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Responses of Understory Vegetation on Highly Erosive Louisiana Soils to Prescribed Burning in May

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SUMMARY

Prescribed burning is necessary to restore the herbaceous plant community normally associated with the fire-dependent longleaf pine, *Pinus palustris* Mill., ecosystem. Usually these burns are done in the winter months. However, burning during the early growing season may allow herbaceous plants to recover better than when burning is conducted during the winter months. It was hoped that the additional herbaceous growth would decrease soil movement, a problem on highly erodible hilltop glades of Kisatchie soil (Typic Hapludalfs). The effects of a May burn on soil movement and vegetation growing on two hilltop glades were monitored through one growing season. A prescribed burn on May 24, 1994, reduced vegetation and litter cover on the soil surface and the number of woody plants in the understory. This treatment also adversely affected the richness of woody plants within the herbaceous layer and initially reduced the herbaceous standing crop compared to preburn conditions. Soil movement doubled after the May burn; but in another study, a November burn had a similar effect on soil losses. Because the May burn adversely affected woody plants while maintaining the herbaceous plant community, this treatment may be preferable to winter burning on steep, highly erodible Kisatchie soils.

INTRODUCTION

The Kisatchie soil series (fine, montmorillonitic, thermic, Typic Hapludalfs) has the highest erosion potential of any series on the 243,000-ha (600,000-acre) USDA Forest Service, Kisatchie National Forest. The Kisatchie series occurs on approximately 11,400 ha (28,200 acres) of National Forest land in Louisiana, with about 12 percent on slopes of less than 5 percent, 65 percent on slopes of 5 to 40 percent, and 23 percent in gullies. This series usually has thin surface horizons, high acidity, low natural fertility, and relatively sparse vegetation, with longleaf pine, *Pinus palustris* Mill., as the dominant forest type.

Prescribed burning has been restricted on these soils for over 12 years because of reported increases in soil erosion after winter burns (Thill and Bellemore 1986). The exclusion of fire can reduce herbaceous plant productivity partly because of an accumulation of litter and development of understory woody vegetation (Haywood and Thill 1995). On hilltop glades of Kisatchie soil, only a minimum of litter accumulation occurs because there is only sparse overstory cover, but understory woody growth can still exclude herbaceous plants.

The effects of fire exclusion on ground cover and vegetation concern forest managers who are attempting to sustain and restore the floristically rich herbaceous plant community normally associated with the fire-dependent longleaf pine ecosystem. The use of fire in restoring this diverse plant community must be balanced with the need to control soil losses.

Growing-season burning may cause less soil loss than winter burning. Growing-season burns are normally followed by rapid recovery of vegetation, and an active root system may retain nutrients flushed into the mineral soil following burning.

To examine the effects of growing-season burning on Kisatchie soils, two steep, highly erodible hilltop glades and the surrounding forested areas were burned on May 24, 1994. Through the growing season, we monitored vegetation, ground cover, and herbaceous standing crops on the two burned glades. Soil movement was also monitored on the two burned glades and on two unburned glades nearby.

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METHODS

Study Areas

Two highly eroded hilltop glades were selected on the USDA Forest Service, Kisatchie National Forest, Kisatchie Ranger District in west-central Louisiana to be control-burned. Both glades were sparsely stocked with longleaf pine seedlings and saplings and some stunted loblolly pines, t? *taeda* L. The primary shrub species were scattered individual yaupon, *Ilex vomitoria* Ait., and blueberries, *Vaccinium* spp.

Vegetation Measurements

On each of the two glades burned in May 1994, the vegetation was measured on six 30-m (1 00-ft) permanent transects using line intercept methods (Canfield 1941). The transects, which were selected to represent different cover and slope conditions on the two glades, were measured in late April (preburn) and July and October (postburn) 1994. No transects for measuring vegetation were established on unburned glades.

Variables of interest included: (1) soil cover estimates for bare ground, rock, litter, and vegetation, (2) percentages of the absolute frequency of herbaceous and small woody vegetation, (3) fall flowering, (4) understory woody plant cover, and (5) herbaceous standing crop. On each measurement date, the soil cover estimates were made within a e-cm-diameter (0.75inch-diameter) circular loop (Parker and Harris 1959) at 100 evenly spaced points along a marked line stretched the length of each transect. These cover estimates were made to the nearest 5-percent increment; i.e., 0, 5, 10, . . .,100 percent. Plants within the loop were tallied and used to compute botanical composition as a percentage of the absolute frequency. On the fall measurement date, flowering (seedhead formation) was noted as being present or absent for the bluestem grasses, *Schizachyrium* spp. and *Andropogon* spp., within each loop.

On each measurement date, woody plants were identified, and ground cover to a height of 1.5 m (5 ft) was determined, over the length of each transect. The dry weight of the herbaceous standing crop was estimated by clipping seven 0.22-m^2 (2.4-ft^2) plots within 2 m (6.6 ft) of each transect, for a total of 84 plots on the two glades burned in May 1994.

Soil Movement

Previous monitoring showed that dormant-season burning of vegetation on Kisatchie soils doubled erosion losses compared to Kisatchie soils on which vegetation had not been burned (Thill and Bellemore 1986). For this reason, the current forest plan for the Kisatchie National Forest requires supervisory staff approval before vegetation on Kisatchie soils can be burned, and vegetation on severely eroded Kisatchie soils is normally excluded from burning.

Growing-season burning may result in less soil movement than dormant-season burning; therefore, we wanted to determine the amount of soil movement that occurs following growing-season burning on Kisatchie soils.

Soil movement was monitored on the two hilltop glades that were prescribed burned in May 1994 and on two nearby glades that were not burned. Stakes for monitoring soil movement were placed at representative locations on the glades 2 months before burning. These locations included gullies and side slopes. The gullies and side slopes were under two levels of overstory basal area: (1) 0 to 9.2 m^2/ha (0 to 40 ft^2/acre) and (2) over 9.2 m^2/ha (40 ft^2/acre).

Soil movement was measured by placing a mark on each stake where the soil surface touched the stake.The changes in soil level were measured monthly from April through December 1994 to determine soil accumulation or loss to the nearest 0.25 cm (0.1 in).

Prescribed Burning

The two hilltop glades were burned by personnel at the Kisatchie National Forest using standard firing methods on May 24, 1994. The initial back and flanking fires were set on the northeast side of the area at 10:00 a.m.; relative humidity was 55 percent, air temperature was 28 °C (82 °F), and wind speeds were 5 km/h (3 mi/h) from the south.The last weather data were taken at 4:30 p.m.; relative humidity was 41 percent, air temperature was 31 °C (87 °F), and wind speeds were 10 km/h (6 mi/h). Flame lengths were about 61 cm (2 ft).The mixing height was 610 m (2,000 ft), with southern transport winds of 11 km/h (7 mi/h).

Based on field observations, some litter was left after burning, 80 percent of the herbaceous fine fuels were consumed, and about 80 percent of the understory trees and shrubs were controlled. None of the longleaf and loblolly pine trees in the overstory suffered crown scorch or stem damage.

RESULTS AND DISCUSSION

Ground Cover

The changes in percentages of ground litter between April (preburn) and July (postburn) supported field ob-

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servations made during the prescribed burns (table 1). Consumption of living and dead fuels exposed more rock and bare soil on both burned glades. However, the litter layer and understory vegetation were not completely destroyed on either burned glade. Litter cover decreased on the north glade from 73 percent in April to 63 percent in July and on the south glade from 83 percent in April to 63 percent in July. There was a greater reduction in litter on the south glade than on the north glade because there were more fine fuels or litter on the south glade to carry the fire.

Vegetation cover decreased from 20 percent in April to 12 percent in July on the north glade and from 19 percent in April to 17 percent in July on the south glade (table 1). Vegetation recovered through the remainder of the growing season, and by October 31, 1994, vegetation covered 18 percent of the soil surface on both glades.

Understory Woody Plants

In April 1994, the principal understory woody plants on the two burned glades were yaupon and *V. corymbosum* L. (also known as *V. virgatum* Chapm. and *V. elliottii* Chapm.) (table 2). The north glade had a richer understory woody plant community, with a total of 10 species; the south glade had a total of 6 species.

Prescribed burning reduced the percentage of woody plant cover on both glades (table 2). Total line-intercept coverage on the north glade was 33 percent in April before burning and 2 percent in July after burning, and on the south glade coverage was 17 percent in April and 1 percent in July. Some of the understory woody plants had begun to reestablish in the understory by the end of the growing season. On October 31, woody plant cover was 3 percent on the north glade and 4 percent on the south glade. At the end of the growing season, woody species present in the understory of the north glade were yaupon; tree sparkleberry, *V. arboreum* Marsh.; longleaf pine; and loblolly pine; species present on the south glade were yaupon, tree sparkleberry, and *V. corymbosum*.

Herbaceous Standing Crop

The amount of herbaceous plant biomass was initially reduced by prescribed burning. The ovendried weight of the herbaceous standing crop on the two glades averaged 564 kg/ha (504 lb/acre) in April before burning and 241 kg/ha (215 lb/acre) in July after burning (table 3). However, vegetation recovered from the fires during the remainder of the growing season. By October 31, the herbaceous standing crop averaged 547 kg/ha (488 lb/acre) on the two burned glades.

Botanical Composition

The frequency of occurrence of the grasses was largely unaffected by prescribed burning. As a yearly average, grasses were found at 28 percent of the sampling points on the north glade and at 52 percent of the sampling points on the south glade (table 4). Pinehill bluestem, *Schizachyrium scoparium* var. *divergens* (Hack.) Gould, was the most common plant on both glades, being found at 26 percent of the sampling points as a yearly average for both glades. Also, slender bluestem, *S. tenerum* Nees, was found at 4 percent of the sampling points across both glades. The other bluestems, *Andropogon* spp.; purple lovegrass, *Eragrostis spectabilis* (Pursh) Steud.; and bearded skeletongrass, *Gymnopogon ambiguus* (Michx.) BSP., continued to develop on both glades throughout 1994. The low panicums, *Dicanthelium* spp., decreased in occurrence. However, based on past experience, these patterns of occurrence would have probably resulted had the glades not been burned.

The grasslike plants continued to develop on both glades throughout 1994 (table 4). The beakrushes, *Rhynchospora* spp., and the razorsedges, *Scleria* spp., were more common on the south glade than on the north glade.

The other herbs decreased in frequency of occurrence between April and October 1994 (table 4). For both glades, the other herbs were found at 26 percent of the

Table 1.— *Percentages of rock, bare ground, litter, and plant cover on two hilltop glades of Kisatchie soil before and after the prescribed burn on May 24, 1994*

Sampling dates in 1994	North hilltop glade				South hilltop glade			
	Rock	Soil	Litter	Vegetation	Rock	Soil	Litter	Vegetation
	Percent							
Preburn								
April 28	16.4	10.1	73.4	19.9	10.8	5.5	83.2	19.3
Postburn								
July 13	21.2	15.1	63.1	11.9	15.0	21.6	63.4	16.9
October 31	22.1	13.5	64.3	17.8	16.2	12.5	71.3	18.3

Table 2.— *Line-intercept coverage (percent) of principal understory woody plants on two hilltop glades of Kisatchie soil before and after the prescribed burn on May 24, 1994'*

Taxa	North hilltop gladet			South hilltop glade†		
	April	July	October	April	July	October
	Percent					
Ilex vomitoria Yaupon	17.5	0	1.5	8.3	0	2.2
Myrica cerifera Southern bayberry	1.3	0	0	—	—	—
Vaccinium arboreum Tree sparkleberry	2.8	0	0.2	1.5	0.5	0.5
Vaccinium stamineum Common deerberry	—	—	—	0.5	0	0
Vaccinium corymbosum, or *V. virgatum,* rabbiteye; and *V. elliottii,* Elliott blueberries	7.8	0	0	8.2	0	1.5
Quercus stellata Post oak	0.3	0	0	0.2	0	0
Quercus falcata Southern red oak	0.2	0	0	—	—	—
Quercus marilandica Blackjack oak	0.7	0	0	—	—	—
Nyssa *sytvatica* Blackgum	0.7	0	0	0.3	0	0
Pinus palustris Longleaf pine	0.3	0.2	0.2	—	—	—
Pinus taeda Loblolly pine	1.5	1.5	1.5	—	—	—
Total	32.9	1.7	3.4	17.0	0.5	4.2

*Inventories were made before (April 28) and after (July 13 and October 31) the burn.
†Absence of data (percent) for some species means that these species were not present in April 1994.

Table 3.— *Herbaceous standing crop (ovendried weight) on two hilltop glades of Kisatchie soil before and after the prescribed burn on May 24, 1994*

Sampling dates in 1994	North hilltop glade	South hilltop glade	Means
	kg/ha (lb/acre)		
Preburn			
April 28	384 (343)	743 (883)	564 (504)
Postburn			
July 13	185 (147)	318 (284)	241 (215)
October 31	459 (410)	836 (568)	547 (488)

sampling points in April before burning and at 22 percent of the sampling points in October after burning. However, based on past experience, this reduction in overall occurrence would probably have occurred even if the glades had not been burned.

Among the other herbs, the most common composites on both glades were rayless goldenrod, *Bigelowia nuttallii* L.C. Anderson; gayfeathers, *Liatris* spp.; and asters, *Aster* spp. (table 4). Pencilflower, *Stylosanthes biflora* (L.) BSP., and Virginia tephrosia, *Tephrosia virginiana* (L.) Pers., were common legumes on both glades.

Four species noticeably declined on both glades—sticky sundew, *Drosera brevifolia* Pursh; braken fern, *Pteridium aquilinum* var. *pseudocaudatum* (Clute) Heller;

Table 4.— *Frequency of occurrence (percent) of vegetation on two hilltop glades of Kisatchie soil before and after the prescribed burn on May 24, 1994**

Taxa	North hilltop glade†			South hilltop glade†		
	April	July	October	April	July	October
	Percent					
Grasses						
Schizachyrium scoparium var. *divergens* Pinehill bluestem	19.8	18.2	18.8	33.5	32.7	31.8
S. tenerum Slender bluestem	2.2	2.0	1.7	6.8	6.5	6.5
Andropogon spp. Bluestems present were *A. virginicus*, broomsedge; *A. subtenuis*, fineleaf bluestem; *A. ternarius*, paintbrush bluestem; and *A. elliottii*, Elliott bluestem	0.8	1.1	1.8	0.2	2.5	2.1
Dicanthelium spp. Low panicum grasses	5.2	5.7	4.0	13.0	9.7	9.0
Aristida spp. Mostly *A. purpurascens*, Arrowfeather threeawn	0.5	1.3	1.5	1.0	0.3	0.5
Eragrostis spectabilis Purple lovegrass	0	0.2	0.2	—	—	—
Gymnopogon ambiguus Bearded skeletongrass	0	0.2	0.2	0	0.3	0.2
Subtotal	28.3	28.7	28.2	54.5	52.0	50.1
Grasslike plants						
Rhynchospora spp. Pinehill beakrushes	0	0	0.2	0.8	0.5	0.7
Scleria spp. Razorsedges	0.7	0.2	0.8	3.5	4.0	4.3
Subtotal	0.7	0.2	1.0	4.3	4.5	5.0
Other herbs						
Bigelowia nuttallii Rayless goldenrod	7.8	5.7	7.5	5.0	2.8	3.3
Liatris spp. Mostly *L. pycnostachya*, Kansas gayfeather	2.2	1.5	2.2	6.8	7.3	7.7
Helianthus angustifolius Swamp sunflower	—	—	—	4.3	2.8	4.5
Heterotheca graminifolia Grassleaf goldaster	0	0.2	0.7	1.7	1.7	1.5
Solidago spp. Present were *S. odora*, fragrant goldenrod; and *S. nitida*, shiny goldenrod	0	0.2	0.2	0.3	0.3	0
Aster spp. Mostly *A. hemisphericus*, hemisphere aster	2.3	2.0	2.8	4.5	3.5	3.8

Table 4.—*Frequency of occurrence (percent) of vegetation on two hilltop glades of Kisatchie soil before and after the prescribed burn on May 24, 1994 * (continued)*

Taxa	North hilltop glade+			South hilltop glade+		
	April	July	October	April	July	October
	Percent					
Vernonia texana Texas ironweed	0	0.2	0	0.3	0.5	0.5
Stylosanthes biflora Pencilflower	0.7	0.8	1.0	1.3	1.0	0.3
Tephrosia virginiana Virginia tephrosia	1.2	2.3	1.7	0.8	1.2	1.0
Aureolaria pectinata Oakleech combleaf	—	—	—	0.8	0.3	0.3
Drosera brevifolia Sticky sundew	0.5	0	0	0.3	0	0
Hypoxis hirsuta Common goldaster	0	0.2	0	0	0.2	0.3
Mitchella repens Partridgeberry	0.2	0.2	0.2	—	—	—
Viola pedata Birdsfoot violet	0	0	0.2	0.3	0.2	0.5
Pteridium aquilinum var. *pseudocaudatum* Braken fern	2.3	1.7	0.5	2.0	1.7	1.0
Cladonia dimorphoclada A lichen	4.0	2.2	1.8	2.0	0.8	0.7
Selaginella spp. Spikemosses	0.3	0	0	0.3	0	0
Subtotal	21.5	17.2	18.8	30.7	24.3	25.4
Shrubs, trees, and vines						
Ilex vomitoria Yaupon	26.0	3.8	15.8	3.7	2.5	4.7
Myrica cerifera Southern bayberry	0.3	0.3	0.3	—	—	—
Vaccinium arboreum Tree sparkleberry	0.5	0.2	0.2	—	—	—
Vaccinium stamineum Common deerberry	0.3	0	0.3	1.0	0.2	0.2
Vaccinium corymbosum, or *V. virgatum*. rabbiteye; and *V. elliottii*, Elliott blueberries	1.5	0.5	0.3	2.0	1.5	2.3
Ascyrum hypercoides St. Andrewscross	0	0.2	0	—	—	—
Quercus spp. Present were *Q. stellata*, post oak; *Q. falcata*, southern red oak; and *Q. marilandica*, blackjack oak	0.2	0.4	0.7	—	—	—
Nyssa sylvatica Blackgum	—	—	—	0.2	0	0
Pinus palustris Longleaf pine	0.2	0	0.2	0.2	0	0
Pinus taeda Loblolly pine	0.2	0	0.3	—	—	—
Gelsemium sempervirens Carolina jessamine	2.0	0.3	0.8	0.5	0	0
Smilax glauca Cat greenbriar	0.7	0.7	1.7	0.2	0.8	0.5
Subtotal	31.9	6.4	20.6	7.8	5.0	7.7
Total	62.4	52.5	68.6	97.3	85.8	88.2

'Inventories were made before (April 28) and after (July 13 and October 31) the burn.
†Absence of data (percent) for some species means that these species were not present in April 1994.

a lichen, *Cladonia dimorphoclada*, no common name; and the spikemosses, *Selaginella* spp. Fire-related desiccation may have partly caused the decrease in occurrence of these species, or this might have been a natural seasonal pattern even without fire.

One of the largest initial effects of fire on botanical composition was the reduction in average frequency of occurrence among the shrubs, trees, and vines (table 4). On the north glade, woody plants were found at 32 percent of the sampling points in April before burning and at 6 percent of the sampling points in July after burning. The woody vegetation partly recovered during the remainder of the growing season, being found at 21 percent of the sampling points in October. There were fewer woody plants on the south glade, so the effect of fire was less striking.

Because of the decline among the other herbs and woody vegetation on both glades, there was a lower total frequency of occurrence in October after burning than in April before burning (table 4). On the north glade, total frequency of occurrence was 82 percent in April and 69 percent in October. On the south glade, total frequency of occurrence was 97 percent in April and 88 percent in October.

Percentages of Bluestem Grasses in Flower

All of the pinehill bluestem; broomsedge, *Andropogon virginicus* L.; fineleaf bluestem, *A. subtenuis* Nash; paintbrush bluestem, *A. ternarius* Michx.; and Elliott bluestem, *A. elliottii* Chapm., grasses had flowered by November 1994. However, slender bluestem did not flower following the May burn, but factors other than the fire might have been the cause.

Soil Movement

The amount of soil movement was greater on both glades following the May burn than on nearby unburned glades. By December 1994, sheet movement averaged 58.5 Mg/ha (26.1 tons/acre) on the burned glades and 31.3 Mg/ha (14.0 tons/acre) on the unburned glades (table 5). Soil movement in the gullies averaged 187 Mg/ha (83.5 tons/acre) on the burned glades and 81.3 Mg/ha (36.3 tons/acre) on the unburned glades. Although May burning doubled soil movement rates, Thill and Bellemore (1986) reported that erosion rates also doubled following a prescribed burn in November on other highly erodible Kisatchie soils.

Maximum tolerable soil loss is an estimate of the annual soil loss that will permit a sustained level of soil productivity. Tolerable soil losses for Kisatchie soils over a 60-year rotation are 56 Mg/ha (25 tons/acre), with losses for a single year not to exceed 9.4 Mg/ha (4.2 tons/acre), as stated in the "Kisatchie National Forest Final Land Resource and Management Plan."Therefore, soil loss is too great on steep, highly erodible glades, whether burned or not.

CONCLUSIONS

Prescribed burning on steep, highly erodible glades of Kisatchie soils may be controversial because the need to nurture fire-dependent plant communities must be balanced with the need to control soil losses. Prescribed burning in May resulted in less vegetation and litter cover on the soil surface and initially in less herbaceous standing crop. By the end of the growing season, herbaceous

Table 5. -Soil *movement under different levels of overstory basal area of longleaf pine (P. palustris Mill.) on two hi//top glades of Kisatchie soil prescribe-burned in May 1994 and on two nearby unburned glades*

Basal areas and burning status	Average soil movement from April to December	
	Sheet movement	Gully movement
	Mg/ha (tons/acre)	
0 to 9.2 m^2/ha (0 to 40 ft^2/acre)		
Burned	60.0 (26.8)	130.1 (58.1)
Unburned	13.4 (8.0)	65.0 (29.0)
Over 9.2 m^2/ha (40 ft^2/acre)		
Burned	56.9 (25.4)	243.9 (108.8)
Unburned	49.1 (21.9)	97.7 (43.6)
Averages for both basal areas		
Burned	58.5 (26.1)	187.0 (83.5)
Unburned	31.3 (14.0)	81.3 (38.3)

vegetation had recovered from the fire. Burning reduced the number of woody plants in the understory, and the richness of woody plants within the herbaceous layer was initially reduced by fire. Soil movement doubled after the May burn, but a November burn in another study (Thill and Bellemore 1986) had a similar effect on soil movement. Because the May burn adversely impacted woody plants while maintaining the herbaceous plant community, this fire technique may be better than winter burning of vegetation on highly erodible Kisatchie soils.

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