Miller, James H.; Zutter, Bruce. 1987. A region-wide study of loblolly pine seedlings growth relative to four competition levels after two growing seasons. In: Proceedings Fourth Biennial Southern Silvicultural Research Conference, 1986 November 4-6; Asheville NC. Gen. Tech. Rep. SE-42. Atlanta, GA: U.S. Department of Agriculture, Forest Service: 581-592.

A REGION-WIDE STUDY OF LOBLOLLY PINE SEEDLING GROWTH RELATIVE TO FOUR COMPETITION LEVELS AFTER TWO GROWING SEASONS-?

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and

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Abstract.--A common study design was simultaneously established at 13 locations in the Southern United States to examine the scope of regional variation in loblolly pine (Pinus taeda L.) growth relative to four competition levels. The following competition levels were created and maintained for 2 years using selective herbicides and directed applications of nonselective herbicides: (a) complete control of all competition; (b) voody control, leaving the herbaceous competition; (c) herbaceous control, leaving the woody competition; and (d) no control, with both herbaceous and woody competition. Effects on planted pines are being examined at 12 locations, and natural regeneration is being studied at one Arkansas location.

During the first 2 years the herbaceous component generally had more negative influence on pine growth than the woody component. Diameter growth was more often influenced than height growth. The size of trees grown without competition represents unique benchmarks of growth across the region by which results from other vegetation management studies can be gauged.

INTRODUCTION

Early in the life of pine plantations, an array of woody and nonwoody vegetation competes at various levels across the landscape with individual crop seedlings. If all nonarboresent vegetation is considered as herbaceous, then the array of woody and herbaceous vegetation and the resulting pine growth can be conceptually viewed as a response surface (fig. 1). Woody and herbaceous competition are the X and Y variables and pine size is the response variable, 2. Vegetation management treatments are applied to shift the amounts of these components to areas on the response surface where more favorable pine growth will occur. Unfortunately, very few areas on this response surface have been investigated, and only on a few sites, often using different types and timings of treatments. Knowing some key responses across many sites on this surface should allow scattered research findings to be compared to these knowns and thus to each other.

[1/] Paper presented at Southern Silvicultural Research Conference, Atlanta, Georgia, November 4-6, 1986.

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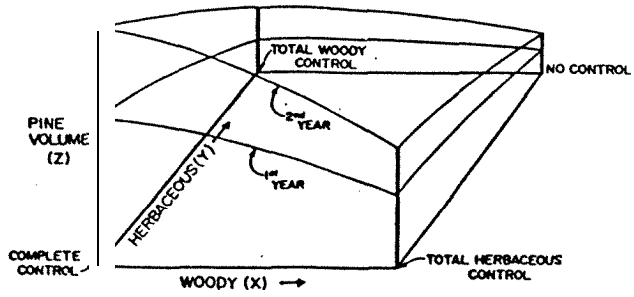

Figure 1.--Conceptual response surface showing the four corners studied in the Competition Omission Monitoring Project

In 1982, at the Second Southern Silvicultutal Research Conference, a group of investigators met and began planning a project to define the four corners of this response surface. The primary study objective was to establish a southern region framework of growth response on major soil sites for newly established loblolly pine relative to four competition levels: (1) no control, (2) hardwood and shrub (woody) control, (3) herbaceous control, end (4) total competition control. These control levels are to be maintained for at least 4 years. A second objective was to make a strict comparison between the reiative importance of herbaceous vs. woody competition as they affect loblolly pine growth on a wide range of sites. Measurements of plant moisture stress were to be made on two locations to aid in data interpretation. A third objective was to describe both the herbaceous and woody vegetation at each location to identify the principle competitors in the region.

This cooperative effort has since been termed the Competition Omission Monitoring Project or COMP, because selected components are omitted and pine response is closely monitored. Sixteen sites have been established using a common study plan, with some minor alterations. The 2-year results from 13 locations established in 1984 are presented in this paper.

METHODS

Study Locations

Study locations are shown in figure 2 and physiographic provinces noted in table 1. Locations were clearcut in late 1982 or 1983, except for Crossett, AR, and Pembroke, GA. At Crossett, hardwoods greater than 1 inch in d.b.h. were injected with herbicide in 1980 prior to a seed-tree regeneration cut (1981); then brush cutting to a height of 2.5 feet occurred before seed tree removal (1983). At Pembroke, a 6-year old plantation that had burned in a wildfire was rebedded in 1983, the only bedded study location.

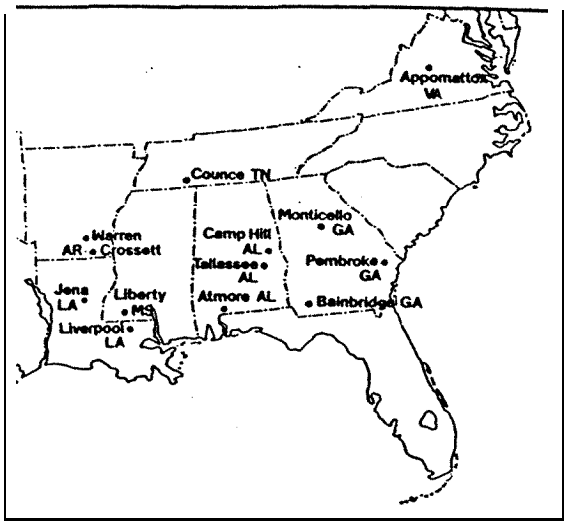

Figure 2.--Study area locations

The other sites were chopped and burned in 1983, except for Atmore, AL, which was fuelwood harvested and Councr, TN, which was sheared and vi nd roved . At some locations, chain saws and tree injection were used to remove scattered standing trees after site preparation.

Plot Establishment and Treatment

Sixteen treatment plots measuring 104 by 104 ft (0.25 acres) were established at most locations using a randomized complete block design with four blocks of four plots. At Bainbridge, GA, a completely randomized design was used, and at Pembroke, CA, 20 plots were established with 5 blocks of 4 plots. All blocking was by topography except at Crossett, AR, and ail slope positions were included except the medium to steep slopes. Blocking at Crossett was by pine stocking levels.

Interior measurement plots were 63 by 63 ft (0.09 acres), which accommodated precisely positioned planting spots measured at 9 by 9 ft, except at the natural regeneration and bedded sites. Thus there were 121 planting spots within the 0.25-acre treatment plots and 49 spots within the measurement plots. At each planting spot, two 1-O loblolly pine seedlings were planted within 5 inches of the spot marker. Double planting was performed to assure full stocking for long-term growth measurements. Either improved or Livingston Parish seedlings were planted. After the first growing season, randomly generated codes were used to thin seedlings to one per spot. This was done to maintain population means and variance's of initial seedling size. All 49 measurement seedlings were permanently identified. For the natural regeneration study location at Crossett, AR, 50 seedlings on each plot were randomly selected and tagged for measurements.

Table 1.-Location, phyaiographic province, soil series, and soil properties for two depths for each study site

Location	Province	Soil Striea	Depth	Sand	Silt	Clay	OM	Available PO4	pH
			inches			percent		mg/kg	
Crossett, AR	HCP[1]	Bude , Providence	0-6	35	51	14	2.5	0.13	5.4
			6-24	33	51	16	0.7	0.03	5.1
Warren, AR	HCP	Saffell, Stough	O-6	59	30	11	3.7	2.23	5.7
			6-24	57	28	15	1.9	0.90	5.1
Jena, LA	MCP	Cameran, Anacoco	O-6	55	34	11	2.7	0.36	5.3
			6-24	46	30	24	1.1	0.03	5.2
Liverpool, LA	HCP	Tangi, Providence	O-6	39	49	12	3.0	0.25	5.2
			6-24	35	46	19	2.2	0.13	5.2
Liberty, MS	MCP	Saffell	o-6	7s	20	5	2.0	1.35	5.8
			6-24	65	23	12	0.5	0.33	5.5
Counce, TN	HCP	Silerton, Lutta	O-6	9	54	37	2.2	0.10	4.9
			6-24	8	51	41	1.1	0.05	4.9
Atrore, AL	MCP	Orangeburg	O-6	64	14	22	1.5	0.07	5.4
			6-24	61	14	25	1.2	0.01	5.4
Tallassee, AL	HCP	Cowarts	o-5	83	11	6	1.3	1.79	5.2
			b-24	75	13	12	0.7	0.61	5.3
Camp Hill, AL	P	Cecil, Pacolet	Q-6	72	17	11	2.1	0.43	5.4
			6-24	61	16	23	0.8	0.05	5.3
Bainbridge, GA	MCP	Orangeburg, Esto	o-6	86	5	9	0.9	0.90	5.8
			6-24	79	4	17	0.9	0.20	5.4
Monticello, GA	P	Davidaon	O-6	64	20	16	3.6	1.05	5.8
			6-24	49	21	30	1.1	0.08	5.4
Pembroke, GA	LCP	Mascottee, Pelham	o-6	88	6	6	3.1	0.38	4.3
			6-24	88	7	5	1.9	0.33	4.5
Appomattox, VA	P	Cecil, Cullen, Iredell	O-6	42	34	24	3.8	0.85	4.9
			6-24	32	26	42	1.5	0.16	4.7

[1] HCP=Hilly Coaatal Plain, MCP=Middle Coastal Plain; LCP=Lower Coastal Plain; P=Piedmont

The four treatments, or desired competition situations, were established and maintained as follows:

No control (none)--After the initial aite preparation treatment, no further broadcast treatmenta were applied. Vine infestations were spot treated at most location6 using ahielded directed sprays of glyphoaate (Roundup') or wick applications and directed sprays of triclopyr (Garlon™).

Woody control--Preeatabliahwnt herbicide applications of foliar and basal sprays were used. For two groving seasons, three to six herbicide treatments were applied to eliminate individual hardwood stems and vine infestations using directed sprays of glyphoeate and/or tricloypr and basal wipes of triclopyr. Poliar-active herbicides were ueed to minimize seedling damage.

Herbaceous control (herb control)--March to May applications of sulfometuron methyl (Oust™) at 3 to 6 oz product per acre were the main control treatments. In the second year, glyphosate at 18 oz product per acre or oxyfluorfen (Goal") at 0.6 gal product per acre were included in a tank mix with aulfometuron methyl. At three to five times during a growing • [illegible] shielded directed • praya of glyphoaate (2-percent solution) were applied to scattered regrowth. At Crossett and Bainbridge, eethoxydim (Poast™) was used as a broadcast spray for grass control.

Total control--A combination of treatmeats uaed on the woody and herbaccous control plots were applied as outlined above.

Through careful applications, minimum pine damage occurred within the plots.

Measurements and Analyses

Study sites were located on prevalent series for the provinces and some location6 are on common series (table 1). Soil6 were aampled in early spring of 1984 on all plots to characterize sites. Twenty tube (l-inch diameter) samples per plot were composited by depth; 0 to 6, 6 to 12, and 12 to 24 inches. A range of textural classes are encompassed by the study sites with most surface soil6 being in the loamy classes with medium to high sand contents. The exception is Counce, TN, which is a silty clay loam. Surface soil organic matter (OM) ranges from 0.9 to 3.8 percent, available phosphorus from an extremely low level at 0.07 mg/kg to a high of 2.23 mg/kg, and pH from 4.3 to 5.8.

Seedlings were measured during the winter after the first two growing seasons. Heights and groundline diameters (GLD's) were measured the first year, and diameter at 6 inches above groundline (D6) was included the second year. Damage incidence by tipmoth (Rhyacionia spp.) and fusiform rust (Cronartium quercuum (Berk.) Miyabe ex Shirai f.sp. fusiforme) were recorded by stem location for all seedlings.

Competition levels were assessed in September for the first two growing seasons to document the variation in competitive specie6 acroaa the region and the degree of treatment success. Woody rootstocks were counted by species and by 1-ft height categorica on three systematically located 9- by 18-ft plots per measurement plot. These 9- by 18-ft plot6 were halved and herbaceoua component6 (grasses, forbs, semiwoody vines, and shrubs) and bare ground were visually estimated by percent cover on the six 9- by 9-ft plots. Herbaceous species having a cover greater than 15 percent were recorded. In the second growing season, additional cover estimates were made for woody competition and crop pines. At Pembroke, GA, 11- by 15-ft plot6 centered on the 11-ft spaced beds were used instead of the 9- by 18-ft plots. At Crossett, AR, rootstock counts and cover estimates were made on 10 circular milacre plots per measurement plot.

Pine growth data, tipmoth and fusiform incidence, and competition cover estimates were analyzed separately by location using the appropriate analysis of variance (ANOVA) with arcsine square-root transformations for percent data. If treatments were significantly different at the 0.05 level, treatment means were separated using Duncan's multiple range test.

Pine Moisture Stress

To delve closer into cause-and-effect relations between competition and its influence on moisture stress of pine seedlings, in late-September 1984, predawn moisture stress was taken on the pines at Tallessee and Camp Hill, AL. These locations were planted with seedling from the same source, on sites located within 30 miles of each other, representing Coastal Plain (Tallassee) and Piedmont (Camp Hill) soils. The pressure chamber method (Waring and Cleary 1967) was used on two consecutive mornings after a rainless period of about 20 days. Seedling lateral branches were clipped and xylem pressure potential (XXP) was read in negative megapascals (MPa). Eight seedlings were randomly selected from each of the four treatments on two blocks at each location. Plot means were then calculated. After inspection for homogcnity, the data from both locations were combined and analyzed using ANOVA and Duncan's multiple range test. Linear regression techniques were used to explore the relation between xylem pressure potential and first-year GLD.

RESULTS

Woody and Herbaceous Species Composition

Panicum grasses were common at nine locations in the first year with broomsedge being the second most common grass across the region (table 2). These grasses generally increased in frequency and percentage of cover in the second year. The asteraceae forbs (asters, horseweed, dogfennel, goldenrod, etc.) played a conspicious role in early succession, with member species present but differing by location and by year. Blackberry was a component at most locations on the no control and herb control treatments. Like blackberry, honeysuckle and other vines increased coverage in the second year.

Sumacs were the most common woody species. The range of wood species and percent composition was fairly unique by location. The study locations represent a vide 'spectrum in the abundance of woody competition, and densities were greater than 3,000 rootstocks per acre at most locations in the second growing season.

Cover Estimates

The success of control treatments can be judged by the cover estimates for the first and second growing seasons shown in table 4. Coverage the second year may total to more than 100 percent of the area because the herbaccous, woody, and pine cover6 can simultaneously occupy different aerial strata. The specified competition levels have been reached at most locations, with yearly improvement6 being made toward the absolute competition levels. In general, the percent bare ground in table 4 shows good overall control on total control treatments, considering the amount of competition controlled and the effort expended. Early season control of herbaceous vegetation in the first year was nearly complete at most locations following the pre-emergent herbicide applications. The late-season cover values in table 4 do not reflect this degree of control due to some subsequent regrowth of grasses and vines.

Table 2.—The percent frequency and cover of prevalent herbaceous species on no control plots in the first and second year and the percent composition of prevalent woody species in the second year (scientific names are given in Table 3)

First Year Herbaceous			Second Year Herbaceous			Second Year Woody		
Species	Frequency	Cover	Species	Frequency	Cover	species	Composition	Rootstocks
	percent	percent		percent	percent		Percent	No./A
Crossett, AR								
blackberry	a0	29	blackberry	75	24	Am. beautyberry	35	14,700
panicum grass	65	21	honeysuckle	60	26	winged sumac	21	
honeysuckle	55	21	greenbriar	50	11	huckleberry	19	
common grape	42	11	uniola grass	39	12	sassafras	10	
Warren, AR								
falsedandelion	92	21	panicum grass	88	36	winged sumac	47	1,725
panicum grass	sa	7	broomsedge	a3	13	bitternut hickory	10	
crotonopsis	42	4	dogfennel	38	2	white oak	a	
broomsedge	37	3	horseweed	29	19	willow	6	
Jena, LA								
panicum grass	a7	20	panicum grass	92	39	loblolly pine	69	7,335
dogfennel	79	32	dogfennel	88	31	winged sumac	7	
woolly croton	42	10	blackberry	50	12	southern red oak	5	
blackberry	33	3	common lespedeza	25	11	beauty berry	5	
Liverpool, LA								
broomsedge	a3	29	panicum grass	100	20	waxmyrtle	19	5,243
panicum grass	79	15	broomsedge	92	28	huckleberry	16	
aster	42	4	goldenrod	54	5	winged sumac	14	
goldenrod	42	3	rushes	46	5	blackgum	10	
Liberty, MS								
			blackberry	71	11	winged sumac	49	7,843
	no		partridge pea	54	12	dogwood	13	
	data		goldenrod	46	6	water oak	9	
			honeysuckle	46	a	sweetgum	7	
Counce, TN								
panicum grass	100	35	panicum grass	100	57	winged sumac	47	2,823
broomsedge	67	a	broomsedge	100	32	blackgum	17	
falsedandelion	46	4	boneset	46	5	post oak	16	
nutsedge	21	2	nutsedge	25	5	bitternut hickory	3	
Atmore, AL								
panicum grass	100	47	panicum grass	100	65	gallberry	a3	10,868
southern dewberry	71	12	blackberry	58	7	dogwood	3	
blackberry	so	5	broomsedge	42	4	staghorn sumac	3	
broomsedge	37	3	southern dewberry	29	2	persimmon	2	
Tallassee, AL								
dogfennel	63	1	broomsedge	63	11	sweetgum	51	3,944
common lespedeza	42	10	panicum grass	58	9	water oak	21	
pineweed	33	5	dogfennel	58	a	waxmyrtle	a	
horseweed	29	5	horseweed	33	7	huckleberry	3	
Camp Hill, AL								
panicum grass	100	60	panicum grass	96	48	winged sumac	42	15,170
partridge pea	50	10	aster	50	11	smooth sumac	23	
goldenweed	42	a	horseweed	37	7	water oak	10	
ragweed	33	5	broomsedge	33	6	sweetgum	a	
Bainbridge, GA								
horseweed	38	12	dogfennel	50	24	sassafras	34	6,229
greenbriar	33	5	partridge pea	42	15	winged sumac	28	
partridge pea	33	5	blackberry	29	11	sweetgum	6	
trumpet creeper	29	13	greenbriar	25	5	water oak	5	
Monticello, GA								
american burnweed	79	13	nutsedge	58	12	smooth sumac	64	7,350
dogfennel	79	9	little bluestem	46	7	sweetgum	9	
honeysuckle	37	4	goldenrod	42	5	persimmon	7	
little bluestem	25	2	boneset	38	5	water oak	5	
Pembroke, GA								
panicum grass	100	58	panicum grass	100	32	gallberry	64	10,472
broomsedge	a7	11	broomsedge	97	29	huckleberry	14	
boneset	70	2	boneset	73	4	sweetbay	9	
wiregrass	13	3	wiregrass	20	4	cudjoe	7	
Appomattox, VA								
horseweed	71	17	desmodium	42	4	winged sumac	51	8,201
panicum grass	33	10	strawberry	38	7	yellow poplar	9	
pokeweed	33	6	blackberry	37	4	smooth sumac	9	
american burnweed	33	4	panicum grass	33	4	dogwood	6	

Table 3.—Common and scientific names of species discussed in the text

Common Name	Scientific Name	Common Name	Scientific Name
Herbaceous Species		**Woody Species**	
Am. burnweed	Erichtites hieracifolia L.	Am. beautyberry	Callicarpa americana L.
asters	Aster spp.	blackgum	Nyssa sylvatica Marsh.
blackberry	Rubus spp.	cudjoe	Jacquinia keyensis Mez.
boneset	Eupatorium spp.	dogwood	Cornus florida L.
broomsedge	Andropogon virginicus L.	gallberry	Ilex glabra L.
crabgrass, hairy	Digitaria sanguinalis L.	hickory, bitternut	Carya cordiformis Koch.
crotonopsis	Crotonopsis elliptica Willd.	huckleberry	Vaccinium spp.
desmodium	Desmodium spp.	loblolly pine	Pinus taeda L.
dogfennel	Eupatorium capillifolium Lam.	oak, post	Quercus stellata Wong.
falsedandelions	Pyrrhopappus carolinianus (Walt.) DC.	oak, southern red	Q. falcata Michx.
goldenrod	Solidago spp.	oak, water	Q. nigra L.
goldenweed	Polypremum procumbens L.	oak, white	Q. alba L.
grape, common	Vitis rotundifolia Michx.	persimmon	Diospyros virginiana L.
greenbriar	Smilax spp.	red maple	Acer rubrum L.
honeysuckle	Lonicera japonica Thumb.	sassafrass	Sassafras albidum Nutt.
horseweed	Conya candensis var. pusilla Nutt.	sumac, smooth	Rhus glabra L.
Hypericums	Hypericum spp.	sumac, staghorn	R. hirta L.
lespedeza, common	Lespedeza striata Thumb.	sumac, shining	R. copallina L.
little bluestem	Andropogon scoparius Michx.	sweetbay	Magnolia virginiana L.
nutsedge	Cyperus esculentus L.	sweetgum	Liquidambar atyraciflus L.
panicum grass	Panicum spp.	waxmyrtle	Myrica cerifera L.
partridge pea	Cassia fosciculata Michx.	willow	Salix nigra Marsh
pineweed	Hypericum gentianoides L.	yellow poplar	Liriodendron tulipifera L.
pokeweed	Phytolacca americana [Tourn.] L.		
ragweed	Ambrosia artemisiifolia L.		
rushes	Juncus spp.		
southern dewberry	Rubus trivialis Michx.		
strawberry	Fragaria virginiana Duchesne		
trumpet creeper	Campsis radicans L.		
uniola grass	Chasmanthium sessiliforum Poir.		
wiregrass	Aristida spp.		
wooly croton	Croton capitatus Michx.		

The htrbactous component on the plots with no control ranged from 40 to 95 percent in the second year. Due to cart in herbicide applications and innovative methods in treating woody stems, the htrbaccous coverage increased in the second year on the woody control treatments at most locations. Herbaceous control has beta successful at most locations, yielding less than 15 percent cover, except at Jtna, LA, Crossttt AR, and Bainbridgt, GA. At the Jena location, severe infestations of woolly croton developed prior to evaluation. Vine infestations, although undergoing control treatments, still remain a problem at the Crossttt and Bainbridge locations.

In the second year, woody cover was less than 11 percent on all woody and total control plots. Woody competition on the no control plots varied widely by location, from a low at Warren, AR, of less than 2 percent, to three locations with over 40 percent woody cover. American beautyberry and sumacs have required constant control pressure. At nine locations, the control of herbaceoua competition appears to have released the woody cover, as noted by greater cover values on herb control compared to no control treatments.

Pint cover is still low after two growing seasons, but a significant response to treatment is evident at most locations. The greatest amount of pint cover was at Bainbridgt and in the naturally regenerated stand at Crossttt.

Pine Response

Pine growth (table 5) at all locations was generally, but not consistently, least on the no control treatments and greatest with total control. In the first year, seedling heights were significantly different by trtatwnt at 7 locat ions, while groundline diameters were significantly different at 11 locations. None of the locations with significant growth differences showed any additional growth with woody control compared to no control. Thus woody competition had not significantly detracted from growth. Herbaceous control did however yield significantly increased height grovth at 5 locations and larger GLD's at 10 locations.

In the second year, diameters differed significantly bttvttn treatments at all locations, while height differed significantly at all but four

Table 4.—Percent cover of competition components and percent bare ground and loblolly pin cover after the first and second years, by treatment control classes, for 13 sites in the Southern United States

Vegetation Control	Crossett AR	Warren AR	Jena IA'	Liverpool LA	Liberty MS	Liberty TN	Counce Atmore AL	Tallassee AL	Camp Hill AL	Bainbridge GA	Monticello GA	Pembroke GA	Appomattox VA
FIRST YEAR							**Bare ground**						
NONE	1.0 c	45.7. b	13.8 b	6.0 b	m	25.0 b	9.7 c	-il.2 c	2.0 d	8.0 b	54.6 b	16.3 c	11.8
WOODY	7.1 b	44.7 b	17.8 b	14.3 b	data	30.9 b	20.5 c	7.7 c	16.5 c	13.1 b	75.4 a	23.7 c	31.8 NS
HERB	86.7 a	98.3 a	96.2 a	62.9 a		93.8 a	55.6 b	83.3 b	45.8 b	21.6 b	80.9 a	62.1 b	27.5
TOTAL	91.8 a	98.7 a	98.7 a	56.7 a		97.0 a	97.3 a	96.1 a	97.1 a	82.0 a	87.0 A	86.8 a	32.6
							Herbaceous Cover						
NONE	89.2 a[1]	54.3 a	81.3 a	93.7 a	no	75.0 a	71.4 a	67.8 b	87.7 a	87.3 a	45.6 a	72.3 a	55.7 a
WOODY	92.3 a	55.0 a	83.0 a	85.4 a	data	69.0 a	75.1 a	91.8 a	83.4 a	80.5 a	24.6 b	75.7 a	52.9 a
HERB	13.1 b	2.5 b	1.8 b	36.3 b		5.7 b	23.6 b	2.3 c	1.9 b	67.5 a	19.0 b	23.1 b	37.5 b
TOTAL	7.7 b	1.3 b	0.8 b	43.3 b		2.1 b	2.0 c	3.0 c	1.8 b	13.7 b	12.8 b	11.3 b	37.9 b
SECOND YEAR							**Bare ground**						
NONE	0.4 c	1.6 b	3.5 b	1.8 c	0.3 c	2.7 b	4.5 c	7.8 c	1.6 c	1.6 c	6.5 c	3.0 c	12.0 d
WOODY	2.3 c	4.1 b	6.9 b	2.5 c	5.0 c	4.9 b	10.8 c	2.7 c	2.8 c	2.1 c	30.9 b	4.7 c	61.8 b
HERB	37.5 b	78.6 a	54.2 a	60.3 b	42.5 b	74.5 a	67.7 b	56.3	24.5 b	9.8 b	70.0 a	64.1 b	40.4 c
TOTAL	73.0 a	85.0 a	48.4 a	95.5 a	90.1 a	86.5 a	97.4 a	89.5 A	96.9 a	83.3 a	85.5 a	84.2 a	92.8 a
							Herbaceous Cover						
NONE	95.0 a	93.8 a	90.0 a	77.9 b	55.8 b	85.5 a	75.2 a	62.4 b	88.9 a	95.7 a	69.6 a	71.4 b	40.4 a
WOODY	96.9 a	92.7 a	87.8 a	91.4 a	83.0 a	88.3 a	84.4 a	96.3 A	95.8 a	97.3 a	61.7 a	91.8 a	34.9 a
HERB	26.9 b	2.2 b	39.1 b	14.6 c	22.1 c	5.0 b	4.3 b	2.2 c	0.9 b	70.8 b	14.4 b	10.1 c	9.4 b
TOTAL	22.7 b	6.8 b	49.9 b	1.8 d	2.6 d	5.1 b	1.8 b	3.1 c	2.1 b	3.0 c	6.2 b	1.4 d	3.0 b
							Woody Cover						
NONE	26.5 a	1.8 ab	4.8 ab	16.9 a	44.2 a	7.4 ab	22.7 a	31.1 a	46.5 b	21.0 ab	18.8 a	25.1 a	53.3 a
WOODY	1.3 b	0.7 b	1.8 b	1.3 b	10.8 b	1.6 bc	1.3 b	0.2 b	1.4 c	7.3 bc	1.6 c	1.1 b	4.4 b
HERB	31.3 a	12.4 a	9.4 a	23.1 a	31.7 a	12.5 a	25.7 a	40.8 a	70.3 a	35.9 a	8.8 b	19.4 a	52.9 a
TOTAL	0.2 b	0.3 b	0.8 b	0.3 b	0.6 c	0.2 c	0.3 b	0.0 b	0.3 c	0.3 c	0.8 c	2.3 b	4.4 b
							Pine Cover						
NONE	3.2 bc	2.0	2.7 b	2.0	2.0 c	4.9 b	2.0 b	2.0 a	2.0 b	3.3 c	6.7	2.2 c	2.0
WOODY	3.1 c	2.0 Ns	2.3 b	2.0 NS	2.0 c	5.3 b	2.3 b	2.0 c	2.0 b	2.3 c	7.9 NS	3.7 bc	2.0 NS
HERB	i5.6 a	10.0	7.0 a	2.0	4.7 b	8.2 a	4.3 ab	5.0 b	2.0 b	8.7 b	7.7	5.0 b	2.0
TOTAL	7.9 '	10.0	5.7 a	2.0	8.S a	8.4 a	8.1 a	9.0 a	7.3 a	15.4 a	9.0	9.4 a	2.0

[1] Means in a column followed by the same letter are not significantly different at the 0.05 lml as determined by Duncan's multiple range test. NS=treatment effect not significant at the 0.05 level as determined by an analysis of variance and Duncan's multiple range teat not applied.

Table 5.—Loblolly pine growth relative to control of competition components after the first and second years, at 13 sites in the Southern United States

Vegetation Control	Crossett[1] AR	Warren AR	Jena LA	Liverpool LA	Liberty MS	Counce TN	Atmore AL	Tallassee AL	Camp Hill AL	Bainbridge GA	Monticello GA	Pembroke GA	Appomattox VA
FIRST YEAR							**Height (feet)**						
NONE	1.58	1.26	1.63 ab[2]	1.23	1.63 b	1.02	1.29	1.08 b	1.14 b	1.50 b	1.17	1.64 c	0.74 c
WOODY	1.47 Ns	1.44 NS	1.54 b	1.29 NS	1.82 b	1.04 NS	1.36 NS	1.03 b	1.18 b	1.53 b	1.21 NS	1.84 bc	0.80 bc
HERB	1.33	1.34	1.77 a	1.18	2.42 a	1.02	1.14	1.37 a	1.24 b	1.96 a	1.29	2.20 a	0.86 b
TOTAL	1.15	1.35	1.82 a	1.26	2.41 a	[illegible]	[illegible]	1.50 a	1.43 a	2.03 a	1.32	2.06 ab	1.00 a
							Groundline Diameter (inches)						
NONE	0.28	0.29 b	0.46 b	0.22 c	0.39 c	0.31 b	0.23[3] b	0.25 c	0.20 c	0.29[3] c	0.21	0.33 b	0.17 c
hum	0.29 Ns	0.31 b	0.45 b	0.25 bc	0.45 c	0.33 b	0.27 b	0.27 c	0.23 c	0.25 c	0.21 NS	0.38 b	0.18 c
HERB	0.35	0.46 a	0.64 a	0.29 b	0.78 b	0.40 a	0.25 b	0.44 b	0.30 b	0.42 b	0.26	0.60 a	0.21 b
TOTAL	0.30	0.46 a	0.63 a	0.32 a	O.% a	0.38 a	0.33 a	0.59 a	0.51 a	0.55 a	0.32	0.60 a	0.26 a
SECOND YEAR							**Height (feet)**						
NONE	2.88	2.79 b	4.02 b	2.54 b	3.67 b	2.82	2.44 b	2.71 c	2.65 c	4.05 b	2.74	3.93 c	2.w
WOODY	2.64 NS	3.14 b	3.54 b	2.90 ab	4.16 b	2.85 NS	2.61 b	2.79 c	2.63 c	4.07 b	3.28 NS	4.52 b	2.42 NS
HERB	3.38	3.94 a	5.20 a	3.24 a	6.34 a	2.m	2.54 b	4.47 b	3.68 b	6.03 a	3.46	6.18 a	2.76
TOTAL	2.54	4.12 a	5.13 a	3.48 a	6.24 a	2.84	3.29 a	4.96 a	4.76 a	6.65 a	3.91	6.21 a	2.84
							Groundline Diameter (inches)						
NONE	0.57 b	0.71 b	1.11[4]	0.53 c	0.75 d	0.86 b	0.50 b	0.68 c	0.57 c	1.01[5] c	0.62 c	0.98 d	0.43 c
WOODY	0.56 b	0.78 b	1.13	0.66 c	0.90 c	0.89 b	0.65 b	0.83 c	0.71 c	0.87 c	0.94 b	1.18 c	0.68 b
HERB	1.01 a	1.53 a	2.11	0.93 b	1.82 b	1.21 a	0.70 b	1.34 b	0.93 b	1.46 b	1.06 ab	2.13 b	0.58 b c
TOTAL	0.97 a	1.66 a	2.32	1.23 a	2.30 a	1.31 a	1.19 a	2.10 a	1.81 a	2.49 a	1.31 a	2.41 a	0.98 a
							Diameter at 6 Inches above Groundline (inches)						
NONE	0.44 b	0.54 b	0.88 b	0.44 c	0.63 d	0.67 b	0.49 b	0.51 c	0.45 c	0.78 c	0.51 c	0.74 c	0.32 c
WOODY	0.44 b	0.61 b	0.79 b	0.56 c	0.82 c	0.68 b	0.62 b	0.63 c	0.55 c	0.82 c	0.78 bc	0.90 c	0.53 b
HERB	0.76 a	1.21 a	1.62 a	0.78 b	1.53 b	0.92 a	0.66 b	1.05 b	0.73 b	1.35 b	0.87 ab	1.73 b	0.44 bc
TOTAL	0.72 a	1.34 a	1.60 a	1.04 a	2.01 a	0.99 a	1.06 a	1.68 a	1.53 a	2.09 a	1.10 a	1.97 a	0.76 a
							Tipmoth Infestation = Branch and/or Stem (percent infested)						
NONE	38.2	77.1 b	43.1	98.0	09.4 ab	99.5	95.9	47.3	42.8 b	99.0	93.1	0	16.7 b
WOODY	34.8 NS	82.6 ab	41.0 NS	99.0 Ns	90.4 ab	100.0 NS	98.4 Ns	9n.9 Ns	68.2 a	99.0 Ns	98.9 Ns	0 NS	31.8 b
HERB	39.9	91.7 ab	36.7	99.5	94.6 a	100.0	92.7	sa.4	47.8 b	100.0	97.2	0	26.4 b
TOTAL	32.0	90.6 a	38.4	99.4	80.8 b	100.0	93.2	100.0	33.0 b	85.7	96.7	0	51.7 a
							Fusiform Rust Incidence = Branch and/or Stem (percent infected)						
NONE	3.0	0	0	0	0	0	0	0.6 b	0.0 b	4.6	2.1 ab	0.4	.0
WOODY	4.2 NS	0 NS	0 NS	0.5 NS	0 NS	ONS	0 NS	1.1 b	1.6 b	2.6 NS	0.6 b	1.2 NS	Otis
HERB	2.5	0.5	0.5	0	0	0	0.6	4.0 a	1.5 b	6.7	1.6 ab	3.4	0
TOTAL	1.6	0	0.5	0	0	0	0	7.7 a	6.3 a	7.7	4.3 a	1.7	0

[1] Naturally regenerated stands, all others are plantation establishments.
[2] Means in a calm followed by the same letter are not significantly different at the 0.05 level as deterrained by Duncan's multiple range test. NS=treatment effect not significant at the 0.05 level as determined by an analysis of variance and Duncan's multiple range test not applied.
[3] Actually D6.
[4] Only me block measured.
[5] Mean of five trees per plot.

rites. Of the nine location8 with significant difference8 in second year heights, eight of these shoved no difference betveen the voody control 8ituation and no control. Likewise, D6's were not different at 11 location8 when comparing voody control and no control. Thus herbaceous competition ha8 acted similar to total competition in detracting growth. The same trends with herbaceous competition, yielding reduced grovth, were also evident vith the second year GLD's, but results of the mean separations were more variable in groupings. The largest seedlings for both the first and second year were grown on lover and middle Coastal Plain sites.

Tipmoth infested seedlings averaged greater than 80 percent at eight locations, which resulted in few significant difference8 due to treatment. At Warren, AR, all control treatment8 showed increased tipmoth incidence, especially the herb and total control treatments. At Liberty, MS, herb control treatment8 also yielded the most tree8 attacked, but total control had the least. At Camp Hill, AL, woody control treatments had the most tipmoth incidence, while at Appomattox, VA, the total control was significantly greater than the other competition situations.

Fusiform rust infection was greatest in the area of normally high incidence-upland sites in Alabama and Georgia. Increased infection was found mainly with increasing control of the herbaceous component. Monticello, GA, had lover level8 of herbaceour cover on the no control treatments (table 4), which may have influenced increased rust incidence.

The overall pine size wan8 for the plantation sites are presented in table 6. This shows more clearly the trend of improved early growth with herbaceour veed control. Seedling8 in the first year on the total control treatment were 75 percent larger in CLD's and 18 percent taller when compared to the no control treatments. Herbaceous control alone yielded seedlings that vere 50 percent larger in diameter and 14 percent taller, while seedlings on the woody control treatments vere only slightly larger than the no control pines. After the second growing season, the size differences vere attenuated. Seedlings vith total control averaged 147 percent larger in GLD's, 145 percent larger in D6's, and 47 percent taller when compared to those with maximum competition. In comparison to the no control situation, seedlings on plots vhere only the herbaceous competition vas-controlled resulted in GLD's that were 85 percent larger compared to only 26 percent larger vith woody control. Many locations had seedlings that were 8 ft tall with 2-inch GLD's after two growing seasons of total control.

Table 6.--Overall diawter and height means for planted loblolly pine sites[1] by treatment after the first and second years

Vegetation	First Year		Second Year		
Control	GLD[2]	Height	GLD	D63	Height
	inches	f _ e	--inches--		feet
None	0.28	1.26	0.66	0.56	2.96
Woody	0.30	1.33	0.83	0.68	3.18
Herb	0.42	1.44	1.22	1.04	4.05
Total	0.49	1.49	1.63	1.37	4.34

[1] Bainbridge, GA, not included due to missing diameter data.
[2] GLD=groundline diameters.
[3] D6=diameter at 6 inches above groundline.

Pine Moisture Stress

The averages of the moisture stress readings are presented in table 7. The relation between first-year CLD's and plant moisture stress can be seen in figure 3. CLD's were reduced in a nonlinear trend as plant moisture stress increased. The selected regression relation is: $\ln(GLD) = 0.465 + 2.87\ PHS + 1.02\ PWS^2$, where GLD is in inches and FMS is in negative megapascala of xylem pressure potential ($r^2 = 0.93$).

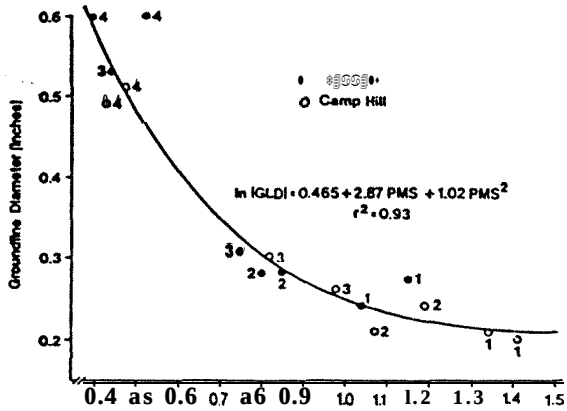

Figure 3.-The relation between xylem pressure potential taken in September and groundline diameters after the first year. 1=no control, 2=woody control, 3=herbaceous control and 4=total control

DISCUSSION

Just how competition affects pine growth is not fully known, only that competition influences the availability of the essential factors of water, nutrients, sunlight, and growing space. When pine seedlings are small, both woody and herbaceous components compete for all of these factors. After about 3 to 4 years, surviving

Table 7.--Xylem pressure potential of loblolly pines taken on September 27 and 28, 1984, during the first groving season after 20 days without rainfall.

Vegetation Control	Tallassee	Camp Hill	Overall[1]
	negative MPa		
None	1.10	1.37	1.23 a
Woody	0.83	1.13	0.98 ab
Herb	0.60	0.90	0.75 bc
T o t a l	0.46	0.45	0.46 c

ANOVA Results :	Pr>F
Treatment	0.02
Block	0.71
Treatment x Block	3.24

[1] Overall means folloved by the same letter are not significantly different at the 0.05 level as determined by Duncan's multiple range test.

pines will stand above herbaceous competitiors and only woody species influence sunlight and aerial growing space. Possibly, herbaceous weeds offer little pine competition after 7 years (Clason 1978). Hardwoods can continue to compete for all essential factors throughout the rotation since they capture both aerial and rooting space.

On most upland sites it is generally assumed that moisture is the most limiting factor when pine growth is affected by competition. Nelson and others (1981) reported that reduced moisture stress as a result of herbaceous weed control was associated with increased early loblolly pine growth. On sites vhere moisture was not limiting, weed control did not result in increased growth. Carter and others (1984) found that both woody and herbaceous competition influenced loblolly pine moisture stress more than they influenced foliar nutritional status. Higher moisture stress levels were found on Piedmont soils compared to pines growing on Coastal Plain soils, the same as found in the current study. In viewing the current data growth of loblolly pine seedlings, and stress levels of -1.4 MPa induced seedling dormancy (Cannel1 and others 1978). Thus only on the lowest competition levels was moisture stress reduced to levels where growth occurring before daylight was not negatively influenced. More information will be reported on nutritional-competition interactions since all COMP locations sampled foliage after the second growing for nutrient analysis in cooperation with the North Carolina State Forest Tree Nutrition Cooperative.

have severe hardwood competition developing. On herb control plots, some pines that are completely surrounded by taller hardwoods already appear retarded. With herb control both the pines and hardwoods have been equally released and the race for canopy position has accelerated, freed of herbaceous weed competition.

The COMP growth values represent biological standards for loblolly pine on the specific study sites and relative to patterns in precipitation. Sizes and growth increments of pine grown completely without competition approach as absolute a value as we have in vegetation management research. At the opposite end of the scale are growth values on plots with no competition control. The growth between these extremes represents a wide spectrum of possibilities for loblolly pine. These growth values' may be usable as a gauging network to assess relative growth for other studies.

The values for the voody control treatments represent the ideal of most operational herbicide treatments for site preparation--control of all woody competition. The long-term value of this current strategy will be evaluated by future COMP test results. Woody control plots should also be similar to abandoned fields or pastures that have been planted or seeded with pines.

Perhaps the most interesting treatment is herbaceous control that allows site resources to be available to only woody vegetation and lets the total wood production of both pines and hardwood be realized. Hardwood growth will be measured more intensively in the coming years to determine the range of volume mixtures possible vith total herbaceous control.

CONCLUSIONS

Herbaceous competition detracts more from early growth of loblolly pines than does juvenile hardwood competition. Pine diameters were reduced by herbaceoue competition more often than heights. The absence of any competition for 2 years yielded pine seedlings that were about SO percent taller and 1.5 times larger in diameter than seedlings grown on predominantly chop and burn treated sites where there was no additional competition control. The predominate herbaceous competitors were panicum grasses, bluestems, and asteraceae forbs . Fusiform rust in high incidence areas may be significantly increased following control of herbaceous vegetation. Tipmoth incidence appears to be more a function of location than of vegetation control treatment.

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