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# Plant response to soils, site preparation, and initial pine planting density

HENRY A. PEARSON, GALE L. WOLTERS, RONALD E. THILL, ALTON MARTIN, JR., AND V. CLARK BALDWIN

*Authors are range scientist, USDA, Agricultural Research Service, South Central Family Farm Research Center, Booneville, Ark. 72927; range scientist, USDA, Forest Service, Rocky Mountain Forest, and Range Experiment Station, Albuquerque, N.M. 87106; research wildlife biologist, USDA, Forest Service Southern Forest Experiment Station, Nacogdoches, Tex. 75962; range technician and forest biometrician, respectively, USDA, Forest Service, Southern Forest Experiment Station, Pineville, La. 71360. At the time of the research, authors were located at Pineville, La., with the USDA, Forest Service, Southern Forest Experiment Station Station, Pineville, La. 71360. Senior author presently with TVCC, Athens, Tex. 75751.*

## Abstract

**This study described the effects of soils, site preparation, and initial pine regeneration spacings on tree growth and the associated understory woody and herbaceous plant succession. Although Sawyer soils appeared more productive than Ruston soils before the harvest and regeneration treatments, woody and herbaceous plant differences were not apparent between the soils after regeneration. During the first 3 years after treatment, the mechanical site preparation method (shear-windrow-burn) reduced woody plant heights more than the underplant-release method; however, these height differences disappeared by the 6th year of post-treatment. Woody plant densities decreased initially, increased by the 6th year after treatment, and decreased to pretreatment levels by the 10th year. Herbage yields increased significantly after site preparation and pine regeneration through the 3rd year, decreased by the 6th year, and declined to levels below pretreatment by the 10th year. Initial pine planting densities did not significantly influence the understory herbage yields during the first 10 years as a result of the confounding effects of the other woody plant growth.**

**Key Words: loblolly pine, tree spacing, Ruston, Sawyer, underplant-release, shear-windrow-burn**

Trees are planted yearly in large areas of the southern United States to increase forest productivity; for example, 850,000 ha were planted in 1985 (Mixon 1988). The greatest potential to increase these timber supplies, with at least 12 million ha (mainly in the loblolly-shortleaf pine-hardwood forest type (*Pinus taeda* L.-*P. echinata* Mill.) currently in production, is through site preparation and regeneration by natural or artificial methods (USDA Forest Service 1988). Effective reforestation to maintain a sustained-yield is often difficult, especially where aggressive hardwood and herbaceous plant competition follows timber harvest. Site preparation methods such as pyric, herbicidal, biological, and mechanical techniques to reduce the competing vegetation have been used to improve establishment and growth of planted pines. Initial spacing of the pine regeneration also can influence the final desired tree product, whether biologically or operationally (Smith and Strub 1991). Generally, pine trees, herbaceous cover, and other woody plants are more abundant on site-prepared areas than on untreated areas (Baskett et al. 1957). Pulpwood or early sawlog production can usually be rapidly achieved through wider initial tree spacings or early thinnings (Burton 1982). Also, low tree densities result in more forage (Wolters et al. 1982). Timber harvesting, site preparation, and reforestation aspects all can affect immediate and long-term understory resources, which provide forage for livestock and habitat for wildlife. Few studies have examined the effects of initial pine spacing on the understory vegetation components. The objective of this study was to describe the effects of soils, site preparation, and initial pine regeneration spacings on tree growth and the associated understory woody and herbaceous plant succession.

## Procedures

The study was located in the loblolly-shortleaf pine-hardwood type of the Kisatchie National Forest in the central Louisiana parishes of Grant and Rapides. Two replications of 2 site preparation treatments (underplant-release and shear-window-burn), 2 soil series (Ruston and Sawyer), and 5 initial pine spacing densities (1.2 × 1.8 m, 1.8 × 2.4 m, 2.4 × 3.7 m, 3.7 × 4.9 m, and an unplanted control) were established in 1970 and 1972. Ruston

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soils are loamy textured, well drained, moderately permeable soils, 3 to 8% slopes, with fine sandy loam to clay loam subsoils in the Ultisols order and Aressias Paleudult subgroup; Sawyer soils are slowly to very slowly permeable clays, 1 to 3% slopes, with slowly permeable silty clay subsoils in the Ultisols order and Aquic Paleudult suborder (Wolters et al. 1977, Haywood and Burton 1989, 1990). The underplant-release site preparation treatment consisted of prescribed burning to reduce logging slash and residual live plant material; hardwoods 2.5-cm diameter breast height (dbh) and larger were injected with 2,4-dichlorophenoxy acetic acid. The shear-windrow-burn site preparation treatment consisted of shearing blade mounted on a crawler tractor to fell cull pine and hardwood trees, piling the slash into windrows with brush rakes, and burning the piled windrows the following winter. Following site preparation, areas were subdivided into five 43.9 × 49.4 m plots and hand planted with loblolly pine seedlings during January.

Herbaceous vegetation, included botanical composition (%) and yield (kg ha$^{-1}$; oven dry wt), was measured on 20 systematically spaced 0.89 m$^2$ quadrants prior to, and 1, 2, 3, 6, and 10 years following site preparation treatments. Floral composition was estimated on each quadrant to the nearest 5% for all species producing 25% or more of the total herbage yield. These estimates were subtracted from 100 and residuals were equally divided among species producing less than 25% of the total herbage. Herbage yields were estimated to the nearest 5 g/0.89 m$^2$.

Woody plant densities (stems ha$^{-1}$), heights (m), and crown (m$^2$ ha$^{-1}$) were measured for plants ≤ 2.5-cm stem diameter (dbh for trees; ground level diameter for shrubs and vines) on 4 systematically spaced 0.004-ha circular quadrants (3.6-m radius). Woody plant densities (stems ha$^{-1}$) and basal areas (m$^2$ ha$^{-1}$) were measured for plants ≥ 2.5-cm diameter, on four 0.01-ha circular quadrants (5.7-m radius). The diameter (dbh) of trees harvested was estimated from residual stumps. All woody vegetation was measured before, and 1, 2, 3, 6, and 10 years after site preparation.

Data were analyzed by analyses of variance based on 3 experimental design configurations with significance accepted at the 0.10 probability level and the main effects being separated using Scheffe's Test (Steel and Torrie 1980). Analysis of the vegetation characteristics before the treatments were applied was done with the basic analysis of variance test between the 2 soils only. The analyses for measurement years 1 through 3 were based on a split plot design with soils, site preparation, and planting spacing as the treatments. For measurement years 6 and 10, the split plot design was modified to only include site preparation and planting spacing treatments. This change was required because major fires and other catastrophic events after year 3 destroyed nearly all of the plots for one replication on the Ruston soil, and many plots of the same replication on the Sawyer soil. Fortunately, in the measurement years 1 through 3 analyses, soil effects on the various vegetation measures were almost never statistically significant (only shrub height in year 2 was significant). Therefore, rather than not be able to statistically test results for measurement years 6 and 10, we elected to eliminate the data from the few remaining plots on the Sawyer soils. This left us with only one-half (20) the number of plots we started with (40), but it gave us 2 complete replications for the site preparation and planting spacing treatments for analysis in later years. The reader is cautioned that years 6 and 10 results may thus be affected to some degree because of our procedural change. Common and scientific names of plants in this article follow nomenclature by Hicks and Stephenson 1978, USDA Forest Service 1974, Grelen and Hughes 1984, Gould 1975, Clewell 1985, and Wolters et al. 1977.

## Results and Discussion

### Pretreatment Vegetation

Before site treatment, the larger diameter (≥2.5-cm) tree and shrub densities and basal areas were about 60% greater on Sawyer (1,729 stems ha$^{-1}$, 23.7 m$^2$ ha$^{-1}$) than on Ruston (1,097 stems ha$^{-1}$, 15.0 m$^2$ ha$^{-1}$) soils (Table 1). On Ruston soils, blackjack oak (*Quercus marilandica* Muenchh.) was the most uniformly distributed and dominant woody species; on Sawyer soils, no tree dominance was observed although red maple (*Acer rubrum* L.) was uniformly distributed. Woody plant densities and basal areas were greatly reduced by timber harvest (Table 2).

**Table 1. Pretreatment density and basal area of trees and shrubs ≥2.5-cm dbh before harvest.**

| Species | Density | | Basal area | |
|---|---|---|---|---|
| | Ruston | Sawyer | Ruston | Sawyer |
| | ---- stems ha$^{-1}$ ---- | | ---- m$^2$ ha$^{-1}$ ---- | |
| Red Maple | 57 | 148 | 0.2 | 0.3 |
| Hickory | 264 | 148 | 1.8 | 0.9 |
| Flowering dogwood | 57 | 12 | 0.2 | t[1] |
| Sweetgum | 25 | 25 | t | 0.1 |
| Shortleaf pine | 0 | 136 | 0 | 8.7 |
| Loblolly pine | 91 | 457 | 3.5 | 4.2 |
| Oaks | 553 | 210 | 9.2 | 7.8 |
| Tree huckleberry | 42 | 111 | t | 0.1 |
| Other trees and shrubs (11 spp.) | 8 | 482 | 0.1 | 1.6 |
| Total | 1097 | 1729 | 15.0 | 23.7 |

[1]t = ≤0.05 m$^2$ ha$^{-1}$

**Table 2. Pretreatment density and basal area of trees and shrubs ≥2.5-cm dbh following harvest.**

| Species | Density | | Basal area | |
|---|---|---|---|---|
| | Ruston | Sawyer | Ruston | Sawyer |
| | ---- stems ha$^{-1}$ ---- | | ---- m$^2$ ha$^{-1}$ ---- | |
| Red Maple | 22 | 37 | 0.1 | 0.1 |
| Hickory | 74 | 37 | 0.3 | 0.2 |
| Flowering dogwood | 22 | 2 | 0.1 | t[1] |
| Sweetgum | 5 | 5 | t | t |
| Shortleaf pine | 0 | 22 | 0 | 0.2 |
| Loblolly pine | 25 | 111 | 0.1 | 0.8 |
| Oaks | 118 | 40 | 1.7 | 0.7 |
| Tree huckleberry | 15 | 27 | t | t |
| Other trees and shrubs (11 spp.) | 3 | 119 | t | 0.2 |
| Total | 284 | 400 | 2.3 | 2.2 |

[1]t = ≤0.05 m$^2$ ha$^{-1}$

Before treatment, the smaller stem diameter (<2.5-cm) woody plants greatly exceeded the densities of the larger woody stems on both soils (Tables 1, 2, and 3). American beautyberry (*Callicarpa americana* L.) was dominant, with arrow-wood (*Viburnum dentatum* L.), southern red oak (*Q. falcata* Michx.), and red maple subdominant, on Sawyer soils. American beauty-

Table 3. Pretreatment density and canopy cover of trees, shrubs, and vines <2.5-cm stem diameter.

| Plant type | Species identified | | Density | | Canopy cover | |
|---|---|---|---|---|---|---|
| | Ruston | Sawyer | Ruston | Sawyer | Ruston | Sawyer |
| | ---- no. ---- | | -- stems $ha^{-1}$ --- | | --- $m^2$ $ha^{-1}$ --- | |
| Trees | 16 | 12 | 3730 | 6337 | 519 | 591 |
| Shrubs | 6 | 11 | 2636 | 8251 | 757 | 847 |
| Vines | 7 | 7 | 6956 | 5807 | — | — |
| Total | 29 | 30 | 13322 | 20395 | 1276 | 1438 |

berry and shining sumac (*Rhus copallina* L.) were the principal species on Ruston soils. Tree huckleberry (*Vaccinium arborum* Marsh.) was less abundant but was common on both soils.

Grape (*Vitis* spp.) was the most abundant vine species on both soils. Poison ivy (*Toxicodendron radicans* (L.) Kuntze) was common on Ruston soils while cross-vine (*Bignonia capreolata* L.) and yellow jessamine (*Gelsemium sempervirens* (L.) Ait.) were abundant on Sawyer soils.

Pretreatment herbage yields were greater on Sawyer than on Ruston soils (Table 4). Since the Sawyer soils also supported

Table 4. Pretreatment herbage yields.

| Plant type | Species identified | | Yields | |
|---|---|---|---|---|
| | Ruston | Sawyer | Ruston | Sawyer |
| | ----- no. ----- | | ---- kg $ha^{-1}$ ---- | |
| Grasses | 16 | 12 | 185 | 309 |
| Sedges & rushes | 1 | 1 | 2 | 27 |
| Forbs | 22 | 19 | 59 | 45 |
| Ferns | 1 | 0 | 1 | 0 |
| Total | 40 | 32 | 247 | 381 |

greater woody plant densities, it appeared initially that these soils were more productive than the Ruston soils. However, great variability occurred among herbaceous plants on both soils. Longleaf uniola (*Chasmanthium sessiliflorum* (Poir.) Yates) and spike uniola (*C. laxum* (L.) Yates) combined produced about 55% of the herbage on Sawyer soil less than 5% on Ruston soils. On the other hand, pinehill bluestem (*Schizachyrium scoparium* var. *divergens* (Hack.) Gould) and broomsedge bluestem (*Andropogon virginicua* L.) together produced 40% on Ruston soils but less than 5% on Sawyer soils. Low panicums (*Dichanthelium* spp.) were a major herbaceous component on both soils as was spreading panicum (*Panicum anceps* var. *rhizomatum* (Hitchc. & Chase) Fern.) on the Sawyer soils. Tickclover (*Desmodium* spp.) and common carpet grass (*Axonopus affinis* Chase) were important herbage producers on Ruston soil while sedges and spreading panicum were important on Sawyer soils. Threeawn (*Aristida* spp.) was less abundant but produced similarly on both soils.

## Post-treatment Vegetation

**Pine Regeneration**—Pine survival rates the 1st year after planting averaged 82%; survival rate differences were not observed among the initial spacing densities (Table 5). Third year

Table 5. Survival of planted loblolly pines by various spacings and dates.

| Spacings (m) | 1st year | 3rd year | 10th year |
|---|---|---|---|
| | --- | % | --- |
| 3.7 × 4.9 | 82a[1] | 80b | 80a |
| 2.4 × 3.7 | 85a | 86a | 78a |
| 1.8 × 2.4 | 77a | 82ab | 80a |
| 1.2 × 1.8a | 84ab | 84ab | 74a |
| Average | 82 | 83 | 78 |

[1]Within column, means with the same lowercase letter are not significant at $P \leq 0.10$.

survival rates averaged 83%, slightly higher than the 1st year, indicating either sampling error or additional natural seedling establishment indistinguishable from the planted pines. In the 3rd year, the 3.7 × 4.9 m spacing had a significantly lower loblolly pine survival rate than the 2.4 × 3.7 m spacing; other spacing densities were not different during that year. By the 10th year, artificially planted pine survival rates averaged 78% and were not different among the spacing densities.

Less natural pine regeneration occurred within the more dense initial spacing treatments; wider spacings had more open ground

Table 6. Density of loblolly pines at various spacings and dates.

| Spacings (m) | Planted pines | 1st year | 3rd year | 10th year |
|---|---|---|---|---|
| | --- | --- | stems $ha^{-1}$ | --- |
| 3.7 × 4.9 | 580d[1] | 474d | 472d | 1,596b |
| 2.4 × 3.7 | 1,146c | 973c | 981c | 1,388b |
| 1.8 × 2.4 | 2,258b | 1,744b | 1,596b | 1,811b |
| 1.2 × 1.8a | 4,451a | 3,638a | 3,749a | 3,011a |

[1]Within column, means with the same lowercase letter are not significant at $P \leq 0.10$.

and, consequently, more natural regeneration (Table 6). Between the 3rd and 10th years after artificial pine regeneration, many of the natural loblolly pine seedlings became indistinguishable from the artificially planted pines. Ten-year-old loblolly pine heights (8.7 m) and diameters (dbh's) (10.4 cm) were not different among the initial pine spacing densities.

**Trees (≥2.5-cm dbh)**—By the 6th year after pine regeneration, woody plant densities for trees ≥2.5-cm diameter (dbh) were not different between soils, between site preparation treatments, or among initial pine planting densities, except for sweetgum (*Liquidambar styraciflua* L.). Sweetgum had significantly more stems on the 2.4 × 3.7 m pine spacings (358 stems $ha^{-1}$) than on the 1.8 × 2.4 m (49 stems $ha^{-1}$) and 1.2 × 1.8 m (74 stems $ha^{-1}$) spacings; other spacings had intermediate sweetgum densities and were not different from each other. Densities of red maple (284 stems $ha^{-1}$), oaks (*Quercus* spp. 210 stems $ha^{-1}$), sweetgum (198 stems $ha^{-1}$) were consistently high especially on unplanted control treatments; even loblolly pine densities were high on the unplanted controls (309 stems $ha^{-1}$). Woody plant densities varied from 877 to 1,803 stems $ha^{-1}$ across the various spacings. Basal areas of the woody stems ≥2.5-cm dbh were only 2.0 $m^2$ $ha^{-1}$ by the 10th year, of which 0.1 $m^2$ $ha^{-1}$ was natural pine (42 stems $ha^{-1}$).

**Trees (<2.5-cm dbh)**—Trees with stems <2.5-cm diameter (dbh) remained relatively constant, varying from 5,017 stems ha$^{-1}$ during the 1st year to 3,663 the 2nd year, 3,097 the 3rd year, 5,224 the 6th year, and 5,996 the 10th year; yearly fluctuations were the result of the new woody plant establishment which were shaded out or grew into the larger dbh category by the 10th year. Principal tree species during the 10th year were flowering dogwood (*Cornus florida* L.), white oak (*Quercus alba* L.), southern red oak, and mockernut hickory (*Carya tomentosa* (Poir.) Nutt.). Woody plant sprout densities were not different between the Ruston and Sawyer soils, between the underplant-release and shear-windrow-burn site preparation treatments, or among the initial pine spacings during the post-treatment years.

Tree heights (stems <2.5-cm dbh) were significantly influenced by site preparation treatments during the first 3 years after treatment; heights averaged 1.1, 1.9, and 2.9 m during 1st, 2nd, and 3rd years on the underplant-release and 0.6, 1.4, and 1.6 m on the shear-windrow-burn treatment, respectively. By the 6th year, tree heights averaged 4.7 m and were not different between site preparation treatments. For trees <2.5-cm diameter (dbh) heights were not different between soils or among the initial pine spacings for any of the post-treatment years.

Canopy covers (crown cover/plant × trees/ha) of trees with stems <2.5-cm diameter (dbh) were not different among initial pine spacings or between soils but were different between site preparation treatments during the 2nd and 3rd post-treatment years. Canopy cover (355 m$^2$ ha$^{-1}$) was not different between site preparation treatments during the 1st year. Canopy cover on the underplant-release treatments averaged 1,036 m$^2$ ha$^{-1}$ and 1,192 m$^2$ ha$^{-1}$ during the 2nd and 3rd post-treatment years and 259 m$^2$ ha$^{-1}$ and 97 m$^2$ ha$^{-1}$ on the shear-windrow-burn treatment, respectively. The 3rd year decrease in canopy cover from the 2nd year on the shear-windrow-burn was a result of the diameter stem growth which shifted some trees into the ≥2.5-cm dbh category. Canopy cover differences between the underplant-release and shear-windrow-burn treatments disappeared by the 6th year; at that time, tree <2.5-cm dbh canopies averaged 5,908 m$^2$ ha$^{-1}$ (Fig. 1). By the 10th year, the midstory tree canopies decreased to 477 m$^2$ ha$^{-1}$.

**Shrubs**—Shrub densities (<2.5-cm stem diameter) varied from 5,832 stems ha$^{-1}$ during the 1st post-treatment year to 8,403 during the 2nd year, 3,470 the 3rd year, 4,550 the 6th year, and 5,996 the 10th year. During the 10th year, the principal shrubs were American beautyberry, shinning sumac, and Elliott blueberry (*Vaccinium elliottii* Chapm.). Shrub densities were not different between soils, between site preparation treatments, or among the initial pine spacings during post-treatment.

Shrub heights differed between site preparation treatments during the first 3 years following treatment; shrub heights averaged 0.8, 1.2, and 1.6 m during 1st, 2nd, and 3rd years of post-treatment on the underplant-release and 0.4, 0.6, and 0.8 m on the shear-windrow-burn treatments, respectively. Shrub heights did not differ by the 6th year, when heights averaged 3.1 m. Shrub heights differed between soils only during the 2nd post-treatment year when heights were 0.7 m on Ruston soils and 1.2 m on Sawyer soils. Shrub heights among pine spacing densities differed only during the 1st post-treatment year, being highest on the 2.4 × 3.7 m spacing (0.7 m) and lowest on the unplanted control (0.5 m); heights did not differ (0.6 m) for the other spacings. Shrub heights between soils, between site treatments, or among pine spacings were not different by the 6th year.

Canopy covers of shrubs with stems (<2.5-cm diameter did not differ among pine spacings or soils but did differ between site preparation treatments during the 1st and 3rd years post-treatment, with average canopies of 183 and 109 m$^2$ ha$^{-1}$ on the shear-windrow-burn treatment and 412 and 245 m$^2$ ha$^{-1}$ on the underplant-release treatments, respectively. Shrub canopies during the 2nd (594 m$^2$ ha$^{-1}$), 6th (2,287 m$^2$ ha$^{-1}$), and 10th (633 m$^2$ ha$^{-1}$) years did not differ between site preparation treatments.

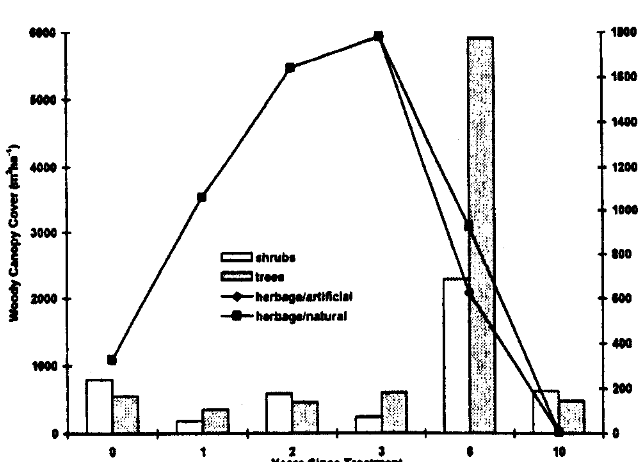


**Fig. 1. Woody canopy cover and herbage yields with and without artificial pine regeneration.**

**Vines**—Woody vine densities within the study areas were 4,142, 5,790, 5,688, 10,275, and 5,996 stems ha$^{-1}$ during the 1st, 2nd, 3rd, 6th, and 10th years post-treatment respectively. During the 10th year, vine densities were the lowest for the post-treatment period, due to the closing canopy; the most prevalent vines were greenbriers (*Smilax rotundifolia* L., *S. glauca* Walt., *S. bona-nox* L.), muscadine grapes (*Vitus rotundifolia* Michx.), and blackberries (*Rubus* spp.). Vine density did not differ significantly between soils, between site preparation treatments, or among pine spacing densities for any of the years.

**Herbage**—Herbage yields increased significantly the 1st year after site and pine regeneration treatments, continued increasing through the 2nd year, and leveled during the 3rd year (Fig. 1). By the 6th year, herbage yields decreased on all treatments, including the unplanted controls. During the 6th year, herbage yields on the unplanted controls were 48% higher (924 kg ha$^{-1}$) than on the pine regenerated areas (626 kg ha$^{-1}$), regardless of spacing density. Apparently the pine and other woody plant midstory and overstory "out-competed" the herbage for light, nutrients, and water. By the 10th year, herbage yields were well below pretreatment levels as a result of the regenerated pines and other woody plant regrowth, even on the unplanted controls. These responses are similar to results from other Louisiana and Texas studies where yields increased through the 3rd and 4th year but decreased substantially by the 5th and 6th year (Tiarks and Haywood 1986, Stransky and Halls 1981, Stransky et al. 1986).

Herbage botanical composition groups responded differently through the first 6 years (Table 7). Grasses dominated the sites during pretreatment while forbs were less than 20%. By the end of the 1st year after treatment, forbs increased to more than 50% of the botanical composition, indicating their rapid response to site disturbance and competititon removal. By the 6th year, grass-

Table 7. Botanical composition of herbage before and after loblolly pine plantings.

| Plant groups | Pretreatment | Years since planting 1st | 2nd | 3rd | 6th | 10th |
|---|---|---|---|---|---|---|
| | | | | % | | |
| Grasses | 79.1 | 42.7 | 56.6 | 66.5 | 79.3 | 78.3 |
| Bluestem | 20.2 | 18.9 | 27.5 | 35.0 | 14.2 | 1.5 |
| Panicums | 14.0 | 9.8 | 13.2 | 13.5 | 6.3 | 5.1 |
| Paspalums | 0.6 | 0.8 | 2.2 | 1.4 | 0.9 | 1.8 |
| Uniolas | 33.2 | 3.3 | 9.5 | 13.9 | 55.4 | 62.5 |
| Others | 11.0 | 9.9 | 4.2 | 2.5 | 2.7 | 7.4 |
| Grasslikes | 4.4 | 3.3 | 6.8 | 7.9 | 8.8 | 2.3 |
| Rushes | 0 | 0.4 | 5.5 | 6.2 | 8.1 | 1.4 |
| Sedges | 4.4 | 2.7 | 1.3 | 1.7 | 0.7 | 0.9 |
| Forbs | 16.4 | 54.1 | 36.6 | 25.6 | 11.9 | 19.4 |
| Composites | 5.1 | 41.7 | 23.3 | 17.6 | 7.4 | 3.4 |
| Legumes | 4.8 | 1.5 | 3.1 | 3.0 | 1.1 | 9.2 |
| Others | 6.5 | 11.0 | 10.2 | 5.1 | 3.4 | 6.9 |

es were again dominant, with uniolas being most abundant and remaining so through the 10th year. Bluestems, 2nd in abundance during pretreatment, became the dominant grass in the 3rd year as a result of the overstory removal. By the 6th year, bluestems reverted again to 2nd place, similar to the pretreatment. These results are similar to studies in Florida where composites appeared first after site preparation, followed by perennial grasses (Grelen 1962). Thirteen years later, wood plants on the Florida site were still sparse while dog-fennel (*Eupatorium compositifolium* Walt.) and broomsedge bluestem (*Andropogon virginicus* L.) were common (Hebb 1971). In Texas studies, herbages increased more than woody plants during the early years after site preparation (Stransky and Halls 1978) while in Florida, site preparation actually reduced herbaceous cover and yield the 1st year but outproduced untreated sites by the 2nd and 3rd years (Beckwith 1964). In other Florida studies, herbage yields peaked in 2 to 4 years while woody plants peaked later (Umber and Harris 1974).

No differences in herbage production were found among the various pine spacings. Apparently woody plants (trees, shrubs, and vines), other than planted pines, obscured any influences of the initial pine spacings. Only during the 3rd year were any of the herbaceous species groups significantly influenced by pine spacing; paspalum yields were highest on the 1.2 × 1.8 m spacings, intermediate on the unplanted clearcuts, 3.7 × 4.9 m and 2.4 × 3.7 m spacings, and least on the 1.8 × 2.4 m spacing. Uniolas yielded more on 1.8 × 2.4 m spacings, were intermediate on 3.7 × 4.9 m spacings, and were least on unplanted clearcuts, 2.4 × 3.7 m and 1.2 × 1.8 m spackings. Since uniolas are shade tolerant, they were expected to increase under the denser pine spacings; however, the other woody plants (trees, shrubs, and vines) masked the initial pine spacing influence.

## Conclusions

Generally, no differences in plant responses occurred because of soils. Although trees, shrubs, and herbage yielded more on Sawyer soils than Ruston soils before site treatment and pine regeneration, they were not different after treatment, except during the 2nd year post-treatment when shrub heights were greater on Sawyer soils than Ruston soils. These differences disappeared by the 3rd year.

Although tree densities were originally reduced by the site preparation, they were not influenced differently between the 2 methods, indicating that either technique would be satisfactory. Shrub heights during the first 3 years were greater on underplant-release treatments than on shear-windrow-burn treatments, but these differences disappeared by the 6th year. Vine densities and herbage yields were not affected by the 2 site preparation methods, which is contrary to other Louisiana studies where mechanically prepared sites had greater herbage yields than underplant-release sites (Haywood et al. 1981).

Initial pine regeneration spacings had little influence on the herbaceous and woody plant responses, at least in the long term. Wide spacings had more natural pine regeneration than close spacings as a result of the additional open canopy. Planted pine heights and dbhs were not different after 10 years as a result of the initial pine spacings. Vine density differences were not affected by initial pine spacings.

Understory and midstory trees were consistently present and abundant on the sites but generally were not influenced by the different soils, different site preparation methods, or different initial pine spacings; only sweetgum was significantly affected by the initial pine spacings.

The general treatment was that herbages increased during the first 3 years following site preparation and pine regeneration but decreased by the 6th year and thereafter. By the 10th year, herbage yields were below pretreatment levels as a result of the pine and other wood plant growth.

Woody plants respond slower than herbaceous plants following site preparation; in our study, no woody plant cover changes were apparent during the first 3 years but increased nearly 10 fold by the 6th year, indicating its rapid recovery to site preparation after the 3-year delay. Woody plants decreased to pretreatment levels by the 10th year as a result of crown closure by the overstory trees.

## Management Implications

Since tree and forage responses were similar among soils, site preparation, and pine spacing, silvicultural and livestock management approaches would apply regardless of treatment. Forage yields increase after removal of the tree overstory until the subsequent pine regeneration again overtops the understory vegetation and forages decrease. The increased forage yields potentially provide substantial livestock grazing during the early pine regeneration years; however, careful management of the livestock in the newly established stands is required to prevent livestock damage to the young pines. After 4 to 6 years, the tree and shrub midstory and overstory appreciably reduces forage yields, thus requiring livestock reductions on regeneration areas. Likewise, woody plants used as food for wildlife, increase during the early years following overstory tree removal and decrease after canopy closure at 6 to 8 years of age. Understory vegetation produced during the early successional stages of the pine regeneration process provides abundant wildlife habitat, especially for deer but also for birds and other ground dwelling animals.

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