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A Comparison of Tree Growth in Loblolly Pine (*Pinus taeda*) Plantations and Silvopasture Settings in East Texas

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Abstract

A desire by landowners to diversify potential income sources has resulted in an increased interest in silvopasture. This intensive land management option allows for the production of timber, livestock and/or forage on the same land base. With traditional plantation systems featuring loblolly pine (*Pinus taeda*) common in the western gulf coast region of the southeastern United States, comparisons of tree growth are needed to justify the use of silvopasture. This study evaluated the height, diameter and volume growth 13 years post-establishment of loblolly pine in both silvopasture and plantation spacings on a single site in east Texas. Individual trees in silvopasture plots had greater diameter and volume than those in plantation plots; however, plantation plots yielded greater volume per hectare. The greater volume per hectare was driven by the greater number of trees planted (1282 trees ha^{-1}) in plantation plots than those planted (598 trees ha^{-1}) in silvopasture. In silvopasture, site resources are concentrated on producing larger-diameter, sawtimber size, and theoretically, higher-value trees.

Keywords: Silvopasture; Loblolly pine; Wood volume

Introduction

The closed canopy of standard pine plantations significantly limits livestock forage production. Silvopasture, however combines wider tree spacing with management for understory species such as bahiagrass (*Paspalum notatum*) or other forage crops to combine shorter term financial returns of livestock, such as cattle, with the longer-term investment of timber production. The integrated silvopasture system is intensively managed to diversify economic returns from both timber and livestock production [1-5].

Silvopasture systems may be established from either an existing plantation, or more commonly, an open pasture [6]. Landowners and managers have a great deal of flexibility in tree arrangements (i.e., tree species, spacing, forage species), that make this form of land management potentially of interest to a wide number of producers. In the western gulf coast region, research has evaluated the viability of silvopasture [2,6], seedling establishment [7], and the use of poultry litter in silvopasture systems [8]. However, actual data on tree growth rates in silvopasture compared to traditional plantations is limited across the region.

Objectives

The objective of this study was to compare the variation in growth of the height and volume of loblolly pine trees 13 years after establishment between silvopasture spacing (598 trees ha^{-1}) and pine plantation spacing (1282 trees ha^{-1}).

Methods

Site description

The study site was an established Bahia grass (*Paspalum notatum*) pasture south of Carthage, Texas, approximately 80 km southwest of Shreveport, Louisiana. Soils at the site ranged from well-drained to moderately well-drained, and consist of: Eastwood soils (Chromic Vertic Hapludalfs) Lilbert soils (Arenic Plinthic Paleudults), Latex soils (Glossic Paleudalfs) and Scottsdale soils (Glossaquic Paleudalfs). The climate is classified as subtropical, permanently humid climate with a mean growing season of 240 days and mean annual precipitation of 112 cm (NRCS 2004).

Field layout

Four replicates were established 2003, each containing a 4.1 ha silvopasture block (1.8 × 9.1 m for 598 trees ha^{-1}) and a 4.1 ha plantation block (2.1 × 3.7 m for 1282 trees ha^{-1}). Containerized loblolly pine (*Pinus taeda*) seedlings were planted in single rows in both spacings. Prior to winter planting, a banded application of Imazapyr (Arsenal) at 47.8 ml ha^{-1} was applied in the fall of 2003, the rows ripped, and seedlings then planted. Banded Oust Extra (56.25% sulfometuron and 15% metsulfuron methyl) at 35.5 ml ha^{-1} (granular dry product converted to liquid equivalent) was applied in the spring of 2004 to further control herbaceous competition, followed by a summer fertilizer treatment of 20-8-15 at 68 kg ha^{-1}. A second application of Oust Extra was applied in the summer of 2006. Pruning of lower branches ("lifting") was performed in 2013 and 2016 for both spacings.

Tree measurement

In December 2016 - January 2017, all tree heights were measured from a distance of 20.12 m using a Suunto clinometer and a 15 m

loggers tape to the nearest 0.1 m, and Diameter at Breast Height (1.36 meters; dbh) was measured to the nearest mm using a diameter tape and basal area (BA) calculated. Volume was calculated following previously published equations [9]. Data were analyzed using An Analysis of Variance on individual tree height, dbh, BA and volume with treatment (silvopasture or plantation) as a fixed effect and block, and interaction between block and treatment and error as the random factors, was performed using SAS [10]. Individual tree basal area and volume were summarized to per hectare basis using appropriate expansion factors by block, and the difference between the two treatments was tested using t-test with α=0.05. Treatment means were calculated using the Estimate function.

Results

For each individual tree trait, effects of block and the interaction between block and treatment explained less than 2% of the total variation. Trees in silvopasture plots displayed a significantly greater DBH, BA, and volume than those in the pine plantation plots. Heights were not significantly different between the treatments (Table 1). Although the individual trees in the silvopasture plots were larger than those in the pine plantation plots, the increased density of the pine plantation resulted in a significantly higher volume and basal area on a per hectare basis (Table 1).

	Individual Tree				Per Hectare	
Treatment	**DBH (cm)**	**Height (m)**	**BA (m^2)**	**Volume (m^3)**	**Basal area (m^2)**	**Volume (m^3)**
Pine Plantation	20.57 (0.45)a	14.64 (0.76)a	0.035 (0.002)a	0.273 (0.015)a	39.02 (0.95)a	290.29 (7.88)a
Silvopasture	23.55 (0.46)b	13.24 (1.07)a	0.046 (0.002)b	0.361 (0.016)b	24.20 (0.92)b	191.45 (7.88)b

Table 1: Mean diameter (DBH), height, basal area, and volume for individual trees in each treatment and per hectare averages of basal area and volume for each treatment, with respective standard errors in brackets. Values within a column followed by different letters differ significantly (Pr<0.05) between them.

Discussion

The data support the basic assumption that, on an individual basis, trees in the silvopasture treatment would have greater diameters, which results in greater BA and, with comparable heights, a greater volume than those in the pine plantation treatment Although plantations have greater basal area and volume per hectare, the increase is due to greater numbers of trees, rather than size of individual trees. The ultimate goal of both treatments is to maximize economic return from the production of timber. For pine, this is achieved by maximizing the production of the highest-value product, in this case, sawtimber. In traditional plantation management, removal of smaller, inferior form or quality trees (thinning) is necessary to redistribute site resources to the remaining trees in order for the remaining trees to reach sawtimber size. However, in the silvopasture system, lower densities necessary to achieve sawtimber-size trees in a relatively short rotation are implemented at establishment, thus reducing the need for thinning. The lower density of the silvopasture treatment also results in additional site resources being available for livestock forage production.

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