FREQUENCY AND SEASON OF PRESCRIBED FIRE AFFECT UNDERSTORY PLANT COMMUNITIES IN LONGLEAF PINE STANDS

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ABSTRACT

Prescribed fire research on the Kisatchie National Forest in Louisiana spanned the last 7 decades and led to a greater understanding of fire behavior and the importance of fire in longleaf pine (*Pinus palustris* Mill.) stands. Early research focused on management of the bluestem (*Andropogon* spp. and *Schizachyrium* spp.) range for livestock forage. Because of its tolerance to fire, range burning favored longleaf pine over other woody plants making the establishment of pure longleaf pine stands possible once feral hogs were controlled and other livestock placed under management. Through its continued application, fire greatly influenced the production and composition of the overstory and midstory plant communities, and both the frequency and season of prescribed burning affected herbaceous plant production. The importance of frequency and season of prescribed burning is discussed using both past and recent research results.

INTRODUCTION

The bluestem (*Andropogon* spp. and *Schizachyrium* spp.) range extended from northwestern Florida and southern Alabama to eastern Texas, and occupied primarily the Gulf Coastal portion of the longleaf pine (*Pinus palustris* Mill.) -- slash pine (*P. elliottii* Engelm.) timber type (Grelen 1974). It included about four million hectares in 1935. By the 1930s, uncontrolled harvesting had denuded most of the original longleaf pine within the bluestem range of the West Gulf Coastal Plain. The remaining vegetation was being burned too frequently, heavily grazed by cattle, foraged by feral hogs (*Sus scrofa*) and other livestock so that tree reproduction could not establish naturally (Hopkins 1947, 1948, Wade and others 2000). For example, a feral hog (first introduced 470 years ago by DeSoto) could strip the root bark from 200 to 400 uprooted longleaf pine seedlings per day. The problem was so severe in the West Gulf region that Hopkins (1947, 1948) recommended slash pine as a replacement for longleaf pine because slash pine roots were less desirable to hogs. Longleaf pine management became possible once feral hogs were controlled and other livestock placed under management. Because of the history of range use for forage, however, much of the range remained under livestock management in the West Gulf region, although range grazing has now largely ceased across the South (Grelen 1978).

Even after livestock damage was no longer considered as serious a problem, artificial reforestation efforts across the South focused on establishing loblolly (*P. taeda* L.) and slash pine rather than longleaf pine because foresters mistakenly believed that longleaf pine could not be artificially regenerated (Croker 1989). Nevertheless, longleaf pine still recovered naturally where advanced regeneration and seed trees were present on some forestlands (Haywood and others 2001), albeit on only a fraction of longleaf pine's native sites (Landers and others 1995, Outcalt and Sheffield 1996, Brockway and others 2005).

Research in the bluestem range began on the Kisatchie National Forest during the mid-1940s and originally emphasized the effects of prescribed burning on range resources and herbage quality (Campbell and others 1954; Duvall 1962; Duvall and Whitaker 1964; Grelen and Epps 1967a, 1967b). Cattlemen burned the range to remove litter and suppress brush development so that the production and quality of fresh herbage, primarily grasses, could be increased (Duvall 1962, Duvall and Whitaker 1964). Burning was done in March to obtain fresh herbage at the beginning of the growing season. However, grass quality decreased through the growing season (Campbell and others 1954), and so, May burning was practiced as a way to once again obtain fresh herbage of better quality than the herbage that began growth in March (Grelen and Epps 1967a, 1967b). Rotational burning, that is a portion of the range was burned in March or May every three years, was practiced and the cattle moved between ranges to access the best quality herbage (Duvall and Whitaker 1964).

In these early range studies, longleaf pine regeneration tolerated fire and it became the dominant woody plant (Grelen 1975, 1983b). This occurred partly because during its unique grass-stage period longleaf pine seedlings growing in full sunlight reach sufficient girth to tolerate high temperatures because large tufts of needles protect the terminal bud when fire moves quickly through grass cover. Once longleaf pine seedlings emerge from the grass stage, they are more susceptible to heat injury until about 2 m tall (Bruce 1951). Nevertheless, the majority of longleaf pine

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seedlings survive while the other woody species are top killed by fire (Duvall 1962; Haywood 2009, 2011).

Prescribed fire applied repeatedly over a number of years profoundly changed forest structure and the productivity of the understory on the Palustris Experimental Forest (Grelen 1983a; Haywood 2009, 2011; Haywood and Grelen 2000; Haywood and others 2001). Both the frequency at which fires were applied, whether annually, biennially, or triennially, and the season of burning, whether in March, May, or July, were believed to be important, but demonstrating these differences required installing and monitoring field studies over many years.

STUDY FINDINGS

Herein, the results from five long-term studies are presented that support the belief that the frequency and season of burning affected overstory development, herbaceous plant production, and stocking of understory woody vegetation.

DIRECT SEEDED LONGLEAF PINE STUDY

The first study compared vegetative composition in unburned plots to plots where prescribed fire was applied over a 20-year period in a direct seeded stand of longleaf pine (Haywood and Grelen 2000). The alternative burning regimes included biennial or triennial applications of fire in either March or May. At study initiation, vegetation on the seeded site was primarily native perennial grasses, mostly bluestems, periodically prescribed burned for open-range grazing. Following seeding, longleaf pine seedlings were abundant across the area. All overtopping pines and hardwoods were girdled to form an even-aged stand of longleaf pine regeneration; however, pines outside of the study area remained as a natural seed source.

Not applying fire or any other vegetation management treatment over a 20-year period allowed volunteer loblolly pines to dominate the overstory and hardwoods to form a midstory that resulted in the near exclusion of longleaf pine trees (Table 1, Haywood and Grelen 2000). In addition, litter accumulation on the unburned plots and the greater amount of overstory cover smothered and shaded out the understory vegetation on the unburned plots. Higher overstory basal areas have been associated with less herbaceous plant production in other work as well (Grelen and Enghardt 1973; Grelen and Lohrey 1978; Wolters 1973, 1982).

Biennial burning in March resulted in the lowest longleaf pine basal area among the prescribed fire treatments, which was significantly less on plots biennially burned in March than on plots either biennially or triennially burned in May (Table 1, Haywood and Grelen 2000). The detrimental effect of biennial prescribed burning in March on the basal area of longleaf pine compared to prescribe burning in May is supported by others work. For example, Grelen (1975) reported that when prescribed fire was applied in March, it resulted in smaller longleaf pine saplings than if fire was applied in May. Haywood (2009) also reported that prescribed burning in March resulted in slower sapling and pole-size longleaf pine height and volume per tree growth than prescribed burning in May. Because biennial burning in March resulted in the least longleaf pine basal area, it also resulted in the most understory plant production, which was an outcome reported in other research as well (Grelen and Enghardt 1973; Grelen and Lohrey 1978; Wolters 1973, 1982).

PLANTED SLASH PINE STUDY

The second study began in a 4-year-old slash pine plantation in which the understory was dominated by bluestem grasses and the most abundant woody plants were wax myrtle (*Morella cerifera* (L.) Small) and southern red oak (*Quercus falcata* Michx.) (Grelen 1983a). Prescribed fire treatments, annual, biennial, or triennial burning in March or May, were applied over the next 8 years on some plots with others not being burned. Repeated fires kept brush suppressed, and Haywood and others (2000) found that annual burning suppressed the stature of wax myrtle more than biennial burning, and shrub stature was greatest when prescribed fires were applied triennially.

By stand age 12 years on the unburned plots, fire-intolerant species flourished. Blackberry (*Rubus spp*.) grew into impenetrable thickets in places, and natural loblolly pines grew as fast as the planted slash pines (Grelen 1983a). The brush suppressed herbaceous plant production on the unburned plots compared to plots annually or biennially burned in March or annually burned in May (Table 2).

On all of the prescribed burned plots, grass was the dominant understory taxon (Grelen 1983a)—primarily little bluestem (*Schizachyrium scoparium* (Michx.) Nash) and slender little bluestem (*Schizachyrium tenerum* Nees), several other bluestem (*Andropogon spp*.) grasses, many miscellaneous grasses, and a myriad of forb species. Annual burning in March resulted in significantly more herbaceous plant production than either triennial March burning or burning in May regardless of frequency (Table 2). However, the amount of herbaceous plant production was more associated with individual tree stature than with slash pine basal area, and basal area did not differ significantly among treatments (Grelen 1983a).

NATURALLY REGENERATED LONGLEAF PINE STUDY

In the third study, longleaf pine trees originated from natural regeneration. In 1962, all pine and hardwood trees and shrubs above 30-cm tall were severed and removed across the study site to help create uniform cover conditions over the entire area (Haywood and others 2001). However, scattered longleaf and loblolly pines outside the study area were seed sources. Prescribed fire was discontinued on some plots in 1961. The unburned plots were mowed and raked in 1962 and 1963 as part of a simulated grazing study, but no further treatments were applied after 1963. Plots used for the three prescribed fire treatments were biennially burned 20 times from 1962 through 1998 in March, May, or July.

After 37 years, the herbaceous plant community was nearly eliminated on the unburned plots due largely to a well-developed hardwood midstory, a large number of hardwood trees and shrubs in the understory, and accumulated litter that smothered the herbage (Table 3, Haywood and others 2001). Although pine basal area on all four treatments was comparable, on the unburned plots, loblolly pine comprised 40 percent of the basal area originating from seed from adjacent trees after the study began. There were no volunteer loblolly pines or midstory hardwoods on the three prescribed fire treatments.

Among the three months in which prescribed fire was applied, March, May, or July, there were no significant differences in herbaceous plant production (Haywood and others 2001). Plots burned in July had fewer understory trees and shrubs of shorter stature than plots burned in March. Understory woody vegetation on plots burned in May was similar to July burned plots. Haywood and others (2000) had similar results in which burning in July reduced wax myrtle stature compared to burning in March, and May burning was intermediately effective.

DELAYED BURNING IN A LONGLEAF PINE PLANTATION

The fourth study was initiated in a longleaf pine plantation beginning in the seventh growing season after planting (Haywood 2009). The understory was dominated by bluestem grasses with low scattered brush. Beginning in the seventh growing season, prescribed fire was applied biennially to plots in March, May, or July. Additionally, biennial chemical woody plant control was applied to another set of plots, and there was an untreated check.

By the fourteenth growing season, the herbaceous plant community had collapsed on the untreated and chemical woody plant control plots (Table 4, Haywood 2009). An 8-year accumulation of litter in the absence of burning was the likely reason for the decrease in herbaceous plant cover, although the greater longleaf pine basal area, i.e. stand density, on the untreated and chemical woody plant control plots than on the three prescribed fire treatments was undoubtedly a contributing factor (Grelen and Enghardt 1973; Grelen and Lohrey 1978; Wolters 1973, 1982). In addition, the percentage of tree and shrub cover in the midstory and understory of the untreated plots had a further adverse effect on percentage of grass cover when compared to the chemical woody plant control treatment. Woody vine cover was greater on the two unburned treatments than on the three prescribed fire treatments because vines commonly found in the Southeast are susceptible to heat injury.

Nevertheless, chemical or mechanical woody plant control as a supplement to prescribed burning might allow for a longer frequency between prescribed fires, but prescribed fire will still be necessary to remove litter in longleaf pine plant communities especially when large areas of forests have to be burned each year. For example, the Southern Region of the US Forest Service prescribed burned 375,000 hectares per year from 2001 through 2009 (Personal Communication. 2011. William E. Bratcher. Fire/Lands Team Leader, Kisatchie National Forest, 2500 Shreveport Highway, Pineville, LA 71360), and such a task would not be possible by mechanically removing litter because of cost and terrain restraints.

Regardless of the benefits of fire in maintaining a herbaceous plant cover, the loss in longleaf pine growth on the prescribed fire treatments was a concern (Table 4). However, fire intensities were high regardless of when the burns were conducted and averaged 700 kJ/s/m of fire front across all prescribed fires (Haywood 2009), which was four times more intense than the 173 kJ/s/m threshold recommended for low intensity fires by Deeming and others (1977). Luckily, fires are not always this intense in native grass cover (Haywood 2011).

July burning was associated with greater grass and forb cover than burning in either March or May (Table 4). Although not statistically significant, plots burned in March had the lowest longleaf pine basal area of the three fire treatments, but the cover of grasses and forbs was similar to plots burned in May.

Overall, applying prescribed fire in May was a medium treatment that produced a good combination of outcomes when considering longleaf pine development, grass and forb cover, and control of woody vines and brush. Earlier work by Grelen (1975, 1983b) also reported that May (spring) was a better time to burn than March (late winter) or July (summer) in terms of longleaf pine seedling growth because of its morphological stage of development. Sword Sayer and Haywood (2009) found that longleaf pine seedlings were in good physiological condition to recover quickly from needle loss due to scorch from May applied fires, and Haywood (2009) reported that fire intensities were lower in May than if prescribed fires were applied in March or July.

EARLY BURNING IN A LONGLEAF PINE PLANTATION

In the fifth study, prescribed fire was first applied in May of the second growing season after longleaf pine seedlings were planted, and fire was reapplied another three times

(Haywood 2011). The intensive vegetation management treatment included both pre- and post-plant herbaceous and woody plant control practices. After 10 years, the untreated plots had significantly less longleaf pine basal area but more tree and shrub cover in the understory than the prescribed burned or intensive vegetation management treatments (Table 5). Therefore, unlike the fourth study, the prescribed burned plots had greater pine basal area than the untreated plots (Tables 4 and 5). One reason was probably the lower fire intensities at study 5 than 4, in which the fire intensities averaged 512 kJ/s/m of fire front study and were only three times more intense than the 173 kJ/s/m threshold recommended by Deeming and others (1977). The vegetation management treatment had the greatest longleaf pine basal area, but prescribed burning in May resulted in the greatest herbaceous plant cover and the fewest woody vines (Table 5). Thus, applying prescribed fire in May was again a medium treatment that produced a good combination of outcomes when considering longleaf pine development, grass and forb cover, and control of woody vines and brush.

CONCLUSIONS

Burning annually in March produced more forage than burning less frequently in March or burning in May regardless of frequency because more frequent burning kept litter from accumulating and smothering fresh herbage (Duvall 1962) and March burning allowed herbage to grow for the entire growing season (Tables 1 and 2). Conversely, percentages of grass and forb cover were significantly greater on plots burned in July than earlier in the growing season in Haywood's (2009) work (Table 4). However, percent cover and production are different variables and can not necessarily be compared nor do they always result in the same conclusions (Haywood 2010).

Overstory stand development, which was expressed as basal area per hectare, also influences herbage production (Grelen and Enghardt 1973; Grelen and Lohrey 1978; Wolters 1973, 1982). In Haywood and Grelen's (2000) work, the low basal area of overstory longleaf pine was partly responsible for the high production by understory vegetation (Table 1). Pine overstory basal areas did not significantly differ among burning treatments in Haywood and other's (2001) work, and there were also no significant differences among March, May, or July burns (Table 3).

These five studies directly apply to longleaf pine plant communities in the West Gulf region, and may be applicable in grass communities outside of the West Gulf region as well. It is difficult to statistically prove treatment differences in herbaceous production and percentage of cover in prescribed fire studies because natural variation often masks apparent treatment effects. By synthesizing information from these five studies, it was shown that frequency and season of prescribed burning affect understory production. The more frequent the burning, the more productive the understory herbaceous plant community will be. Two factors that affect this outcome are overstory basal area and the density and stature of understory woody plants, and long-term fire use especially influences understory and midstory woody vegetation. March burning was associated with more woody understory plants than May or July burning, which is counterproductive if herbaceous vegetation is the primary concern. Burning in July resulted in less longleaf pine basal area than burning in May. Therefore as a compromise treatment, burning in midspring rather than late winter or summer should result in acceptable longleaf pine growth, herbaceous plant production, and control of understory and midstory woody vegetation.

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Table 1—Stand characteristics after 20 years of prescribed burning; initially, the site was direct seeded in November 1968, prescribe burned 16 months later in 1970, and the overtopping trees were felled in early 1973 to form an even-aged stand of longleaf pine regeneration (Haywood and Grelen 2000)

		Basal areas		
Treatments	Understory production[a]	Longleaf pine	Loblolly pine	Hardwoods
	(kg/ha)	(m^2/ha)	(m^2/ha)	(m^2/ha)
Unburned after 1970	< 1 b[b]	1.3 c	32.9 a	3.0 a
Biennial March burns	2027 a	9.1 bc	0 c	0.1 b
Triennial March burns	245 b	18.0 ab	0 c	0.4 b
Biennial May burns	550 b	21.3 a	1.9 b	0.2 b
Triennial May burns	339 b	24.4 a	0.2 c	0.7 b

[a] Understory vegetation was all herbaceous vegetation and woody plants less than 2.5 cm in diameter at 1.4 m above the ground.
[b] Based on Duncan's Multiple-Range Tests, columnar means followed by the same letter are not significantly different.

Table 2—Stand characteristics after 8 years of prescribed burning; the site was a 4-year-old slash pine plantation when prescribed burning began (Grelen 1983a)

Treatments	Understory condition	Herbaceous production	Pine basal area
		(kg/ha)	(m^2/ha)
Unburned	brush	205 c[a]	21.6 a
Annual March burns	grass	1123 a	17.2 a
Biennial March burns	grass	817 ab	19.3 a
Triennial March burns	grass	389 bc	20.0 a
Annual May burns	grass	651 b	22.7 a
Biennial May burns	grass	575 bc	22.3 a
Triennial May burns	grass	462 bc	21.3 a

[a] Based on Duncan's Multiple-Range Tests, columnar means followed by the same letter are not significantly different.

Table 3—Stand characteristics after 37 years of prescribed burning in a natural stand of longleaf pine, prescribed fire ceased on the unburned plots in 1961, but the other plots continued to be burned from 1962 through 1998 (Haywood and others 2001)

		Overstory basal areas		Understory	
Treatments	Herbaceous production	Pine	Hardwoods	Trees & shrubs	Average height
	(kg/ha)	(m^2/ha)	(m^2/ha)	(stems/ha)	(m)
Unburned after 1961	12 b[a]	18.4 a	8.3	19,800 ab	0.91 a
Biennial March burns	940 a	22.3 a	…	37,900 a	0.63 a
Biennial May burns	1016 a	30.2 a	…	7300 c	0.33 b
Biennial July burns	1380 a	15.1 a	…	10,900 bc	0.38 b

[a] Based on Duncan's Multiple-Range Tests, columnar means followed by the same letter are not significantly different.

Table 4—Stand characteristics after four biennial prescribed fires or biennially applied chemical weeding treatments in a 14-year-old longleaf pine plantation; treatments began in the seventh growing season and ended in the thirteenth growing season (Haywood 2009)

		Percent cover[a]			
Treatments	Longleaf pine basal area	Grasses	Forbs	Woody vines	Trees and shrubs
	(m^2/ha)	(%)	(%)	(%)	(%)
Untreated	24.1 a[b]	2 d	1 c	13 a	53 a
Biennial weeding	23.4 a	4 c	1 c	11 a	5 c
Biennial March burns	13.8 b	35 b	3 b	2 b	17 b
Biennial May burns	16.4 b	32 b	3 b	1 b	10 bc
Biennial July burns	15.5 b	44 a	9 a	1 b	8 bc

[a] Percentages were arcsine square root transformed before analysis.
[b] Based on Duncan's Multiple-Range Tests, columnar means followed by the same letter are not significantly different.

Table 5—Stand characteristics after four biennial prescribed fires applied in May or intensive vegetation management with herbicides in a 10-year-old longleaf pine plantation; the first burns were applied in the second growing season and ended in the ninth growing season and vegetation management began before planting and continued through third growing season after planting (Haywood 2011)

Treatments	Longleaf pine basal area	Percent cover[a]			
		Grasses	Forbs	Woody vines	Trees and shrubs
	(m^2/ha)	(%)	(%)	(%)	(%)
Untreated	7.1 c[b]	7 b	1 b	10 b	91 a
May prescribed fires	11.6 b	38 a	4 a	4 c	24 b
Intensive vegetation management	22.4 a	3 b	1 b	23 a	27 b

[a] Percentages were arcsine square root transformed before analysis.
[b] Based on Duncan's Multiple-Range Tests, columnar means followed by the same letter are not significantly different.