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Improving Mixed Hardwood Stands

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INTRODUCTION

HARDWOOD INGROWTH is natural and prolific on sites where high quality hardwoods can be grown in quantity and where soil moisture is relatively abundant. Such site conditions exist on many upland bottoms in the Southeast. Most of these contain complex mixtures of vines, shrubs, and trees of many sizes and grades, preventing desirable hardwoods from utilizing the site potential to their fullest advantage. Conversion of these hardwood sites to pine is generally difficult and costs frequently exceed the gain in value of growing pure pine. Therefore, the policy of management should have for its goal developing stands of desirable hardwoods.

Objectives of this study were to compare costs and effectiveness of various cull tree control methods in two situations: (1) a merchantable stand that had not been cut for over 20 years and (2) a stand that had been recently cut over.

Several problems have been encountered in studies on weed-tree control measures applied for the purpose of improving mixed hardwood stands. Putnam, Furnival, and McKnight *(4)* stated that weed-tree control limited to large trees, the usual practice following cutting in hardwood stands, will not significantly improve areas where there are thickets of smaller weed-trees. Minckler and Jensen *(3)* indicated that poor species offer more competition on good sites than on poor sites and that the better sites usually require some special treatment. Arbogast *(1)* indicated that a stand of high quality hardwoods can be developed and maintained by removing poor trees over the entire range of size classes. To develop a better stocking of desirable species it is sometimes advantageous to have cull trees deadened in advance of cutting *(4)*.

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Starr *(6)* has shown that mist blowers can be used for understory control in hardwood stands without damaging even the easy to kill over-story trees. Lindmark *(2)*, Romancier *(5)*, and Weatherly *(7)* have indicated that basal wetting is an effective way of controlling thin bark tree species in the lower diameter classes. They also indicated that the injection of 2,4-D and 2,4,5-T was more effective for the control of all sizes of cull trees.

Study Area

The area involved in this study was situated in Fayette County, Alabama, in the Upper Coastal Plain region. The treatment area was located on upland hollows of small drainages. Soils belonged predominantly to the Mantachie series, consisting primarily of local alluviums that were generally deep but imperfectly drained. Site index for loblolly pine ranged from 85 to 100.

The forest was of the mixed hardwood type with the following species making up the bulk of the stand: loblolly pine (*Pinus taeda,* L.), sweetgum (*Liquidambar styraciflua,* F.), yellow-poplar (*Liriodendron tulipifera,* L.), black gum (*Nyssa sylvatica,* Marsh.), red maple (*Acer rubrum,* L.), oaks (*Quercus spp.,* L.), and hickory (*Carya spp.,* Nutt.). The understory had some of all the above species plus many dogwoods (*Cornus florida,* L.), persimmon (*Diospyros virginiana,* L.), sourwood (*Oxydendrum arboreum,* DC.), swamp-privet (*Forestiera acuminata* Poir.), muscadine grape vines (*Vitis rotundifolia,* Michx.), and common greenbriar vines (*Smilax rotundifolia,* L.).

Two stand conditions were selected for treatment: a merchantable stand in which no cutting had been made for more than 20 years (Stand 1) and an originally similar stand that had been selectively cut 6 years prior to treatment (Stand 2). Prior to treatment in 1962 Stand 1 contained 205 trees per acre over 4 inches d.b.h. and 1,130 trees per acre from 1 to 4 inches d.b.h. Diameters ranged to 30 inches with ages to approximately 100 years. Stand 2 contained 141 trees per acre over 4 inches d.b.h. and 2,215 trees per acre from 1 to 4 inches d.b.h. Diameters ranged to 19 inches with ages to approximately 60 years, Table 1.

Basal areas of trees 4 inches d.b.h. and larger averaged 80 sq. ft. per acre in Stand 1 and 39 sq. ft. per acre in Stand 2. Gross volumes of all trees 4 inches d.b.h. and larger averaged 1,649 cu. ft. and 619 cu. ft. per acre, respectively.

TABLE 1. STOCK AND STAND DATA FOR TREATMENT AREA, PER ACRE BASIS

Treatment and stand	1962				1966		
	DBH	Trees	B.A.	Vol.	Trees	B.A.	Vol.
	In.	*No.*	*Sq. ft.*	*Cu. ft.*	*No.*	*Sq. ft.*	*Cu. ft.*
Stand 1							
Check	3.6-9.0	137	20.96	427	111	15.10	198
	> 9.0	67	58.96	1,341	29	21.66	910
Total	----	204	79.92	1,768	140	36.76	1,108
Injection	3.6-9.0	135	21.47	354	47	7.75	112
	> 9.0	54	52.87	1,065	23	12.60	306
Total	----	189	74.34	1,419	70	23.35	418
Basal spray	3.6-9.0	145	23.60	424	49	8.38	181
	> 9.0	64	60.80	1,383	20	38.26	476
Total	----	209	84.40	1,807	69	46.64	657
Mist—inj.	3.6-9.0	154	22.64	395	49	9.31	223
	> 9.0	62	58.90	1,302	30	22.36	564
Total	----	216	81.54	1,602	79	33.67	787
Mean	----	205	80.05	1,649	------	--------	------
Stand 2							
Check	3.6-9.0	123	18.08	260	181	26.61	515
	> 9.0	34	26.69	486	33	27.23	766
Total	----	157	44.47	746	214	53.84	1,281
Injection	3.6-9.0	114	16.19	235	107	17.01	288
	> 9.0	23	20.24	390	20	12.26	243
Total	----	137	26.43	625	127	29.27	531
Basal spray	3.6-9.0	116	16.47	227	93	13.67	242
	> 9.0	30	23.16	405	24	16.70	345
Total	----	146	39.63	632	117	30.37	587
Mist—inj.	3.6-9.0	100	19.00	211	132	19.40	319
	> 9.0	23	14.35	262	23	15.73	294
Total	----	123	33.35	473	155	35.13	613
Mean		141	38.47	619	------	--------	------

Methods

A randomized block plot layout, consisting of 4 treatments (including an untreated check) with 5 replications, was established in each stand. Plots were rectangular, 1½ chains by 2 chains, comprising 0.3 acre in area. Initial treatments, applied in 1962, were as follows:

1. Check – No weed tree control measures applied.
2. Injection – Injecting all undesirable trees (culls, weed species, and shrubs) with stems larger than 1 inch in diameter at 2 inches above the ground line with a mixture of 1 gallon of 2,4,5-T ester (containing 4 pounds acid equivalent/gallon) in 20 gallons of fuel oil. Injections were made 2 inches apart at the base of all undesirable trees except hickory and sourwood, both of which received a continuous ring of injections.
3. Basal Spray – A back-pack garden sprayer was used to apply a spray mixture of 1 gallon of 2,4,5-T ester (containing 4

pounds acid equivalent/gallon) in 25 gallons of fuel oil to the lower 7 inches and exposed roots to the point of runoff.

4. Mist Blowing plus Injection – A back-pack mist blower was used to apply a mist in a mixture of 1 gallon of 2,4,5-T ester (containing 4 pounds acid equivalent/gallon) in 9 gallons of fuel oil to the understory (spray nozzle kept nearly horizontal) in June 1962 to leaf surfaces of vegetation up to approximately 20 feet in height. Later that same year the larger undesirable trees not apparently affected by the mist application (generally larger than 3 inches d.b.h.) were injected as in Treatment 2.

In Stand 1 an average of 757 trees per acre less than 4 inches d.b.h. and 89 trees larger than 4 inches d.b.h. were treated. In Stand 2 an average of 980 trees per acre less than 4 inches d.b.h. and 46 trees larger than 4 inches d.b.h. were treated. All original treatments were completed by the end of July 1962.

In the fall of 1964 an improvement cut was made on all areas involved in this study. The cut removed all undesirable merchantable trees plus some merchantable trees that were competing with desirable (fast growing plus high quality) trees. Approximately 460 cu. ft. per acre were cut from Stand 1 whereas only 60 cu. ft. per acre were cut from Stand 2. Not all trees recommended for removal in the improvement program were merchantable. Unmerchantable trees were treated by injection on all plots regardless of the former treatment.

RESULTS AND DISCUSSION

Cost of Treatments

Total costs, the amount of labor, and the volume of chemical used varied by treatment and stand conditions. Costs given in Table 2 are valid only for comparisons between treatments and not as current costs per acre. Costs of each treatment were considerably less in Stand 1, the uncut stand, than in Stand 2, the cutover stand. This can be attributed to two factors: (1) The total number of stems treated was less in Stand 1 and (2) there was greater ease of maneuverability in Stand 1. Both factors resulted in smaller amounts of labor required to apply treatments.

Labor requirements for Treatment 4 were the lowest in each stand even though the area had to be traversed twice, Table 2. Labor requirements for the other two treatments were variable. In Stand 1 labor for Treatment 2 was considerably less than for

TABLE 2. TREATMENTS, NUMBER OF TREES TREATED, LABOR AND MATERIAL USED, AND COST PER ACRE AND PER 1,000 TREES

Treatment	Stems treated		Labor[1]		Material	Total cost	
	< 4 in. dbh	> 4 in. dbh	Acre	1,000	Volume	Acre	1,000
	No.	*No.*	*Hr.*	*Hr.*	*Gal.*	*Dol.*	*Dol.*
Stand 1							
Injection[2]	720	87	3.6	4.5	4.8	8.45	7.99
Basal spray[3]	770	92	4.5	5.2	19.9	14.00	16.24
Mist—inj.	780	88	3.3	3.8	9.8	10.61	12.22
Mist[4]			0.5		4.5	4.80	
Injection[2]			2.8		5.3	5.81	
Stand 2							
Injection[2]	1,020	43	7.2	6.8	9.9	13.41	12.62
Basal spray[3]	960	50	6.8	6.7	22.3	17.71	17.54
Mist—inj.	960	44	5.5	5.5	13.1	15.68	15.62
Mist[4]			0.8		6.1	6.85	
Injection[2]			4.7		7.0	8.83	

[1] Labor at $1.15 per hour.
[2] One gallon of 2,4,5-T (4 lb./gal. acid equiv.) in 19 gallons of No. 2 fuel oil at $0.49 per gallon.
[3] One gallon of 2,4,5-T (4 lb./gal. acid equiv.) in 25 gallons of No. 2 fuel oil at $0.44 per gallon.
[4] One gallon of 2,4,5-T (4 lb./gal. acid equiv.) in 9 gallons of No. 2 fuel oil at $0.98 per gallon.

Treatment 3. In Stand 2 labor for Treatment 3 was less than for Treatment 2, the reverse of that in Stand 1. This can be traced to the fact that the extra large trees in Stand 1 required much more labor to treat by basal spraying than by injection.

Total costs, which included labor and chemicals, were lowest for Treatment 2 in each stand. Treatment 3 was the most expensive for both stands. Costs of Treatment 2 differed most between stands, partly because of the difference in the total number of stems treated. Total cost of Treatment 4 in each stand was more than Treatment 2 and less than Treatment 3.

Effectiveness of Treatments in Killing Trees

Two years after treatment the degrees of kill tallied on trees less than 4 inches d.b.h. were nearly equal for all treatments in both stands, that is, over 95 per cent kill, Table 3. Trees larger than 4 inches d.b.h. responded similarly to Treatments 2 and 4, where the kill averaged 80 per cent. Treatment 3 resulted in an average kill of only 47 per cent on trees larger than 4 inches d.b.h., which was significantly less (0.05 per cent level) than the kill by Treatments 2 and 4.

For all treatments the per cent of kill was reduced as the size

TABLE 3. PER CENT OF KILL BY TREATMENT AND SIZE CLASS, 1964

Treatment	Size (diameter) class				
	< 3.6 in.	3.6-7.5 in.	7.6-11.5 in.	> 11.5 in.	Av. > 3.6 in.[1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Stand 1					
Injection	97	96	84	70	83a
Basal spray	99	75	48	6	43b
Mist—inj.	100	94	79	73	82a
Stand 2					
Injection	97	94	76	76	82a
Basal spray	96	75	51	10	45b
Mist—inj.	97	97	80	73	82a

[1] Means of treatments, if followed by the same letter, do not differ at the 0.05 level of significance.

class of trees increased. In Treatment 3 all the trees over 12 inches d.b.h. that were killed were red maple. No other species of this size were killed by this method. Treatment 3 was very effective in killing all sizes of red maple and in preventing resprouting. Treatment 4 produced the best results by killing most of the shrubs and trees up to 20 feet high, thereby eliminating many of the small trees not treated in the other two treatments.

Regeneration

Treatment by basal spraying or mist blowing plus injection resulted in a much greater increase in the regeneration of desirable seedlings than did no treatment or injection only, Table 4. It was apparent that spraying treatments reduced competition from lesser vegetation more than did chemical injection. This increase was more pronounced in Stand 1 where desirable seedlings were approximately 4 times more numerous for Treatments 3 and 4 than for Treatments 1 and 2. Seedlings in Stand 2 were approximately twice as numerous for Treatments 3 and 4 as for Treatments 1 and 2. In all cases adequate numbers of seedlings were present. However, with the expected competition from the overstory present (undesirable species and weeds) a number much larger than 1,000 per acre was considered desirable.

Increases in Good Growing Stock

In 1962 the per cent of good growing stock in Stand 1 was considerably less than in Stand 2, Table 5. By 1964 all treatments in both stands had produced an increase in the per cent of good growing stock. This increase was greater in Stand 1 than in Stand 2 and apparently related to the original stand conditions.

TABLE 4. AVERAGE NUMBER OF DESIRABLE SEEDLINGS PER ACRE BY YEARS[1]

Treatment	Stand 1		Stand 2	
	1962	1964	1962	1964
	No.	*No.*	*No.*	*No.*
Check	700	3,100	800	1,150
Injection	800	4,100	100	1,200
Basal spray	650	16,500	200	4,400
Mist—inj.	500	14,000	200	2,800

[1] Desirable seedlings include yellow-poplar, sweetgum, white oak, and loblolly pine.

TABLE 5. PER CENT OF PULP AND SAWTIMBER TREES CLASSIFIED AS GOOD GROWING STOCK BY YEARS[1]

Treatment	1962	1964	Increase[2]	1966	Increase[3]
	Pct.[4]	*Pct.*[4]	*Pct.*[4]	*Pct.*[4]	*Pct.*[4]
Stand 1					
Check	61.9	61.9	0.0	63.1	1.2
Injection	49.2	84.3	35.1	97.3	13.0
Basal spray	54.2	71.5	17.3	89.4	7.9
Mist—inj.	54.7	86.0	31.3	98.0	12.0
Stand 2					
Check	65.1	67.6	2.5	70.2	2.6
Injection	64.5	82.4	17.9	87.9	5.5
Basal spray	68.0	80.9	11.9	92.7	11.8
Mist—inj.	70.0	93.0	23.0	97.7	4.7

[1] All trees with no disease, good form, and capable of developing quality timber.
[2] Increase in per cent of growing stock 2 years after treatment.
[3] Increase in per cent of growing stock 2 years after an improvement cut, or 1966 over 1964 conditions.
[4] By stem count of trees 3.6 in. dbh and larger.

In both stands, treatments which included injection of herbicides increased good growing stock over the treatment by basal spraying.

Two years after the improvement cut and the retreatment of all plots in 1964, an inventory was made, Table 1, and changes in good growing stock calculated, Table 5. In 1966 all treated areas showed added increases in good growing stock to more desirable levels ranging from 88 to 98 per cent of all trees. The check area remained comparatively low, 63 per cent in Stand 1 and 70 per cent in Stand 2.

Growth Increases

The 5-year diameter growth increase per tree (average of the four desirable species) was less in Stand 1 than in Stand 2, with ranges from 0.55 inches to 1.12 inches in the former and from 1.41 inches to 1.94 inches in the latter, Table 6. In Stand 1 the

TABLE 6. MEAN DIAMETER GROWTH PER TREE BY TREATMENT AND SPECIES, 1962-1967

Treatment	S. gum	Y. pop.	Lob. pine	W. oak	Av.[1]
	In.	*In.*	*In.*	*In.*	*In.*
Stand 1					
Check	0.49	0.71	0.46	0.56	0.55a
Injection	1.03	1.31	0.60	1.49	1.12b
Basal spray	0.68	0.74	0.98	0.95	0.77b
Mist—inj.	0.56	1.28	0.78	0.82	1.06b
Av. of inj., bs., m-i	0.76	1.11	0.78	1.09	0.98
Stand 2					
Check	1.38	1.42	1.56	1.12	1.41c
Injection	1.71	1.77	2.38	2.20	1.85d
Basal spray	1.25	1.90	1.53	1.52	1.62c
Mist—inj.	1.57	2.28	2.33	1.82	1.94d
Av. of inj., bs., m-i	1.51	1.98	2.08	1.86	1.80

[1] Values followed by the same letter do not differ at the 0.05 level of significance.

growth was significantly greater (0.05 per cent level) in all treatments than the growth of the check. In this stand the greatest growth for the three hardwood species occurred in Treatment 2. Loblolly pine growth responses were the reverse of that for hardwoods with the least growth in Treatment 2 and the greatest growth in Treatment 3.

In Stand 2 the growth was significantly greater (0.05 per cent level) in Treatments 2 and 4 than in the check. No significant differences were found between Treatments 2 and 4 and Treatment 3 or between Treatment 3 and the check. In this stand all hardwood species and loblolly pine had growth increases in Treatments 2 and 4.

SUMMARY

Time and cost of treatments required to control undesirable plants in mixed hardwood stands were consistently less in stands in which no cuttings had been made for long periods than in stands in which commercial cuttings had been made recently. One apparent reason for this difference was the difficulty of movement through the recently cutover stand because of the heavier understory. Treatment by basal spray was more expensive to apply and less effective in the degree of kill attained except in the case of red maple. Red maples of all sizes were effectively controlled by basal spraying.

Desirable regeneration increased more on areas treated by mist

blowing or by basal spraying than on those treated by individual stem injection or not treated. Injection alone did not increase the establishment of desirable species over that of no treatment.

All treatments increased stocking per cent of desirable trees although basal spraying resulted in considerably less increase than the other two treatments.

In the uncut stand where mean diameter growth on the check plots was low all treatments resulted in the increase of growth. The greatest diameter growth increase for all three hardwood species resulted from the injection treatment, but this produced the smallest growth increase for loblolly pine.

In the cutover stand, mean diameter growth rate in the check plots was almost three times that of the uncut stand. This relatively high growth rate was increased after treatments by injection and mist plus injection for all hardwood species and loblolly pine. The basal spray treatment resulted in small increases in growth for yellow-poplar and white oak and no increase for sweetgum or loblolly pine.

CONCLUSIONS

Less time and cost are required to control undesirable plants in uncut stands as compared to recently cutover stands.

Mist blowing plus injection treatment resulted in the best overall performance by increasing desirable regeneration, by favorably increasing the stocking per cent of desirable trees, and by increasing the diameter growth of the residuals.

Injection alone was the least expensive and was highly effective in increasing the stocking per cent of desirable trees and in increasing the growth rates of the three hardwood species, but it did not increase desirable regeneration.

Basal spraying was the most expensive treatment and generally the least effective.

LITERATURE CITED

(1) Arbogast, Carl, Jr. 1957. Marking Guide for Northern Hardwoods Under the Selection System. Lake State Exp. Sta. Pap. 56.

(2) Lindmark, R. D. 1965. Removing Undesirable Trees. Lit. Rev. C.S.F.E.S. Columbus, Ohio.

(3) Minckler, Leon S. and Chester E. Jensen. 1959. Reproduction of Upland Central Hardwoods as Affected by Cutting, Topography, and Litter Depth. J. For. Vol. 57 No. 26, 424-428.

(4) Putman, John A., George M. Furnival, and J. S. McKnight. 1960. Management and Inventory of Southern Hardwoods. USDA Agr. Handbook No. 181. For. Ser.

(5) Romancier, Robert M. 1965. 2,4-D; 2,4-5-T and Related Chemicals for Woody Plant Control in the Southeastern United States. Rep. No. 16. Ga. For. Res. Coun.

(6) Starr, John. 1964. The Use of the Mist Blower for Control of Undesirable Hardwoods. Miss. State Univ. Agr. Exp. Sta. Bull. 692.

(7) Weatherly, John H. 1962. Frilling-Basal Application Combination – A Tool in Forest Management. 15th So. Weed Conf. Proc.