DESCRIPTION OF VEGETATION IN SEVERAL PERIODICALLY BURNED LONGLEAF PINE FORESTS ON THE KISATCHIE NATIONAL FOREST[1]

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Abstract-In January 1993, the Kisatchie National Forest and Southern Research Station began a cooperative project on two Ranger Districts to monitor how prescribed burning affects tree, shrub, and herbaceous vegetation in upland longleaf pine (*Pinus palustris* Mill.) forests in Louisiana. Longleaf pine is the dominant species on all four sites and represents 81 to 99 percent of the total stand basal area. On all four sites, the most frequently occurring herbaceous plants were pinehill bluestem (*Schizachyrium scoparium var. divergens* [Hack.] Gould), swamp sunflower (*Helianthus angustifolius* L.), and grassleaf goldaster (*Heterotheca graminifolia* [Michx.] Shinners). Despite repeated prescribed burning, canopy cover and regrowth of woody vegetation reduced the productivity and occurrence of herbaceous plants.

INTRODUCTION

The reestablishment of longleaf pine (*Pinus palustris* Mill.) on lands historically stocked by this species concerns public land managers in the Southern United States. Longleaf pine is a fire subclimax type, and prescribed burning is considered a necessary management practice, because failure to use fire allows encroachment by hardwood trees and shrubs (Boyer 1995). The formation of a closed tree and shrub canopy creates an unfavorable habitat for plants and animals that require the open and light rich environment found in periodically burned upland longleaf pine landscapes. The net effect is a poorer herbaceous plant community in terms of species richness and productivity.

Prescribed burning is used to obtain a desired future condition in longleaf forests described as open stands of pine with species rich, productive herbaceous plant communities. However, little information exists on how operational prescribed burning influences plant development, structure, and diversity in upland longleaf stands. In January 1993, the USDA Forest Service Kisatchie National Forest and Southern Research Station began a cooperative ecosystem management project on two Ranger Districts (RD) to monitor the effects of their prescribed burning programs. Results from this monitoring effort are presented.

MONITORING SITES

Sites were selected from existing stands of predominately longleaf pine that were repeatedly prescribed burned in the past and would be burned again within several months of selection. Two sites were selected on both the Catahoula and Calcasieu (originally the Vernon) RD's of the Kisatchie National Forest near Alexandria and Leesville, Louisiana, respectively. All sites were within the upland longleaf pine forest type of the humid temperate, subtropical, outer coastal plain mixed forest, and coastal plains and flatwoods Western Gulf Ecoregion of the Southern United States (McNab and Avers 1994).

The mean January and July temperatures are 10 and 28 °C on the Catahoula RD and 9 and 28 °C on the Calcasieu RD, respectively (Louisiana Office of State Climatology 1995). Annual rainfall averages 1433 mm on the Catahoula RD and 1345 mm on the Calcasieu RD and is well distributed throughout the year.

On the Catahoula RD, Stand 71 is a 15-ha stand in Compartment 71, Grant Parish, Louisiana at an average elevation of 78 m. The Ruston and Smithdale (Typic Paleudults) and Malbis (Plinthic Paleudult) sandy loams form a gently rolling upland. The compartment is intermittently prescribed burned. The last burn was in February 1993 and produced almost no crown scorch. Stand 88 is a 30-ha stand in Compartment 88, Grant Parish, Louisiana at an average elevation of 81 m. The Ruston and Smithdale sandy loams form a gently rolling upland. The compartment is prescribed burned every 2 to 3 years. The last two burns were in July 1993 and May 1995 (after the inventory) and both produced almost no crown scorch.

On the Calcasieu RD, Stand 10 is a IO-ha stand in Compartment 10, Vernon Parish, Louisiana at an average elevation of 78 m. The Briley (Arenic Paleudult) and Malbis soils form a slightly sloping upland. The compartment is prescribed burned every 2 to 3 years. The last burn was in March 1995 and produced some crown scorch that was concentrated in scattered areas within the stand. Stand 22 is a 16-ha stand in Compartment 22, Vernon Parish, Louisiana at an average elevation of 91 m. The Malbis sandy loam forms a slightly sloping upland. The compartment is intermittently prescribed burned. The last burn was in February 1994 and produced almost no crown scorch.

Vegetative cover is described in detail in the Results and Discussion Section of this paper. The burning techniques historically used in these four stands varied and included back, flank, striphead, and spot fires. The first three kinds of bum were started with either hand carried drip torches or power torches mounted on 4-wheelers. The spot fires were started with helicopter mounted ignition systems. The burns were done to improve wildlife habitat.

PROCEDURES

In each stand, 10 square 0.04-ha plots were established along transects that were laid out perpendicular to the topography. There were three or four plots along each transect. Woody plants with diameters at breast height

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(d.b.h.) >10 cm were individually tagged. Total stem heights were measured with a height instrument to the nearest 30 cm and d.b.h. was measured with a diameter tape to the nearest 3 mm. The tagged vegetation was measured in May 1996 in all four stands. In Stand 71, the last prescribed bum occurred 39 months before these measurements were taken. This period was 34 months in Stand 86, 14 months in Stand 10, and 27 months in Stand 22.

Within the 0.04-ha plots, five circular 4-m^2 subplots were established for identifying and counting trees and shrubs ≤10 cm d.b.h. One subplot was placed in the center of each quarter of the main plot, and the fifth subplot was placed in the main-plot center. Only plants with their pith at groundline within the subplot were counted. Total height and crown cover of the individual stems were measured with a height pole to the nearest 3 cm. Vines were also identified and counted but height and crown spread were not measured. The woody vegetation ≤10 cm d.b.h. was inventoried in August 1995 in Stand 71, April 1995 in Stand 66, and November 1995 in Stands 10 and 22. In Stand 71, the last prescribed bum occurred 30 months before these inventories. This period was 21 months in Stand 86, 8 months in Stand 10, and 21. months in Stand 22.

In eachstand, twelve 100-point transects were permanently located to evaluate the soil cover (bareground, litter, and vegetation) and inventory herbaceous plant species (Parker and Harris 1959). Transects were aligned perpendicular to the slope of the terrain. Each transect was 30 m long and readings were made every 30 cm. Readings at each point on the transects were made through a 2-cm diameter circular loop held about 30 cm above the ground and 30 cm from the eye. All herbaceous plants seen through the loop were identified and plant composition by absolute frequency was calculated from these tallies. Canopy cover was measured with a spherical densiometer at the beginning, middle, and end of each transect. The herbaceous vegetation was inventoried and the canopy cover was estimated in August 1995 in Stand 71, April 1995 in Stand 66, and October 1995 in Stands 10 and 22.

Current-year herbaceous biomass was clipped to groundline within seven 0.22-m^2 quadrants adjacent to each transect. The samples were oven-dried at 60 °C for at least 24 hours before determining aboveground production. Herbage production was sampled in September 1995 in Stands 71 and 66 and November 1995 in Stands 10 and 22.

RESULTS AND DISCUSSION

Woody Vegetation >10 cm d.b.h.

Table 1 displays total stocking, basal area, and canopy cover for woody plants >10 cm d.b.h. Longleaf pine was the dominant species in all stands. Based on basal area, all four stands were classed as pure longleaf pine (Helms 1996). The number of species varied. More species were present on the Catahoula RD than on the Calcasieu RD, and species other than longleaf pine represented a greater portion of the stand basal area on the Catahoula RD than on the Calcasieu RD (table 1).

Stand 71 had the greatest number of species of woody plants >10 cm d.b.h.—longleaf pine, loblolly pine (*P. taeda* L.), mockemut hickory (*Carya tomentosa* [Poir] Nutt.), flowering dogwood (*Comus florida* L.), sweetgum (*Liquidambar styraciflua* L.), southern red oak (*Quercus falcata* Michx.), post oak (Q. *stellata* Wangenh.), black oak (Q. *velutina* Lam.), and sassafras (Sassafras *albidum* [Nutt.] Nees). In Stand 66, the woody plants > 10 cm d.b.h. were longleaf pine, loblolly pine, mockemut hickory, blackgum (*Nyssa sylvatica* Marsh.), southern red oak, blackjack oak (*Q. marilandica* Muenchh.), post oak, and black oak.

In Stand 10, the only species of woody plants >10 cm d.b.h. were longleaf pine and shortleaf pine (*P. echinata* Mill.). 'In Stand 22, the woody plants > 10 cm d.b.h. were longleaf pine, loblolly pine, flowering dogwood, sweetgum, blackgum, southern red oak, blackjack oak, and tree sparkleberry (*Vaccinium arboreum* Marsh.).

Woody Vegetation ≤10 cm d.b.h.

For stems ≤10 cm d.b.h., the Catahoula RD had more tree, shrub, and vine species, more stems per hectare, and a

Table l-Number and basal area of trees and shrubs >10 cm in d.b.h. and the percentage of the stand in longleaf pine

Ranger districts and stands	Total	Longleaf pine	Total	Basal area: Longleaf pine	Basal area: Percent longleaf pine	Total canopy cover
	Stems/hectare			*m^2/hectare*		*Percent*
Catahoula RD						
Stand 71	279	*124*	*24.36*	*19.65*	*61*	*77*
Stand 66	210	*153*	*24.40*	*21.69*	*90*	*57*
Calcasieu RD						
Stand 10	*420*	*418*	*28.55*	*28.86*	*99*	56 61

greater average height of hardwood trees and shrubs than the Calcasieu RD (table 2). On the Catahoula RD, there were 16 tree and 16 shrub species in Stand 71 and 12 tree and 16 shrub species in Stand 66. On the Calcasieu RD, there were four tree and six shrub species in Stand 10 and 12 tree and 12 shrub species in Stand 22.

Overall, common tree species with stems ≤10 cm d.b.h. were red maple (*Acer rubrum* L.), flowering dogwood, sweetgum, blackgum, black cherry (*Prunus serotina* Ehrh.), southern red oak, post oak, and sassafras (table 2). Red maple was not in the overstory in any of the stands.

Table 2-Number of stems and average height (ht) of the common trees and shrubs ≤10 cm in d.b.h.-excluding longleaf and loblolly pine

	Catahoula RD stands				Calcasieu RD stands			
	71		86		10		22	
Taxa	Stems	Ht	Stems	Ht	Stems	Ht	Stems	Ht
	Per ha	*m*	*Per ha*	*m*	*Per ha*	*m*	*Per ha*	*m*
Trees								
Acer rubrum	346	1.3	2,323	0.8	—[a]	—	791	0.9
Cornus florida	2,768	.7	9,933	.6	—		49	.2
Liquidambar styraciflua	1,433	1.6	148	.3	544	.9	1,779	.9
Nyssa *sylvatica*	297	.6	2,372	1.1	198	.3	49	.2
Prunus serotina	939	2.1	1,631	.9	—	—	198	.4
Quercus falcata	2,125	.7	1,631	.6	—	—	1,087	.4
Q. *stellata*	198	.3	8,896	.5	—	—	—	—
Sassafras albidum	2,817	.6	4,893	.8	49	.2	—	—
Shrubs								
Callicarpa *americana*	5,387	1.4	3,805	1.2	—	—	297	.9
Myrica cerifera	9,489	.7	7,611	.3	99	.5	1,878	.4
Rhus copallina	3,212	.9	6,820	.5	6,128	—	494	.6
Rubus spp.	19,719	.9	9,390	.4		.4	10,181	.4
Vaccinium arboreum	544	.7	1,631	.6	346	.3	6,820	.6
V. virgatum, elliottii, and stamineum	6,870	.6	6,374	.2	2,521	.2	10,378	.3
All trees and shrubs[b]	60,146	.8	74,130	.5	10,873	.4	35,008	.4
Vines								
Berchemia scandens	10,724	—	395	—	—	—	—	—
Gelsemium sempervirens	15,963	—	10,625	—	—	—	—	—
Lonicera japonica	297	—	17,989	—	—	—	—	—
Rubus trivialis	9,340	—	26,588	—	—	—	692	—
Smilax bona-nox, glauca, rotundifolia, and *smallii*	6,030	—	13,690	—	197	—	1,680	—
Toxicodendron toxicarium	14,282	—	9,093	—	19,916	—	6,820	—
Vitis rotundifolia and *aestivalis*	5,634	—	5,337	—	—	—	1,730	—
All vines[b]	71,117	—	86,632	—	20,113	—	12,849	—

[a] Taxon was not present when inventoried or the heights were not estimated.
[b] Number of stems and average height for all trees and shrubs and number of stems for all vines include all taxa not listed in the table, except for the pines.

This may be directly related to stem die-back produced by prescribed burning because red maple does not tolerate heat injury (Haywood 1995). Other hardwoods are also adversely affected by fire (Chen and others 1975). Prescribed burning normally results in an increase in stem numbers, which are smaller in stature, than not burning because while the tops are killed back by fire the root *system* is less affected (Silker 1961). However, repeated burning especially on an annual or biennial basis will eventually reduce the number and vigor of woody stems (Chen and others 1975).

Long-term trends in vegetation development may not favor oak and hickory although these taxa are currently in the >10 cm d.b.h. class. For example, in Stand 71 there are large diameter mockemut hickory and black oak but none were found in the ≤10 cm d.b.h. class. in Stand 66, this same diameter distribution was determined for mockemut hickory, black oak, and blackjack oak. In Stand 22, mockemut hickory was in the >10 cm d.b.h. class but not in the (IO cm d.b.h. class. Because oak is generally favored by burning (Barnes and Van Lear 1998), other factors may explain its absence from the ≤10 cm d.b.h. class. The number of oaks with acceptable mast yields on these sites may be insufficient for adequate regeneration; repeated prescribed burning may be causing a gradual decline in the hardwood component; and competition may be keeping oak regeneration from establishing on these sites.

Overall, common shrub taxa were American beautyberry (*Callicarpa americana* L.), southern baybeny (*Myrica cerifera* L.), shining sumac (Rhus *copalina* L.), blackberry (*Rubus* spp.), tree sparkleberry, and other blueberries (*Vaccinium* spp.) (table 2). Stocking and average height of the shrubs varied among stands.

There were 3, 9, 15, and 12 vine species in Stands 10, 22, 71, and 66, respectively. Overall, common vine taxa were rattanvine (*Berchemia scandens* [Hill] K. Koch), Japanese honeysuckle (*Lonicera japonica* Thunb.), Carolina jessamine (*Gelsemium sempervirens* [L.] Alt. f.), dewbeny (*Rubus trivialis* Michx.), greenbtier (*Smilax* spp.), poison oak *(Toxicodendron* toxicarium [Salisb.] Gillis), and grapes (*Vitis* spp.) (table 2). Vines were more common on the Catahoula than Calcasleu RD.

The longleaf and loblolly pine sdedlings were poorly developed. The root collar diameters of longleaf seedlings were below 5 mm due to shading and competition for water and nutrients. Because these seedlings were too small to tolerate heat injury, each successive bum reduced the number of pine seedlings. However, the population recovered between bums. The number of longleaf pine seedlings still in the grass stage ranged from 600 per hectare 7 months after prescribed burning in Stand 10 to 13,100 per hectare 21 months after burning in Stand 86. The number of loblolly pine seedlings ranged from none in Stand 10 to 7,400 per hectare 30 months after burning in Stand 71. This regeneration cycle will continue until either natural processes or human intervention disrupts the structure of these stands.

Herbaceous Vegetation

On the Catahoula RD, the total current-year production was 452 kg per hectare (dry matter) in Stand 71 and 753 kg per hectare in Stand 86. On the Calcasieu RD the total current-year production was 1640 kg per hectare in Stand 10 and 1160 kg per hectare in Stand 22. The inventories in Stands 71.66, and 22 determined that no bare soil was present 21 to 30 months after burning. Following burning in Stand 10, 5 percent of the soil remained exposed 8 months after the last bum. Litter covered most of the soil surface on all sites; coverage was 98 percent in Stand 71, 90 percent in Stand 86, 80 percent in Stand 10, and 94 percent in Stand 22. Vegetative cover was 9 percent in Stand 71, 21 percent in Stand 86, 22 percent in Stand 10, and 16 percent in Stand 22.

Grasses-The grasses were the most numerous group of herbaceous plants in these four upland stands based on the absolute frequency values, i.e., the number of rooted-plant occurrences per 1,200 sampling points per stand (table 3). Species or genera of grasses numbered 24 in Stand 71, 17 in Stand 86, 25 in Stand 10, and 19 in Stand 22. Across all four sites, the two most frequently occurring grass taxa were pinehill bluestem and the low panicums (*Dicanthelium* spp.), with average frequencies of occurrence of 23 and 9 percent, respectively. Pinehill bluestem was more common on the Calcasieu RD (37 percent) than on the Catahoula RD (8 percent).

Table 3—Representative grass taxa (percent frequency of occurrence exceeded 1 percent on at least one site)

	Catahoula RD stands		Calcasieu RD stands	
Taxa	71	86	10	22
	Percent			
Andropogon gerardii	2.67	0.75	0.42	0.33
Andropogon virginicus	.33	.58	.58	1.50
Aristida purpurascens	.08	1.25	1.06	1.25
Axonopus affinis	.08	—[a]	.33	1.67
Chasmanthium laxum end *C. sessiliflorum*	2.25	2.00	—	—
Coelorachis cylindrica	.08	—	2.42	—
Dichenthelium spp.	1.50	12.67	16.25	5.67
Eragrostis elliottii and *E. spectabilis*	.25	.08	1.92	1.25
Gymnopogon ambiguus	.17	1.42	.33	.17
Muhlenbergia expansa	.08	—	.83	2.63
Panicum enceps	1.83	1 .00	1.08	.17
Panicum virgatum	1.67	.08	—	—
Paspalum *setaceum* var. ciliatifolium	—	.08	1.92	.42
Schizachyrium *scoparium* var. *divergens*	7.58	6.08	45.42	29.42
Schizachyrium *tenerum*	—	—	3.92	1.67
Sorghasfrum eveneceum	.67	1.08	—	.17
Sporobolus junceus	.33	—	.75	1.42

[a] Taxon was not present when survey was taken.

Table 4—Botanical composition of representative herbaceous plants (percent frequency of occurrence was at least 1 percent on at least one site) excluding the grasses

Taxa	Catahouia RD stands		Caicasieu RD stands	
	71	86	10	22
	Percent			
Grasslike plants				
Scleria spp.	0.42	0.08	1.41	0.17
Composites				
Helianthus angustifolius	.17	4.42	3.67	2.33
Heterotheca graminifolia	1.83	3.83	1.08	2.25
Solidago odora	—[a]	.58	2.08	—
Solidago rugosa var. *rugosa*	—	1.67	—	.17
Vemonia texana	—	.75	1.17	.17
Legumes				
All legumes	1.08	3.68	2.00	1.25
Other forbs				
Diodia teres	—	—	2.67	—
Euphorbia corollata	—	2.25	.17	.08
Mitchella repens	—	—	—	1.17
Oxalis violacea	—	1.33	—	—
Pycnanthemum tenuifolium	1.50	.17	—	—
Ferns				
Pteridium aquilinum var. *pseudocaudatum*	.17	17.25	1.50	3.08

[a] Taxon was not present when the inventory was taken.

Other herbaceous plants-The most frequently occurring grasslike plant on these four uplands was nutrush (*Scleria* spp.) (table 4). Only four grasslike species or genera were recorded across ail four stands.

Across all four stands, the two most frequently occurring composites were swamp sunflower *(Helianthus angustifolius* L.) and grassleaf goldaster *(Heterotheca graminifolia* [Michx.] Shinners) (table 4). Their combined frequency of occurrence averaged 3 percent on the Catahouia RD and 2 percent on the Caicasieu RD. Overall, the species or genera of composites numbered 9 in Stand 71, 22 in Stand 86, 17 in Stand 10, and 9 in Stand 22.

The frequency of occurrence of the legumes averaged only 2 percent on both Ranger Districts (table 4). None of the legumes were numerous but representative species were creeping lespedeza *(Lespedeza repens* [L.] Bart.), pencil flower *(Stylosanthes biflora* [L.] BSP.), and Virginia tephrosia *(Tephrosia virginiana* [L.] Pers.). Eight legume taxa were present in Stand 71, fourteen in Stand 86, nine in Stand 10, and five in Stand 22.

Although several species were recorded in the other forbs group, the only species recorded in three of the four stands was flowering spurge (*Euphorbia corollata* L.) (table 4). Taxa of the other forbs numbered 10 in Stand 71, 18 in Stand 86, 17 in Stand 10, and 4 in Stand 22.

Ferns-Bracken fern *(Pteridium aquilinum* var. *pseudocaudatum* [Clute) Heller) represented 94 percent of the total fern population in ail four stands and was most common in Stand 86 (table 4). Only two or three taxa of ferns were recorded on each site.

Table 5—Influence of woody plants on current-year herbaceous plant production

Stand description	Woody plants >10 cm in d.b.h. basal area	Trees and shrubs <10 cm d.b.h. Total	Height	Canopy cover	Current-year herbage production
	m^2/ha	Stems/ha	m	Percent	kg/ha
Catahouia RD					
Stand 71	24.4	60,146	0.8	77	452
Stand 86	24.4	74,130	.5	57	753
Caicasieu RD					
Stand 10	22.5	10,873	.4	56	1,640
Stand 22	28.5	35,008	.4	81	1,160

Effect of Woody Plants on Herbage Production

Woody plant basal area and canopy cover and the number and stature of trees and shrubs ≤10 cm in d.b.h. affected current-year herbage production on each site (table 5). Stand 71 had intermediate basal area, the greatest canopy cover, the tallest woody plants ≤10 cm d.b.h., and the least current-year production. Stand 10 had the lowest basal area and canopy cover, the fewest and shortest woody plants ≤10 cm d.b.h., and the greatest current-year production of the four sites.

Repeated prescribed burning can reduce understory woody vegetation over a number of years which may renew herbage production (Chen and others 1975, Silker 1961). However, as a pine canopy closes, the ill effects of shading by the overstory and competition for water and nutrients cannot be entirely overcome (Wolters 1962). A decline in the herbaceous community is unfortunate, because the desired future condition may not be reached. Thinning of the overstory to reduce canopy cover and continued prescribed burning to reduce small woody vegetation should improve conditions for herbaceous plant development (Grelen and Lohrey 1976).

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