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# Response of Competing Vegetation to Site Preparation on West Gulf Coastal Plain Commercial Forest Land

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## SUMMARY

The response of woody and herbaceous vegetation to site preparation, subsoil texture, and fertilization was measured on the West Gulf Coastal Plain. The influences of these treatments on competing vegetation were short-term. Drastic soil disturbance and fertilization briefly increased herbage production. Shear-windrow and shear-disk were generally the most effective methods to control early shrub density, height, and crown cover. Seven years after treatment, however, shrub and sapling densities were unrelated to treatments.

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## INTRODUCTION

Land managers of the West Gulf Coastal Plain of Louisiana and Arkansas routinely apply an array of hardwood control techniques to improve the establishment and growth of planted loblolly pine (*Pinus taeda* L.). Under proper environmental conditions, mechanical (e.g., shearing, chopping, and disking), chemical, and fire treatments used singularly or in combination provide the control necessary for pine regeneration (Grano 1970, Slay and others 1987, Tiarks and Haywood 1986, Trousdell 1970, Trousdell and Langdon 1967). Cultural treatments are also frequently used the first few years after planting to increase survival and promote rapid growth of young pines (Schmidtling 1973, Tiarks and Haywood 1986). However, little information is available on the effects of site preparation and cultural treatments on associated understory woody and herbaceous vegetation. This study was initiated to determine: (1) the response of saplings, shrubs, and herbaceous vegetation to various mechanical, chemical, and burning treatments on soils common throughout the West Gulf Coastal Plain of Louisiana, Arkansas, and Texas and (2) how fertilization affects understory vegetation response to site preparation on these soils.

## STUDY AREA AND METHODS

### Study Area

This study was conducted on commercial forest land dispersed throughout the West Gulf Coastal Plain of southern Arkansas and northwestern and west-central Louisiana that had been managed for loblolly and shortleaf pines (*P. echinata* Mill.). The dominant overstory consisted primarily of mixed loblolly and shortleaf pines, but proportions varied greatly (Wolters and Wilhite 1973). Hardwoods that commonly formed a moderately dense midstory were blackgum, *Nyssa sylvatica* Marsh.; flowering dogwood, *Cornus florida* L.; mockernut hickory, *Carya tomentosa* (Poir.) Nutt.; post oak, *Quercus stellata* Wangenh.; red maple, *Acer rubrum* L.; southern red oak, *Q. falcata* Michx.; sweetgum, *Liquidambar styraciflua* L.; and white oak, *Q. alba* L. Woody species common in the understory included American beautyberry, *Callicarpa americana* L.; blueberries, *Vaccinium* spp.; greenbriers, *Smilax* spp.; hawthorns, *Crataegus* spp.; yaupon, *Ilex vomitoria* Ait.; and a mixture of small hardwood trees. Little bluestem, *Schizachyrium scoparium* (Michx.) Nash, was usually the main grass in forest openings. Longleaf uniola, *Chasmanthium sessiliflorium* (Poir.) Yates, and spike uniola, *C. laxum* (L.) Yates, were associated with little bluestem where the overstory was moderately dense, and uniola species occurred in nearly pure, although sparse, stands on heavily shaded sites. Other grasses, legumes, and composites were common but ordinarily produced little herbage.

Climate of the area is semihumid subtropical. The frost-free season generally extends from mid-March to mid-November, approximately 235 days. Annual precipitation averages about 55 inches, more than 3 inches each month, and about 25 inches during the April–September growing season.

### Soils

This study included five classes of soil ranging in B-horizon texture from loam to clay. The series represented were primarily Boswell, Henry, Kirvin, Ruston, and Sawyer. See Haywood and Burton (1990) for a comprehensive description of these five soil series. The

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A-horizon for all soils generally ranged from sandy to silty loam.

### Site-Preparation Treatments

Seven site-preparation treatments were tested on each soil:

(1) Underplant-inject—plots were burned where possible to reduce logging slash and residual live plant material. Living hardwoods ≥1 inch in d.b.h. were injected with 2, 4-D [(2,4-dichlorophenoxy) acetic acid] the spring after planting.

(2) Chop-burn—vegetation was chopped with a crawler-tractor-drawn, rolling-drum chopper and burned after fine fuels had dried.

(3) Chop-burn-disk—(hereafter referred to as chop-disk) same as chop-burn except plots were plowed with a crawler-tractor-drawn disk after burning.

(4) Double-chop—vegetation was chopped with a crawler-tractor-drawn, rolling-drum chopper and then rechopped after several days to several weeks, usually at a 90° angle to the initial chop.

(5) Shear-burn—a shearing blade mounted on a crawler tractor was used to fell cull pine and hardwood trees; after all fine fuels had dried, the plots were burned.

(6) Shear-windrow—cull pine and hardwood trees were felled as with shear-burn, then piled into windrows with brush rakes.

(7) Shear-windrow-disk—(hereafter referred to as shear-disk) same as shear-windrow except the cleared area between windrows was cultivated with a crawler-tractor-drawn disk.

### Fertilization Treatments

Each site-preparation treatment was applied to rectangular 144- by 152-ft (0.51-acre) plots. Each treated plot was then split into a 144- by 50-ft fertilized and a 144- by 102-ft control area. All fertilized split plots received 150 lb/acre of $P_2O_5$ triple superphosphate (65.5 lb/acre phosphorus, P) surface broadcast before pines were planted (Haywood and Burton 1990).

### Site Description

Before site preparation, all merchantable timber was harvested. Residual woody stems ≥1 inch in d.b.h. averaged about 2,700 per acre with a total (nonmerchantable pine plus hardwood) basal area of 72 $ft^2$/acre (Wolters and others 1977). Due to extreme variation in density and basal area of hardwoods on the upper West Gulf Coastal Plain, study plots selected contained at least 500 hardwood stems with 20 $ft^2$/acre of basal area before site preparation. Such stands generally had been selectively cut for merchantable pines and hardwoods and protected from fire.

Loblolly pines (1+0 seedlings) were hand planted on 6- by 8-ft spacings either the winter preceding herbicide injection of hardwoods or the winter after mechanical site preparation. One set of 35 plots planted during the winter of 1970–71 was considered a replication; a second set (replication) was planted during the winter of 1971–72, with a few of the second set planted during the winter of 1972–73.

### Vegetation Sampling

Ovendry weight of herbaceous plant material (grasses, grasslikes, and forbs) was estimated in 20 quadrats 9.6 $ft^2$ in size on each split plot using a weight-estimate procedure (Pechanec and Pickford 1937). Density of shrubs (shrubs, vines, and hardwood seedlings <1 inch in d.b.h.) was ocularly estimated in four 0.01-acre circular quadrats on each split plot. Height and crown cover of shrubs were also ocularly estimated on these four quadrats. Production of herbaceous vegetation and density, height, and crown cover of shrubs were sampled during fall of the first, third, and seventh growing seasons after loblolly pine seedlings were planted. Seven growing seasons after planting loblolly pines, naturally regenerated sapling (≥1 inch in d.b.h.) densities were sampled in four 0.025-acre circular quadrats on each split plot. For ease of discussion, saplings are separated into one of the following genera or groups: maples *(Acer* spp.), hickories *(Carya* spp.), oaks *(Quercus* spp.), conifers *(Pinus* and *Juniperus* spp.), gums *(Liquidambar styraciflua* and *Nyssa silvatica),* other big-tree species (all other species generally taller than 30 ft at maturity), and small-tree species (all species generally less than 30 ft tall at maturity).

### Experimental Design and Analysis

Data collected the first and third year after treatment were tested by analysis of variance for a completely randomized split-plot design with blocking by year ($P$ = 0.10). The data from replication two were not available for analysis in year 7; thus, year 7 data were tested only for main effects. Main effects were separated using Scheffe's Test (Steele and Torrie 1980) at the 0.10-probability level.

## RESULTS AND DISCUSSION

### Site Preparation Effects

***Herbaceous Plant Response.***—Although herbage production varied greatly among treatments, differences were not significant within any year (table 1). Herbage production remained high the third year after treatment, but approached pretreatment levels (Wolters and others 1977) by the seventh year.

Species composition changed greatly from the first to the third year after treatment. Early sere forbs were released by site-preparation disturbance and comprised about 75 percent of total herbage the first year after treatment compared with less than 5 percent before treatment (Wolters and others 1977). By year 3, perennial grasses and forbs comprised about 65 percent and 35 percent, respectively, of total herbage production. Three years after treatment, forb production was significantly less on underplant-inject sites than on the sites drastically disturbed by mechanical treatment.

Abundance of herbaceous vegetation, particularly forbs, apparently had little impact on survival and early diameter growth of planted loblolly pines (Haywood and Burton 1990). In fact, diameter and density of 12-year-old loblolly pines were generally greater on chop-disk and shear-burn, where forb production was greatest immediately following treatment, than on underplant-inject. However, Tiarks and Haywood (1986) and Haywood and Tiarks (1990) reported significantly greater survival of planted loblolly pines with complete herb removal three times a year. Similar response to frequent cultivation was reported in Mississippi (Schmidtling 1973) and Florida (Swindel and others 1988).

***Shrub Response.***—Shear-disk provided the best control of shrub density, height, and crown cover the first 3 years after treatment, although differences among other treatments were generally not significant (table 1). DeWit and Terry (1983) also reported that shear and pile treatment reduced hardwood sprouting more than treatments where hardwood rootstocks were left intact. Shear-disk and chop-disk also resulted in the best loblolly pine regeneration (Haywood and Burton 1990). Shrub density, height, and crown diameter were similar on all site-preparation treatments after seven growing seasons.

***Sapling Response.***—Total sapling density was not influenced by site-preparation method seven growing seasons after treatment (table 2). Large variation among species within methods apparently masked treatment responses. Even though differences were not significant, sapling density ranged from a high of 847 per acre on underplant-inject to a low of 435 per acre on double-chop sites. Pehl and Bailey (1983) also

Table 1.— *Herbage and shrub response to seven site-preparation methods 1, 3, and 7 years after treatment*

| Plant variable and year after site preparation | Site-preparation method: Underplant inject | Chop-burn | Chop-disk | Double-chop | Shear-burn | Shear-windrow | Shear-disk |
|---|---|---|---|---|---|---|---|
| | *Lb / acre* | | | | | | |
| Herbage production | | | | | | | |
| First year | 1,582* | 2,376 | 2,502 | 2,125 | 1,945 | 1,733 | 1,882 |
| Third year | 1,485 | 1,833 | 1,961 | 2,102 | 1,869 | 1,924 | 2,145 |
| Seventh year | 84 | 109 | 87 | 381 | 250 | 102 | 99 |
| | *Number / acre* | | | | | | |
| Shrub density | | | | | | | |
| First year | 10,347ab | 12,321a | 7,229ab | 7,550ab | 8,786ab | 8,295ab | 5,329b |
| Third year | 7,347ab | 8,042a | 5,400ab | 6,186ab | 5,745ab | 5,354ab | 4,679b |
| Seventh year | 5,733 | 5,401 | 5,516 | 6,128 | 5,330 | 6,690 | 5,431 |
| | *Ft* | | | | | | |
| Shrub height | | | | | | | |
| First year | 7.22a | 5.01bc | 4.28bc | 4.11bcd | 5.47abc | 3.57cd | 2.54d |
| Third year | 14.87a | 14.16a | 10.87ab | 10.94ab | 11.75ab | 8.88b | 6.76b |
| Seventh year | 26.21 | 24.38 | 21.23 | 16.95 | 21.60 | 22.30 | 18.19 |
| Shrub crown diameter | | | | | | | |
| First year | 2.60a | 2.18ab | 1.82bc | 1.67bc | 1.83bc | 1.63bc | 1.22c |
| Third year | 4.42a | 4.39a | 3.01ab | 3.04ab | 3.30ab | 2.84b | 2.19b |
| Seventh year | 5.86 | 5.77 | 5.20 | 4.57 | 4.73 | 5.78 | 4.32 |

*Values within rows lacking letters or followed by the same letter are not significantly different ($P = 0.10$).

Table 2.— *Effect of seven site-preparation methods on sapling density and basal area 7 years after treatment*

| Species group | Site-preparation method | | | | | | |
|---|---|---|---|---|---|---|---|
| | Underplant inject | Chop-burn | Chop-disk | Double-chop | Shear-burn | Shear-windrow | Shear disk |
| | *Number / acre* | | | | | | |
| Maples | 71* | 134 | 63 | 15 | 40 | 37 | 51 |
| Hickories | 66 | 23 | 11 | 8 | 41 | 71 | 55 |
| Oaks | 242 | 217 | 99 | 103 | 178 | 158 | 101 |
| Conifers | 1 | 0 | 2 | 0 | 7 | 97 | 123 |
| Gums | 182 | 185 | 127 | 134 | 221 | 226 | 134 |
| Other big trees[†] | 110 | 29 | 69 | 31 | 43 | 61 | 25 |
| Small trees[‡] | 173 | 190 | 246 | 144 | 179 | 67 | 114 |
| Total density | 847 | 781 | 603 | 435 | 720 | 717 | 606 |
| | *$Ft^2$ / acre* | | | | | | |
| Basal area | 13.7 | 11.4 | 6.8 | 5.5 | 11.0 | 8.6 | 8.4 |

*Values within rows are not significantly different ($P = 0.10$).
[†]All other species generally taller than 30 ft at maturity.
[‡]All species generally less than 30 ft tall at maturity.

reported fewer hardwood stems ≥1 inch in d.b.h. on intensively prepared sites (disk and chop) 10 years after planting than on the control. Double-chop may be preferred in stands dominated by maples, hickories, oaks, and other big-tree species. On the other hand, shear-windrow and shear-disk may favor natural regeneration of loblolly pines.

Sapling basal area was nearly twice as great on underplant-inject, chop-burn, and shear-burn as on chop-disk and double-chop 7 years after treatment, but as with sapling density, these differences were not significant (table 2).

## Soil Effects

***Herbaceous Plant Response.***—The effects of subsoil texture on herbage production varied with time (table 3). The first year after treatment, herbage production ranged from nearly 1,600 lb/ acre on gravelly clay subsoil to about 2,400 lb/acre on loam, although these differences are not significant. Two years later, however, herbage production was significantly greater on loam than on gravelly clay and silt. By the seventh year, total herbage production had declined 75 to 95 percent on all soils.

Graminoid (grass and grasslike plants) production was significantly greater on loam the first and third years after treatment than on silty clay and clay, whereas the opposite was true for forbs. But, by the end of the seventh growing season, production of grasses, forbs, and total herbage was greater on silty clay than on loam. Nevertheless, loblolly pines became better established on the more mesic, medium-textured, silty clay subsoils than on well-drained loam, gravelly clay, and silt (Haywood and Burton 1990).

***Shrub Response.***—Subsoil texture significantly influenced density of shrubs the first three growing seasons after site preparation (table 3), although densities the first growing season after treatment did not differ greatly from pretreatment densities (Wolters and others 1977). The early differences were probably due to the amount of residual rootstock associated with the various subsoil textures. However, by the seventh year, shrub densities were similar across soil textures due to natural mortality, particularly on gravelly clay, but to a lesser extent on clay and silty clay subsoils. Subsoil texture effects on shrub height and crown diameter were minor and insignificant. Seven years after treatment, shrub density, height, and crown diameter were not influenced by subsoil texture.

The high density of shrubs on gravelly clay subsoil during the critical establishment period may explain why loblolly pine survival at age 12 was lowest for this subsoil class (Haywood and Burton 1990). Gravelly clay subsoils are typically found on dry upper slopes and ridgetops where herbage production is low and where low loblolly pine survival would be expected. It is also possible that low woody plant density the first year after treatment on silty-clay and clay subsoils allowed greater loblolly pine establishment there than on other subsoils.

***Sapling Response.***—Density of all sapling groups was influenced by subsoil texture seven growing seasons after treatment (table 4). Before treatment, only red maple, elms, and common persimmon were significantly influenced by subsoil, with silt subsoils support-

Table 3.— *Herbage and shrub responses to five subsoil textures 1, 3, and 7 years after treatment*

| Plant variable and year after treatment | Soil texture | | | | |
|---|---|---|---|---|---|
| | Loam | Gravelly clay | Silt | Silty clay | Clay |
| | *Lb/acre* | | | | |
| Herbage production | | | | | |
| First year | 2,374* | 1,582 | 1,874 | 2,070 | 2,303 |
| Third year | 2,584a | 1,544bc | 1,305c | 1,940abc | 2,237ab |
| Seventh year | 75b | 56b | 103ab | 343a | 218ab |
| | *Number/acre* | | | | |
| Shrub density | | | | | |
| First year | 6,243b | 11,188a | 8,862a | 8,257ab | 7,906ab |
| Third year | 5,134b | 7,512a | 6,346ab | 5,912ab | 5,325ab |
| Seventh year | 5,629 | 5,732 | 7,377 | 5,320 | 4,670 |
| | *Ft* | | | | |
| Shrub height | | | | | |
| First year | 3.90b | 4.11ab | 5.23a | 4.20ab | 5.30a |
| Third year | 10.75 | 10.50 | 12.26 | 11.19 | 10.59 |
| Seventh year | 22.75 | 20.61 | 22.01 | 19.70 | 22.44 |
| Shrub crown diameter | | | | | |
| First year | 1.58 | 1.82 | 1.90 | 1.83 | 2.10 |
| Third year | 2.65b | 3.39ab | 3.88a | 3.28ab | 3.20ab |
| Seventh year | 5.74 | 4.78 | 5.56 | 4.92 | 4.86 |

*Values within rows lacking letters or followed by the same letter are not significantly different ($P = 0.10$).

Table 4.— *Effect of five subsoil textures on density and basal area of saplings 7 years after treatment*

| Species group | Soil texture | | | | |
|---|---|---|---|---|---|
| | Loam | Gravelly clay | Silt | Silty clay | Clay |
| | *Stem density/acre* | | | | |
| Maples | 163a* | 78ab | 12b | 11b | 44b |
| Hickories | 14bc | 66ab | 84a | 6c | 23ab |
| Oaks | 330a | 132b | 105b | 121b | 111b |
| Conifers | 0b | 0b | 153a | 0b | 3b |
| Gums | 345a | 206b | 94b | 82b | 153b |
| Other big trees† | 126a | 84ab | 9b | 34b | 17b |
| Small trees‡ | 152ab | 301a | 122ab | 79b | 144ab |
| Total density | 1,130a | 867ab | 583bc | 334c | 500bc |
| | *$Ft^2$/acre* | | | | |
| Basal area | 18.4 | 15.1 | 8.0 | 4.0 | 5.6 |

*Values within rows lacking letters or followed by the same letter are not significantly different ($P = 0.10$).
†All other species generally taller than 30 ft at maturity.
‡All species generally less than 30 ft tall at maturity.

ing more saplings than other soils (Wolters and others 1977). After treatment, density of maples, oaks, gums, other big-tree species, and total saplings was greater on loam subsoil than on silt, silty clay, or clay subsoil. Hickories and pines generally were denser on silt subsoil and were scarce to absent on silty clay subsoil.

Data did not permit testing to determine if site-preparation methods were less effective on loam subsoils or if deciduous trees typically regenerate better there. However, pretreatment data (Wolters and others 1977) suggest that density of some woody species varied greatly with subsoil texture. Thus, viable rootstock may have been more extensive on loam subsoils; therefore, site-preparation methods may or may not have been as effective in controlling hardwood regeneration on these subsoils.

Sapling basal area was not influenced by subsoil texture even though basal area ranged from 4 $ft^2$/acre on silty clay to over 18 $ft^2$/acre on loam subsoils. Large within-soil variation may have masked true subsoil differences.

Loblolly pine survival at age 12 (Haywood and Burton 1990) appeared to be inversely related to sapling and sapling-plus-shrub density 7 years after treatment. For example, sapling and shrub densities were lowest on clay and silty clay where the best survival of loblolly pines was reported; survival of loblolly pines was lower on loam, gravelly clay, and silt subsoils where density of saplings and shrubs was greater.

### Fertilization Effects

***Herbaceous Plant Response.***—Phosphorus significantly increased herbage production the first 3 years after application (table 5). Early sere forbs responded rapidly to fertilization and produced approximately 24 percent more on fertilized plots than on the control plots the first year after application. Three years after application, forbs were still producing more on fertilized plots (770 lb/acre) than on the controls (580 lb/acre), but graminoids had increased in importance and were producing about twice as much as forbs. Herbage production diminished on both fertilized and control plots with time but was greater on the control plots 7 years after treatment than on fertilized plots.

Swindel and others (1988) reported that fertilization alone can quintuple volume of southern pines at age 4, and fertilization plus complete control of competing vegetation can produce a short-term tenfold increase in pine volume on some sites. Tiarks and Haywood (1986) and Shiver and others (1990) reported that control of herbaceous vegetation significantly increased pine growth. The greater volume per tree and larger d.b.h. of planted pines on fertilized sites after 12 years of growth (Haywood and Burton 1990) suggest that, even though herbage production was greater on fertilized plots during the early years of establishment, herbaceous vegetation did not significantly impair loblolly pine establishment or growth.

***Shrub Response.***—Shrub density was not influenced by phosphorus fertilization (table 5). Height and crown diameter were significantly greater on fertilized plots than on the controls 3 years after treatment, but by the seventh year that advantage had disappeared. Wolters and Schmidtling (1975) also found that shrub density and crown cover were greater on fertilized plots 12 years after treatment than on the control. Haywood and Burton (1990) reported fertilization did benefit growth of planted loblolly pines.

***Sapling Response.***—Fertilization alone did not influence total sapling density, density of sapling groups, or total sapling basal area 7 years after treatment (table 6).

### Interactions

***Herbaceous Plant Response.***—A few significant interactions were identified that could have important management implications.

First- and third-year average forb production was greatest on fertilized clay sites and somewhat less on fertilized loam, gravelly clay, silt, and silty clay subsoils, and still less on all nonfertilized subsoils. Interestingly, Tiarks and Haywood (1986) and Haywood and Burton (1990) reported rapid loblolly pine tree growth when phosphorus was applied to loam, gravelly clay, and silty clay subsoils. Apparently, young loblolly pines use supplemental phosphorus more effectively than do forbs on some subsoils.

Total herbage production was greatest on loam subsoil 3 years after treatment. However, greatest herbage response to fertilization (25 percent) occurred on clay subsoils.

Fertilizer × subsoil texture effects were somewhat blurred 7 years after treatment. For example, forb production, representing about one-third of the total herbage, averaged less than 15 lb/acre on loam, gravelly clay, and silt subsoils and about 85 lb/acre on silty clay, whether fertilized or not. Fertilizer seemed to have a negative effect on clay subsoil, reducing forb production from more than 100 lb/acre to less than 40 lb/acre.

***Shrub Response.***—Significant site-preparation × subsoil texture interactions also influenced shrub height. Underplant-inject was generally least effective in controlling first-year shrub heights on nearly all soils, especially clay. Shear-burn was least effective on silt soils. Thus, underplant-inject and shear-burn should probably not be applied across subsoil textures if first-year shrub height is a concern.

Three years after treatment, shear-disk was the most effective method for control of shrub height.

Table 5.— *Herbage and shrub response to fertilization 1, 3, and 7 years after treatment*

| Plant variable and year after treatment | Not fertilized | Fertilized |
|---|---|---|
| | *Lb / acre* | |
| Herbage production | | |
| First year | 1,809b* | 2,255a |
| Third year | 1,794b | 2,031a |
| Seventh year | 192a | 125b |
| | *Number / acre* | |
| Shrub density | | |
| First year | 8,588 | 8,436 |
| Third year | 6,128 | 6,011 |
| Seventh year | 5,863 | 5,635 |
| | *Ft* | |
| Shrub height | | |
| First year | 4.42 | 4.64 |
| Third year | 10.54b | 11. 60a |
| Seventh year | 21.52 | 21.45 |
| | *Ft* | |
| Shrub crown diameter | | |
| First year | 1.82 | 1.85 |
| Third year | 3.14b | 3.43a |
| Seventh year | 5.26 | 5.08 |

*Values within rows lacking letters or followed by the same letter are not significantly different ($P = 0.10$).

## CONCLUSIONS

The response of most competing vegetation to site preparation, fertilization, and subsoil texture appeared to be short-term. Neither a single treatment nor a combination of treatments controlled all competing woody and herbaceous vegetation 1, 3, and 7 years after treatment. In fact, all combinations of overstory removal and site preparation actually stimulated herbage production for a few years.

All site-preparation methods except underplant-inject significantly increased production of early seral forbs. Shear-disk was the most effective treatment for controlling density of shrubs up to 3 years after application. Most site-preparation methods reduced shrub density, height growth, and crown diameter slightly the first 3 years after treatment. Shear-disk was one of the most effective methods, whereas underplant-inject and chop-burn were generally ineffective.

Herbage production was generally lower on silt subsoil than on other subsoil textures the first 7 years after site preparation. Early shrub reestablishment was greatest on gravelly clay subsoil and minimal on loam. Seven years after treatment, shrub and sapling densities were greatest on silt and loam subsoils, respectively. Herbage production was greatest on silty clay subsoil where sapling density was lowest. Although no single attribute limited the success of loblolly pine regeneration, Haywood and Burton (1990) reported greatest survival at age 12 on silty clay where 7-year herbage production was high and sapling density, low.

Fertilization significantly increased forb and total herbage production up to 3 years after treatment. Shrub height and crown diameter were also greater on fertilized plots 3 years after application.

Fertilizer produced the greatest herbage response on clay subsoil; production on other subsoils was only minimally influenced. Site-preparation methods were equally effective in controlling shrub height the first year after treatment, except that shear-burn was ineffective on silt subsoil.

Phosphorus fertilization alone did not appear to increase shrub density, crown cover, or height growth enough to create pine regeneration problems. Shrubs were significantly taller 3 years after fertilization of underplant-inject and shear-burn plots than on the controls, but fertilization did not influence shrub height growth on other site-preparation treatments.

The density of gums ≥1 inch in d.b.h. 7 years after site preparation was greater on fertilized than on control gravelly clay and silt subsoils but not on any other subsoils. Site preparation did not influence density or basal area of saplings 7 years after treatment, but subsoil texture did influence sapling density. Sapling density was minimal on silty clay subsoil, where Haywood and Burton (1990) observed maximum density of 12-year-old loblolly pine trees.

Table 6.— *Effect of fertilization on sapling density and basal area 7 years after treatment*

| Species group | Not fertilized | Fertilized |
|---|---|---|
| | *Stem density / acre* | |
| Maples | 60* | 59 |
| Hickories | 34 | 45 |
| Oaks | 165 | 149 |
| Conifers | 24 | 39 |
| Gums | 176 | 171 |
| Other big trees† | 63 | 42 |
| Small trees‡ | 135 | 185 |
| Total density | 659 | 693 |
| | *Ft²/ acre* | |
| Basal area | 9.8 | 10.6 |

*Values within rows lacking letters or followed by the same letter are not significantly different ($P = 0.10$).

†All other species generally taller than 30 ft at maturity.

‡All species generally less than 30 ft tall at maturity.

## LITERATURE CITED

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The response of herbaceous and woody vegetation to site preparation and fertilization of common loblolly pine forest soils was studied in southern Arkansas and northwestern and west-central Louisiana. The succession of competing vegetation is quantified the first, third, and seventh years after site preparation and fertilization.

**Keywords:** Browse, ecology, herbage, loblolly pine, plant succession, regeneration.