TREE ESTABLISHMENT ON PHOSPHATE MINED LANDS IN FLORIDA AS AFFECTED BY PLANT INTERACTIONS [1]

by

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Abstract: The effects of plant competition on tree growth and survival on mined overburden in central Florida were assessed in periodically weeded and unweeded plots of primrose willow (*Ludwigia peruviana*), a wetland shrub, and of saltbush (*Baccharis halimifolia*), an upland shrub. In an additional study, wax myrtle (*Myrica cerifera*), slash pine (*Pinus elliotii*) and bushy beardgrass (*Andropogon glomeratus*) were evaluated as nurse crops, and their effects on tree growth and survival were compared with the effects of a hay mulch, an established perennial cover of bahiagrass (*Paspalum notatum*), and a temporary winter cover of annual grasses (cereal rye, *Secale cereale*, plus ryegrass, *Lolium perenne*). After 4 growing seasons, competition from primrose willow at a reclaimed wetland site has had only a minor effect on baldcypress (*Taxodium distichum*) growth. On a drier reclaimed upland site, saltbush competition cut laurel oak growth (*Quercus laurifolia*) in half but only reduced live oak (*Quercus virginiana*) growth by 20%. Interplanting of wax myrtle as a woody nurse crop, or application of a hay mulch each enhanced the growth of laurel oak trees on a mesic overburden site in comparison with the temporary annual grass cover crop. The slash pine and bahiagrass were not significantly different from the annual grass control in their effects on laurel oak growth, but bahiagrass caused a slight reduction in tree survival after four years. The bushy beardgrass treatment resulted in reduced tree growth, but this appeared to be related more to the rapid invasion of other plant species than to the bushy beardgrass itself, which was rather sparse.

Additional Key Words: *Ludwigia, Taxodium, Myrica, Baccharis, Quercus*

Introduction

The warm, humid subtropical climate of central Florida, combined with the fertility of the overburden soils created by surface mining for phosphate (more fertile than the native sandy soils), promotes rapid plant growth and increases the potential for competition from less desirable plant species. The possible value of reducing plant competion to promote tree establishment and growth must also be balanced against the need to control erosion. Not all plant interactions are necessarily negative. The concepts of plant succession and the intentional practice of planting nurse crops are based on the premise that some plants may modify the environment to favor other plant species.

Plant Competition

Florida regulations require that "nuisance" plants, such as **primrose willow** (*Ludwigia peruviana*), a native flowering shrub, must be limited to less than 10% of the total cover on forested wetlands. To comply with these requirements on reforested wetlands, the primrose willow must be controlled chemically with repeated applications of herbicides, mechanically, or by labor-intensive manual means. But is this noxious weed control necessary ecologically or just aesthetically? There is growing speculation that the desired tree species will eventually overtop the weeds and shade them out. Perhaps patience is required to let plant succession solve the problem.

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Saltbush (*Baccharis halimifolia*) is a native Florida upland shrub that commonly invades phosphate mined lands. Its effects on tree establishment had not been documented prior to this study.

Bahiagrass (*Paspalum notatum*) is an exotic grass commonly used in the reclamation of phosphate mined lands in Florida. It is not uncommon for trees to be planted after sites have been stabilized with bahiagrass, but bahiagrass may inhibit tree growth (Fisher and Adrian 1981).

Nurse Crops

Nurse crops are planted as relatively short term cover crops to facilitate the establishment of another crop, in this case forest trees. Nurse crops may reduce the drying effects of sun and wind, augment soil nitrogen (through N-fixing symbionts), add organic matter to the soil (through decomposition of leaf litter and roots), physically condition the soil (e.g. loosen compacted soil through root action), or a combination of these. Woody nurse crops may help shade out highly competitive, but shade-intolerant plants, while allowing shade tolerant forest trees to become established and grow. The following potential nurse crops were tested in this study.

Wax Myrtle (*Myrica cerifera*) is a large shrub or small tree native to central Florida. It sometimes occurs in the understory of riverine forests and commonly colonizes reclaimed mines. Its evergreen foliage provides year-round shade and protection from wind. Actinomycetes associated with wax myrtle roots fix nitrogen (Permar and Fisher 1983). Plass (1977) found that interplanting of European alder (*Alnus glutinosa*), a nitrogen fixing tree, among several tree species on mine spoils in Kentucky enhanced growth of the other trees. Wax myrtle may serve a similar purpose in Florida.

Slash Pine (*Pinus elliottii*) is a pioneer species which is very tolerant of poor soils and a wide range of site conditions. Southeastern pines generally occur in fallow field succession (Kurz 1942, Snedaker and Lugo 1972) and could aid hardwood establishment. A nurse crop such as slash pine can be easily removed mechanically without fear of resprouting, or if we are patient, the hardwoods are expected to eventually replace the shade-intolerant pine.

Bushy Beardgrass (*Andropogon glomeratus*) is an indigenous bunchgrass that frequently dominates recently abandoned croplands with relatively wet soils (Kurz 1942). Trees readily colonize bushy beardgrass dominated sites, and bushy beardgrass, therefore, seems to serve as a natural nurse crop. Where no other perennial cover has been planted, bushy beardgrass frequently volunteers on mined lands over a period of several years and largely replaces other weedy colonizing plants. There is a possibility of accelerating this natural process by intentionally planting trees and concurrently planting bushy beardgrass, or its close relative broomsedge (*Andropogon virginicus*), as a nurse crop on freshly reclaimed land. Broomsedge often occurs on drier sites than bushy beardgrass.

Objectives

The specific objectives of this study were to: (1) evaluate the competition effect of primrose willow on baldcypress and the competitive effect of saltbush on live oak and laurel oak, and (2) evaluate the effects of 3 potential nurse species (wax myrtle, slash pine and bushy beardgrass) on growth and survival of laurel oak in comparison with the effects of an annual grass cover crop.

Methods

Competition

To evaluate the effects of primrose willow competition on tree growth, a natural stand of primrose willow on a seepage wetland on mined land at the IMC Fertilizer Co.'s Clear Springs Mine was cut to the ground in the dry season with a tractor-drawn mower (to approximate postmining conditions) prior to tree planting. Primrose willow was allowed to regrow on the "unweeded" study plots while the "weeded" plots were periodically mowed

with a steel-bladed, gasoline powered mechanical trimmer. A similar approach was taken in the study of saltbush competition. Natural stands of saltbush on an upland overburden site at the Clear Springs Mine were utilized, but because saltbush does not resprout to any great extent, only the weeded plots were mowed with a mechanical trimmer.

There were eight replicate blocks of paired weeded and unweeded plots. Each individual competition plot had 5 trees of each species for a total of 40 trees per species per treatment. Laurel oak (*Quercus laurifolia*) and live oak (*Quercus virginiana*) were planted in the saltbush plots, and baldcypress (*Taxodium distichum*) was planted in the primrose willow plots. The trees were gallon-sized nursery stock (15 cm diameter by 15 cm depth pots) and were planted 2 m apart.

Nurse Crops aud Cover Crops

The studies of nurse crops and cover crops were conducted at IMC Fertilizer Co.'s Noralyn and Clear Springs phosphate mines, located south of Bartow in central Florida. At each mine, two sites (total of four sites) were established on areas of recently (1985-87) reclaimed overburden. The overburden was in the loamy sand textural classification (average of 83% sand, 7% silt, and 10% clay), and there were few rocks or pebbles. Overburden pH averaged 5.7, and Mehlich III extractable nutrients included 22 mg/kg of K and 650 mg/kg of P. The sites were considered mesic. Annual precipitation measured at a station within 6 miles of the study sites was 100, 87, 121 and 96 cm for 1989, 1990, 1991 and 1992, compared to a long term average of 115 cm per year. Each individual test plot was 0.028 ha in area, and each individual treatment was replicated four times (once at each site).

The study sites had been stabilized with mostly bahiagrass cover, but to better simulate freshly graded overburden typical of postmining conditions, the established vegetation and 15 to 20 cm of surface overburden were removed with bulldozers and the sites were graded during 1988. The bare areas, except for the bushy beardgrass treated plots, were disked and broadcast seeded with 50 kg of cereal rye (*Secale cereale*) and 22 kg of ryegrass (*Lolium perenne*) per ha in October 1988. All the scalped plots were fertilized at the time of seeding with 45 kg N, 45 kg P_2O_5 and 45 kg K_2O per ha. The primary purpose of the fertilizer was to promote establishment and growth of the cover crop. The rye plus ryegrass treatment alone was considered as the "control."

Gallon-sized nursery stock of laurel oak was planted in all trials. Outplanting occurred from January 30 through February 10, 1989. All nurse crops and soil amendments were in place by February 1989. Each tree planting location was marked with a stake wire flag, and each tree was tagged with a permanent aluminum tag with an individual identification number. All test trees were measured for initial height shortly after planting. Trees that died during the initial winter dry season were replanted in the following wet season (July 10-21, 1989) from extra trees of the original stock that were reserved at the nursery. The replanting was done to maintain adequate numbers of trees for statistical analysis of growth parameters in subsequent years.

Woody nurse species (tubeling slash pine and gallon wax myrtle) were planted between rows of test trees (1 m from test trees) in early February 1989. The herbaceous nurse crop, bushy beardgrass, was planted in late October 1988, prior to tree planting, by scattering recently harvested panicles and lightly disking the surface soil.

A hay mulch treatment, which was expected to reduce plant competition below that in the rye plus ryegrass control, was included in the study. The test plots were seeded and fertilized as above, but in addition, squares of bahiagrass hay about 8 cm thick were sliced from hay bales, cut in half with a machete, and centered around each tree after it was planted.

Established stands of bahiagrass near the nurse crop test plots were planted with laurel oak in the same manner as the nurse crop tests except that the bahiagrass plots were not fertilized.

Measurements

Tree heights and stem diameters at a 15-cm height were measured at the time of planting and each winter thereafter. Survival was assessed at the time of summer replanting and each winter thereafter. Crown diameters (average of two perpendicular measurements) were determined during the fourth growing season. At the end of the fourth growing season, stem diameter at breast height (DBH), rather than at a 15-cm height, was measured on baldcypress because of the basal swelling of the rapidly growing trees. Growth data were only analyzed and presented for those trees still alive at the end of the fourth growing season.

Results and Discussion

Competition

By the end of four growing seasons, stem diameter at breast height (DBH) and crown diameter of baldcypress were about one-third greater on plots where primrose willow was repeatedly cut to the ground (Table 1). Baldcypress trees were about 13% taller on the weeded than on the unweeded plots, but this difference was only statistically significant at the 0.10 level. It should be noted that more than half of the baldcypress trees had overtopped the 2.7-m-tall primrose willow on the unweeded plots. Height growth of baldcypress was actually greater the first year on the unweeded primrose willow plots, suggesting a possible beneficial nurse crop effect (Table 2). However, baldcypress growth was clearly better on the weeded plots in the third and fourth growing seasons. Primrose willow seems to only slightly inhibit the growth of baldcypress, and the fact that the majority of the baldcypress has overtopped the primrose willow in four years, suggests that the baldcypress may eventually shade out the primrose willow. Elderberry (*Sambucus canadensis*) intermingled with the primrose willow at the study site appeared to be doing well, and at another site, Clewell and Raymond (1991) have observed good growth of planted trees and even the colonization of new seedlings of such species as popash (*Fraxinus caroliniana*) and red maple in the presence of primrose willow. Intensive and expensive efforts to control primrose willow in the early stages of forested wetland development may not be necessary.

The saltbush competition study site was drier than the nurse crop study sites, and laurel oak growth was correspondingly less (compare Tables 3 and 5). Live oak was better adapted to the saltbush study site and its growth was much greater than that of laurel oak (Table 3). Live oak height and stem diameter after four years were about 20% less in the presence of saltbush than with saltbush removed, but crown diameter and survival were not significantly affected by saltbush presence. The less vigorous laurel oak was inhibited more by saltbush competition than was live oak; laurel oak heights and crown diameters were 50% less and survival was 18% less in the presence of saltbush than without it. Height growth of live oak and laurel oak was not affected by saltbush in the first growing season, but inhibition by saltbush was evident in subsequent years (Table 4).

Table 1. Primrose willow effect on size (cm) and survival of baldcypress after four growing seasons.

Treatment	Height	DBH	Crown Diameter	Percent Survival
Unweeded	327	3.6	109	98
Weeded	377	5.0*	145*	95

* Significantly different from unweeded control at 0.05 level

Table 2. Primrose willow effect on height growth (cm) of baldcypress during four growing seasons.

	Growing Season				
	1	2	3	4	Total
Unweeded	51	73	72	57	253
Weeded	29*	89	94*	93*	306

* Significantly different from unweeded control at 0.05 level

Table 3. Saltbush effect on size (cm) and survival of live oak and laurel oak after four growing seasons.

		Height	Stem Diameter	Crown Diameter	Percent Survival
Live Oak					
	Unweeded	201	3.0	95	93
	Weeded	242*	3.8*	107	95
Laurel Oak					
	Unweeded	62	0.8	32	78
	Weeded	93*	1.1*	49*	95*

* Significantly different from unweeded control at 0.05 level

Table 4. Saltbush effects on height growth (cm) of live oak and laurel oak.

		Growing Season				
		1	2	3	4	Total
Live Oak						
	Unweeded	11	31	58	49	149
	Weeded	11	45	63	72*	191*
Laurel Oak						
	Unweeded	6	1	8	13	28
	Weeded	7	11	21*	18	57*

* Significantly different from unweeded control at 0.05 level

Nurse Crops and Cover Crops

After four growing seasons, the wax myrtle nurse crop and the hay mulch had resulted in greater laurel oak heights and crown diameters than did the control treatment (Table 5). The hay mulch also caused increases in stem diameter. Planting of bushy beardgrass instead of rye and ryegrass resulted in decreased height and stem diameter of laurel oak. The beneficial effect of the hay mulch on height growth of laurel oak was apparent the first growing season, whereas the wax myrtle nurse crop did not have any apparent beneficial effects until the third year (Table 6). Even the slash pine nurse crop caused a significant increase in laurel oak height growth in the third year, and although the cumulative effect after four years was not quite statistically significant, the pine nurse crop did seem to promote laurel oak growth compared to the control. The stunting of laurel oak in the bushy beardgrass treatment became evident in the second growing season.

Table 5. Effects of nurse crops, cover crops, and hay mulch on size (cm) and survival of laurel oak after four growing seasons.

	Height	Stem Diameter	Crown Diameter	Percent Survival
Control	143	1.67	75	93
Pine	174	1.78	79	96
Wax Myrtle	183*	1.74	88*	85
Bushy Beardgrass	99*	1.23*	63	90
Hay Mulch	184*	2.28*	100*	94
Bahiagrass	136	2.00	81	78*

* Significantly different from control at 0.05 level

Table 6. Effects of nurse crops, cover crops, and hay mulch on height growth (cm) of laurel oak.

	Growing Season				
	1	2	3	4	Total
Control	3	12	29	38	82
Pine	6	14	44*	47	111
Wax Myrtle	3	16	43*	55*	117*
Bushy Beardgrass	2	0*	5*	26*	33*
Hay Mulch	9*	17*	49*	49	126*
Bahiagrass	2	4	19	39	65

* Significantly different from control at 0.05 level

The enhancement of laurel oak growth by the wax myrtle nurse crop may have been due to two factors. First, the dense canopy effectively shaded out most of the weedy plants found on plots with the other treatments. The accumulation of leaf litter may also have had some effect on weed germination. Apparently, laurel oak is sufficiently shade tolerant to grow within the wax myrtle canopy. Second, wax myrtle fixes nitrogen through an actinomycete symbiont (Permar and Fisher 1983). The slash pine may also have suppressed weeds but not to the same extent as wax myrtle. The hay mulch inhibited weeds and probably helped reduce soil moisture loss as well. The stunting of trees in the bushy beardgrass treatment probably had nothing to do with the presence of the limited bushy beardgrass cover; rather, this warm season grass was slow to establish and allowed rapid invasion of potentially competitive plants, including *Indigofera hirsuta, Cassia nictitans, Baccharis halimifolia, Ambrosia artemisifolia, Eupatorium capillifolium, Paspalum notatum, Andropogon virginicus, Rhyncheletrum repens,* and *Cynodon dactylon*. On the control and other treatments, the winter annual grasses (rye and ryegrass) became quickly established and helped inhibit invasion of other plants. Even after the rye and ryegrass died back in the summer the dead plant material continued to serve as a mulch and slowed, although it did not stop, plant invasion.

Bahiagrass (*Paspalum notatum*) and other grasses have been observed to inhibit tree growth (Fisher and Adrian 1981, Plass 1968, Smith 1989). Laurel oak trees were planted into established stands of bahiagrass near the nurse crop and soil amendment study plots, and although survival was reduced slightly, it appears that bahiagrass was no more harmful to laurel oak growth than the volunteer vegetation in the control plots (Tables 5 and 6).

Conclusions and Recommendations

Primrose willow competition was not a major factor in the establishment and growth of baldcypress on a seepage wetland site. Primrose willow even appeared to have a beneficial nurse crop effect on bald cypress the first year. Mechanical and chemical means available for controlling primrose willow may often do more harm than good. For example, although baldcypress may be somewhat tolerant of the broadleaf herbicides used to control primrose willow, many other tree and understory species are not. Our results suggest that intensive and repeated efforts to control primrose willow may not be necessary when baldcypress is planted. Baldcypress should overtop primrose willow in a few years and, if it is planted densely enough (e.g. 1.7 to 2.0 m apart), should eventually shade out the primrose willow.

Saltbush competition with live oak on an upland site was not serious enough to justify the expense of control measures. In contrast, laurel oak growth would likely be aided by control of saltbush on a similar site. However, laurel oak should probably not even be planted on a site where it is not well adapted.

Wax myrtle appears to be a useful nurse crop for interplanting among desired hardwoods such as laurel oak on mesic sites. The beneficial effects of the wax myrtle became apparent in the third growing season when its canopy cover exceeded 50%. We are uncertain what the relative contributions of symbiotic nitrogen fixation or the inhibition of weeds by shading may be to wax myrtle's enhancement of laurel oak growth . The optimum density for interplanting of wax myrtle has not yet been determined, but we feel that wax myrtle may not need to be planted as densely as in this study.

The hay mat mulch around the base of each newly planted tree was beneficial the first growing season, and although the mulch disappeared in the third growing season, the head start in growth was valuable.

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