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Long-Term Responses of Understory Vegetation on a Highly Erosive Louisiana Soil to Fertilization

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SUMMARY

Responses of vegetation on highly eroded Kisatchie soils to a broadcast application of 600 lb/acre of 16-30-l 3 granular fertilizer were monitored for 12 years. Understory woody and herbaceous vegetation responded to fertilization immediately, and thus the soil surface was protected from erosion sooner in the fertilized area than in the two unfertilized areas. After 1 year, herbage on the fertilized area increased to 4,712 lb/acre, and woody plants shaded about 13 percent of the soil surface. Herbage and shade cover increased more slowly on the two unfertilized areas. After 12 years, herbaceous plant yield was 964 lb/acre in the fertilized area and averaged 614 lb/acre in the unfertilized areas, and understory woody plants shaded 19 percent of the soil surface in the fertilized area and an average of 27 percent of the soil surface in the unfertilized areas. The frequencies of occurrence of many plant species increased or remained almost constant, but low panicums, *Dicanthelium* spp., disappeared from all areas over the 12-year period.

INTRODUCTION

The Kisatchie soil series (fine, montmorillonitic, thermic, Typic Hapludalfs) has the highest erosion potential of any soil on the 600,000-acre USDA Forest Service, Kisatchie National Forest (Thill and Bellemore 1986). The Kisatchie series occurs on approximately 28,200 acres of National Forest land in Louisiana, with about 12 percent on slopes 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, relatively sparse vegetation, and longleaf pine, *Pinus palustris* Mill., as the dominant forest type.

Prescribed burning is restricted on Kisatchie soils because of reported increases in soil erosion after winter burns (Thill and Bellemore 1986). One way to increase vegetative cover to reduce soil erosion is the application of fertilizers. In May 1982, five sites totaling 220 acres were fertilized to determine understory vegetation responses to nutrient amendment on sites where burning was not practiced. Thill and Bellemore (1986) reported vegetation responses through the third year after treatment. Vegetation responses on two of the sites through 12 growing seasons after fertilization are summarized in this report.

STUDY SITES AND METHODS

The field work was done in west-central Louisiana on the Kisatchie National Forest's Kisatchie Ranger District. Site 1 (47 acres) supported a 44-year-old sparsely stocked pole-timber stand consisting mostly of longleaf pine but including some loblolly pine, *P. taeda* L. Site 2 (49 acres) was logged and then planted with seedling loblolly pine in February 1982. Longleaf pine had dominated Site 2 prior to logging. The 50-year site index for longleaf pine was 40 feet for Site 1 and 60 feet for Site 2, which are below the average 50-year site index of 80 feet for longleaf pine on the Kisatchie National Forest. The 50-year site index for loblolly pine averages 65 feet on Kisatchie soils and 90 feet on the Kisatchie National Forest.

Samples of pine foliage and soil were analyzed for nitrogen, phosphorus, and potassium concentrations. On the basis of these analyses (table 1), 16-30-l 3 granular fertilizer was applied by helicopter at the rate of 600 lb/acre to parts of Sites 1 and 2 in May 1982. Untreated 9-acre strips along the edges of the fertilized areas served as controls.

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Table 1. — ***Preliminary foliar and soil analyses for Sites 1 and 2***

Site	Plant Type	Foliage N	Foliage P	Foliage K	Soil P
		g/kg			--ppm--
Site 1	Longleaf pine	9.1*	0.63*	3.2	0.8
	Loblolly pine	10.3*	0.71'	2.9	0.8"
Site 2	Loblolly seedlings+	—	—	—	0.7*

*Nutrient concentration is below the critical level for optimum plant development; fertilization was recommended.

†Seedlings were in first growing season, and no foliar samples were taken.

Vegetation on six 100-ft-long permanent transects in each fertilized and control area was measured. The six transects in each fertilized area were located randomly. The transects in the adjacent control area were then selected to match the vegetation along the fertilized transects. Transects were confined to slopes of less than 10 percent. Vegetation within gullies was not measured, but some general observations were made.

A marked line was stretched tightly along each 1 00-ft transect, and a 3/4-inch-diameter circular loop was used at 100 equally spaced points along the marked line to make ocular vegetation measurements (Parker and Harris 1959). The vegetation measurements (ground cover, herbaceous plant composition, and absolute frequency) were made in May 1982 just before treatment and again in May 1983, May 1985, and November 1993. Ground cover was reported as percentage bare ground, rock, and vegetative cover (defined as litter plus live vegetation). The percentage of ground cover in each category was to the nearest 5-percent increment; i.e., 0, 5, 10, ... 100 percent. Herbaceous plants rooted within the loop were tallied, and plant composition by absolute frequency was calculated from these tallies. Line intercept methods (Canfield 1941) were used to estimate woody plant cover to a height of 5 feet over the transects each time the other vegetation measurements were made.

The herbaceous standing crop (ovendried weight) was estimated in late August 1982, August 1983, August 1985, and November 1993. The herbaceous material in seven 1 .5-ft^2 subplots within 6.6 feet of each transect was clipped, dried, and weighed. There were 168 subplots (2 sites x 2 treatments [fertilized and control] x 6 transects per site/treatment combination x 7 subplots per transect).

Before the November 1993 plant survey, the understory vegetation on half of the fertilized transects in Site 2 was removed to improve habitat conditions within a red-cockaded woodpecker, *Picoides* borealis, (RCW) colony. Disturbance by animals caused extensive gully erosion in another third of the transects. Since only two of the fertilized transects at Site 2 were left undisturbed, data from the fertilized transects at Site 2 were not used.

RESULTS

Ground Cover

Fire was excluded from the study sites over the 12-year period to allow vegetation to develop and litter to accumulate so that soil loss would be reduced. Before treatment, vegetative cover (litter and live vegetation) was 64 percent in fertilized transects at Site 1 and 68 percent in the control transects at that site (table 2). One year after fertilization, vegetative cover averaged 96 percent in the fertilized transects. On the control transects, cover increased from 68 percent in May 1982 to 97 percent in November 1993. Vegetative cover on fertilized transects was 91 percent in November 1993.

On Site 2, there was little change in vegetative cover for the first four growing seasons (table 2). However, logging debris was present in 1982, and vegetation and litter covered 86 percent of the soil surface at the beginning of the study. Litter accumulated over the 12-year period; therefore, vegetative cover averaged 97 percent in 1993.

Because the percentage of ground cover classed as rock changed little from May 1982 to November 1993, erosion, which would expose more rock at places already

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Table 2. — *Percentages of vegetative cover, rock, and bare ground on control and fertilized areas in May 1982 (before fertilization), May 1983, May 1985, and November 1993*

Site	Treatment	Year	Ground cover		
			Vegetation	Rock	Bare ground
			Percent		
Site 1	Control	1982	88.2*	1.5	30.3
		1983	77.7	1.5	20.8
		1985	84.4	1.9	13.7
		1993	97.2	0.8	2.0
	Fertilized	1982	84.0	0.0	36.0
		1983	95.6	0.0	4.4
		1985	96.0	0.0	4.0
		1993	90.8	0.0	9.2
Site 2†	Control	1982	85.7	1.8	12.5
		1983	88.8	2.5	8.7
		1985	85.8	2.8	11.4
		1993	96.5	2.2	1.3

*Vegetative cover included both plant litter and live vegetation.

†Fertilized transects on Site 2 were not used because prior to measurement either the understory vegetation was removed to improve habitat conditions within a red-cockaded woodpecker colony or disturbance by animals had caused extensive erosion across the transects.

bald, was counterbalanced by the accumulation of litter on existing bald places (table 2). Little bare ground remained at either study site by 1993, and thus the exclusion of fire reduced exposed soil with or without fertilization.

Woody Plants

Woody-plant cover in the understory was similar at all sampling areas just before treatment in May 1982 (table 3). Carolina jessamine, *Gelsemium sempervirens* (L.) Ait. f.; yaupon, *Ilex vomitoria* Ait.; southern bayberry or waxmyrtle, *Myrica cerifera* L.; and blackjack oak, *Quercus marilandica* Muenchh., were the principal species on Site 1. Yaupon; southern bayberry; tree sparkleberry, *Vaccinium arboreum* Marsh.; and blueberries; primarily *V. elliottii* Chapm. and *V. virgatum* Chapm., were the principal species on Site 2.

At Site 1, woody cover in the understory of the fertilized transects increased from 6 percent in May 1982 to 13 percent in May 1983, and woody cover on the control transects increased from 6 percent in May 1982 to 8 percent in May 1983 (table 3). At Site 2, understory woody cover on the control transects was 5 percent in both May 1982 and May 1983. In November 1993, understory woody cover averaged 19 percent on the fertilized transects and 26 percent on the control transects at Site 1. At Site 2, understory woody cover averaged 28 percent on the control transects in November 1993. It is known that fertilization increases the leaf area of pine trees (Teskey and others 1994), and so the slower long-term development of understory woody cover in the fertilized transects may have resulted from increased overstory shading.

By November 1993, yaupon, southern bayberry, and loblolly pine contributed most to the increase in understory woody cover at Site 1 (table 3). The understory woody species present at Site 2 in November 1993 were yaupon, southern bayberry, loblolly pine, tree sparkleberry, and blueberries.

Herbaceous Plants

The herbaceous standing crop varied substantially from year to year (table 4), with ovendried herbaceous production on control areas averaging 1,011 lb/acre in August 1982 and 614 lb/acre in November 1993. The fertilized area produced an average of 4,712 lb/acre 3 months after treatment, but the amount of production decreased to 594 lb/acre by November 1993. The decline in herbaceous production was associated with an increase in woody plant cover in the understory (table 3) and probably with greater leaf area in the overstory.

Herbage composition values summarized in table 5 were calculated as absolute frequencies; i.e., the number of rooted-plant occurrences/total number of sampling points. In 1982, low panicums, *Dicanthelium* spp., and pinehill bluestem, *Schizachyrium scoparium* var. *divergens* (Hack.) Gould, were the most abundant grasses on both study sites (table 5). Among the grass-

Table 3. — *Line-intercept coverage (percent) of principal woody plants on control and fertilized transects in May* ***1982*** *(before fertilization), May 1983, May 1985, and November 1993*

Taxa	Site 1								Site 2*			
	Control				Fertilized				Control			
	1982	1983	1985	1993	1982	1983	1985	1993	1982	1983	1985	1993
	Percent											
Gelsemium sempervirens Carolina jessamine	0.6	1.0	1.6	0.0	0.6	1.7	1.9	0.0	0.3	0.4	1.3	0.0
Ilex *vomitoria* Yaupon	2.9	3.4	3.6	9.0	2.8	6.7	6.9	5.3	1.8	1.8	2.4	15.0
Myrica cerifera Southern bayberry	0.7	1.3	1.0	4.7	1.0	2.3	3.2	3.5	0.5	0.2	0.9	1.5
Pinus *palustris* **Longleaf** pine	0.5	0.5	0.4	0.7	0.1	0.0	<0.1	1.2	0.1	0.0	0.0	0.0
Pinus *taeda* Loblolly pine	0.1	co.1	0.1	9.7	0.1	0.3	0.8	7.5	0.1	0.1	1.0	2.3
Quercus *marilandica* Blackjack oak	1.4	1.3	1.4	0.7	0.6	0.9	0.5	0.0	0.0	0.0	0.0	0.0
Rubus spp. Blackberries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.1	<0.1	0.0
Vaccinium arboreum Tree sparkleberry	0.0	0.0	co.1	0.0	0.1	0.3	0.2	0.0	0.8	0.8	1.1	3.3
Vaccinium spp. Blueberries	<0.1	0.0	0.0	0.7	0.1	0.2	0.4	1.3	1.1	1.6	1.4	6.2
Others	<0.1	0.2	0.1	0.0	0.2	0.2	0.5	0.0	0.4	0.3	0.2	0.0
Totals	6.3	7.7	8.2	25.5	5.6	12.6	14.4	18.8	5.2	5.3	8.3	28.3

‘Fertilized transects on Site 2 were not used because prior to measurement either the understory vegetation was removed to improve habitat conditions within a red-cockaded woodpecker colony or disturbance by animals had caused extensive erosion across the transects.

like and forb plants, the beakrushes, ***Rhynchospora*** spp.; fringe razorsedge, ***Scleria ciliata*** Michx.; and **rayless** goldenrod, ***Bigelowia nuttallii*** L.C. Anderson, were the most abundant.

The low panicum grasses began declining in absolute frequency of occurrence after the initial inventory and were not found on any of the transects in 1993 (table 5). Other **taxa** also declined in frequency on certain transects during the **12-year** period: threeawns, ***Aristida*** spp.; cutover muhly, ***Muhlenbergia expansa*** (DC.) Trin.; fringe rasorsedge (on the fertilized transects only); stargrasses, ***Aletris*** spp.; and gayfeathers, ***Liatris*** spp.

However, the absolute frequency of **pinehill bluestem** increased during the study, and following fertilizer treatment, **pinehill bluestem** formed dense stands 3 to 5 feet tall over much of the fertilized area and accounted for most of the increase in **herbage** by August 1982 (Thill

Table 4. — *Herbaceous standing crop (ovendried weights) on control and fertilized areas during August of the treatment year* ***(1982),*** *August 1983, August 1985, and November* ***1993****

Year	Site 1		Site 2†
	Control	Fertilized	Control
	Lb/acre		
1982	770	4,712	1,252
1983	849	2,239	1,872
1985	1,971	1,120	891
1993	751	964	476

*The fertilizer was applied in May 1982.

†**Fertilized** transects on Site 2 were not used because prior to measurement either the understory vegetation was removed to improve habitat conditions within a red-cockaded woodpecker colony or disturbance by animals had caused extensive erosion across the transects.

Table 5. — Herbaceous composition values (frequency of occurrence) on control and fertilized transects in May 7982 (before fertilization), May 1983, May 1985, and November 1993

Taxa	Site 1								Site 2			
	Control				Fertilized				Control			
	1982	1983	1985	1993	1982	1983	1985	1993	1982	1983	1985	1993
	Percent											
Grasses												
Aristida purpurascens												
Arrowfeather **threeawn**	0.0	0.1	0.0	0.0	0.0	1.9	0.0	0.2	0.0	0.1	0.0	0.7
Aristida spp.												
Threeawns	0.2	0.9	0.8	0.0	0.2	0.1	0.0	0.0	0.8	1.0	0.0	0.8
Dicanthelium spp.												
Low panicum grasses	6.4	5.4	6.1	0.0	3.1	4.3	1.1	0.0	11.0	10.2	6.1	0.0
Muhlenbergia expansa												
Cutover muhly	1.8	1.1	1.9	0.8	0.8	1.2	1.6	0.7	0.0	0.1	0.0	0.0
Schizachyrium scoparium var. *divergens*												
Pinehill bluestem	3.8	6.4	7.6	27.8	7.4	23.0	22.8	24.2	7.2	6.6	7.7	21.8
S. tenerum												
Slender **bluestem**	0.0	0.3	0.6	3.2	0.0	0.1	0.5	1.0	0.4	0.4	1.6	2.2
Others: mostly ***Panicum,*** *Andropogon,* and ***Sporobolus junceus***	0.2	0.1	0.0	9.2	0.0	0.5	0.6	7.5	0.0	0.0	0.0	8.9
Subtotal	12.4	14.3	17.0	41.0	11.5	31.1	26.6	33.6	19.4	18.4	15.4	34.4
Grasslike plants												
Rhynchospora spp.												
Beakrushes	5.5	6.8	5.8	3.2	3.8	2.3	1.3	3.7	1.3	0.8	1.5	1.0
Scleria ciliata												
Fringe razorsedge	1.0	1.6	1.6	0.8	1.4	2.1	1.2	0.2	1.4	1.4	0.5	1.7
Others: mostly *Juncus*	0.4	0.2	0.0	0.0	1.0	0.2	0.0	0.7	0.2	0.6	0.0	0.0
Subtotal	6.9	8.6	7.4	4.0	6.2	4.6	2.5	4.6	2.9	2.8	2.0	2.7
Other herbs												
Aletris spp.												
Stargrasses	0.4	0.4	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aster dumosa												
Bushy aster	0.8	0.4	0.1	0.7	0.2	0.0	0.8	1.0	0.0	0.1	0.1	0.0
Bigelowia nuttallii												
Rayless goldenrod	9.0	10.3	10.9	6.7	12.6	7.3	4.0	14.3	4.0	4.2	4.5	7.0
Helianthus angustifolius												
Swamp sunflower	0.9	1.1	0.4	1.2	0.5	0.9	0.9	1.2	0.9	1.8	3.1	0.5
Liatris spp.												
Gayfeathers	0.1	1.4	1.8	0.0	0.1	0.5	0.1	0.0	1.4	0.8	2.6	0.2
Cladonia dimorphoclada												
A lichen	1.9	2.8	3.6	2.8	2.8	0.4	0.1	8.7	1.8	2.1	1.6	4.7
Selaginella spp.												
Spikemosses	0.9	0.4	1.2	21.5	0.6	0.6	1.8	3.9	0.8	1.9	2.9	4.2
Others: mostly ***Heterotheca*** *graminifolia* and ***Solidago nitida***	1.7	1.4	1.6	3.8	1.3	1.3	1.4	2.3	1.4	1.7	1.7	1.3
Subtotal	15.7	18.2	19.8	36.7	18.2	11.0	9.1	31.4	10.3	12.6	16.5	17.4
Total	35.0	41.1	44.2	81.7	35.9	46.7	38.2	69.6	32.6	33.8	33.9	55.0

'Fertilized transects on Site 2 were not used because prior to measurement either the understory vegetation was removed to improve habitat conditions within a red-cockaded woodpecker colony or disturbance by animals had caused extensive erosion across the transects.

and Bellemore 1988). A thick mat of litter accumulated as this herbage died over winter, and this mat smothered subsequent herbage production. Weight of the standing crop in the fertilized area decreased by 52 percent between August 1982 and 1983 and decreased by 76 percent between August 1982 and 1985 (table 4). However, vegetation and litter still covered 91 percent of the soil surface in the fertilized area in 1993 (table 2).

Slender bluestem, *Schizachyrium tenerum* Nees; *Panicum* spp.; *Andropogon* spp.; and pineywoods dropseed, *Sporobolus junceus* (Michx.) Kunth-as well as the dominant pinehill bluestem-were more frequent on both study sites in November 1993 than they were in May 1982 (table 5). The beakrushes were still common on both study sites in 1993. Rayless goldenrod was still found frequently on areas where it was common in 1982, as were the lichen *Cladonia dimorphoclada* (no common name); spikemosses, *Selaginella* spp.; goldaster, *Heterotheca graminifolia* (Michx.) Shinners; and shiny goldenrod, *Solidago nitida* T.&G.

DISCUSSION

The fertilizer used in this study was a custom formulation designed to meet the nutrient deficiencies of the pine trees rather than those of the native herbage (Thill and Bellemore 1986). However, forest managers now prefer to use diammonium phosphate, which increases pine productivity on upland forest soils regardless of other management practices (Haywood and Burton 1990, Haywood and Tiarks 1990).

Nutrient amendment is largely unnecessary to protect Kisatchie soils from erosion provided fire is excluded, but the use of fertilizer speeds plant growth, and the soil is protected sooner if fertilizers are used. Also, fertilizer may have to be applied where gullies and balds are common. Thill and Bellemore (1986) observed that grass became well established near the gullies and on the more level, lower portions of several gullies in the fertilized area. The presence of this ground cover may have reduced overland flow into the gully and thereby gully-bank cutting.

Protection from erosion is a management objective on Kisatchie soils. Neither study site was burned during the 12-year study period, and the herbaceous standing crop declined as the woody understory and forest floor litter developed. Several herbaceous plant taxa declined in frequency by the end of the study, and the accumulation of litter was probably largely responsible for the decreases in plant occurrence. However, other herbaceous plant taxa increased in occurrence.

Management of the longleaf pine ecosystem to protect understory herbaceous plant communities is another objective on Kisatchie soils. The need to use fire to reduce litter accumulation and help maintain herbaceous vegetation in this ecosystem may outweigh the importance of maximizing erosion control.The exclusion of fire no doubt contributed to the general decrease in herbaceous plant productivity over the 1 2-year period, especially on the fertilized area where a very productive cover of pinehill bluestem developed after fertilizer application.

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