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Land and Resource Management on Typic Quartzipsamments

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LAND AND RESOURCE MANAGEMENT ON TYPIC QUARTZIPSAMMENTS [1]

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Abstract. Survival and growth of seven species/treatment combinations were tested on Tonkawa fine sand (thermic, coated Typic Quartzipsamment) in Nacogdoches County, Texas. In January 1983, seedlings were hand-planted on an intensively prepared clearcut site on the Tonkawa soil series in northern Nacogdoches County. Tonkawa sands serve as recharge zones for the Carrizo aquifer, a major source of clean groundwater for much of East Texas. Intensive management practices on this sensitive site created severe site conditions, providing incentive for the study. Species/treatment combinations were: untreated loblolly (*Pinus taeda* L.) pine (LOB/CON); Terra-Sorb™-treated loblolly (LOB/TER); kaolin clay slurry-treated loblolly (LOB/CLA); untreated slash (*P. elliottii* Engelm.) pine (SLA/CON); Terra-Sorb-treated slash (SLA/ TER); kaolin clay slurry-treated slash (SLA/ CLA); and containerized longleaf pine (*P. palustris* Mill.) (LL/CONT). Treatments were applied as a bareroot dip prior to planting, to increase soil moisture retention near the roots, and subsequently increase survival. Containerized longleaf yielded the highest survival (greater than 50 percent) throughout the study, followed by LOB/TER (38 percent), while all other treatments were unacceptable (below 30 percent by the end of the sixth year). Management recommendations include reforest the site in longleaf pine or allow the natural scrub vegetation to inhabit the site, while managing for nontimber resources, such as groundwater, wildlife, and recreation.

Introduction

In forested areas on deep, dry sands, special management techniques are required to establish and maintain a viable forest ecosystem. Many droughty sands are classified as Quartzipsamments and are found on sandhills throughout the Atlantic and Gulf Coastal Plains, from New Jersey southward to Florida and westward to Texas (Burns and Hebb 1972). The original vegetation on the sandhills was an association of longleaf pine (*Pinus palustris* Mill.), turkey oak (*Quercus laevis* Walt.), and bluejack oak (*Q. incana* Bartr.), commonly called "scrub oaks," and pineland threeawn (*Aristida stricta* Michx.), commonly known as wiregrass (Hebb 1957). During the "cut out and get out" era of forestry in the South, stands of longleaf pine were harvested from sandhill sites with no provision made for regeneration. The understory scrub oaks and wiregrass assumed dominance since they are well adapted to

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droughty sands. Subsequent efforts to reforest these sites have met little success, leaving undesirable vegetative cover on these areas.

Droughty sands possess low potential for production of quality timber, due to their low inherent fertility and low water holding capacity. However, the ever-increasing demand for land available for production of food and fiber dictates the necessity to develop effective methods of reforestation of such sites. Conventional forest management techniques usually produce unacceptable results when applied to these droughty sites. Consequently, millions of acres of land that once supported stands of high quality pine timber throughout the Southeastern United States are now covered with scrub oaks and grasses. This greatly reduces the value of the land and its productivity.

The South Carolina State Commission of Forestry has found that successful reclamation of sandy scrub oak land can be accomplished at reasonable costs (Lehockey and Lee 1954). In south and central peninsular Florida, citrus production is the primary land use on droughty sands. Other uses include hay production, certain agricultural crops, and mineral extraction. Several studies have indicated that droughty sites are capable of being reforested with proper management programs. More research is needed to support these findings and to develop more effective methods of establishing forests on Quartzipsamments,

In 1983, a study was initiated in east Texas to develop management strategies for reforestation and alternative land uses of sandhill (Kroll et al., 1985). This report will consolidate the first 8 years of survival and growth results of that study, and will provide management recommendations for Typic Quartzipsamments in this region. These results will allow us to develop effective management techniques that will increase productivity of sandhills, thereby contributing to the worldwide reforestation effort.

Objectives

The central purpose of this study is to develop integrated land use and resource management strategies for Typic Quartzipsamments that are economically as well as ecologically sound and are compatible with the land.

Specific objectives are to:

1. Determine optimum tree species and treatments for reforestation;
2. Recommend practical alternative land uses and management strategies for Typic Quartzipsamments.

Background

In east Texas there are approximately 23,000 ac of soils classified as Quartzipsamments, extending from northern Nacogdoches and Rusk Counties eastwardly into Panola and San Augustine Counties. Tonkawa series, classified as a thermic, coated Typic Quartzipsanunent, is characterized by low fertility, rapid permeability (up to 20 inch/hr), and extremely acid reaction. These soils developed on thick, sandy deposits of the Eocene epoch, and presently occur on broad, slightly convex, interstream divides, with slopes ranging from 0 to 20 percent. In some places, these sands occur in contiguous units of more than 2,000 ac (Dolozel 1980). Tonkawa sands developed on an outcrop of the Carrizo formation, an important water-bearing sand that provides an excellent quality groundwater source for most of the east Texas Basin (Guyton and Associates 1970).

The primary land use on Tonkawa sands is woodland, although the potential is low for pines as well as most cultivated crops due to the droughty and infertile nature of the sand. Typical site index is 55 for shortleaf pine (P. echinata Mill.). The most recent forest cover was dominated by shortieaf pine and bluejack oak, with a few natural stands of longleaf pine and turkey oak. The longleaf grew mostly near the transition zones between Tonkawa sands and Osier sands, an associated soil series occuring on concave slopes at the lower elevations of these sandhills (Dolozel 1980). Osier soils are also fine sands, but are usually waterlogged due to their topographic position with respect to the Carrizo aquifer. Many springs discharge in the Osier sand.

Past Operations

From 1973 to 1975, approximately 6,000 ac on Tonkawa soils in northern Nacogdoches and southern Rusk Counties were clearcut, followed by chopping and burning on some sites, or scalping with V-blades on others. Site preparation was accomplished primarily by a LeTourneaux tree crusher, or prepared with a drum chopper during the summer prior to planting. In some areas, a whole-tree chipper was used for complete hardwood and slash removal. Essentially, this removed all organic matter and surface litter from the site and exposed bare mineral soil to the sun and wind. This greatly reduced the moisture-holding capacity of the soil and increased surface temperature.

Subsequently, from 1974 to 1981 several attempts to reforest the area using both machine and hand-planting methods were unsuccessful. Most of these plantings were failures (less than 10 percent survival) primarily due to the droughty site conditions. Minor factors included cottontail rabbit [Sylvilagus floridanus (Allen)], pocket gopher [Geomys bursarius (Shaw)] , and Texas leaf cutting ant [At ta texana (Buckley)] damage. Town ant predation is common on droughty sands, where pine seedlings are often the most succulent, and during winter are the only green vegetation available (Moser 1984). These circumstances provided incentive for this study.

Design And Treatments

Study plots were established in January 1983 to test the survival and growth of seven species/treatment combinations on this site. A randomized block design was used, in which the same seven treatments were randomly arranged within each of eight replicates. Within each treatment, 48 seedlings were planted on a 8 x 8 ft spacing in four rows of 12 seedlings each.

Replicates are 208 x 104 ft, with a buffer zone of the same size between each. The buffer zones were planted with bare rooted loblolly pine seedlings. Detailed plot layout is presented in Kroll et al. (1985).

The seven treatments are:

1. untreated loblolly pine (LOB/CON);
2. Terra-Sorb™-treated loblolly pine (LOB/TER);
3. kaolin clay slurry treated loblolly pine (LOB/CLA);
4. untreated slash pine (SLA/CON);
5. Terra-Sorb-treated slash pine (SLA/TER);
6. kaolin clay slurry treated slash pine (SLA/CL-A), and;
7. containerized longleaf pine (LL/CONT).

Terra-Sorb is a family of starch, or synthetic, absorbent polymers capable of absorbing hundreds of times their weight in water. It is a hygroscopic media that may be used as a root dip to increase the moisture-holding capacity of the soil around seedling roots. Kaolin clay slurry is similar, but an inorganic compound that is also a hygroscopic substance. It is commonly used as a standard packing media for pine seedlings.

Replicates were hand-planted using standard methods in January 1983. No additional site preparation was performed, since the site had been intensively prepared earlier. Survival data were collected in April, June, and December of the first year (1983), and in May, August, and December of the second year (1984). Thereafter, survival counts were taken in May 1985, in August 1986, and in December 1988.

In December 1983, height and root collar diameter measurements were taken for all surviving seedlings except the LL/CONT. During the winter of 1984-1985, four of the eight replicates were accidentally destroyed by fire, reducing the sample size by one-half. Survival and growth rates of the residual replicates were then compared to those that perished in the fire. There was no significant difference in survival or growth, so the results reported here reflect only those data from the residual four replicates. Height and diameter measurements were again taken in December 1988 and October 1990.

Soil samples were collected at random locations within the study plots (TN-l), from another area within the same clearcut (TN-2), and from an undisturbed natural stand (TN-3), all on Tonkawa soil series. Texture analysis by Bouyoucos method was performed for composite samples from each site, at several depths. Results of the texture analysis, reported by Kulhavy et al. (1987), confirm the sandy nature of the soil and classification as a Quartzipsamment.

Precipitation data were obtained from two sources within the area. They correlate relatively well with survival and growth, especially during the first 2 years of seedling establishment.

Data were analyzed on the Honeywell CP6 mainframe computer at Stephen F. Austin State University, SPSS[x] statistical package. All tests were conducted at the 95 percent confidence level ($P \leq 0.05$).

Survival and growth data were grouped by treatment and replicate, then two-way analysis of variance (ANOVA) was performed to test for significant effects of both variables. As expected, treatment was the effective variable in most cases. One-way analysis of variance (ONEWAY) was performed on survival and growth, using Duncan's multiple range test to identify significant differences between treatments and to determine which treatments differed significantly from others.

Survival volume index (SVI) (Tuttle et al., 1987) was calculated for each treatment (height x root collar diameter^2 x percent survival), with the first- and sixth-year data. SVI was tested for significant differences between treatments using one-way analysis of variance (ONEWAY), and Duncan's multiple range test to determine which treatments differed significantly from others.

Results And Discussion

First-Year Survival and Growth

First year survival of the seven treatments on Quartzipsamments was significantly higher for containerized longleaf (LL/CONT), followed by Terra-Sorb-treated loblolly pine (LOB/TE-R), with 85.2 and 79.7 percent, respectively (Fig. 1). Survival rates of the other five treatments were not significantly different, ranging from 54.7 percent for clay slurry-treated loblolly (LOB/CLA) down to 33.3 percent for clay slurry-treated slash (SLA/CLA) . Initial survival rates (3 months after planting) were significantly higher for LL/CONT, LOB/TER, and Terra-Sorb-treated slash pine (SLA/TER), (97.9, 95.6, and 94.3 percent, respectively), followed by untreated slash (SLA/CON), LOB/CLA, SLA/CLA, and LOB/CON, (90.1, 88.0, 85.9, and 83.1 percent, respectively). By June, LL/CONT and LOB/TER had significantly higher survival (96.9 and 95.6 percent, respectively) than the other treatments. This trend continued throughout the 6 years (Fig. 1). Survival rates based on averages of all eight replicates did not differ significantly from rates based on four replicates for any of the seven treatments. The overall survival decline between June and October was attributed to the low precipitation levels during that period (Kroll et al., 1985). Although the months of May and June were relatively wet (above normal precipitation), July through October had lower than normal levels and November and December both had above normal precipitation.

Average height of loblolly was significantly greater than that of slash after 1 year (Fig. 2), but there was no significant difference in height between the three treatments within species. The LOB/TER seedlings were taller (0.96 ft), followed by LOB/CON (0.93 ft), and LOB/CLA (0.91 ft). Slash seedlings were consistently shorter: 0.79 ft, 0.79 ft, and 0.78 ft, for SLA/CON, SLA/CLA, and SLA/TER, respectively. Mean root collar diameter was significantly greater for slash than for loblolly (Fig. 3). The SLA/CON had a significantly larger diameter than the SLA/CLA, but neither of these *was* significantly different from the SLA/TER. There were no differences between the three loblolly treatments. Survival volume index, (height x root collar diameter^2 x percent survival) of LOB/TEE was significantly higher than that of any other treatment (Fig. 4). The LOB/CLA was significantly different from the other three treatments. Survival volume

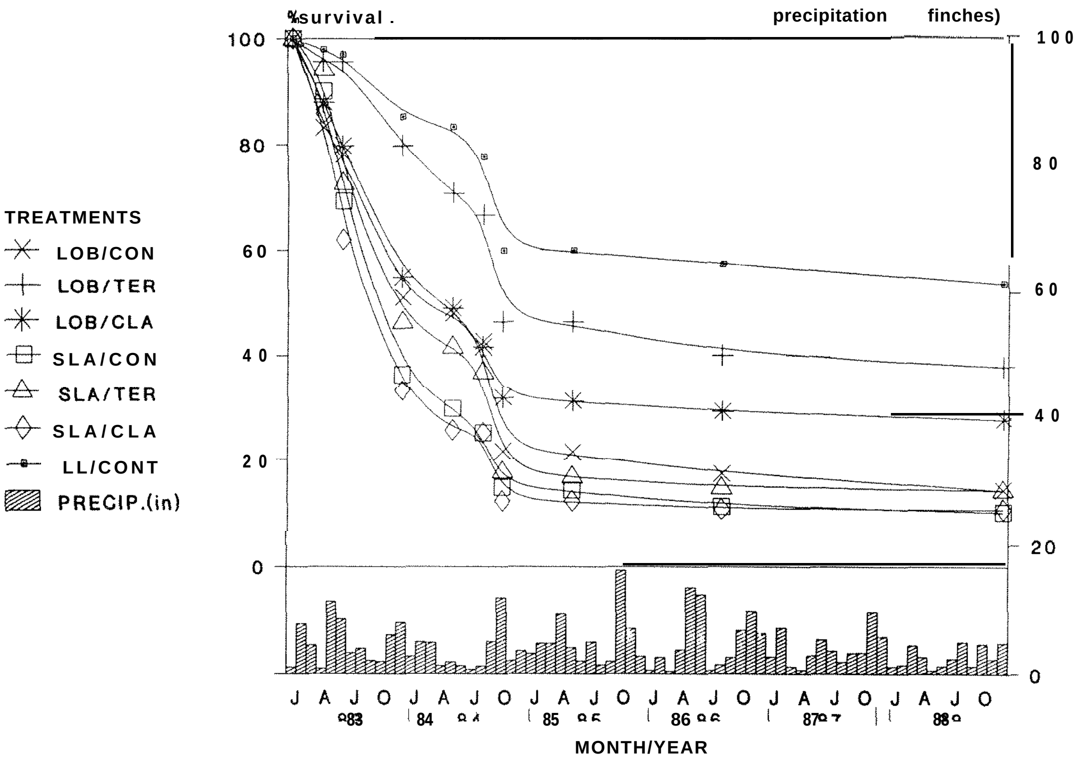

Figure 1. Survival of treated seedlings) 1983-1988, Typic Quartzipsamments.

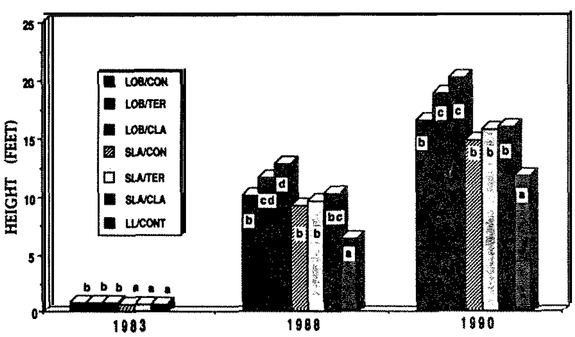

Figure 2. Height, Typic Quartzipsaments, 1983–1990.

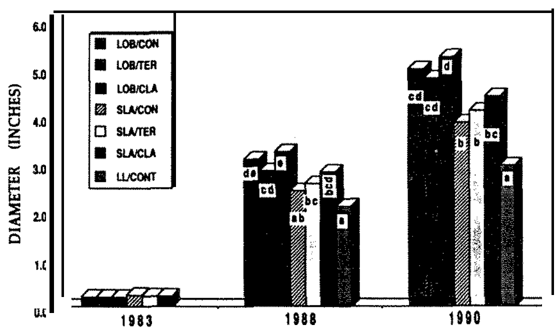

Figure 3. Diameter, Typic Quartzipsaments, 1983-90.

index (SVI), like plot volume index (PVI), serves as an indicator of overall performance in response to each combination of treatments (Walker et al., 1989), but SVI has the advantage of being comparable among sites since it is independent of the number of planted seedlings per plot or treatment (Tuttle et al., 1987).

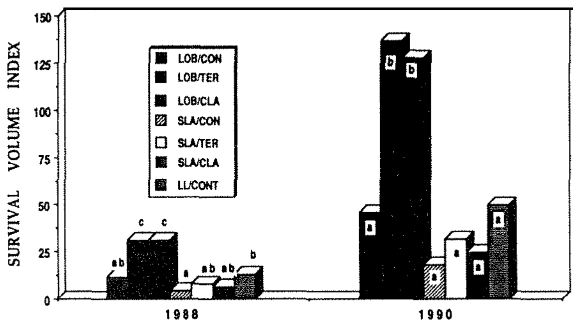

Figure 4. Survival. **volume** index **(SVI),** Typic **Quartzipsamments,** 1988-1990.

Second-year Survival

Total precipitation in Nacogdoches during 1984 was, again, below normal and less than in 1983. Although relatively consistent through the summer, the precipitation levels were too low to provide these highly permeable sands with adequate moisture through the warm summer months. As a result, by October, survival rates had decreased drastically across the site, with LL/CONT and LOB/TER at 59.9 and 46.4 percent, respectively* All other treatments were below 32 percent. Throughout the remainder of the study, all treatments showed less than 10 percent decline in survival, indicating their stability, once established (Fig. 1).

Third- And Fourth-year Survival

While most treatments sustained less than 4 percent mortality over this 2-year period, the LOB/TER seedlings declined by 6.3 percent, primarily due to defoliation by the Texas leaf cutting ant, or town ant, a pest of pine seedlings (Moser 1984). Damage to pine seedlings occurs mostly during the winter and early spring, while there is little or no other green vegetation available to forage. They prefer open areas of deep sandy soils, that are easy to excavate, to build their vast subterranean "towns," which may be several acres in area and up to 23-ft deep (Moser 1984). Town ant nest tunnels extend laterally up to 295 ft or more, but their foraging trails, aboveground, may extend hundreds of feet from entrance holes to plants under attack (USDA 1985).

Fifth- And Sixth-year Survival And Growth

After the fourth year, survival rates began to stabilize (Fig. 1). All treatments declined less than 4 percent during the fifth and sixth years. The largest decline in survival was the LL/CONT (-3.7 percent), followed by LOB/CON (-3.1 percent), LOB/TER (-2.1 percent), and LOB/CLA (-1.6 percent). The slash treatments declined less than 1 percent. One LOB/TER seedling was cut and removed (unrelated to study), which contributed about ½ percent to the "apparent" decline in their survival. Precipitation is not as critical a factor once the trees are established. Precipitation levels were below normal for both 1987 and 1988, with fewer rain days for both years. These 2 years were considered droughty , not only in east Texas, but throughout many parts of the Southeast.

Mean height and root collar diameter were larger for the LOB/CLA trees (12.89 ft and 3.24 inches). Average height of LOB/TER (11.71 ft) was second in rank, followed by SLA/CLA (10.28 ft), respectively. The shortest trees were the containerized longleaf (LL/CONT) (6.42 ft), but due to the innately different growth patterns between longleaf and other southern yellow pines, the measurements cannot be effectively compared. Root collar diameter was significantly larger for LOB/CLA than all other treatments, except LOB/CON (3.08 inches), which was significantly larger than SLA/CON (2.40 inches), SLA/TER (2.56 inches), and LL/CONT (2.08 inches), but not SLA/CLA (2.80 inches). Survival volume index (SVI) was significantly greater for LOB/TEE and LOB/CIA trees than for any other treatments. Although LL/CONT trees were shorter and thinner than any other treatment on the average, the high survival rate yielded the third highest SVI (13.06) for this treatment.

Potential evapotranspiration, calculated for the 1951-80 period in Nacogdoches, was compared to normal monthly precipitation levels to determine when water deficits normally occur in the area. January through April have a diminishing water surplus, ranging from +3.69 inches in January to +1.77 inches in April. Water deficit begins in May, with -0.13 inches, increases to -4.56 inches in July, then decreases to -1.11 in September. Water surplus is +0.37 inches in October, and increases to +3.70 inches in December. This indicates the normal long-term water balance and does not take into consideration the site conditions. On the study site, the water balance is more extreme, with smaller surplus values and larger deficits, over longer periods. Although transpiration may be lower, due to lack of vegetation on the site, evaporation is extremely high during the warm summer months due to reflected heat from the exposed sands.

Eighth-year Survival And Growth

Survival rates remained stable after the sixth year. No decline indicates that the trees are well established. Growth rate patterns (both height and diameter) remained consistent also (Fig. 2 and 3). Average heights of the LOB/TEE (18.92 ft) and LOB/CLA (20.28 ft) were not significantly different from each other, but were significantly greater than all other treatments. Average heights of LOB/CON (16.63 ft), SLA/CON (14.89 ft), SLA/TER (15.81 ft), and SLA/CLA (16.08 ft) were not significantly different from each other, but were significantly greater than that of LL/CONT (11.90 ft) (Fig. 2).

Average diameters of all three loblolly treatments did not differ significantly from each other, but the LOB/CLA diameter (5.24 inches) was significantly greater than that of the slash and longleaf treatments. The average diameter of SLA/CLA (4.40 inches) did not differ significantly from that of the other slash treatments, LOB/CON (4.98 inches), or LOB/TEE (4.79 inches), but average diameter of all loblolly and slash treatments was significantly greater than that of LL/CONT (2.94 inches) (Fig. 3).

Survival volume index (SVI) of LOB/TEE (136.35) and LOB/CLA (127.51) was significantly greater than that of all other treatments, while the others did not differ significantly from each other (Fig. 4).

Apparently, all trees in the study are well established and growing vigorously in the eighth year, as indicated by the significant increases in all measurements. Although the harsh site conditions made initial establishment difficult, results indicate that once established, pines are well adapted to the site.

Summary And Conclusions

Based on these results, Typic Quartzipsamments may be successfully reforested in pine. Management strategies are simple, but must be adhered to carefully. On forested sites, the most critical rule is to avoid clearcutting. This results in overexposure of the surface to the sun and drying winds. Minimum exposure to drying winds conserves moisture and reduces decomposition of humus and organic remains (Wilde 1948, 1958). Underplanting is recommended, followed by deadening of residuals after planted seedlings are established. Natural regeneration by seed-tree or shelterwood systems is also recommended for deep, dry sands.

On sites already clearcut, site preparation must be accomplished with minimal displacement of topsoil. Organic materials must remain on the site, since they retain moisture that the sands cannot. Some Typic Quartzipsanunents have a loamy or clayey layer 6 to 10 ft below the surface which will hold some moisture within reach of tree roots. Tonkawa sands generally have no such layer, resulting in the characteristic rapid percolation rates.

The species recommended for reforestation of deep sands in the southern United States is longleaf pine. It is well-suited to deep, dry sands, and historically inhabited millions of acres of sandhills across the Southern and Southeastern United States. Containerized is the planting method of choice. It is more time consuming and labor intensive, but generally more successful than other methods.

Results of the root treatments demonstrate their effectiveness in improving survival as well as growth. The Terra-Sorb treatment had a greater influence on survival, while the kaolin clay slurry yielded greater growth. Further research on the operational use of both of these treatments is recommended. Planting longleaf with one or both of these treatments is also recommended for further research.

Site quality of these droughty sands is obviously low in terms of timber production. Therefore nontimber values of sandhills, such as aesthetics, groundwater protection, and wildlife management should take a higher priority when developing management plan for such sites. Since these sands serve as a major recharge zone for an important aquifer, groundwater protection and development is a viable alternative land use, and is encouraged to ensure a plentiful supply of clean water for the region. Management strategies for this option are very simple. Allow the natural scrub vegetation to inhabit the site and limit activities that cause runoff and erosion. Prohibit applications of chemicals and disposal of wastes, materials which, if leached into the aquifer, would contaminate the valuable water supply.

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