase in cover of grasses in 2017 photograph.

Fig. 3. Unburned plot: 14 October 2012 and 1 August 2017. Notice dense understory of *Ilex vomitoria* (small glossy leaves) and apparent reduction of *Callicarpa americana* (larger light green leaves) in 2017 photograph.

recorded in plots vigorously resprout following fires and counting resprouting individuals as one plant would have presented misleading and inaccurate assessments of changes to the vegetation. Vegetation was analyzed and quantitatively described as outlined in USDI (2003) and FEAT/Firemon Integrated (FFI) software (FFI 2009) using the following specific protocols (Fig. 4). Data for overstory trees greater than 15 cm at diameter at breast height (dbh, 1.37 m above ground level) were collected in the entire 50 m × 20 m plot. Pole tree (2.5 cm to 14.9 cm dbh) data were collected in a 20 m × 10 m plot (all of Q1). Seedling tree (< 2.5 cm dbh) data were collected in a 10 m × 5 m plot within Q1. Data for shrub and woody vine transects were collected on a 1 m wide transect. All shrub and woody vine species, but not including tree species recorded in the tree plots, were recorded. Point-line intercepts were counted for all species, except tree species over 2 m tall. However, shrub and woody vine species over 2 m in height and in the canopy above the 2 m sampling rod, but not coming into contact with the rod, were not counted. Herbaceous data were collected using a 1 m square at ten locations (9 m, 19 m, 29 m, 39 m and 49 m) along two 50 m transects. Canopy cover data were collected at each plot corner (Q1–Q4) and at the plot origin using a canopy densiometer (Ganey & Block 1994) (Appendix 1). Digital photographs were taken in each plot following protocols outlined in USDI (2003). Point-biserial correlation coefficients were calculated using the Indicspecies package (De Cáceres & Legendre 2009; De Cáceres et al. 2011) in Program R (The R Foundation, Auckland, New Zealand). Standard error is presented with a ± symbol throughout the text. Nomenclature for species recorded in plots generally follows in order of precedence: Diggs et al. (2006), FNA Editorial Committee (1993+), and Turner et al. (2003). Nomenclature for families follows Stevens (2019) (Appendix 2).

RESULTS

Prior to introduction of prescribed fire at CBC, vegetation composition surrounding all eight plots was similar with dense woody understories dominated by *Ilex vomitoria* (pers. obs.). Frequent prescribed burning throughout the property created much different habitat conditions in the understory as frequently burned areas appeared much more open (Figs. 2 & 3). Overstory tree species composition remained similar in both treatment types as *Pinus taeda*, *Pinus echinata*, *Quercus margarettiae*, *Quercus nigra*, *Quercus falcata*, *Liquidambar styraciflua,* and *Ulmus alata* were the dominant overstory species. Table 1 shows all overstory tree species according to basal area (m^2/ha). Basal area is commonly used in forest management to define the area of a given section of land that is occupied by the cross-section of tree trunks and stems at their base (Elledge & Barlow 2012). Basal area was stable in frequently burned plots indicating that frequent fire is having little effect on overstory tree density and composition (Fig. 5). By 2017, canopy cover was 3.3% greater in unburned plots compared to 2012, but was not statistically significant (paired t-test, p-value = 0.2015) (Fig. 6). This difference was probably due to dense midstory trees and shrubs covering overstory gaps that obstruct the densiometer readings in unburned plots (Ganey & Block 1994).

The number of pole-sized or midstory trees was substantially less (178.8% difference) in frequently burned plots ($\bar{x}$ = 60 ± 25.8 stems/ha) vs. unburned plots (1070 ± 319.3 stems/ha). However, the number of seedlings in frequently burned plots was greater (172.8% difference) than in unburned plots ($\bar{x}$ = 39,752 ± 17,775 stems/ha vs. 2,901 ± 819 stems/ha) (Figs. 7 & 8). These values suggest that the introduction of prescribed fire caused the mortality of some pole-sized trees, but allowed for substantial germination and resprouting of seedling trees following fire. Eleven species were recorded in unburned pole-sized tree plots with only four species recorded in frequently burned plots by 2017. These four species include *Nyssa sylvatica* ($\bar{x}$ = 30 ± 14.2 stems/ha), *Pinus echinata, Quercus margarettiae*, and *Quercus nigra* (each only recorded in one plot). Both *Liquidambar styraciflua* and *Pinus taeda* were recorded in 2012, but were no longer present in pole tree plots by 2017. Conversely, the two most common species in unburned plots were *Liquidambar styraciflua* (increased from an avg. 380 ± 186.5 stems/ha in 2012 to 500 ± 304 stems/ha in 2017) and *Pinus taeda* (decreased from an avg. 340 ± 395.9 stems/ha in 2012 to 210 ± 212.1 stems/ha in 2017). These values indicate that density of pole-sized trees of these two species can be reduced by frequent fires and that increased *Liquidambar styraciflua* trees may actually decrease the density of *Pinus taeda* pole-sized trees in unburned

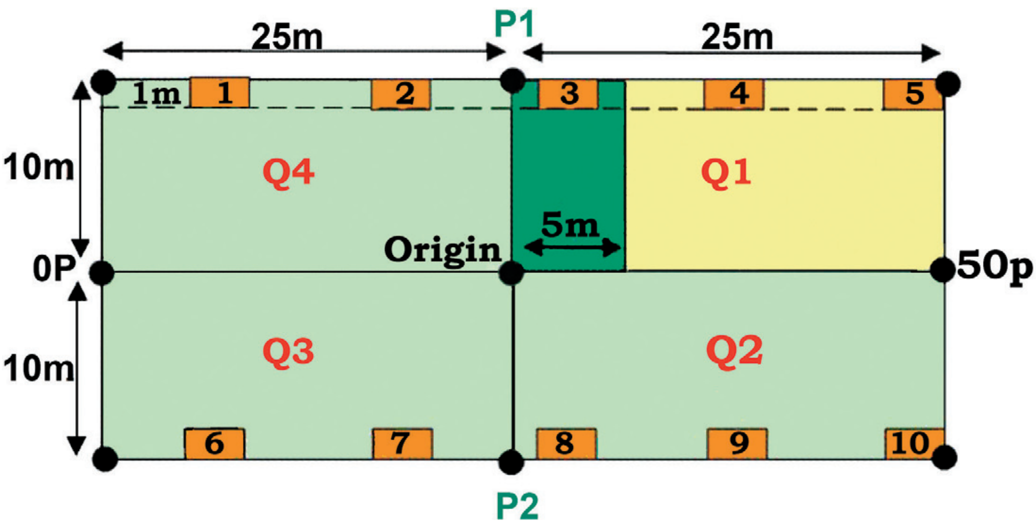

Fig. 4. Diagram of a permanent forest Fire Monitoring Handbook (FMH) vegetation plot, including overstory tree plot (Q1 through Q4), pole tree plot (Q1), seedling tree plot (dark green rectangle, shrub plot (1 m wide along Q4 to Q1 transect), herbaceous plots, (orange numbered rectangles, and point intercept transect (along edge of plot from Q4 to Q1).

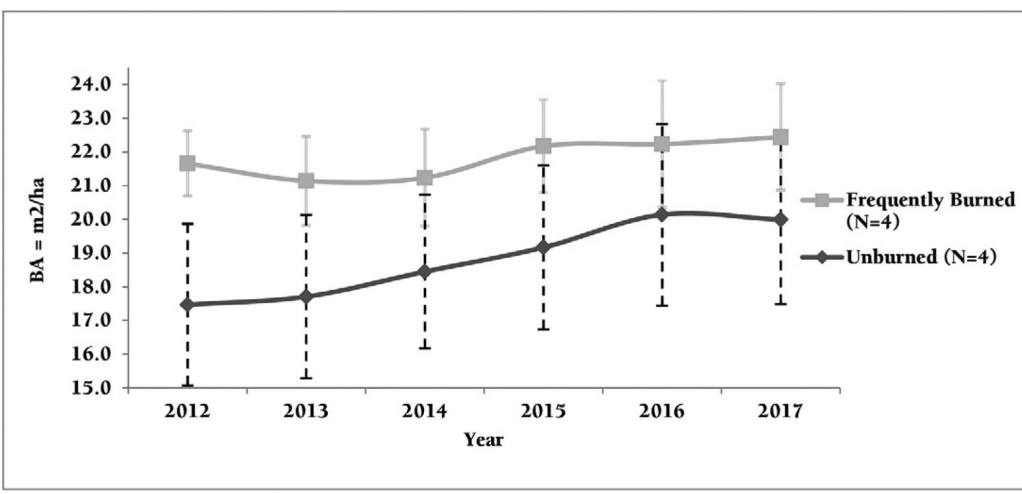

Fig. 5. Total basal area of overstory trees (> 15 cm dbh) as recorded in 50 m × 20 m plots in frequently burned and unburned plots from 2012 to 2017.

forests through interspecific competition. The number of pine seedlings (particularly *Pinus taeda*) in frequently burned plots fluctuated from year to year depending on rainfall and time since the last fire, while unburned plots typically had few to no pine seedlings in any given year. *Pinus taeda* seedlings in frequently burned plots fluctuated from 350 ± 231 stems/ha in 2013 to 621,449 ± 340,346 stems/ha in 2015 while only two *Pinus taeda* seedlings were recorded in one unburned plot on one occasion in 2017. The most abundant seedling trees recorded in frequently burned plots other than *Pinus taeda*, were *Pinus echinata* (5,400 ± 7,071 stems/ha), *Quercus nigra* (4,400 ± 2,641 stems/ha), *Liquidambar styraciflua* (3,650 ± 2,051 stems/ha), and *Ulmus alata* (2551 ± 1,696 stems/ha). The most abundant species in unburned plots was *Quercus nigra* (1200 ±

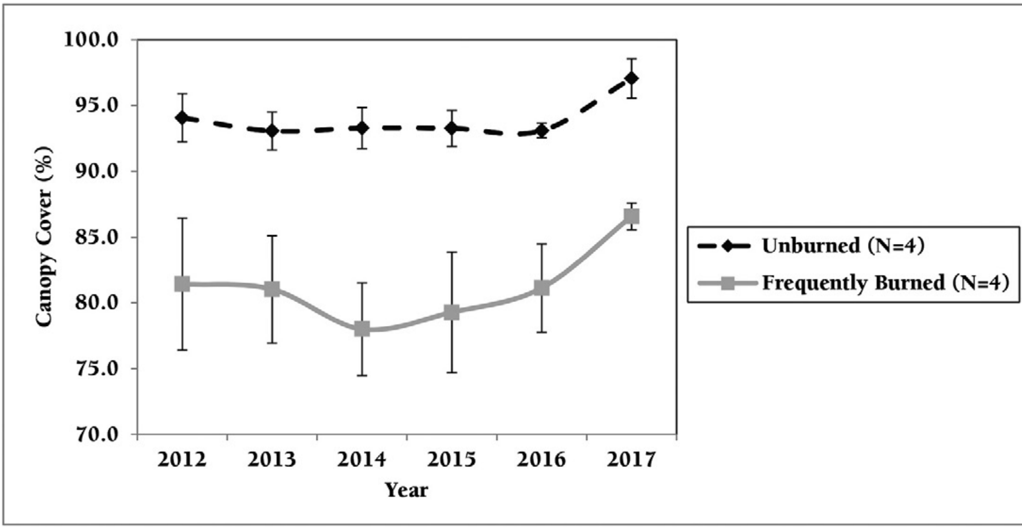

Fig. 6. Canopy cover values in frequently burned and unburned plots from 2012 to 2017.

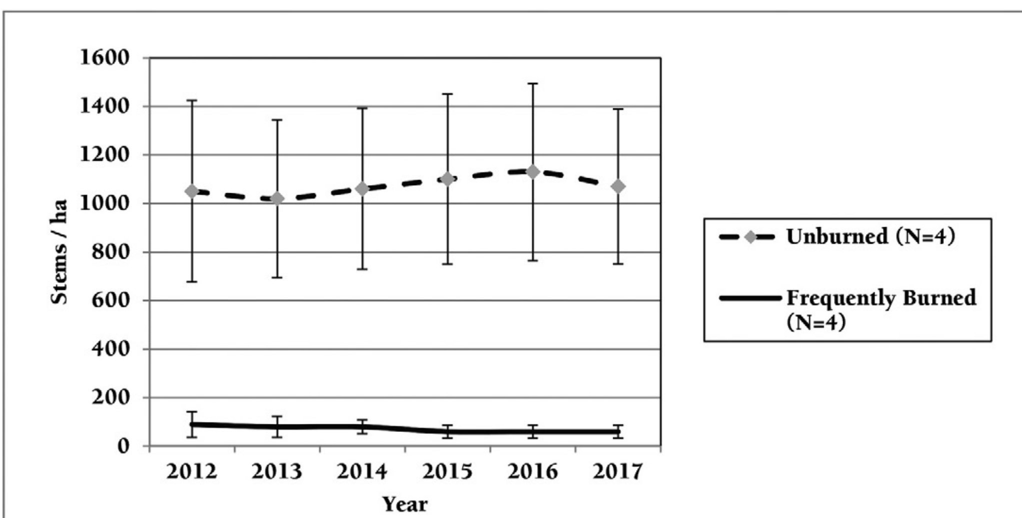

Fig. 7. Density, as expressed in stems/ha, for all pole-sized trees (2.5 cm to 15 cm dbh) in frequently burned and unburned plots from 2012 to 2017.

744 stems/ha), *Liquidambar styraciflua* (800 ± 577 stems/ha), *Nyssa sylvatica* (250 ± 212 stems/ha), and *Quercus phellos* (100 ± 0 stems/ha).

Similarly to seedling tree densities, shrub transect stems were also considerably greater (80.6% difference) in frequently burned plots than in unburned plots (159,050 ± 39,174 stems/ha vs. 67,701 ± 13,354 stems/ha) because of the greater number of stems growing from root bases following burning (Fig. 9). Species recorded in shrub transects include all woody species that do not regularly grow to 15 cm in diameter (tree species), but include woody vines (vine species that retain above ground stems from year to year). Point-biserial correlation analysis showed 3 statistically significant species correlated with frequently burned plots

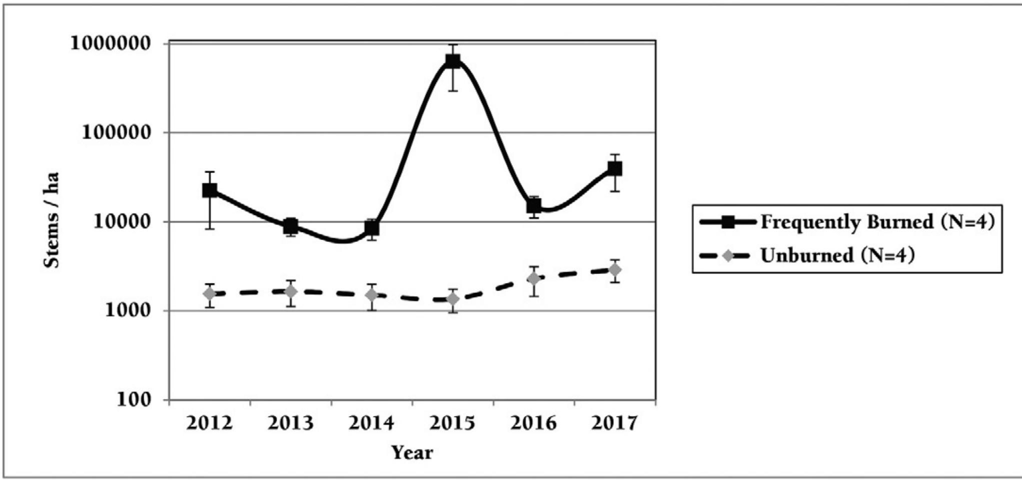

Fig. 8. Density, as expressed in stems/ha, for all seedling trees (< 2.5 cm dbh) as recorded in 10 m × 5 m plots in frequently burned and unburned plots from 2012 to 2017.

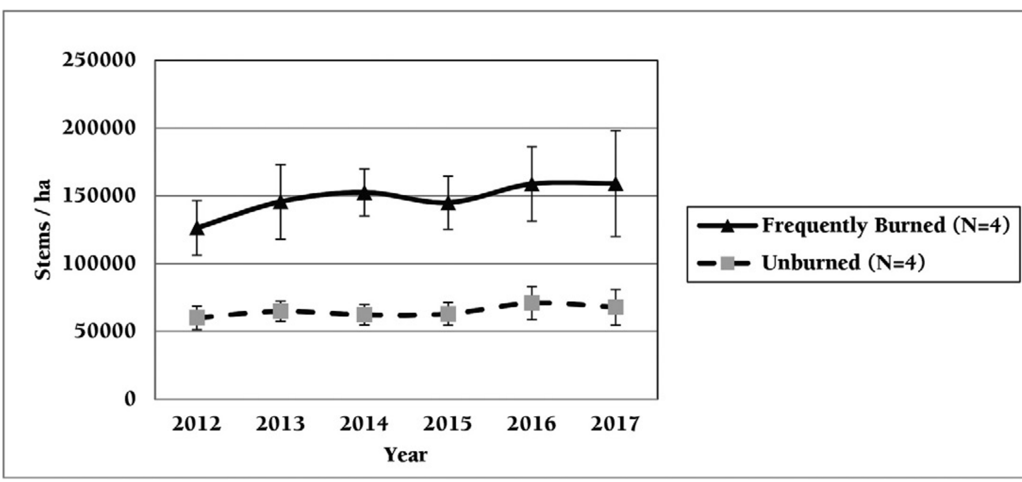

Fig. 9. Density, as expressed in stems/ha, for all shrub and woody vine species as recorded in 50 m × 1 m plots in frequently burned and unburned plots from 2012 to 2017.

and 9 correlated with unburned plots (Fig. 10). Species correlated with burned plots included *Callicarpa americana* ($r_{pb} = 0.75$, p-value = 0.0001), *Ilex vomitoria* ($r_{pb} = 0.62$, p-value = 0.0001), and *Yucca louisianensis* ($r_{pb} = 0.36$, p-value = 0.0236). By 2017, two species, *Callicarpa americana* (39,200 ± 9,509 stems/ha—burned; 8,850 ± 2,120 stems/ha—unburned) and *Ilex vomitoria* (115,700 ± 31,855 stems/ha—burned; 50,300 ± 13,709 stems/ha –unburned), accounted for 97.7% of the total stems in frequently burned plots and 87.4% in unburned plots. However, each species apparently responded differently to fire or lack thereof. In frequently burned plots, *Ilex vomitoria* increased from 91,700 ± 12,720 stems/ha in 2012 to 115,700 ± 31,855 stems/ha in 2017, but declined slightly from 120,550 ± 21,866 stems/ha in 2016. In unburned plots, *Ilex vomitoria* stems increased slowly but incrementally in each year from 38,300 ± 8,332 stems/ha in 2012 to 50,300 ± 13,709 stems/ha in 2017. Density of *Ilex vomitoria* stems was relatively stable in frequently burned plots, and

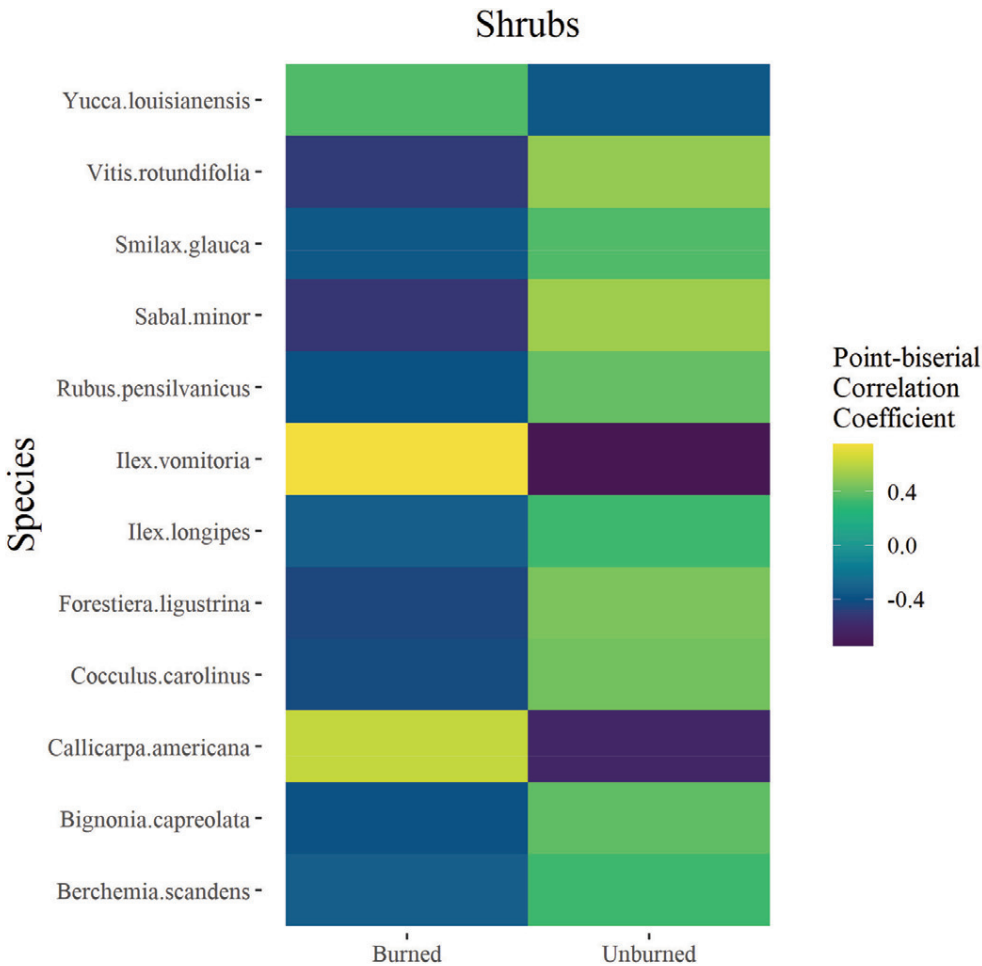

Fig. 10. Point-biserial correlation coefficient heatmap for all statistically significant ($p \leq 0.05$) shrub species as recorded in 50 m × 1 m plots in frequently burned and unburned plots from 2012 to 2017.

gradually increased in unburned plots (Fig. 11). In unburned plots, it appeared that robust *Ilex vomitoria* individuals out-compete slower growing and less robust species such as *Callicarpa americana*. Evidence of this phenomenon was observed in unburned plots where *Callicarpa americana* stems decreased incrementally each year from 14,201 ± 3,967 stems/ha in 2012 to 8,850 ± 2,120 stems/ha in 2017 and increased in frequently burned plots from 30,800 ± 9,789 stems/ha in 2012 to 39,200 ± 9,509 stems/ha in 2017 (Fig. 12). Furthermore, *Ilex vomitoria* was significantly correlated with frequently burned plots in 2012, but no longer showed statistically significant correlation in 2017 (Table 2). In contrast, *Callicarpa americana* did not initially show correlation with frequently burned plots in 2012, but did show significant correlation in 2017. This data suggests that *Callicarpa americana* is actually pyrophytic rather than being negatively affected by fire and *Ilex vomitoria*, while vigorously re-sprouting and increasing in density following reintroduction of fire, may slowly begin to decrease after many years of frequent prescribed burning.

Absolute cover values indicated all species in the understory, including tree species below 2 m in height and all shrub, woody vine, and herbaceous species. Absolute cover, as recorded in 2017, was higher (49.3% difference) in frequently burned plots, increasing from 64.4 ± 15.2% in 2012 to 108.3 ± 23% in 2017 and

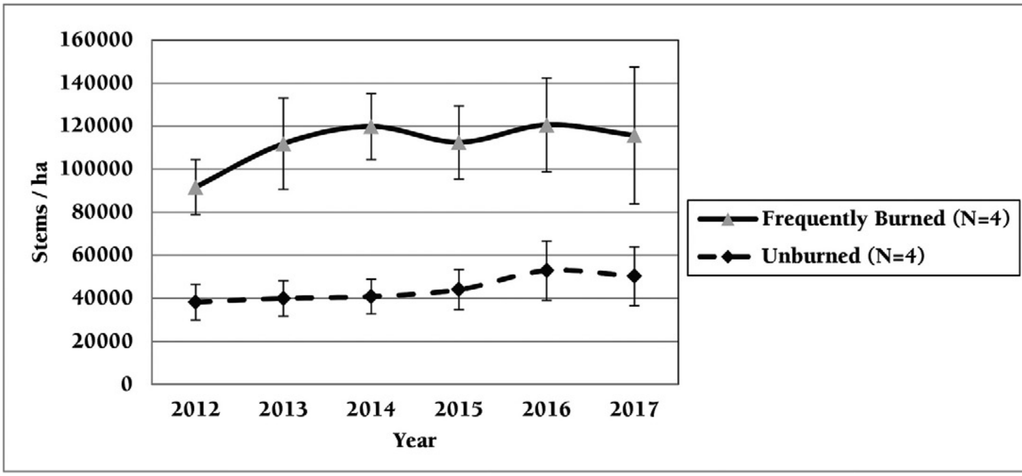

Fig. 11. Density, as expressed in stems/ha, for all *Ilex vomitoria* as recorded in 50 m × 1 m plots in frequently burned and unburned plots from 2012 to 2017.

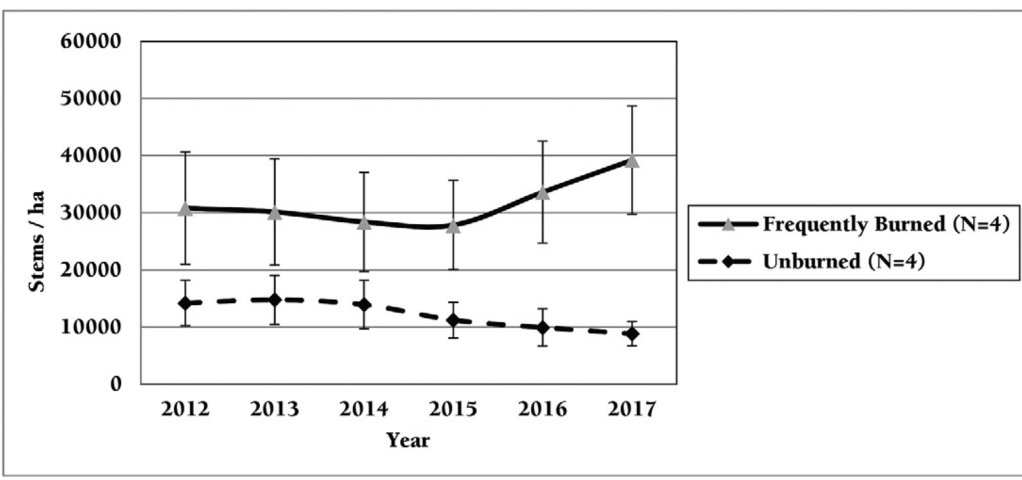

Fig. 12. Density, as expressed in stems/ha, for *Callicarpa americana* as recorded in 50 m × 1 m plots in frequently burned and unburned plots from 2012 to 2017.

decreasing in unburned plots from 80.4 ± 17% in 2012 to 65.5 ± 7.4% in 2017 (Fig. 13). These values reflect relatively dense vegetative cover with close to or greater than one species being recorded at each 0.3 m point. An absolute cover value of 100% would indicate that an average of one species was recorded at each point (USDI 2003). In frequently burned plots, the increased cover values were due to increasing number of herbaceous species colonizing while in the unburned plots, decreased cover was due to increased dominance of *Ilex vomitoria* that represented 75 % of the total cover of the plots due to interspecific competition with other species by 2017. Similarly, species richness also increased (48.3% increase) from an average of 14.5± 1.7 species in 2012 to 21.5 ± 1.6 species in 2017 in frequently burned plots but decreased (15.0% decrease) from an average of 10.0 ± 3.2 species in 2012 to 8.5 ± 1.3 species in 2017 in unburned plots (Fig. 14). As similarly recorded in shrub transects, *Ilex vomitoria* and *Callicarpa americana* represented a majority of the total absolute cover in both frequently burned (97.7%) and unburned (87.4%) plots.

Table 2. Point-biserial correlation coefficients and associated *p*-values for shrub species as recorded in 50 m × 1 m plots in frequently burned plots in 2012 vs. 2017.

Species	2012 Correlation Coefficient	2012 *P*-Value	2017 Correlation Coefficient	2017 *P*-Value
Callicarpa americana	NA	NA	0.786	0.0289
Ilex vomitoria	0.82	0.0267	NA	NA

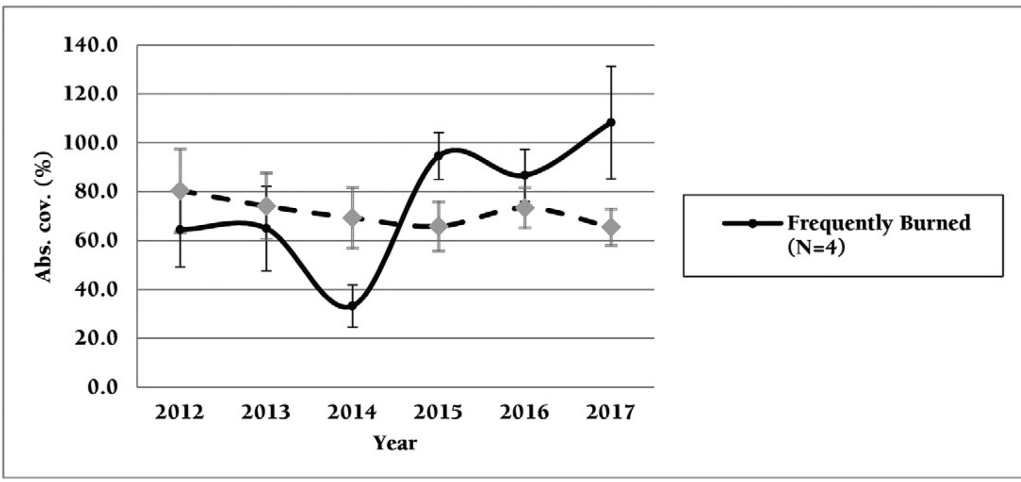

Fig. 13. Percent absolute cover for all understory species (excluding trees > 2 m in height) recorded every 0.3 m along 50 m transects in frequently burned and unburned plots from 2012 to 2017.

Herbaceous species recorded in plots included all annual, biennial, and perennial species that die above ground each year and either reemerge from seed (annuals) or resprout from root bases (biennials and perennials). Herbaceous species richness and densities are often used to measure the health of ecosystems because of their susceptibility to competition from woody species encroachment in fire-suppressed habitats (Gotelli & Colwell 2001). Herbaceous species measurements, including stems density, species richness, and species diversity, were all greater in frequently burned plots than in unburned plots. Herbaceous stem density increased from 44.0 ± 15.2 stems/m^2 in 2012 to 82.2 ± 23.3 stems/m^2 in 2017 (86.8% increase) but decreased in unburned plots from 6.0 ± 2.6 stems/m^2 in 2012 to 3.3 ± 0.9 stems/m^2 in 2017 (45.0% decrease, Fig. 15). Point-biserial correlation analysis showed 31 significant species correlated with frequently burned plots and 2 with unburned plots (Fig. 16). The top 3 species correlated with frequently burned plots were *Dichanthelium portoricense* (r_{pb} = 0.69, *p*-value = 0.0001), *Carex floridana* (r_{pb} = 0.66, *p*-value = 0.0001), and *Dichanthelium commutatum* (r_{pb} = 0.65, *p*-value = 0.0001); the 2 species correlated with unburned plots were *Lygodium japonicum* (r_{pb} = 0.35, *p*-value = 0.0221) and *Galium uniflorum* (r_{pb} = 0.23, *p*-value = 0.0497). In frequently burned plots, species richness increased from an average of 15.5 ± 1.9 species in 2012 to 30.0 ± 4.3 species in 2017 (93.5% increase), while in unburned plots, species richness remained relatively stable and increased slightly from an average of 6.3 ± 2.6 species in 2012 to 6.5 ± 2.3 species in 2017 (3.2% increase, Fig. 17). Additionally, in 2012, only *Dichanthelium laxiflorum* was significantly correlated with frequently burned plots (Table 3), however, in 2017, three additional species, *Carex complanata*, *Carex floridana*, and *Dichanthelium commutatum*, were also found to be significantly correlated with frequently burned plots and the point-biserial correlation coefficient of *Dichanthelium laxiflorum* increased from 0.785 to 0.843. These species and others that are of interest to plant ecologists and botanists are discussed below.

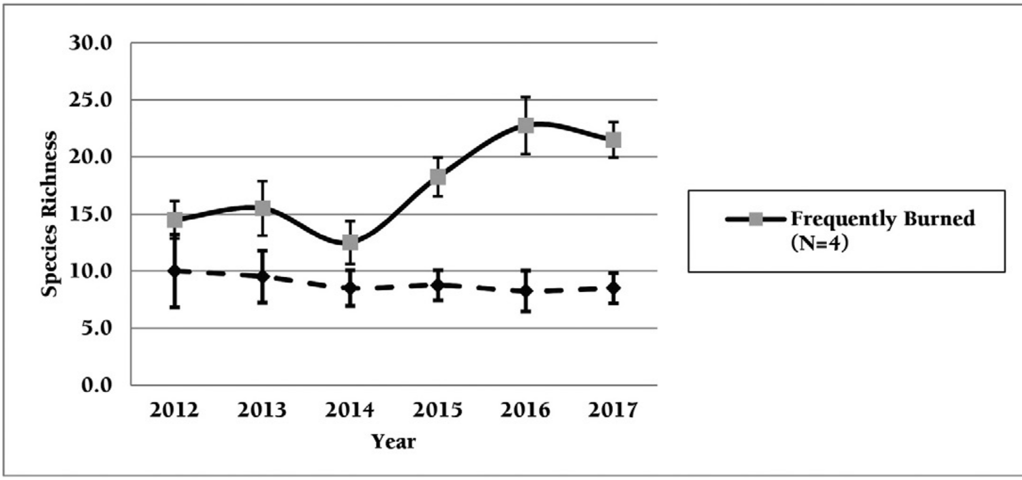

Fig. 14. Species richness for all understory species (excluding trees > 2 m in height) recorded every 0.3 m along 50 m transects in frequently burned and unburned plots from 2012 to 2017.

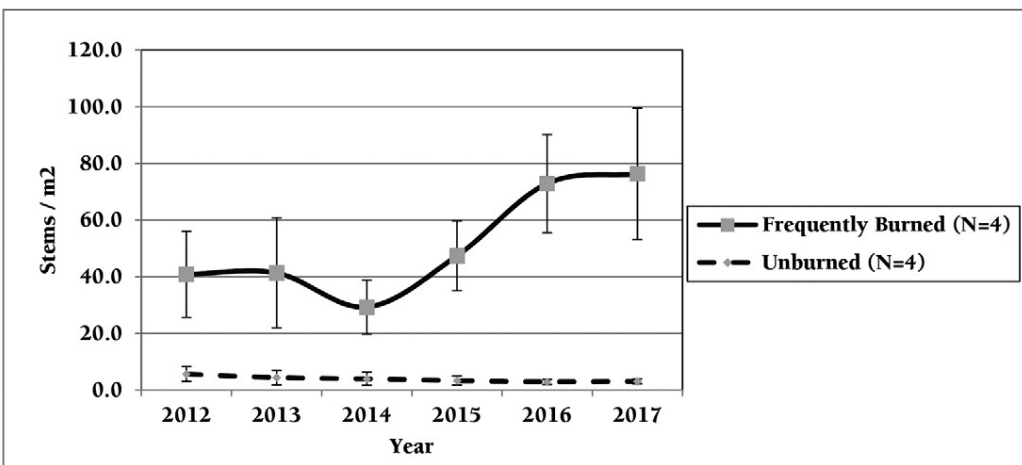

Fig. 15. Density, as expressed in stems/m^2, for all herbaceous species as recorded in ten 1 m^2 plots along two 50 m transects in frequently burned and unburned plots from 2012 to 2017.

Galium uniflorum was the only herbaceous species recorded in unburned plots that was not recorded in frequently burned plots. It gradually increased in abundance in each successive year after being recorded in plots for the first time in 2013. In Texas, this species tends to occur along stream banks, mesic slope forests, and "rich woods" and colonizes mesic and shady uplands in the absence of fire (Correll & Johnston 1970; pers. obs.).

Hypoxis wrightii was the rarest species recorded in plots during this study and was found on CBC only in frequently burned forests. It occurs throughout the Southeastern U.S. (at least, historically) and has been confirmed in five counties in eastern Texas (Diggs et al. 2006). Kartesz (2015) illustrates the species as occurring in nine eastern Texas counties. This study reports the species in Montgomery County for this first time. It was first recorded in plots along the cover transect in 2014 and in herbaceous plots in 2016 and recorded in

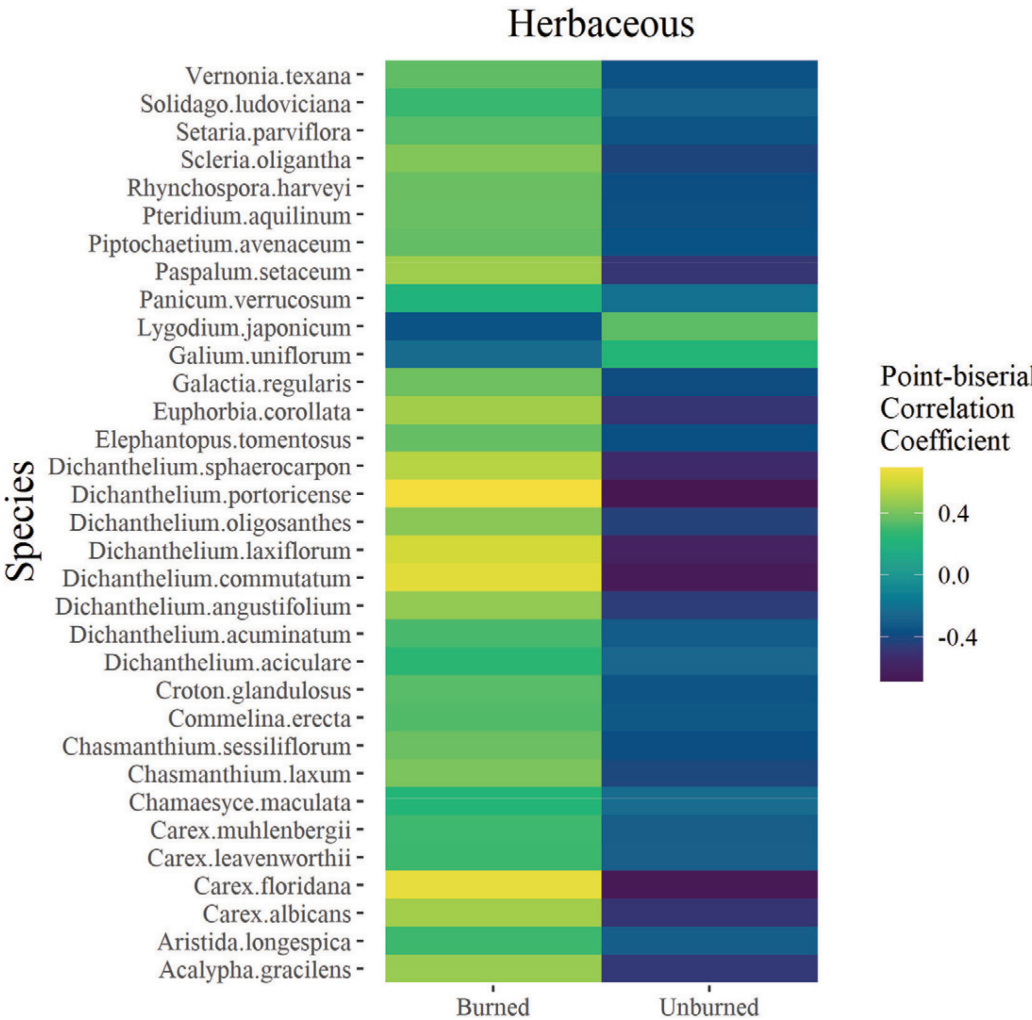

Fig. 16. Point-biserial correlation coefficient heatmap for all statistically significant ($p \leq 0.05$) herbaceous species as recorded in 10 1 m × 1 m plots in frequently burned and unburned plots from 2012 to 2017.

small numbers through 2017. This species appears to be dependent on very frequent fires (or similar disturbance) as we have only observed this species in Texas in forests that have been burned more frequently than every three years. It can be distinguished from similar species by its dull brown seeds (versus black shiny seeds) (Diggs et al. 2006).

Acalypha gracilens is an annual species that occurs throughout the eastern U.S. (Kartesz 2015) and that appears to favor habitat conditions immediately following fires and becomes much less abundant in successive years in the absence of fire (pers. obs.). When first recorded in herbaceous plots in 2012 (0.35 ± 0.09 stems/m^2), it was fairly common but scattered throughout the plots. When these plots were not burned in 2015, it had nearly disappeared (0.08 ± 0.04 stems/m^2). However, in 2016 when fire was reintroduced it became much more abundant (1.02 ± 0.38 stems/m^2) than in any other year. It was also recorded in one unburned plot in a disturbed area created by a large overturned tree (1 stem recorded in 2012 and 2015).

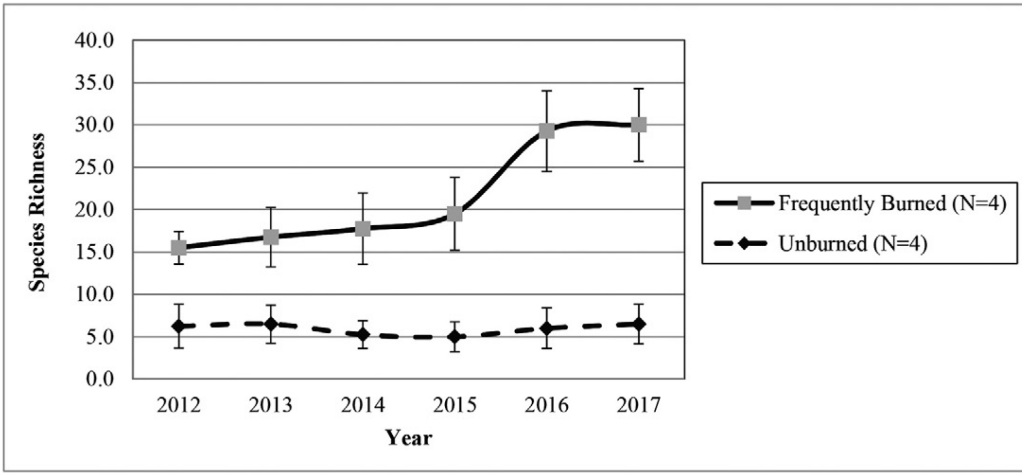

Fig. 17. Species richness for all herbaceous species as recorded in ten 1 m² plots along two 50 m transects in frequently burned and unburned plots from 2012 to 2017.

Table 3. Point-biserial correlation coefficients and associated *p*-values for herbaceous species as recorded in 10 1 m × 1 m plots in frequently burned plots in 2012 vs. 2017.

Species	2012		2017	
	Correlation Coefficient	*P*-Value	Correlation Coefficient	*P*-Value
Carex complanata	NA	NA	0.761	0.031
Carex floridana	NA	NA	0.480	0.031
Dichanthelium commutatum	NA	NA	0.858	0.031
Dichanthelium laxiflorum	0.785	0.0266	0.843	0.031

Chasmanthium sessiliflorum is a common and frequently abundant species in the understory of pine-hardwood forests throughout eastern Texas and the Southeastern U.S. (Diggs et al. 2006; Kartesz 2015). It was the most common grass species recorded in unburned plots and third most common species recorded in frequently burned plots on CBC, but declined in cover and density in unburned plots and was more abundant and increased in frequently burned plots. While the species is apparently not completely dependent on fire, our preliminary data suggest that some fire is beneficial to the species and is not harmed by very frequent fires.

Dichanthelium laxiflorum is a widespread species of the eastern U.S. and eastern half of Texas (Diggs et al. 2006; Kartesz 2015). It was the second most common species of grass recorded in both unburned and frequently burned plots. It remained stable, but in low numbers, in unburned plots (varying from 0.38 ± 0.16 stems/m² in 2013 to 0.73 ± 0.25 stems/m² in 2016), but was much more abundant and increased progressively in frequently burned plots. It increased from 3.20 ± 0.9 stems/m² in 2012 to a high of 17.90 ± 5.5 stems/m² in 2016 (16.25 ± 4.1 stems/m² in 2017). All other species of *Dichanthelium* recorded in plots follow a similar trend either persisting in low numbers or being completely absent from unburned plots and much more abundant in frequently burned plots. Other *Dichanthelium* species recorded in order of abundance include *D. portoricense, D. commutatum, D. acuminatum, D. aciculare* var. *angustifolium, D. sphaerocarpon, D. aciculare* var. *aciculare, D. oligosanthes, D. ravenellii*, *D. ovale*, and *D. consanguineum*. Diggs et al. (2006) illustrate *D. portoricense* as occuring in six counties in eastern Texas. We found this species commonly in sandy uplands throughout the property indicating that this species could be more common in Texas than previously thought, and possibly indicating that it is being misidentified as other species including *D. aciculare* and *D. dichotomum* which the species resembles superficially. *D. aciculare* var. *aciculare* and *D. aciculare* var. *angustifolium* also occurred together fairly frequently in plots and appeared unambiguously distinct and without intermediates. *D. aciculare* var. *angustifolium* is distinguished by its longer spikelets (2.4–3 mm vs. 1.7–2.3 mm) and longer (6–16 mm vs. 3.5–6 mm) and wider leaves (6–8 mm vs. 2–4 mm) (Diggs et al. 2006; pers. obs.).

Polygala polygama is a widespread perennial species of the eastern U.S. and occurring in sandy woodlands and forests in the eastern half of Texas (Correll & Johnston 1970; Kartesz 2015). This species was recorded for the first time on CBC in 2016 and was recorded in three of four (#1, #2, & #9) frequently burned plots.

Pteridium aquilinum is a widespread and highly variable species represented by numerous varieties that occur in temperate climates worldwide (Diggs & Lipscomb 2014). On CBC, it was fairly common in upland forests that receive prescribed burning treatments and relatively uncommon or absent in unburned forests, as it was not recorded in unburned plots. In frequently burned plots, it increased in absolute cover from 3.6 ± 2.1% in 2012 to 10.4 ± 2.3% in 2017 and from 0.27 ± 0.08 stems/m^2 in 2012 to 1.37 ± 1.18 stems/m^2 in 2017.

Schizachyrium scoparium is a widespread grassland species extending from Canada to Mexico and was one of the principal grasses of tallgrass prairies and open pine-hardwood forests and woodlands west of the Mississippi River (Wipff 2003; Diggs et al. 2006). Large scale planting of this species has occurred on CBC in four locations including in the frequently burned stands in November 2014. The no-till row planting near one frequently burned plot appears to have been successful with near solid coverage of grass in the planted rows. This species colonized frequently burned plots with an average absolute cover of 0.45 ± 0.21% in 2016 and increased to 1.05 ± 0.21% in 2017. It is unknown whether the plants recorded in these plots resulted from natural dispersion or as a direct result from plantings. *Schizachyrium scoparium* was present in stands near plots prior to the 2014 plantings.

Vernonia texana occurs in pinelands and scrub oak woodlands on sandy or sandy-clay soils and is known from Arkansas, Louisiana, Mississippi, Oklahoma, and Texas (Strother 2006). On CBC, it has only been recorded in frequently burned plots and has not been recorded in unburned plots. It increased in absolute cover from 0.75% in 2012 (in plot #1 only) to 2.25 ± 1.06% in 2017 (in two plots). The highest density of stems recorded followed a prescribed burn in August 2014 suggesting that the species may respond more favorably to growing season fires.

DISCUSSION

The frequently burned forest was notably more open in the understory and appeared as a forested park setting, while the unburned plots were dense with woody understory vegetation making it difficult to traverse on foot. This data analysis is part of ongoing research at CBC that will continuously monitor and quantify the vegetative changes that occur within mature forest management treatment areas including: prescribed fires conducted during various seasons and frequencies; mechanical mulching; selective herbicide treatments; selective timber harvests; and native species planting. Our data indicates that many vegetative species are dependent on frequent fires for long-term survival and few, if any, are negatively impacted. In the absence of fire, *Ilex vomitoria* creates thickets to the detriment of most herbaceous and some woody species, including *Pinus taeda* and *Pinus echinata*. Without fire or other disturbance, the pine-hardwood forests appear to gradually succeed into upland hardwood forests. Monitoring these vegetation plots will help determine whether implemented management practices are effective in maintaining pine-hardwood forests similar to those found prior to European settlement; and also continue to monitor forest succession in areas that are excluded from fire.

APPENDIX 1

DIRECT counts for each plot sampled from 2012 to 2017.

Plot #	Year	BA (m^2/ha)	# Trees	# Pole Trees	# Seedlings	# Shrubs	Veg. Cover (%)	# Species	# Herb species	# Herb stems	Canopy Cover (%)
Frequently Burned Plots											
1	2012	25.2	24	6	44	565	30.7	11	15	357	85.2
1	2013	25.4	24	5	37	653	35.5	13	18	368	85.5
1	2014	26.1	26	4	37	678	24.7	12	16	294	80.3
1	2015	26.2	25	3	881	683	62.3	15	15	462	78.7
1	2016	26.8	25	3	50	658	54.2	18	23	510	83.6
1	2017	26.9	25	3	350	625	68.7	21	25	513	87.4
2	2012	23.4	35	0	71	538	38.6	14	14	175	88.2
2	2013	23.0	34	0	72	592	55.4	11	13	216	86.6
2	2014	23.4	34	1	65	804	32.5	10	14	283	83.0
2	2015	24.4	34	0	3,436	730	72.3	18	13	408	85.9
2	2016	24.9	34	0	126	850	59.6	19	21	638	87.6
2	2017	25.0	34	0	354	971	72.3	19	21	537	87.2
8	2012	20.1	24	2	321	493	51.8	14	12	347	85.8
8	2013	17.9	23	2	44	532	28.9	16	10	177	83.0
8	2014	18.1	22	2	53	583	12.7	10	11	109	81.1
8	2015	19.3	22	2	7,927	505	65.7	17	18	313	86.0
8	2016	18.0	21	2	90	515	52.2	28	31	694	81.5
8	2017	18.2	21	2	66	345	43.4	20	35	725	88.1
9	2012	17.9	23	1	13	929	77.7	20	21	875	66.5
9	2013	18.2	23	1	25	1,135	71.2	22	25	1013	69.0
9	2014	17.3	22	1	14	984	41.6	18	30	569	67.6
9	2015	18.8	24	1	463	980	74.1	23	31	861	66.5
9	2016	19.2	24	1	36	1,151	72.9	26	42	1287	71.8
9	2017	19.6	24	1	25	1,240	86.7	26	40	1501	83.6
Unburned Plot											
5	2012	11.1	19	11	2	424	91.6	19	14	135	89.3
5	2013	11.3	19	11	2	432	87.3	15	13	121	90.8
5	2014	11.5	19	11	3	482	85.5	13	13	100	90.8
5	2015	11.7	19	11	4	502	84.9	10	13	75	90.8
5	2016	12.8	20	11	5	534	84.3	3	13	50	92.3
5	2017	13.0	20	11	5	538	78.3	11	13	45	99.2
1	2012	17.3	34	14	7	269	46.4	4	4	18	96.4
11	2013	17.7	34	14	7	278	50.6	4	6	11	93.1
11	2014	18.4	35	14	10	290	55.0	4	6	15	93.1
11	2015	18.5	35	14	15	305	65.7	4	5	18	93.1
11	2016	20.0	36	14	24	319	71.1	10	4	25	92.5
11	2017	20.0	36	15	24	280	51.8	5	6	47	92.9
15	2012	18.8	31	52	9	223	49.4	9	3	38	97.4
15	2013	19.0	31	46	9	291	47.6	9	4	20	97.1
15	2014	19.7	33	45	9	290	47.6	9	4	15	97.7
15	2015	20.3	34	44	9	275	47.6	9	3	12	97.1
15	2016	22.3	37	43	8	270	47.0	9	2	9	94.7
15	2017	22.2	37	41	15	281	47.6	10	2	13	96.7
16	2012	22.6	28	28	13	282	78.9	8	4	48	93.1
16	2013	22.9	28	31	15	290	74.7	10	3	33	91.2
16	2014	23.1	28	35	15	290	74.1	10	4	35	91.5
16	2015	23.3	28	38	15	291	73.5	10	4	36	92.0
16	2016	25.5	30	45	9	292	66.9	11	5	38	92.8
16	2017	24.3	29	40	15	255	51.2	8	5	23	99.4

APPENDIX 2

Taxa recorded in plots during this study.

List of taxa recorded in plots, "**FB**" indicates taxa found only in frequently burned plots, "**UB**" indicates taxa found only unburned plots, and no letters indicate that taxa was recorded in both treatment types. Non-native taxa are noted with an asterisk.

Altigiaceae
Liquidambar styraciflua L.

Amaryllidaceae
Nothoscordum bivalve (L.) Britton (FB)

Anacardiaceae
Toxicodendron radicans (L.) Kuntze

Apocynaceae
Trachelospermum difforme (Walter) A. Gray

Aquifoliaceae
Ilex longipes Chapm. ex Trel. (UB)
Ilex vomitoria Sol. ex Aiton

Arecaceae
Sabal minor (Jacq.) Pers. (UB)

Asparagaceae
Yucca louisianensis Trel. (FB)

Asteraceae
Baccharis halimifolia L. (FB)
Conyza canadensis (L.) Cronquist (FB)
Croptilon divaricatum (Nutt.) Raf. (FB)
Elephantopus tomentosus L. (FB)
Erechtites hieracifolia (L.) Raf. (FB)
Eupatorium capillifolium (Lam.) Small ex Porter & Britton (FB)
Eupatorium compositifolium Walter (FB)
Eupatorium serotinum Michx. (FB)
Gamochaeta antilliana (Urb.) Anderb.* (FB)
Gamochaeta argyrinea G.L. Nesom * (FB)
Gamochaeta pensylvanica (Willd.) Cabrera (FB)
Gamochaeta purpurea (L.) Cabrera (FB)
Pseudognaphalium obtusifolium (L.) Hilliard & B.L.Burtt (FB)
Solidago ludoviciana (A. Gray) Small (FB)
Vernonia texana (A. Gray) Small (FB)

Betulaceae
Ostrya virginiana (Mill.) K.Koch (UB)

Bignonaceae
Bignonia capreolata L. (UB)

Cistaceae
Helianthemum georgianum Chapm. (FB)
Lechea mucronata Raf. (FB)

Commelinaceae
Commelina erecta L.

Cornaceae
Cornus florida L. (UB)

Cyperaceae
Bulbostylis ciliatifolia (Elliott) Fernald (FB)
Carex albicans Willd. ex Spreng.
Carex complanata Torr. & Hook.
Carex flaccosperma Dewey
Carex floridana Schwein. (FB)
Carex leavenworthii Dewey
Carex muhlenbergii Kunth ex Boott
Carex retroflexa Muhl. ex Willd. (FB)
Cyperus echinatus (L.) Alph.Wood (FB)
Cyperus hystricinus Fernald (FB)
Cyperus retrorsus Chapm. (FB)
Rhynchospora harveyi W.Boott (FB)
Rhynchospora recognita (Gale) Kral (FB)
Scleria ciliata Michx. (FB)
Scleria oligantha Michx.

Dennstaedtiaceae
Pteridium aquilinum (L.) Kuhn (FB)

Ericaceae
Vaccinium arboreum Marshall

Euphorbiaceae
Acalypha gracilens A. Gray
Croton capitatus Michx. (FB)
Croton glandulosus L. (FB)
Euphorbia corollata L.
Euphorbia maculata L. (FB)
Tragia urticifolia Michx.
Triadica sebifera (L.) Small *

Fabaceae
Albizia julibrissin Durazz.* (UB)
Centrosema virginiana (L.) Benth. (FB)
Clitoria mariana L. (FB)
Erythrina herbacea L.
Galactia regularis (L.) Britton & al. (FB)
Galactia volubilis (L) Britton (FB)
Lespedeza repens (L.) W.P.C. Barton
Strophostyles umbellata (Willd.) Britton (FB)
Stylosanthes biflora (L.) Britton & al. (FB)

Fagaceae
Quercus alba L.
Quercus falcata Michx
Quercus incana Bartram
Quercus margarettiae (Ashe) Small
Quercus nigra L.
Quercus pagoda Raf.
Quercus phellos L. (UB)

Hypericaceae
Hypericum hypericoides (L.) Crantz

Hypoxidaceae
Hypoxis wrightii (Baker) Brackett (FB)

Juglandaceae
Carya texana Buckley

Juncaceae
Juncus dichotomus Elliott (FB)

Lamiaceae
Callicarpa americana L.
Trichostema dichotomum L. (FB)

Lauraceae
Sassafras albidum (Nutt.) Nees (FB)

Lygodiaceae
Lygodium japonicum (Thunb.) Sw.*

Menispermaceae
Cocculus carolinus (L.) DC. (UB)

Molluginaceae
Mollugo verticillata L. (FB)

Nyssaceae
Nyssa sylvatica Marshall

Oleaceae
Chionanthus virginicus L.
Fraxinus americana L. (UB)
Forestiera ligustrina (Michx.) Poir.

Oxalidaceae
Oxalis dillenii Jacq.

Passifloraceae
Passiflora lutea L.

Pinaceae
Pinus echinata Mill.
Pinus taeda L.

Plantaginaceae
Scoparia dulcis L. (FB)

Poaceae
Agrostis hyemalis (Walter) Britton, Sterns & Poggenb. (FB)
Andropogon virginicus L. (FB)
Aristida longespica Poir. (FB)
Aristida purpurascens Poir. (FB)
Chasmanthium laxum (L.) H.O. Yates
Chasmanthium sessiliflorum (Poir.) Yates
Dichanthelium aciculare (Desv. ex Poir.) Gould & C.A.Clark
Dichanthelium aciculare var. *angustifolium* (Elliott) S.L. Hatch
Dichanthelium acuminatum (Sw.) Gould & C.A.Clark
Dichanthelium commutatum (Schult.) Gould
Dichanthelium consanguineum (Kunth) Gould & C.A.Clark (FB)
Dichanthelium laxiflorum (Lam.) Gould
Dichanthelium oligosanthes (Schult.) Gould
Dichanthelium ovale (Elliott) Gould & C.A.Clark
Dichanthelium portoricense (Desv. ex Ham.) B.F.Hansen & Wunderlin
Dichanthelium ravenelii (Scribn. & Merr.) Gould (FB)
Dichanthelium sphaerocarpon (Elliott) Gould
Digitaria ciliaris (Retz.) Koeler (FB)
Panicum brachyanthum Steud. (FB)
Panicum verrucosum Muhl. (FB)
Paspalum notatum Flüggé * (FB)
Paspalum setaceum Michx.
Piptochaetium avenaceum (L.) Parodi (FB)
Schizachyrium scoparium (Michx.) Nash (FB)
Setaria parviflora (Poir.) M.Kerguelen (FB)
Sorghastrum elliottii (C.Mohr) Nash (FB)
Tridens flavus (L.) Hitch. (FB)
Vulpia octoflora (Walter) Rydb. (FB)

Rhamnaceae
Berchemia scandens (Hill) K.Koch
Frangula caroliniana (Walter) A. Gray (UB)

Rosaceae
Prunus serotina Ehrh. (FB)
Rubus pensilvanicus Poir.
Rubus trivialis Michx.

Rubiaceae
Galium uniflorum Michx. (UB)
Oldenlandia boscii (DC.) Chapm. (FB)
Oldenlandia uniflora L. (FB)

Sapotaceae
Sideroxylon lanuginosum Michx.

Scrophulariaceae
Polypremum procumbens L. (FB)

Smilacaceae
Smilax bona-nox L.
Smilax glauca Walter
Smilax smallii Morong

Ulmaceae
Ulmus alata Michx.

Vitaceae
Parthenocissus quinquefolia (L.) Planch.
Vitis rotundifolia Michx.

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