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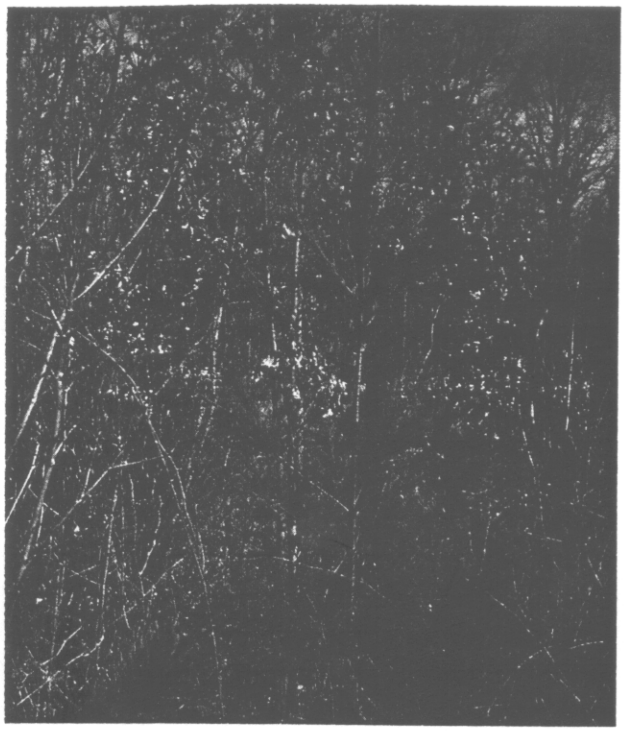
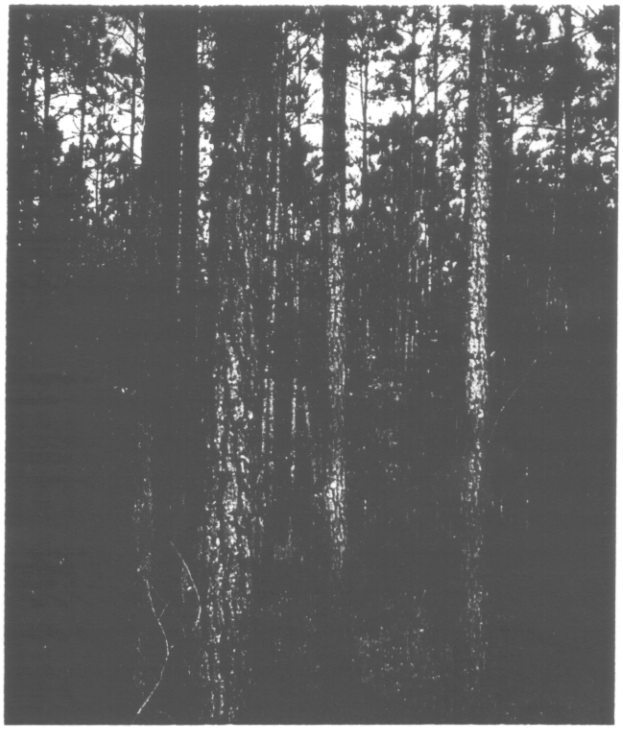




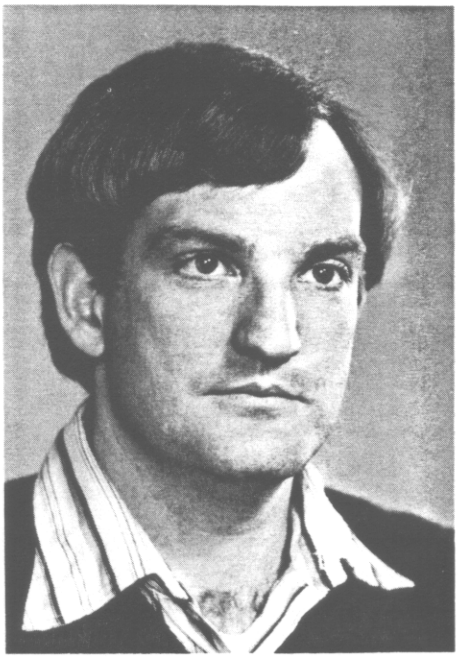
Impact Of Competing Vegetation On Yield Of The Southern Pines

By Glenn R. Glover and Dale F. Dickens

RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

About The Authors



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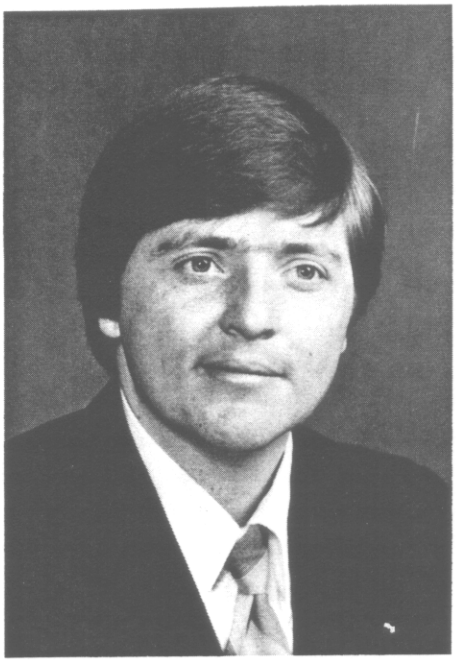

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INTRODUCTION

One of the major problems in growing southern pines is competition from hardwood and herbaceous vegetation for moisture, nutrients and light. Uncontrolled vegetation can reduce survival as well as growth of the desired pines. Use of chemical herbicides to control unwanted vegetation has been common in forestry for three decades, but the long term effect on growth has seldom been documented. This fact became obvious during the 2,4,5-T controversy of the late 1970's (USDA 2,4,5-T Assessment Team, 1979). Within most organizations, a forester's opinion is no longer sufficient to justify the expense of chemical vegetation control. Economic criteria, such as rate of return on investment, must now be considered. To evaluate these criteria, yield information reflecting the effect of vegetation control is needed.

As with most endeavors in forestry, the installation and remeasurement of studies comparing vegetation control to no control is a very long term venture. Recognition of the need for yield information relating to vegetation control has recently prompted establishment of studies, however results are several years away. In an attempt to provide interim information on pine yield response to vegetation control, the project reported on herein was initiated. The major objective of the project was to locate and measure southern pine stands where there was an existing direct comparison of chemical vegetation control to other control methods, or to no control.

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PROCEDURES

Southern forest industries and organizations and chemical companies were asked to identify areas where replicated studies, paired plots, or operational comparisons of chemical vegetation control versus other methods or no control had been installed. For a comparison to be considered, an untreated or mechanically treated area had to be present within the same stand as the treated area. Stands which were treated entirely with chemicals, having no control area for comparison, were not measured. Vegetation control at any age was permissible, but at least three years had to have passed since treatment to allow for pine response. Pine stands ranging from three years to 36 years old were located. A description of each measured stand is given in Table 1.

If measurement plots had been previously established, they were located and remeasured. If measurement plots had not been established, a 0.1-acre circular pine measurement plot was established in the center of small treatment plots, or a series of 0.1-acre plots were systematically established throughout large treated areas. Diameter breast height (dbh) to the nearest 0.1 inch, crown class, damage and species were observed for each pine stem within a measurement plot. A representative subsample of at least 10 pines per plot was measured for total height, to the nearest foot. Merchantable height, in number of 16.3-foot logs, to the nearest one-half log, was observed for each sawtimber pine. In stands less than 10 years old, each pine stem was also classified by the Virginia Division of Forestry Free-To-Grow Classification (Zutter, et al. 1985).

A 0.02- to 0.1-acre hardwood measurement plot, depending on hardwood stem density, was established concentrically within each pine measurement plot. When there were fewer than about 1000 hardwood stems per acre, the entire pine measurement plot area was used for hardwood measurement. As hardwood stem

Table 1. Location and establishment information for measured comparisons.

Study	Location	Establishment information
Dubberly	Long Co., GA	Harvested spring, 1970; entire site roller chopped and burned, summer, 1970; site prep study overlaid; machine planted with loblolly pine January, 1973
Escambia	Escambia Co., AL	Seed tree regeneration of longleaf pine; seed trees removed, regeneration averaged approximately 10 years old at time of treatment in 1957
Fayette	Fayette Co., AL	Conversion study; harvested 1958; mechanical and chemical treatments applied in fall, 1958 and spring, 1959; hand planted in 1959 with loblolly pine
Floyd County	Floyd Co., GA	Harvested in 1970; two pass roller chopped in 1971; direct seeded in January, 1972, with loblolly pine
Grass Creek	King and Queen Co., VA	Loblolly pine plantation, planted 1974
Hobbs-Western	Hardin Co., TN	Sheared in 1966; ineffective burn; direct seeded January, 1967, with loblolly pine
Marston	Charles City Co., VA	Loblolly pine plantation, planted 1973
Mock	Jasper Co., SC	Harvested 1965; planted stand destroyed by wildfire, 1969; harrowed and bedded in fall, 1969; machine planted February, 1970, with slash pine.
Palatka	Putnam Co., FL	Slash pine plantations (3), two planted in 1965, one planted in 1967; all sites were chopped and bedded
Pickens	Pickens Co. AL	Burned October, 1962; injected, August, 1963; hand planted January, 1963, with loblolly pine
Piedmont	King and Queen Co., VA	Loblolly pine plantation, planted 1974
Pineville	Rapides Parrish, LA	Loblolly pine underplanted in a hardwood overstory in 1948
Rochelle	Hardin Co. TN	Disked 1976; machine planted in 1976 with loblolly pine
Ross	Hardin Co., TN	Part bedded in 1978, part not bedded; planted in February, 1979, with loblolly pine
Savannah Town	Effingham Co., GA	Harvested in 1972; KG and bedded, fall, 1972; planted early, 1973, with loblolly pine
Sewanee	Franklin Co., TN	Sheared and chopped, 1976; planted March, 1977, with loblolly pine at an 8'x10' spacing
Shannon	Floyd Co., GA	Site preparation study (rootraking, Velpar, check); planted March, 1978, with loblolly pine
Summerville-1	Dorchester Co., SC	100% KG bladed and windrowed in 1958; burned February, 1959; planted in 1959 with loblolly pine
Summerville-2	Dorchester Co., SC	50% KG bladed in June, 1959; burned October, 1959; planted in 1959 with loblolly pine
Summerville-3	Dorchester Co., SC	Drained cypress/hardwood swamp; 100% KG bladed in 1957; planted in 1958 with loblolly pine
Summerville-6	Dorchester Co., SC	Drained cypress/hardwood swamp; no mechanical preparation; burned January, 1954; planted in 1954 with loblolly pine
Summerville-8	Dorchester Co., SC	60-70% brush drummed in July, 1956; burned November, 1957; planted in 1957 with loblolly pine
Summerville-9	Dorchester Co., SC	Drained cypress/hardwood swamp; 60-70% brush drummed and burned in December, 1956; planted 1957; sprayed with 2,4,5-T in 1958
Summerville-10	Dorchester Co., SC	100% dozer bladed and burned in January, 1961; planted in 1961 with loblolly pine
Summerville-11	Dorchester Co., SC	50% brush drummed and burned in February 1956; planted in 1956 with loblolly pine
Upson County	Upson Co., GA	Site prepared with rolling brush cutter; direct seeded following 1961 growing season with loblolly pine
Waddels	New Kent Co., VA	Loblolly pine plantation, planted 1977

(Note: all establishment dates are given at the beginning of the growing season--i.e. a stand shown as being planted in 1970 was planted during the 1969-70 planting season.)

Table 2. Description of physiography/soils and treatments by study

Study name (age at treatment, measurement)	Physiography/ soils	Treatment information[1]
Dubberly (0,11)	Coastal plain, Leefield-Pelham complex soil	Split-split plot design, with 3 blocks: (a) site prep whole plots: (1) chop and burn; (2) chop, burn and bed; and (3) chop, burn, triple flat harrowed with bedding (note: chop and burn in summer, 1970; harrowing and bedding in July, 1972) (b) Herbicide subplots: (1) weed control (2 lb a.i./ac 2,4,5-T + 5 lb a.i./ac. dalapon + 4 lb a.i./ac. simizine)—for hardwoods and herbaceous weeds; (2) no weed control; (c) Fertilizer sub-subplots: (1) fertilized (40 lb/ac P + 100 lb/ac N); (2) no fertilizer
Escambia (10,37)	Coastal plain	Two release treatments applied by helicopter in May, 1957: (1) 1 lb. a.i./ac 2,4,5-T ester in 4¾ gallons of water (basically ineffective, used as a "check"); (2) 3 lb a.i./ac 2,4,5-T ester in 4¼ gallons of water
Fayette (0,24)	Upper coastal plain	Seven site preparation treatments: (1) bulldozed and piled; (2) check—no treatment; (3) hardwoods girdled—no herbicide; (4) tube injection of herbicide; (5) ax frill plus herbicide; (6) Brady chain frill plus herbicide; (7) mist blown herbicide (note: all herbicide treatments consisted of a mixture of half 2,4-D and half 2,4,5-T at a concentration of 4 lb a.e./gallon)
Floyd (6½,11)	Ridge and valley Montevallo soil series, rocky, shallow silt-loam 5-20% slope	1 X 20 ch strips treated with helicopter on July 14, 1978, 0.5 ch buffers. Herbicides included: (1) triclopyr amine 1 lb. a.i./ac; (2) triclopyr amine, 0.5 lb a.i./ac plus 1 pint/100 gallons X77 surfactant; (3) triclopyr ester, 1 lb a.i./ac; (4) triclopyr ester, 0.5 lb a.i./ac plus 1 pint X77 surfactant; (5) glyphosate, 1 lb a.i./ac; (6) glyphosate, 2 lb a.i./ac; (7) 2,4,5-T ester, 2 lb a.i./ac; (check plots were obtained from buffer areas)
Grass Creek (5,9)	Upper coastal plain, sandy loam, sandy clay loam soil	0.25 ac plots treated April, 1979 with (1) 1.0 lb a.i./ac: and (2) 1.25 lb a.i./ac hexazinone (as Velpar 2cc Gridball); (3) untreated check
Hobbs-Western (6½,18)	Interior low plateau	10X40 ch block operationally treated with 5/8 gal 2,4,5-T (1.25 lb a.i.) +1gallon diesel +6 3/8 gallons water per acre in June, 1972. Untreated block in same stand adjacent to treated area used as a check
Marston (5,10)	Coastal plain	39 acres operationally sprayed in June, 1973 by helicopter with 2 lb 2,4,5-T a.i. in ½ gallon diesel + 4 gallons water per acre; remainder of plantation untreated
Mock (0,14)	Coastal plain Leon-Blanton soil	Split plot design with 4 blocks: (a) fertilizer whole plots: (1) 40 lb/ac P + 100 lb/ac N; (2) no fertilizer; (b) herbicide subplots: (1) simizine, April, 1970; (2) paraquat, May, 1970; (3) no weed control
North End (5,10)	Coastal plain	26 acres operationally sprayed in June, 1973, by helicopter with 2 lb 2,4,5-T a.i. in ½ gallon diesel + 4 gallons water per acre; remainder of plantation untreated
Palatka (12,19-WD) (12,19-PMD) (10,17-VPPD)	Lower coastal plain	Three sets of paired plots (approx. 0.12/ac each)— all vegetation other than planted pines controlled; other plot untreated. One set of plots classified as well drained, another as somewhat poorly and moderately well drained, and the other very poorly and poorly drained. Plots were originally part of Univ. of Ga. PMRC Competing Vegetation Study
Pickens (5,20)	Coastal plain	Middle 40-acre portion of a 100-acre tract operationally treated with 2 lb a.i./ac 2,4,5-T in May, 1968; remaining 60 acres untreated, used as a check
Piedmont (4,9)	Coastal plain	48 acres operationally sprayed in June, 1973, using a helicopter with 2 lb a.i./ac 2,4,5-T in ½ gallon diesel+4 gallons water per acre; remainder of plantation untreated, used as a check

(Table 2 Continued on Page 6)

density increased above 1000 stems per acre, measurement of the entire pine measurement plot area would have taken an inordinate amount of time, so the hardwood measurement plot area was reduced to 0.05 or 0.02 acre, maintaining a minimum sample of 30 hardwood stems. All sample hardwood stems 0.5 inch dbh and larger were tallied by one-inch diameter class, 10-foot height class and species.

For each comparison, information regarding date and type of stand establishment, treatments and rates applied, date treated, forest type, site index, average slope, soil type, drainage and stand history (including injury, fire history, previous stand, etc.) was noted, when available. In addition, percent slope and aspect were observed at each pine measurement plot location. A summary of physiography/soils and treatments is given in Table 2.

RESULTS AND DISCUSSION

Table 3 is a summary of pine and hardwood measurements by treatment. All but five of these studies were hardwood control comparisons. The other five (Dubberly, Mock, Palatka, Ross and Savannah Town) were primarily herbaceous or understory vegetation control studies and will be discussed separately. Examination of this table reveals a great deal of variation in pine and hardwood response to herbicide treatment. In some cases, such as Grass Creek, hardwoods were increasingly controlled (fewer, smaller hardwood stems on herbicide treated plots) and a corresponding greater pine yield was realized with increasing rates of herbicide. But in other cases, such as Pickens and Summerville-3, herbicide treatment did not seem to have an effect. All but one of the comparisons showing no response or negative response of pine yield to herbicide application were operational comparisons using 2, 4,5-T, where initial conditions, herbicide rates and application techniques were often not closely controlled. Results from 2,4,5-T are known to be highly variable, depending on species composition, weather conditions, etc., and misapplication could result in pine damage or mortality.

Considering the inherent variability in operational comparisons, and the fact that several of the research comparisons were installed as tests of rates, timing, soil interactions, etc., the entire story is

Table 2. Description of physiography/soils and treatments (continued).

Study name (age at treatment, measurement	Physiography/ soils	Treatment information [1]
Pineville ((0,1,2),36)	Coastal plain, silt and very fine sandy loam	Ten treatments, two replications were installed—only one replication remained intact. Plots were 0.25 acre. Treatments: (1) plant in openings, no release; the following 9 treatments were planted at regular intervals, selective release included control of hardwood stems greater than 3 inches dbh; complete release included control of hardwood stems greater than 0.5 inches dbh: (2) selective release immediately after planting with AMS (Ammate); (plot destroyed, no data available) (3) selective release immediately after planting by girdling; (4) selective release, 1 year after planting, with AMS (Ammate); (5) selective release, 1 year after planting, by girdling; (6) selective release, 2 years after planting, with AMS (Ammate); (7) selective release, 2 years after planting, by girdling; (8) complete release, immediately after planting with AMS (Ammate); (9) complete release, immediately after planting, by girdling; (10) no release
Rochelle (2,7)	Interior low plateau	(1) 1 lb a.i./ac hexazinone (Velpar 2 cc Gridball); (2) untreated check; 75' X 75' treatment plots
Ross (0,4)	Interior low plateau, Shutuba-Pickwick complex, silt-loam to fine sandy loam soil	Factorial with split-plot design: (a) site preparation whole plots: (1) bedded; (2) not bedded; (b) fertilizer subplots: (1) fertilized with DAP; (2) not fertilized; (c) herbicide sub-plots: (1) hexazinone (Velpar liquid) at 1 lb a.i./ac; (2) no herbicide. (NCSFFC Regionwide Study No. 7)
Savannah Town (0,11)	Coastal plain, Stilson series soil	Split plot design, with 4 blocks: (a) fertilizer whole plots (1) 200 lb/ac CSP; (2) 476 lb/ac ammonium sulfate; (b) herbicide subplots: (1) no weed control; (2) first season weed control with 2 lb a.i./ac 2,4,5-T + 2.5 lb a.i./ac dalapon + 4 lb a.i./ac simazine; (3) annual weed control using same treatment as in (2)
Sewanee (0,6)	Ridge and valley, Hartsells sandy loam soil	Completely randomized design, 1-acre plots: (1) all stems 4.5 ft. or taller injected with picloram + 2,4-D (Tordon 101R); (2) untreated
Shannon (0,5)	Piedmont	Site preparation comparison: (1) rootraking; (2) hexazinone 2 lb a.i./ac (Velpar 2cc Gridball); (3) untreated
Summerville-1 (3,25)	Lower coastal plain	3.8 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June 1962; remainder of plantation untreated, used as a check
Summerville-2 (3,25)	Lower coastal plain	3 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June, 1962; remainder of plantation untreated, used as a check
Summerville-3 (4,26)	Lower coastal plain	4 acres operationally released with 2,4,5-T, 2 lb a.e/ac, June 1962; remainder of plantation untreated, used as a check
Summerville-6 (8,30)	Lower coastal plain	4 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June, 1962; remainder of plantation untreated, used as a check
Summerville-8 (5,27)	Lower coastal plain	4 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June, 1962; remainder of plantation untreated, used as a check
Summerville-9 (5,27)	Lower coastal plain	5 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June, 1962; remainder of plantation untreated, used as a check
Summerville-10 (1,23)	Lower coastal plain	4 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June, 1962; remainder of plantation untreated, used as a check
Summerville-11 (6,28)	Lower coastal plain	5 acres operationally released with 2,4,5-T, 2 lb a.e./ac, June, 1962; remainder of plantation untreated, used as a check
Upson (0,6)	Piedmont	Operational release comparison: (1) 1.5 lb a.i./ac 2,4,5-T in ½ gallon diesel + 3¾ gallons water per acre; (2) 2 lb a.i./ac 2,4,5-T in½ gallon diesel + 3½ gallons water; (3) check
Waddels (3,6)	Loamy fine sand with sandy clay subsoil 9-24" below surface	Three replications of five treatments (replications were on ridge, northwest slope, and southeast slope), 0.20 acre treatment plots: (1) 1.25 lb a.i./ac hexazinone (Velpar 2cc Gridball); (2) 1.5 lb a.i./ac hexazinone (Velpar 2cc Gridball); (3) 1.25 lb a.i./ac hexazinone (Velpar granules); (4) 1.5 lb a.i./ac hexazinone (Velpar granules); (5) check

[1] a.i. = active ingredient
a.e. = acid equivalent

Table 3. Summary of pine and hardwood information by study and treatment.

Study (treatment, measurement age)	Treatment [2]	Number of trees per acre		Basal area per acre (sq ft)		O.B. volume per acre (cu ft)	Mean dbh (in)		Mean total height (ft)		Percent hardwood basal area (%)
		pine	hard.	pine	hard.	pine	pine	hard.	pine	hard.	
Dubberly (0,11)	CB, WC, F	552	312	79.3	3.4	1279.5	5.0	1.1	31	15	4.1
	CB, WC, NF	474	102	47.2	0.6	779.8	4.1	1.0	25	10	1.3
	CB, NWC, F	542	900	62.5	7.2	1041.1	4.3	1.2	28	11	10.3
	CB, NWC, NF	624	189	66.6	1.0	1219.8	4.1	1.0	28	11	1.5
	CBB, WC, F	629	232	116.3	2.2	2234.8	5.7	1.2	39	13	1.9
	CBB, WC, NF	561	29	96.4	0.2	1791.4	5.5	1.0	38	12	0.2

Table 3. Summary of pine and hardwood information (continued).

Study (treatment, measurement age)	Treatment [2]	Number of trees per acre		Basal area per acre (sq ft)		O. B. volume per acre (cu ft)	Mean dbh (in)		Mean total height (ft)		Percent hardwood basal area (%)
		pine	hard.	pine	hard.	pine	pine	hard.	pine	hard.	
	CBB, NWC, F	620	254	77.7	2.4	1442.1	4.5	1.1	33	16	3.0
	CBB, NWC, NF	774	29	83.1	0.2	1462.6	4.3	1.0	28	7	0.2
	CBHB, WC, F	639	29	115.6	0.2	2186.0	5.6	1.0	37	6	0.2
	CBHB, WC, NF	620	44	104.3	0.3	1841.4	5.5	1.0	37	22	0.3
	CBHB, NWC, F	620	58	98.3	0.5	1659.8	5.2	1.0	34	21	0.5
	CBHB, NWC, NF	658	29	83.3	0.0	1493.2	4.6	0.0	32	0	0.0
	CB, mean	548	376	63.9	3.0	1080.0	4.4	1.1	28	12	4.3
	CBB, mean	646	136	93.4	1.2	1732.7	5.0	1.1	34	12	1.3
	CBHB, mean	634	40	100.4	0.5	1795.1	5.2	1.0	35	16	0.2
	WC, mean	579	125	93.2	1.2	1685.5	5.2	1.0	34	13	1.3
	NWC, mean	640	243	78.6	1.9	1386.4	4.5	1.0	30	13	2.6
	F, Mean	600	298	91.6	2.6	1640.6	5.0	1.1	34	14	3.3
	NF, mean	618	70	80.2	0.4	1431.4	4.7	1.0	31	12	0.6
Escambia (10,37)	1 lb 2,4,5-T	358	454	61.2	24.6	2587.8	5.1	2.7	48	20	28.7
	3 lb 2,4,5-T	653	471	74.4	9.0	4933.4	4.0	1.8	45	13	10.8
Fayette (0,24)	Bulldoze	474	837	167.2	16.3	4393.1	7.9	1.6	57	16	8.9
	Hand girdled	212	980	70.5	59.4	1763.9	7.5	2.9	52	28	45.7
	Injection+herb.	371	914	126.1	19.9	3356.8	7.6	1.7	56	16	13.6
	Ax frill+herb.	433	878	153.3	14.8	4002.9	7.9	1.6	56	18	8.8
	Chain frill+herb.	449	934	149.2	18.5	3912.8	7.6	1.7	56	17	11.0
	Herbicide, mean	418	909	142.9	17.7	3757.5	7.7	1.7	56	17	11.1
	Check	204	1045	16.9	108.7	359.0	3.6	3.6	31	28	86.5
Floyd County (6½,11)	1 lb triclopyr amine	1360	1093	46.4	10.6	867.5	2.2	1.2	17	13	18.7
	0.5 lb triclopyr amine + 77	907	1107	36.5	8.9	616.7	2.5	1.2	17	12	19.7
	1 lb triclopyr ester	480	1293	12.1	11.2	183.0	2.2	1.2	12	11	48.1
	0.5 lb triclopyr ester + X77	1160	1067	35.7	12.1	573.9	2.1	1.3	15	12	25.3
	1 lb glyphosate	947	1680	29.9	25.8	569.6	2.2	1.5	16	12	46.3
	2 lb glyphosate	907	1427	35.5	19.8	609.4	2.5	1.4	17	12	35.8
	2 lb 2,4,5-T	547	1467	31.1	21.1	461.7	2.8	1.4	18	13	40.4
	Herbicide, mean	901	1305	32.5	15.6	554.5	2.4	1.3	16	12	33.4
	Check	588	1348	22.8	16.0	317.2	2.2	1.3	15	12	49.0
Grass Creek (5,9)	1.25 lb Velpar, 2cc	760	1333	52.7	10.6	596.1	3.4	1.1	21	10	16.8
	1 lb Velpar, 2cc	783	1500	49.6	18.7	505.0	3.2	1.2	20	14	27.4
	Check	760	2183	43.6	25.5	474.3	3.1	1.3	21	15	36.9
Hobbs-Western (6 ½.18)	1.25 lb 2,4,5-T	432	1636	51.5	39.2	1147.4	4.8	1.8	31	18	43.2
	Check	227	1926	34.1	50.6	647.9	5.4	1.9	35	18	59.6
Marston (5,10)	2 lb 2,4,5-T	458	1136	22.8	13.4	252.3	2.8	1.3	15	13	37.1
	Check	774	1810	22.1	23.8	313.3	2.1	1.4	14	13	52.0
Pickens (5,20)	2 lb 2,4,5-T	336	838	108.6	18.3	2984.0	7.2	1.6	52	17	14.4
	Check	331	1032	112.3	36.0	3150.1	7.7	2.2	56	20	24.3
Piedmont (4,9)	2 lb 2,4,5-T	810	264	44.2	1.7	513.3	2.9	1.1	16	10	3.7
	Check	768	1470	38.9	10.9	479.2	2.8	1.1	17	12	22.0
Mock (0,14)	F,WC (simazine)	454	194	89.2	2.2	1821.6	5.9	1.4	41	13	2.4
	F,WC(paraquat)	427	375	70.8	2.2	1551.1	5.4	1.0	40	9	3.0
	F,NWC	508	230	81.8	3.6	1643.1	5.2	1.3	38	10	4.2
	NF,WC(simazine)	536	145	96.9	1.0	1944.4	5.6	1.0	39	9	1.0
	NF,WC(paraquat)	445	351	75.0	6.9	1492.3	5.3	1.5	38	14	8.4
	NF,NWC	490	254	82.1	2.0	1544.9	5.3	1.1	37	10	2.3
	F, mean	463	266	80.6	2.7	1671.9	5.5	1.2	40	11	3.2
	NF, mean	487	250	84.7	3.3	1660.5	5.4	1.2	38	11	3.9
	WC(simazine),mean	490	170	93.1	1.6	1883.0	5.8	1.2	40	11	1.7
	WC(paraquat),mean	436	363	72.9	4.6	1521.7	5.4	1.3	39	12	5.7
	WC,mean	463	266	83.0	3.1	1702.4	5.6	1.2	40	11	3.7
	NWC, mean	499	242	82.0	2.8	1594.0	5.3	1.2	38	10	3.3

Table 3. Summary of pine and hardwood information (continued).

Study (treatment, measurement age)	Treatment [2]	Number of trees per acre		Basal area per acre (sq ft)		O. B. volume per acre (cu ft)	Mean dbh (in)		Mean total height (ft)		Percent hardwood basal area (%)
		pine	hard.	pine	hard.	pine	pine	hard.	pine	hard.	
North End	2 lb 2,4,5-T	1122	1138	50.5	7.7	663.9	2.5	1.1	16	11	13.2
(5,10)	Check	942	2270	42.9	16.5	642.9	2.7	1.1	17	10	27.8
Palatka	WC-WD	639	0	141.2	0.0	3393.8	6.2	0.0	51	0	0.0
(12,19)	NWC-WD	639	222	142.6	5.6	3325.5	6.3	1.9	49	10	3.8
(12,19)	WC-PMD	489	0	126.9	0.0	3020.6	6.7	0.0	50	0	0.0
	NWC-PMD	489	22	118.1	0.5	2940.9	6.6	0.5	52	12	0.4
(10,17)	WC-VPPD	704	0	154.5	0.0	3714.0	6.2	0.0	50	0	0.0
	NWC-VPPD	680	195	167.3	6.1	4210.2	6.6	2.0	54	12	3.5
	WC,mean	611	0	140.9	0.0	3376.1	6.4	0.0	50	0	0.0
	NWC,mean	603	146	142.7	4.1	3492.2	6.5	1.5	52	11	2.6
Pineville	Open planting no release	280	195	122.7	29.6	4065.0	8.3	3.6	63	23	19.4
((0,1,2),36)	Girdle,selective immediately	230	125	125.8	3.7	4608.7	9.8	2.0	79	14	2.8
	AMS, selective 1 year later	210	120	137.1	0.7	4662.9	10.8	1.0	74	9	0.5
	Girdle, selective 1 year later	205	140	126.5	3.6	4594.8	10.1	2.1	73	16	2.8
	AMS, selective 2 years later	330	840	93.5	13.6	3083.8	6.6	1.6	50	14	12.7
	Girdle, selective 2 years later	240	370	155.9	12.5	6102.0	10.2	2.1	79	17	7.4
	AMS, complete immediately	230	140	116.5	4.4	4074.4	9.5	0.8	73	5	1.8
	No release	180	260	108.5	14.7	3733.0	9.7	1.8	63	16	11.9
	Girdle, mean	226	175	30.0	5.5	4821.4	9.8	1.8	76	13	3.7
	AMS, mean	257	367	115.7	6.2	3940.4	9.0	1.1	66	20	5.6
	No release, mean	230	228	115.6	22.2	3899.0	9.0	2.7	63	20	15.7
	Selective, immediately, mean	230	125	125.8	3.7	4608.7	9.8	2.0	79	14	2.8
	Selective, 1 year later	208	130	131.8	2.2	4628.9	10.4	1.6	74	12	1.7
	Selective, 2 years later, mean	285	605	124.7	13.1	4592.9	8.4	1.9	64	16	10.1
	Complete, immediately, mean	230	102	114.2	3.3	4027.2	9.3	0.8	73	6	2.7
Rochelle	1 lb Velpar	460	580	26.0	4.0	283.0	3.1	1.1	17	11	13.3
(2,7)	Check	510	1485	19.3	17.2	258.2	2.5	1.3	16	16	47.1
Ross	B,F,WC	580	70	14.7	0.4	134.5	2.1	1.0	12	8	2.8
(0,4)	B,F,NWC	600	60	6.1	0.3	54.7	1.3	1.0	9	9	5.1
	B,NF,WC	565	103	14.8	0.6	139.5	2.1	1.0	12	9	4.0
	B,NF,NWC	590	47	6.2	0.3	54.7	1.3	1.0	9	8	4.0
	NB,F,WC	412	212	10.4	1.2	90.4	2.1	1.0	12	9	10.3
	NB,F,NWC	585	158	5.8	0.9	50.1	1.3	1.0	9	8	14.1
	NB,NF,WC	478	258	9.4	1.5	78.2	1.8	1.0	11	9	13.7
	NB,NF,NWC	607	225	4.8	1.3	42.6	1.1	1.0	9	9	21.0
	B,mean	584	70	10.5	0.4	95.9	1.7	1.0	10	8	4.0
	NB,mean	520	213	7.6	1.2	65.3	1.6	1.0	10	9	14.8
	F,mean	544	125	9.3	0.7	82.4	1.7	1.0	10	8	8.1
	NF,mean	560	158	8.8	0.9	78.8	1.6	1.0	10	9	10.7
	WC,mean	509	161	12.3	0.9	110.9	2.0	1.0	12	9	7.7
	NWC,mean	596	122	5.7	0.7	50.5	1.3	1.0	9	8	11.1
Savannah Town	F,WC(1st year)	574	508	96.0	2.8	1724.9	5.4	1.0	37	12	2.8
(0,11)	F,WC(annual)	639	58	108.4	0.3	1996.2	5.5	1.0	38	10	0.3
	F,NWC	537	450	80.8	2.8	1377.0	5.1	1.0	34	11	3.3
	NF,WC(1st year)	566	310	99.3	1.7	1926.0	5.5	1.0	36	14	1.7
	NF,WC(annual)	566	87	91.7	0.5	1550.1	5.2	1.0	34	9	0.2
	NF,NWC	523	242	80.1	1.3	1384.8	5.2	1.0	34	10	1.6
	WC(1st year),mean	570	409	97.7	2.3	1825.5	5.5	1.0	36	13	2.3

Table 3. Summary of pine and hardwood information (continued).

Study (treatment, measurement age)	Treatment [2]	Number of trees per acre		Basal area per acre (sq ft)		O. B. volume per acre (cu ft)	Mean dbh (in)		Mean total height (ft)		Percent hardwood basal area (%)
		pine	hard.	pine	hard.	pine	pine	hard.	pine	hard.	
	WC(annual),mean	602	72	100.1	0.4	1773.2	5.4	1.0	36	10	0.3
	WC,mean	586	241	98.9	1.3	1799.3	5.4	1.0	36	11	1.3
	NWC,mean	530	346	80.5	2.1	1380.9	5.2	1.0	34	10	2.5
	F,mean	584	339	95.1	2.0	1699.4	5.3	1.0	36	11	2.1
	NF,mean	552	213	90.4	1.2	1620.3	5.3	1.0	35	11	1.2
Sewanee (0,6)	Tordon injected	523	1113	20.8	7.4	228.6	2.6	1.1	15	11	26.2
	Check	529	1693	11.6	15.4	175.2	1.8	1.2	13	13	57.3
Shannon (0,5)	2 lb Velpar	375	950	6.3	18.8	99.3	1.7	1.4	12	15	58.3
	Rootrake	580	295	4.2	1.6	44.9	1.1	1.0	9	11	27.6
	Untreated	680	770	0.4	83.1	6.8	0.4	3.2	4	23	99.5
Summerville-1 (3,25)	2 lb 2,4,5-T	294	215	156.4	8.3	5234.5	9.8	2.4	66	14	5.1
	Check	318	516	171.1	9.4	5969.9	9.9	1.6	75	15	5.2
Summerville-2 (3,25)	2 lb 2,4,5-T	294	265	144.0	7.8	4540.0	9.3	1.8	66	14	5.1
	Check	282	552	158.2	14.7	5418.2	10.0	1.8	72	15	8.5
Summerville-3 (4,26)	2 lb 2,4,5-T	196	666	138.1	31.9	4651.4	11.1	2.8	72	28	18.8
	Check	144	764	123.7	44.9	4626.1	12.1	2.8	78	28	26.6
Summerville-6 (8,30)	2 lb 2,4,5-T	192	452	159.1	37.5	5864.9	12.2	3.5	78	26	19.1
	Check	208	656	160.0	34.5	5803.9	12.1	2.6	79	25	27.8
Summerville-8 (5,27)	2 lb 2,4,5-T	232	200	167.8	2.8	6422.6	11.2	1.1	82	9	1.6
	Check	164	524	144.4	46.4	5496.2	12.5	3.7	82	35	24.3
Summerville-9 (5,27)	2 lb 2,4,5-T	146	220	108.3	12.5	3799.2	11.4	2.8	73	25	10.3
	Check	124	618	93.7	42.9	3359.2	11.9	3.3	74	33	31.4
Summerville-10 (1,23)	2 lb 2,4,5-T	342	80	168.9	7.3	5415.8	9.3	3.8	69	30	4.1
	Check	220	180	137.1	17.7	4204.2	10.4	4.4	65	34	11.4
Summerville-11 (6,28)	2 lb 2,4,5-T	142	156	135.4	17.1	4966.3	13.1	4.2	79	34	11.2
	Check	230	88	170.2	8.2	6465.5	11.4	4.0	82	32	4.6
Upson (6,22)	2 lb 2,4,5-T	736	1711	78.5	29.6	1856.7	4.1	1.5	30	16	27.4
	Check	409	1771	86.1	39.8	1877.5	6.1	1.7	42	20	31.6
Waddels (3,6)	1.25 lb 2cc Velpar	613	466	40.2	4.3	396.0	3.3	1.1	15	9	9.7
	1.5 lb 2cc Velpar	657	427	33.0	3.3	312.7	2.9	1.1	13	9	9.1
	1.25 lb Velpar granule	587	2450	39.1	23.8	392.0	3.3	1.1	16	10	37.8
	1.5 lb Velpar granule	623	970	38.8	8.0	393.8	3.2	1.2	15	10	17.1
	Check	430	2750	22.5	23.2	225.3	3.0	1.1	15	11	50.8
	2cc Velpar, mean	635	446	36.6	3.8	354.4	3.1	1.1	14	9	9.4
	Velpar granule,mean	605	1710	39.0	15.9	392.9	3.2	1.2	16	10	27.5

[2] WC=Weed Control
F=Fertilizer
CB=Chop, burn
B=Bedded

WD=Well drained
NWC=No weed control
NF=Not fertilized
CBB=Chop, burn, bed

NB=Not bedded
PMD=Poorly-moderately drained
CBHB=Chop, burn, harrow, bed
VPPD=Very poorly-poorly drained

not revealed if one looks solely at treatment means. A more important relationship is pine yield versus the amount of hardwood present in the stand, regardless of herbicide treatment. One relationship which can be examined is pine yield (square feet of basal area or cubic foot yield) versus hardwood basal area. Figure 1 shows this relationship for the Floyd County comparison. Note the high variability and lack of a definitive trend. Figure 2 shows a transformed relationship where hardwood basal area has been expressed as a percentage of the total basal area (pine plus hardwood). Variation is greatly reduced and a trend is obvious. Relative hardwood basal area appears to be a better indicator of hardwood effects and probably aids in standardizing other site and stand effects.

Burkhart and Sprinz (1984) developed a yield model which incorporated this effect of hardwood basal area. Using measurements from the Fayette study at age 11 and age 24, they noted that percent hardwood basal area on a plot by plot basis remained constant over time. That is, if a plot had 30% hardwood basal area at age 11, it would still have 30% hardwood basal area at age 24. Although pines tend to grow faster than hardwoods, apparently pine mortality and hardwood ingrowth combine to maintain the constant proportion of hardwood basal area. This means that once hardwoods become established in a pine stand, pines do not "out-grow" and dominate the hardwoods, and that hardwoods remain as competition which adversely affects pine yield.

This concept of constant proportion of hardwood basal area supports the idea that measurement of the amount of hardwood basal area in a stand several years after treatment (as was done in this effort) should be an adequate indicator of initial hardwood density and/or treatment effectiveness. This assumes, of course, that hardwood stocking was equivalent across plots at time of treatment — not always a good assumption, particularly in operational comparisons.

The apparent lack of effectiveness of chemical treatment in some operational comparisons may be due to the violation of this assumption, as illustrated in Figure 3 for Summerville-3. The two plots with highest pine volume yield and among the lowest percent hardwood basal areas are untreated—that is, these plots apparently did not have a high proportion of hardwood basal at time of treatment. Likewise, the plot with the next to highest proportion of hardwood and next to lowest pine yield is a treated plot, indicating the treatment was ineffective. This points out that a comparison of treatment means alone is not sufficient. It also indicates the importance of proper plot layout during herbicide study establishment and the need to determine initial pine and hardwood stocking.

Figure 4 (Summerville-6) also illustrates a strong negative effect of percent

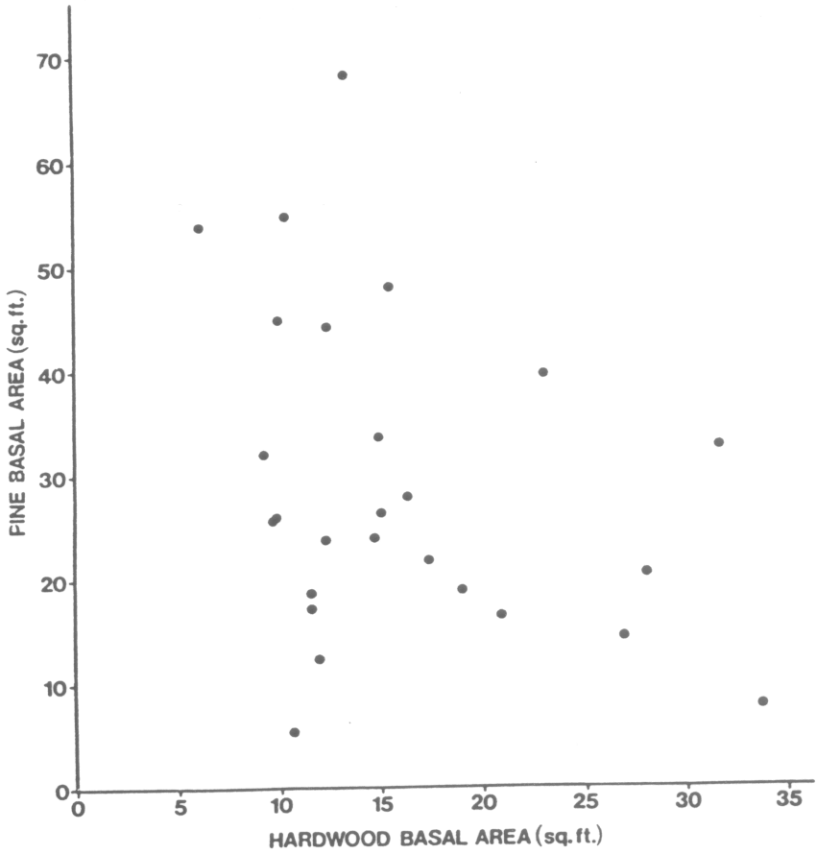


Figure 1. Per acre basal area comparison of pine and hardwood at Floyd County (age 11).

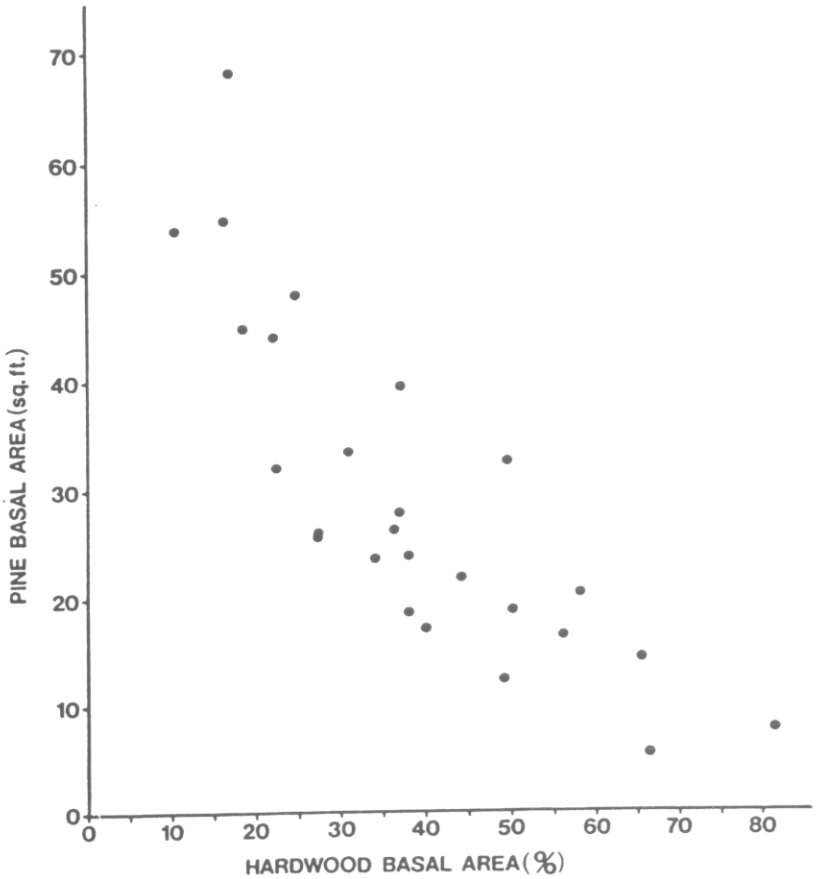


Figure 2. Pine basal area per acre to percent hardwood basal area comparison at Floyd County (age 11).

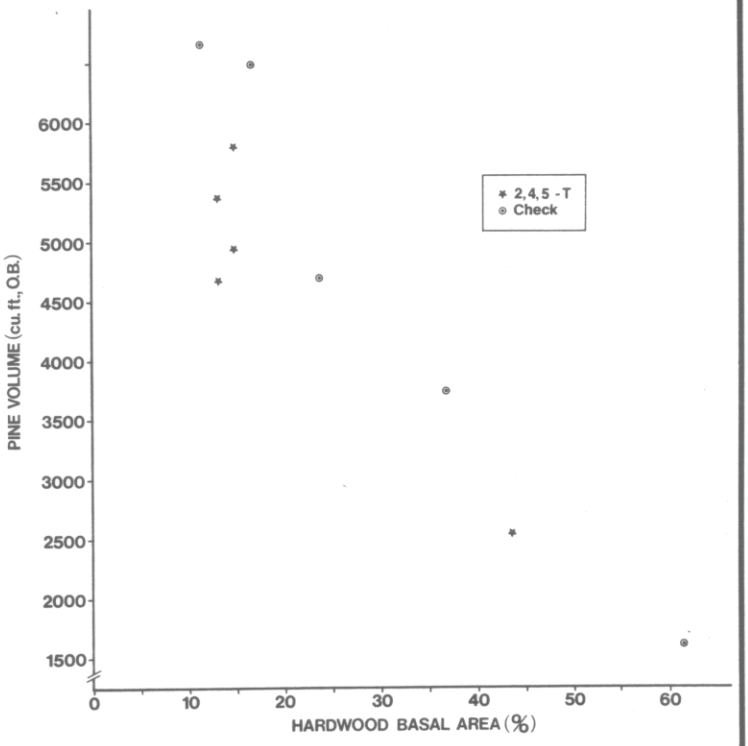


Figure 3. Pine Cubic foot volume per acre to percent hardwood basal area comparison at Summerville-3 (age 26).

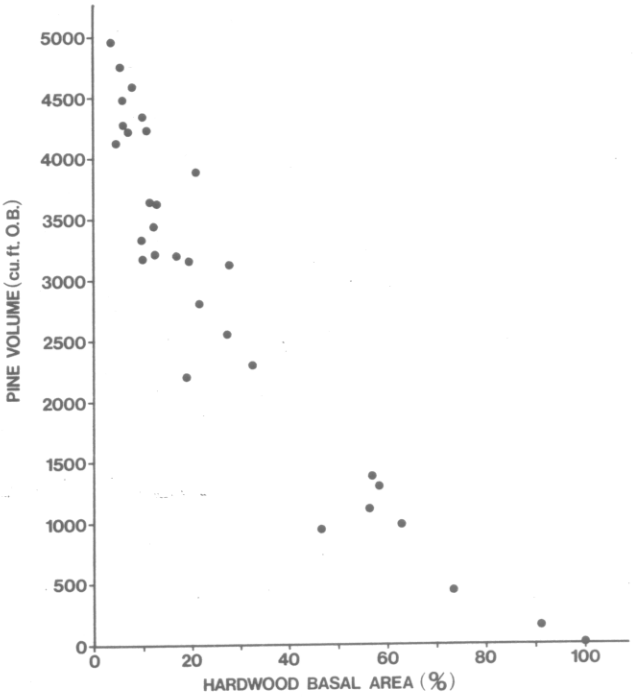


Figure 5. Pine cubic foot volume per acre to percent hardwood basal area comparison at Fayette (age 24).

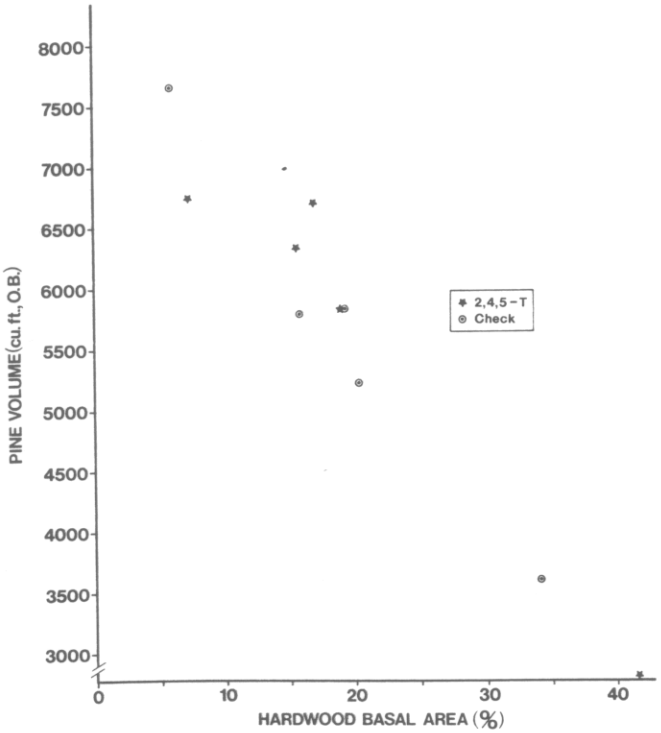


Figure 4. Pine cubic foot volume per acre to percent hardwood basal area comparison at Summerville-6 (age 30).

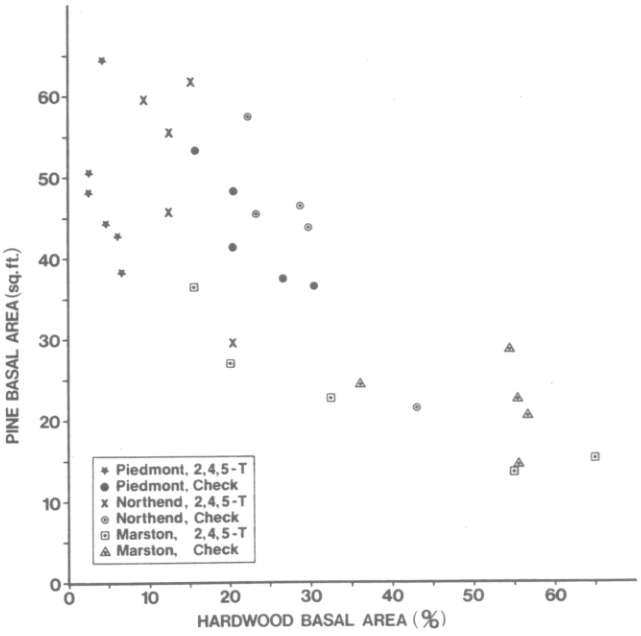


Figure 6. Pine basal per acre to percent hardwood basal area comparison at Piedmont, Northend and Marston (age 10)[3].

3 Values for Piedmont adjusted from age 9 to 10 using mean annual increment.

hardwood basal area on pine yield but a lack of treatment effect. Values in Table 3 indicate that no differences exist between treated and check mean volume, basal area, etc.

Additional figures (Figures 5-7) exhibit similar trends as noted in Figures 2-4. The Fayette Site Preparation Study, Figure 5, is one of the best documented older replicated herbicide studies in the South. Hardwood basal area ranges from near 0 to 100%, allowing examination of the pine yield across a wide range of hardwood levels. The trend in Figure 5 is very well defined. Note that pine yield at 30% hardwood basal area is approximately one-half that at 4% hardwood basal area. This reduction in pine yield is apparent in almost all of the measured comparisons. If hardwood is present in a pine stand, yield will be affected, and evidently affected dramatically at relatively low levels of hardwood stocking.

Figure 6 shows three operational comparisons in separate stands which were treated the same day in Virginia. Piedmont was selected as a pine stand which would normally not be considered to need release (note the relatively low percent hardwood basal area levels). North End was a stand which was marginally in need of release, and Marston was judged to definitely be in need of release. Piedmont was one year younger than the other two stands and for this figure only its basal area yields have been increased by one year's growth (based on age 9 mean annual increment). Note the consistent trend in pine basal area yield relative to percent hardwood basal area for the three stands combined.

Figure 7 shows two research comparisons at different ages, Sewanee at age 6 and Grass Creek at age 9. In each case the trend of pine yield in basal area and percent hardwood basal area is well defined. This figure also illustrates how a trend will probably look over time in the same stand.

There were five herbaceous or understory vegetation control research studies (no operational comparisons). All but one were installed as fertilization/weed control comparisons, with two also including different site preparation treatments. Table 4 is a summary from Table 3 showing weed control effects on pine survival, basal area, volume, dbh and total height. All studies except Palatka show an increase in pine size and yield with weed control. Palatka was three sets of paired plots treated for understory shrub and herbaceous weed control at age 10 (one plot) or 12 (two plots).

The three studies in the Georgia coastal plain, Dubberly, Mock and Savannah Town, show an average 25% increase in volume yield, or about 0.36 cord per acre per year. Chemicals used in these studies were not as effective in controlling herbaceous weeds as chemicals presently being tested and used. Indications from more recent studies with better weed control

Before herbicide application, each stand should be evaluated as to the need for vegetation control and the availability of suitable and effective herbicide treatments.

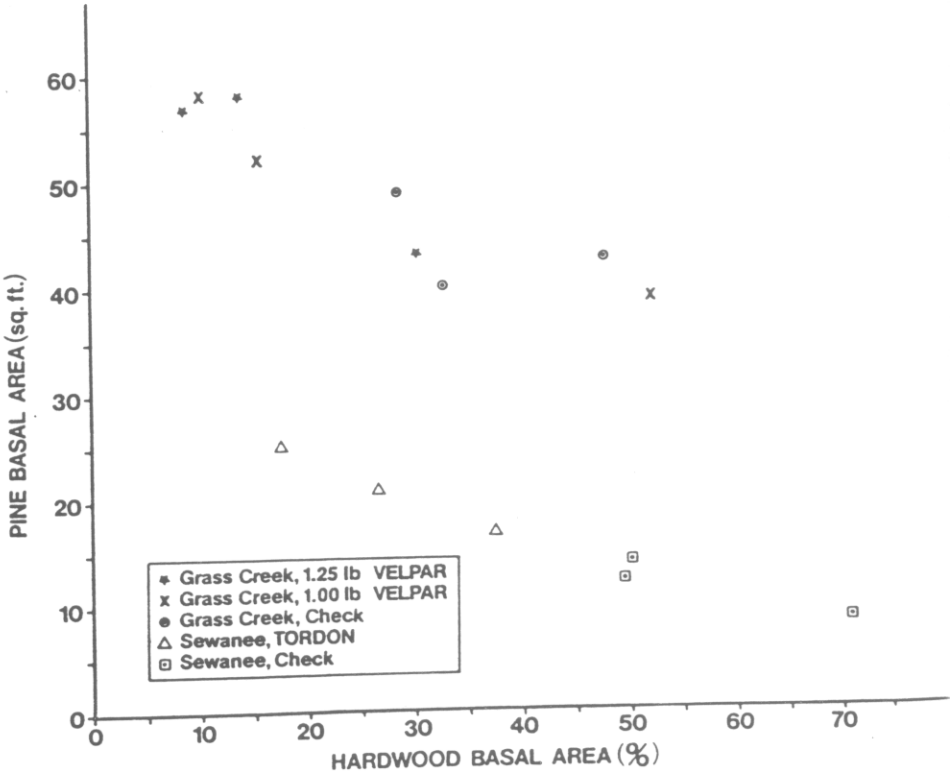


Figure 7. Pine basal area per acre to percent hardwood basal area comparison at Grass Creek (age 9) and Sewanee (age 6).

are that even greater gains can be made from control of herbaceous weeds. One of the newer chemicals, hexazinone, was used at Ross and although the study is still young, basal area and volume show more than a 100% increase at age 4, with a 0.7-inch increase in mean dbh and 3-foot increase in mean height. Other reported studies show similar results (Zutter, 1984; Knowe, et al., 1985).

CONCLUSIONS

The high variability and inconsistent treatment effects found in the operational comparisons, particularly those treated with 2,4,5-T, were unexpected. More consistent treatment effects and yield trends were noted in better controlled research studies. Looking beyond treatment means and examining the relationship between pine yield and amount of hardwood in the stand resulted in stable relationships across most comparisons, operational or research.

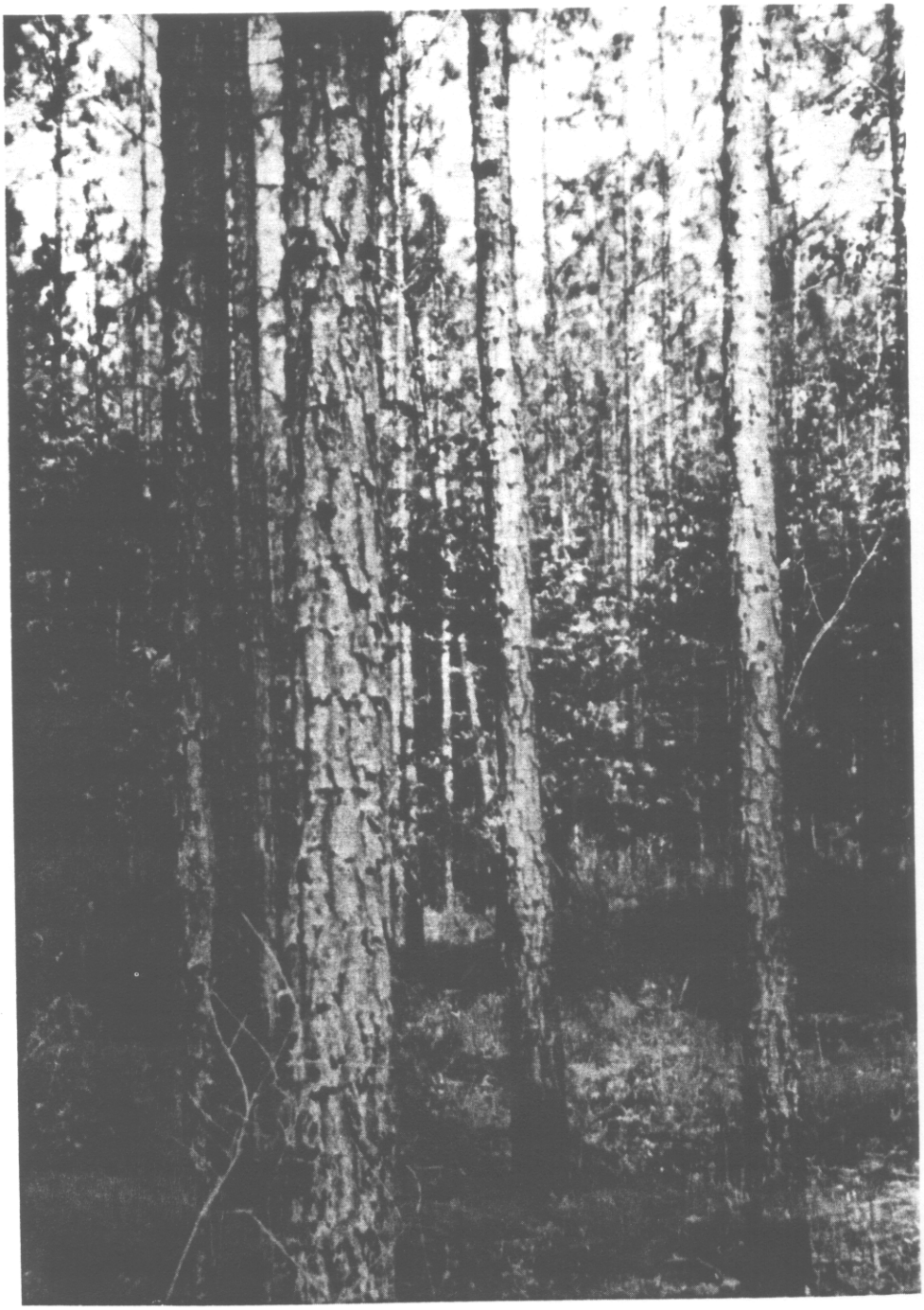
It is obvious from this data that increasing occurrence of hardwoods in pine stands is well correlated with decreasing pine yield. The logical assumption is that it is competition from the hardwood component which is the cause of this yield reduction. Although this set of data is not suitable for growth and yield model development, it is empirical evidence that current ideas regarding the effects of hardwoods on pine growth are valid.

The fact that herbicide application did not always increase pine yield is not indicative of the effect of vegetation control (i.e. herbicide application does not necessarily imply vegetation control). Before herbicide application, each stand should be evaluated as to the need for vegetation control and the availability of suitable and effective herbicide treatments. As data become available from studies specifically designed to evaluate the effect of competing vegetation on pine growth and yield, better models describing these effects will be developed. Until that time, this set of data should provide guidelines for determining the need and gains from control of competing vegetation.

Table 4. Summary of pine information for herbaceous vegetation control comparisons.

Study (treatment, measurement age)	Treatment [4]	Number of trees per acre	Basal area per acre (sq ft)	O.B. volume per acre (cu ft)	Mean dbh (in)	Mean total height (ft)
Dubberly (0,11)	WC	579	93.2	1685.5	5.2	34
	NWC	640	78.6	1386.4	4.5	30
Mock (0,14)	WC(Simazine)	490	93.1	1883.0	5.8	40
	NWC	499	82.0	1594.0	5.3	38
Palatka (12,19; 10,17)	WC	611	140.9	3376.1	6.4	50
	NWC	603	142.7	3492.2	6.5	52
Ross (0,4)	WC	509	12.3	110.9	2.0	12
	NWC	596	5.7	50.5	1.3	9
Savannah Town (0,11)	WC (1st year)	570	97.7	1825.5	5.4	36
	WC (annual)	602	100.1	1773.2	5.4	36
	NWC	530	80.5	1380.9	5.2	34

[4] WC=Weed
NWC=No Weed Control



Although pines tend to grow faster than hardwoods, apparantly pine mortality and hardwood ingrowth combine to maintain the constant proportion of hardwood basal area.

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