LONGLEAF PINE (*PINUS PALUTRIS*) RESTORATION ON GULF LOWER COASTAL PLAIN FLATWOODS SITES: ROLE OF SHRUB CONTROL AND PHOSPHOROUS FERTILIZATION

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Abstract—The longleaf pine (*Pinus palustris*) ecosystem is one of the most threatened ecosystems in North America. Restoration of this ecosystem on flatwoods sites is difficult because of the thick shrub layer and limited nutrient availability of phosphorus (P) that can cause longleaf pine seedlings to remain in the grass stage for a number of years. We hypothesized that elimination of the shrub layer and P fertilization would likely increase the establishment success of planted longleaf pine seedlings on flatwoods sites. In order to test the hypothesis, a trial was established at the Naval Live Oaks area of the Gulf Islands National Seashore, FL with four treatments using a randomized complete block design. The treatments included: 1) Mechanical woody stem removal (M), 2) P fertilization (P), 3) M+P, and 4) Control. First and second year survival, root collar diameter, height, and stem volume index were compared among treatments using ANOVA. After two growing seasons, seedlings in the M+P treatment had slightly greater stem volume compared to seedlings in other treatments ($P < 0.05$). However, survival was poor for all treatments and no seedlings had emerged from the grass stage in any of the treatments.

INTRODUCTION

The longleaf pine (*Pinus palustris*) ecosystem is one of the most threatened ecosystems in North America with less than three percent of the original area remaining today (Brockway and Outcalt 1998, Jose and others 2006). Historically, longleaf pine could be found on sandhill, upland hardwood, and flatwoods sites. The species has the ability to produce a high quality timber product and provides quality habitat for many wildlife species. Because of the positive economic and ecological benefits associated with this species, longleaf pine is an ideal candidate for restoration (Brockway and others 2005). Restoration of longleaf pine, however, can be a difficult process, particularly on flatwoods sites. On these sites, restoration of the overstory is often hampered by the thick shrub layer characteristic of flatwoods sites. Under intense competition from shrubs, longleaf pine seedlings could remain in the grass stage for a number of years (Ranasinghe and others 2005). As a result, woody shrub control seems to be a logical solution to ensure successful establishment of planted longleaf pine seedlings. Another potential factor that influences seedling growth on flatwoods sites is phosphorus (P) nutrition. Phosphorous is often found to be a limiting nutrient on flatwoods sites and low availability can reduce tree growth and survival (Jokela and Long 2000). Phosphorus fertilization has been shown to increase growth of other southern pines on flatwoods sites (Colbert and others 1990, Jokela and others 1989).

The objective of this study was to quantify the survival and growth of planted longleaf pine seedlings in response to shrub control and P fertilization on flatwoods sites. We hypothesized that both shrub control and P fertilization would increase survival and growth of planted longleaf pine seedlings on flatwoods sites.

MATERIALS AND METHODS

In order to test our hypothesis, a trial was established on an ecotonal flatwoods-scrub oak site at the Naval Live Oaks area of the Gulf Islands National Seashore in Pensacola, FL with four treatments and four replications using a randomized complete block design. The treatments included: 1) Mechanical woody stem removal (M), 2) P fertilization (P), 3) M+P, and 4) Control (C).

Containerized longleaf seedlings (0-1) were planted in March at 25 seedlings per plot (15 by 15 m). In early June, woody shrubs were removed from the M and M+P plots using a brush cutter and P was applied at the rate of 55 kg ha^{-1} to the P and M+P plots as triple super phosphate fertilizer (0-45-0). Stem density was assessed for the plots at the time of treatment implementation using a 1 by 1 m subplot inside each plot. Seedlings were measured one and two years after treatment implementation.

Initial stem density of woody shrubs and survival, root collar diameter (RCD), height (HT) and stem volume index [$SVI = RCD^2 * HT$] of longleaf seedlings were compared among treatments using ANOVA. When variables were significantly different in ANOVA ($P < 0.05$), means were separated using Duncan's multiple range test.

RESULTS

Woody Stem Density

Initial woody stem density did not differ among the plots (27 stems/m^2, $P = 0.37$). After one growing season, visual observations showed woody stem height to be much lower in M and M+P plots compared to the C and P plots. This trend was observed after the second growing season as well.

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Longleaf Pine Survival

Longleaf pine survival was less than 60 percent for every treatment after the first growing season (table 1). After the second growing season, survival significantly decreased ($P < 0.05$) and was less than 40 percent for every treatment (table 2). In addition, there was no significant difference in survival among the treatments after the first or second growing season ($P > 0.05$).

Longleaf Pine Growth

After one growing season, survival, RCD, HT, and SVI of the longleaf pine seedlings did not differ among treatments (table 1, $P > 0.05$). After the second growing season, there was a slight difference in RCD and SVI among the treatments (table 2, $P < 0.05$). Seedlings in the M+P treatment had slightly higher RCD than seedlings in the M only treatment and slightly greater SVI than all other treatments (table 2). There was no significant difference in growth for any of the variables between the two growing seasons ($P > 0.05$).

Table 1—Survival, root collar diameter (RCD), height (HT), and stem volume index (SVI) of longleaf pine seedlings after one growing season for four treatments: 1) Mechanical woody stem removal (M), 2) P fertilization (P), 3) M+P, and 4) Control (C)

	Survival (%)		RCD (mm)		HT (mm)		SVI (mm^3)	
Treatment	Mean	SE	Mean	SE	Mean	SE	Mean	SE
M	44	13	10.5	0.9	19.9	2.2	2247	662
P	48	12	10.7	0.6	19.1	2.6	2340	494
M+P	56	12	11.2	0.2	19.6	1.7	2602	330
C	59	06	10.8	0.6	18.7	1.2	2401	400

Table 2—Survival, root collar diameter (RCD), height (HT), and stem volume index (SVI) of longleaf pine seedlings after two growing seasons for four treatments: 1) Mechanical woody stem removal (M), 2) P fertilization (P), 3) M+P, and 4) Control (C)

	Survival (%)		RCD (mm)		HT (mm)		SVI (mm^3)	
Treatment	Mean	SE	Mean	SE	Mean	SE	Mean	SE
M	22	07	09.8a[a]	0.4	18.7	3.7	1890a	558
P	33	12	10.7ab	0.5	16.1	1.6	1911a	190
M+P	39	11	11.6b	0.6	19.5	1.8	2903b	545
C	36	10	10.2ab	0.5	15.7	2.3	1800a	590

[a] Letters following means for an individual column indicate a significant difference ($P < 0.05$).

DISCUSSION

In southern flatwoods sites, woody shrub competition and limited nutrient availability can severely reduce pine growth (Colbert and others 1990). In a study of longleaf pine establishment in an abandoned pasture in FL, Ramsey and others (2003) reported that local resource competition was the leading influential factor on longleaf pine seedling growth. In our study, after two growing seasons, SVI of seedlings in the M+P treatment was slightly greater compared to seedlings in other treatments, supporting the data from Ramsey and others (2003). However, it does not appear that in our study resource competition was altered enough to cause longleaf seedling emergence from the grass stage. Furthermore, the overall poor survival of all treatments suggests that additional factors, such as drought, may have influenced seedling growth and survival.

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