AGRICULTURE EXPERIMENT STATION/R. DENNIS ROUSE, DIRECTOR
AUBURN UNIVERSITY, AUBURN, ALABAMA

Circular 236
July 1977

Alternative Fire & Herbicide Systems for Hardwood Understory Management in a Hilly Southern Pine Forest

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ACKNOWLEDGMENT

The authors are grateful to Amchem Products, Inc. and to Dow Chemical Company for supplying the herbicides used in this research project and for advice on application of the herbicides.

FIRST PRINTING 4M, JULY 1977

Alternative Fire and Herbicide Systems for Managing Hardwood Understory in a Southern Pine Forest

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INTRODUCTION

THE LOBLOLLY (*Pinus taeda* L.) and shortleaf (*P. echinata* Mill.) pine forests of the southeastern Coastal Plain naturally progress toward a composition of mixed hardwood species *(26)*. The more shade-tolerant hardwoods invade in the form of understories. These must be controlled by the forest manager who desires to grow pines, or they will eventually occupy the site and exclude the pines. Further, hardwood understories can contribute to the "wildlife barren" habitat often characterizing pine stands. They become too tall for effective deer browse, while at the same time their competition retards development of other wildlife plant species in the understory *(4,21)*.

In a previous report *(12)*, the effects were described of using two systems of prescribed burning that were designed to retard such understory hardwoods and, at the same time, enhance wildlife values of the understory vegetation. In the present report, results are presented from applying seven herbicide systems in the same forest for the same purposes. Also, formal comparisons of the two burning systems and three of the herbicide systems, in

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terms of both specific hardwood kill or damage and in terms of changes in wildlife food and cover, are made.

The burning systems involved six to seven burns over a period of 10 years, while the herbicide systems involved only one to two sprayings of herbicide over the same period. This is in line with constraints imposed by respective costs, and approximates established practice in the use of these tools for forest management purposes.

The basic herbicides used in this study are 2,4-D and 2,4,5-T, both phenoxys, and picloram.[2]

PREVIOUS WORK

The phenoxy herbicides have an established use in forestry for suppressing unwanted hardwood trees and brush *(1)*. Coniferous trees are relatively resistant. The phenoxy herbicides are generally less costly, less hazardous, and less injurious to the environment than alternative herbicides. Since they are weak acids that are only slightly soluble in water and petroleum oils, they are normally converted into water-soluble amines or oil-soluble esters for more effective use. An "emulsifiable acid" form, consisting of a suspension of the acid in water, has also shown considerable promise *(29)*. Phenoxy herbicides are applied by aircraft, by ground broadcast sprays, and by treating individual trees. Rates of application for both aerial and ground broadcast treatment generally range from 2 to 4 pounds acid equivalent (a.e.) per acre of 2,4,5-T or 2,4-D/2,4,5-T mixture *(1)*. With the advent of the mist blower in 1957 *(31)*, it became possible to ground-spray these amounts in such low total volumes as 5 to 10 gallons per acre. Peevy and Brady *(24)* found no difference in herbicidal effectiveness between mist blowing and other forms of ground spraying of foliage.

Species susceptibility to 2,4,5-T foliar sprays was catalogued through the years *(6,14,25,27,31)*, resulting in a 1976 listing *(23)* of blackgum, white oak, and sweetgum as "easy-to-kill" species and ash, elm, hickory, red maple, red oak, persimmon, and dogwood as "hard-to-kill" species. At 2 pounds a.e. per acre, top killing of easy-to-kill species was 60 percent in Mississippi and 82 percent in Arkansas. Hard-to-kill species were top-killed 26 percent in Mississippi and 43 percent in Arkansas.

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[2] 2,4-D: 2,4-dichlorophenoxyacetic acid. 2,4,5-T: 2,4,5-trichlorophenoxyacetic acid. picloram: 4 amino-3,5,6-trichloropicolinic acid.

Use of herbicides other than the phenoxys is usually warranted only by a high abundance of weed species that are resistant to the phenoxys *(1)*. Picloram and dicamba are less selective, more hazardous, and much more expensive than the phenoxys. In an example of the effective use of picloram as an additive herbicide, Stritzke *(33)* obtained complete killing of 100 percent of winged elms (*Ulmus alata* Michx.) using ½ pound of picloram mixed with 2 pounds a.e. of 2,4,5-T amine per acre. The 2,4,5-T alone resulted in excellent top-killing but no complete killing; the picloram alone top-killed 75 percent of the elms and completely killed 33 percent. Brady *(5)* found that a standard 2,4,5-T ester was significantly improved in the number of species effectively controlled when either picloram or dicamba was added in low concentration. Starr *(32)* concluded that no one herbicide or single rate of application was best for all situations, and that combinations of herbicides are often necessary for increasing the spectrum of species that can be controlled.

Herbicides can be used for improving wildlife habitat. They have been used for making new openings in forest areas or maintaining old ones, for increasing browse, and for selective removal of competing plants in order to favor food producers *(13,22,30)*. Reports from the Lake States *(2,3,17,20,28)* indicate that vegetation control with herbicides can be employed in that region for the benefit of wildlife. Broadcast spraying of herbicides may be harmful to wildlife habitat when it damages or kills mast-bearing trees and shrubs that are important wildlife food sources *(15)*.

Burning is often used in conjunction with herbicides *(1)*. Preliminary burning can improve the effectiveness of herbicide applications and lower overall cost *(16)*. Herbicides are often used prior to burning in order to desiccate the vegetation to be burned while leaving adjoining vegetation green *(1,11)*. This ensures a cleaner burn with minimum smoke plus a low hazard of fire escaping from the treated area. In neither of the specific studies examined *(11,16)* was any attempt made to assign treatment effects separately to the burning or the herbicide.

STUDY AREA AND PROCEDURE

The Main Study

The main study area was established in 1961 at the Lower Coastal Plain Substation, Camden, Alabama. The climate at Camden is characterized as hot and humid, with 237 frost-free days and 57 inches rainfall per year. The physiographic region is the Loam Hills Region of the Hilly Coastal Plain Province *(19)*. Slopes vary from 5 to 35 percent, and the soil types are Ruston and Susquehanna sandy loams, about evenly divided.

When the experiment was started, the pine forest (predominantly loblolly pine) was of old-field origin and about 40 years old. Basal area of the pines varied from 25 to 165 square feet per acre. Invading understory hardwoods were fairly dense, Figure 1, and were mostly under 3 inches d.b.h. (diameter breast high). Sweetgum (*Liquidambar styraciflua* L.), oaks (*Quercus* sp.), winged elm, and hickories (*Carya* sp.) were the most important species.

Thirty-five 1/5-acre plots were located randomly in a 500-acre forest unit. Five understory control systems were assigned, each to seven plots, in a completely randomized design. These control systems were (1) one mist-spraying of butoxy ethanol ester of 2,4,5-T in late spring, 1961, (2) one mist-spraying of emulsifiable acid of 2,4,5-T in late spring, 1961, (3) repeated winter-burning, (4) repeated summer-burning, and (5) protection only (check).

In 1967, when additional damage to understory hardwoods resulting from the initial sprayings of herbicide was no longer evident, three plots from each of the previously sprayed plot groups were re-sprayed with the original chemical. These six plots were combined under a sixth understory control system of "double spraying." Superimposing this system in such a way resulted in an unbalanced statistical design.

Thirty-nine understory hardwoods per plot, ranging in size from a minimum of 5 feet in height to a maximum of 3.5 inches d.b.h., were numbered with wired-on metal tags in 1961 prior to the initiation of treatments. These hardwoods were approximately evenly divided among the following species groups: sweetgum, winged elm, hickories, laurel-water oaks, and red oaks. Laurel-water oaks were *Quercus laurifolia* Michx. and *Q. nigra* L. The principal red oak was southern red oak (*Q. falcata* Michx.).

Two pounds a.e. of 2,4,5-T per acre were applied to the herbicide plots at each spraying, using a gasoline-powered backpack mist blower. The ester form of 2,4,5-T was applied in oil-in-water (1:8 by volume) as the carrier, while the emulsifiable acid form was applied in water. The total volume of solution at each spraying was 5 gallons per acre.

Tagged understory hardwoods in the herbicide plots were tallied first in August 1961 and again in May 1962, June 1963, and July 1964, when it became apparent that there would be no further delayed damage from the 1961 herbicide applications. After the 1967 herbicide applications, it was discovered that many tree-tags had unaccountably disappeared in the re-sprayed plots, so that valid tagged-tree data for the "double-spray" system of understory control were unobtainable. The tagged trees were assigned to condition classes as follows: (1) Complete top-kill without sprouting, (2) Complete top-kill with sprouting, (3) Defoliated more than 50 but less than 100 percent, and (4) Defoliated less than 50 percent. "Complete kill" or "rootstock-kill" is the same as condition Class 1. The term "top-kill", without any reference to sprouting, combines classes 1 and 2. The tallies were expressed as percentages, which for analysis of variance were converted to arcsine equivalents.

Details of the burning applications have been previously reported *(12)*. The winter-burn plots were burned seven times and the summer-burn plots six times in a period of 10 years. Tagged understory hardwoods were tallied as for the herbicide and the check plots, with the final tally in 1971.

Additional data were taken for all plots in the late summer of 1971. In each plot, 100 feet of line intercept *(10)* were used to measure the cover percentage of (1) hardwood canopy more than 6 feet above the ground, (2) hardwood canopy 6 feet and less from the ground, and (3) woody and perennial vines including briars. Herbage was clipped from four randomly located 3.1-foot squares in each plot *(7,8,9)*. The clipped herbage was separated into grasses, legumes, and other forbs, and fresh weights determined. Dry weights were determined through oven-drying sub-samples to a constant weight at 75°C. Litter depths were measured on each plot at four randomly located points.

A Supplementary Study

As a separate experiment, three herbicide systems employing phenoxy-picloram mixtures were initiated in 1967. New plots were established in a different part of the forest at the Lower Coastal Plain Substation. The forest type was loblolly-shortleaf pine of old-field origin, as for the earlier plots, with the stands fairly well-stocked. The soil type was Susquehanna Sandy Loam. The pines were over 35 years old with live crowns that generally began more than 40 feet above the ground. When sprayed in 1967, the hardwoods were fairly dense, as in the earlier plots, and were mostly from 2 to 12 feet in height. The most prevalent hardwood species were sweetgum, winged elm, hickories, red oaks, laurel oak, and water oak.

The three systems, each assigned at random to five 1/5-acre plots, were single sprayings of picloram - 2,4-D mixture, picloram - 2,4-D - 2,4,5-T mixture at single strength, and picloram - 2,4-D - 2,4,5-T mixture at double strength. Understory hardwoods were numbered and tagged as in the earlier study. Foliar applications were made in July 1967 with a backpack mist blower.

The picloram - 2,4-D mixture contained 0.54 pounds a.e. of picloram and 2.0 pounds a.e. of 2,4-D as triisopropanolamine salts in each gallon of solution. Two gallons of solution diluted with 8 gallons of water were applied per acre, giving approximately 1 pound of picloram and 4 pounds of 2,4-D per acre. The picloram - 2,4-D - 2,4,5-T mixture contained 1 pound a.e. of each compound as triethylamine salts in each gallon of solution. For the single-strength treatment, 1 gallon of solution diluted with 9 gallons of water was applied per acre, giving 1 pound of each herbicide compound per acre. All plots were evaluated in May 1968 and June 1969, with tagged understory hardwoods being tallied by condition class as on the 2,4,5-T and burning plots.

RESULTS AND DISCUSSION

Effects of 2,4,5-T and Burning Systems

Both repeated burning systems were highly effective in top-killing all species of tagged understory hardwoods, but generally resulted in poor complete killing, Table 1. The single-spray 2,4,5-T treatments were much less effective than the burning treatments in top-killing of all species, but more effective in complete killing of sweetgum and hickories. The 2,4,5-T ester was superior to the acid in the top-killing of winged elm and laurel-water oaks. As stated previously, no damage and kill data for individual hardwoods subjected to double spraying were obtained because of the loss of tree tags prior to the second spraying.

Data in Table 1 indicate that both single-spray herbicide systems gave good performance in controlling sweetgum and only fair performance for hickories; in addition, the 2,4,5-T ester gave fair performance in controlling laurel-water oaks.

In effects on the degree of cover of woody understory, Table 2, it is obvious that both burning systems had more impact than did the single-spray 2,4,5-T systems. Winter-burned plots showed significantly reduced cover above 6 feet and significantly increased

TABLE 1. EFFECTIVENESS OF TWO HERBICIDE AND TWO BURNING SYSTEMS IN DAMAGING TAGGED UNDERSTORY HARDWOODS AFTER 10 YEARS

Species	Treatment[1]	Degree of kill[2] Complete[3]	Top[3]
		Percent of trees	
Sweetgum	2,4,5-T ester	77.7a	77.7a
	2,4,5-T acid	71.8a	73.0a
	Winter burns	15.6b	94.8b
	Summer burns	26.5b	95.9b
Winged elm	2,4,5-T ester	0 a	24.5a
	2,4,5-T acid	0 a	8.9b
	Winter burns	5.7a	92.5c
	Summer burns	4.0a	100.0c
Hickories	2,4,5-T ester	25.5a	44.6a
	2,4,5-T acid	39.2a	45.1a
	Winter burns	0 b	68.5b
	Summer burns	5.2b	86.2b
Laurel-water oaks	2,4,5-T ester	28.9a	55.2a
	2,4,5-T acid	12.8a	12.8b
	Winter burns	5.4a	89.2c
	Summer burns	12.5a	93.8c
Red oaks	2,4,5-T ester	0 a	14.6a
	2,4,5-T acid	6.8a	9.1a
	Winter burns	9.5a	73.8b
	Summer burns	3.2a	90.3b
Average	2,4,5-T ester	35.3a	49.3a
	2,4,5-T acid	33.1a	36.4a
	Winter burns	7.7b	85.4b
	Summer burns	13.2b	93.4b

[1] One foliar application at 2 lb. a.e. per acre for each 2,4,5-T treatment at the beginning of the 10-year period; damage effects measured after stabilization at 3 years. Damage effects from burning treatments measured at the end of the 10-year period after the seventh winter burning and the sixth summer burning.

[2] Complete kill: Both roots and top were dead; no re-sprouting. Top-kill: Top dead, with roots alive or dead; re-sprouting from live roots.

[3] Percentages followed by the same letter within a species and damage class are not significantly different at the 0.05 level.

lower cover, which is available for deer browse. Summer-burned plots showed greatly reduced cover above 6 feet and somewhat reduced total cover. The only significant effect of single-spraying 2,4,5-T was an increase in cover below 6 feet for the ester treatment. It should be remembered, however, that in the single-spray plots a 10-year re-growth period occurred between the 2,4,5-T treatments and the line-intercept measurements of cover. The double-spray system had a much greater impact (as of 1971) on the hardwood understory cover, producing about the same effects as repeated summer burning, Table 2.

Herbage weights, taken at the same time as the woody cover measurements, are given in Table 3. The burned plots had outstanding superiority over the check plots in weights of legumes

FIG. 1. View of untreated check plot at the end of the 10-year treatment period. Hardwood understory has become a dense midstory.

FIG. 2. View of plot 10 years after foliar spraying with 2,4,5-T ester.

FIG. 3. View of Double-sprayed plot, 10 years after the first spraying and 4 years after the second. Untreated area in background.

FIG. 4. View of plot 4 months after the seventh winter-burning. Untreated area in background.

TABLE 2. EFFECTS OF THREE HERBICIDE AND TWO BURNING SYSTEMS ON THE COVER OF WOODY UNDERSTORIES AFTER 10 YEARS[1]

Treatment	Upper canopy[2]	Lower canopy[3]	Total canopy[4]	Woody vines
		Percent cover		
2,4,5-T ester	50.1	40.7*	90.8	25.1
2,4,5-T acid	43.3	26.1	69.4	14.0
Double herbicide[5]	13.2*	21.7	34.9*	12.1
Winter burns	22.0*	47.9*	69.9	16.8
Summer burns	9.2*	29.5	38.7*	25.6
Check	67.8	24.3	92.1	20.8

[1] From line-intercept data in 1971, 10 years after the 2,4,5-T treatments, 4 years after the second application in the double herbicide treatment, and 1 growing season after the seventh winter burn and the sixth summer burn.

[2] Canopy of hardwood trees and shrubs more than 6 feet above the ground.

[3] Canopy of hardwood trees and shrubs 6 feet and less above the ground.

[4] The sum of upper and lower canopies.

[5] Sprayed with 2,4,5-T, at 2 lb. a.e. per acre, when the other 2,4,5-T plots were sprayed; re-sprayed after 6 years.

* Indicates a significant difference at the 0.05 level when compared to check.

and miscellaneous herbs, with the winter-burned plots significantly superior to the summer-burned plots. In contrast, none of the herbicide treatments produced herbage yields that were significantly greater than those for the check.

Forest floor litter depths are given in Table 4. Not surprisingly, the burned plots had significantly shallower litter than the check plots. The herbicide treatments apparently had no effect on litter depth. The authors believe that the litter reduction effect of burning was closely associated with the tremendous stimulation of herbaceous growth.

TABLE 3. EFFECTS OF THREE HERBICIDE AND TWO BURNING SYSTEMS ON HERBAGE PRODUCTION AFTER 10 YEARS[1]

Treatment	Grasses	Legumes	Miscellaneous[2]	Total herbage
		Pounds per acre[3]		
2,4,5-T ester	70.6	22.7	21.5	114.8
2,4,5-T acid	94.9	25.7	46.6	167.2
Double herbicide[4]	112.2	13.7	45.9	171.8
Winter burns	157.9	272.3*	318.9*	749.1*
Summer burns	58.8	106.0*	145.5*	314.3*
Check	33.8	14.4	7.6	55.8

[1] Data taken in 1971, 10 years after the 2,4,5-T treatments, 4 years after the second application in the double herbicide treatment, and 1 growing season after the seventh winter burn and the sixth summer burn.

[2] Mainly composites; includes all forbs except legumes.

[3] Oven-dry weight.

[4] See note 5, Table 2.

* Indicates a significant difference at the 0.05 level when compared to check. The values indicated are also each significantly different from all other values in the same column.

TABLE 4. EFFECTS OF THREE HERBICIDE AND TWO BURNING SYSTEMS ON AVERAGE LITTER DEPTH AFTER 10 YEARS

Treatment	Number of sprays or burns	Years since last spray or burn	Litter depth
	No.	*Yr.*	*cm*
2,4,5-T ester	1	10	2.1
2,4,5-T acid	1	10	2.3
Double herbicide[1]	2	4	2.2
Winter burns	7	0.5	0.4*
Summer burns	6	1	1.2*
Check	0	40+	2.4

[1] See note 5, Table 2.

* Indicates a significant difference at the 0.05 level when compared to check.

Effects of Picloram Mixture Systems on Tagged Hardwoods

Comparison between the results of the picloram mixture treatments and the results of the earlier 2,4,5-T treatments is not statistically valid. However, the two series of treatments were applied in the same manner to similar vegetation and under similar environmental conditions. Further, results from the work of other investigators *(5,32,33)* lead us to expect improved effectiveness on phenoxy-resistant species from the addition of the picloram. This expectation was verified, Table 5 vs. Table 1, except that there seemed to be little improvement, if any, in top-killing and complete killing of the hickories.

The picloram - 2,4-D (picloram-D) mixture was inferior to both concentrations of picloram - 2,4-D - 2,4,5-T (picloram-D-T) in the complete killing of sweetgum and winged elm, Table 5. It was likewise inferior in top-killing of sweetgum, but the differences for winged elm, though they appeared substantial, were not significant at the 0.05 level.

Doubling the concentration of the picloram-D-T resulted in no practical improvement in understory control. The top-kill for sweetgum was significantly greater than for the single-strength spray, Table 5, but an improvement for only one specie of a top-killing percentage that is already high cannot justify doubling the cost of an initially expensive herbicide.

Comparative Species Susceptibility to 2,4,5-T and to the Picloram Mixtures

Tables 6 and 7 statistically compare, for each herbicide, the susceptibility (or resistance) of all hardwood understory species groups.

TABLE 5. EFFECTIVENESS OF PICLORAM MIXTURES IN DAMAGING TAGGED UNDERSTORY HARDWOODS

Species	Treatment[1]	Degree of kill[2] Complete[3]	 Top[3]
		Percent of trees	
Sweetgum	Picloram - D	40.0a	66.0a
	Picloram - D - T(x1)	77.1b	89.6b
	Picloram - D - T(x2)	82.6b	100.0c
Winged elm	Picloram - D	15.4a	30.8a
	Picloram - D - T(x1)	45.8b	58.3a
	Picloram - D - T(x2)	73.7b	73.7a
Hickories	Picloram - D	30.8a	46.2a
	Picloram - D - T(x1)	16.7a	58.4a
	Picloram - D - T(x2)	21.4a	50.0a
Laurel-water oaks	Picloram - D	51.6a	74.2a
	Picloram - D - T(x1)	46.9a	84.4a
	Picloram - D - T(x2)	71.9a	90.7a
Red oaks	Picloram - D	50.0a	85.0a
	Picloram - D - T(x1)	32.3a	54.9a
	Picloram - D - T(x2)	27.8a	44.5a
Average all species	Picloram - D	39.5a	64.1a
	Picloram - D - T(x1)	50.3b	73.4a
	Picloram - D - T(x2)	55.4b	73.9a

[1] "D" is 2,4-D, and "T" is 2,4,5-T. Treatment rates (in 10 gal. per acre):
Picloram - D: 1 lb. picloram, 4 lb. D.
Picloram - D-T(x1): 1 lb. picloram, 1 lb. D, 1 lb. T.
Picloram - D-T(x2): 2 lb. picloram, 2 lb. D, 2 lb. T.

[2] See note 2, Table 1.

[3] Percentages followed by the same letter within a species and damage class are not significantly different at the 0.05 level.

On the basis of top-killing, susceptibility to the 2,4,5-T ester can be rated as follows from Table 6: susceptible – sweetgum; moderately susceptible – laurel-water oaks and hickories; resistant – winged elm and red oaks. For the 2,4,5-T acid, shift the laurel-water oaks from moderately susceptible to resistant. On the basis of complete killing (no re-sprouting), the winged elm and red oaks should be rated as highly resistant to both forms of 2,4,5-T, and laurel-water oaks as highly resistant to the acid form.

Perhaps the most noteworthy feature of Table 7 is the lack of any statistically significant difference among species in the percentages of top-killing for the picloram-D-T mixture, single strength. All species groups were at least moderately susceptible to this herbicide. The authors conclude that this treatment did attain the "wider spectrum of species effectiveness" expected as the result of using an appropriate mixture of chemicals. Hickories, however, were highly resistant to complete killing in this treatment.

The picloram-D mixture was unique in that it effected a high percentage of top-killing for red oaks and by far the best complete

TABLE 6. SPECIES SUSCEPTIBILITY TO 2,4,5-T APPLICATIONS AT 2 POUNDS A.E. IN 5 GALLONS PER ACRE

Species[1]	Damage classes[2]				
	1[3]	2	3	4	1+2[3]
			Percent of trees		
		Butoxy ethanol ester			
Sweetgum	77.7a	0	3.2	19.1	77.7a
Laurel-water oaks	28.9b	26.3	7.9	36.8	55.2ab
Hickories	25.5b	19.1	14.9	40.4	44.6bc
Winged elm	0 c	24.5	22.4	53.1	24.5cd
Red oaks	0 c	14.6	22.0	63.4	14.6d
Average all species	35.3	14.0	12.1	38.6	49.3
		Emulsifiable acid			
Sweetgum	71.8a	1.2	3.5	23.5	73.0a
Hickories	39.2b	5.9	5.9	49.0	45.1b
Laurel-water oaks	12.8c	0	8.5	78.7	12.8c
Red oaks	6.8cd	2.3	13.6	77.3	9.1c
Winged elm	0 d	8.9	17.8	73.3	8.9c
Average all species	33.1	3.3	8.8	54.8	36.4

[1] Species arranged in order of susceptibility to top-killing (damage class 1+2).
[2] 1. Complete top-kill without sprouting.
2. Complete top-kill with sprouting.
3. More than 50 percent but less than 100 percent defoliated.
4. Less than 50 percent defoliated.
[3] Means with different superscripts differ at $P<0.05$.

killing for that species, Table 7. The results indicate that this mixture might be superior for controlling understories with a high proportion of red oaks and laurel-water oaks.

CONCLUSIONS

Generally, the effects of the herbicide treatments on the tagged understory hardwoods tend to verify results as reported by other workers. If cost can be ignored and if the trees are small enough for foliar treatment from the ground, numbers and condition of understory individuals can probably be regulated at will. This can be accomplished through choosing the appropriate mix of chemicals to meet intended objectives for the species involved and, perhaps, by repeating treatments one or more times during an overstory rotation. Costs, however, can rarely be ignored. It is often difficult to justify economically more than one application per rotation of the relatively cheap phenoxy herbicides. For the much more costly picloram, it is often difficult to justify even one application during a rotation.

The same potentiality and economic limitations are of course applicable to ground-spraying for regulating height and cover per-

TABLE 7. SPECIES SUSCEPTIBILITY TO APPLICATIONS OF VARIOUS PICLORAM MIXTURES IN 10 GALLONS PER ACRE

Species[1]	Damage classes[2]				
	1[3]	2	3	4	1+2[3]
			Percent of trees		
		Picloram-D mixture[4]			
Red oaks	50.0a	35.0	5.0	10.0	85.0a
Laurel-water oaks	51.6a	22.6	12.9	12.9	74.2ab
Sweetgum	40.0a	26.0	22.0	12.0	66.0ab
Hickories	30.8ab	15.4	23.1	30.8	46.2bc
Winged elm	15.4b	15.4	30.8	38.5	30.8c
Average all species	39.5	24.6	16.9	19.0	64.1
		Picloram-D-T mixture, single strength[5]			
Sweetgum	77.1a	12.5	6.3	4.2	89.6a
Laurel-water oaks	46.9b	37.5	15.6	0	84.4a
Hickories	16.7c	41.7	8.3	33.3	58.4a
Winged elm	45.8b	12.5	29.2	12.5	58.3a
Red oaks	32.3bc	22.6	22.6	22.6	54.9a
Average all species	50.3	23.1	15.4	11.3	73.4
		Picloram-D-T mixture, double strength[6]			
Sweetgum	82.6a	17.4	0	0	100.0a
Laurel-water oaks	71.9a	18.8	9.4	0	90.7a
Winged elm	73.7a	0	5.3	21.1	73.7b
Hickories	21.4b	28.6	28.6	21.4	50.0bc
Red oaks	27.8b	16.7	38.9	16.7	44.5c
Average all species	55.4	18.5	15.4	10.8	73.9

[1] Species arranged in order of susceptibility to top-killing (damage class 1+2).
[2] See note 2, Table 6.
[3] Means with different superscripts differ at $P<0.05$.
[4] One lb. picloram plus 4 lb. 2,4-D per acre.
[5] One lb. picloram plus 1 lb. 2,4-D plus 1 lb. 2,4,5-T per acre.
[6] Two lb. picloram plus 2 lb. 2,4-D plus 2 lb. 2,4,5-T per acre.

centage of woody understories. A deer browse layer, for instance, could probably be maintained by means of repeated applications of herbicides that top-killed without completely killing, but the cost would normally be excessive.

When herbicide effects are kept separate from fire effects, the stimulation of herbage production due to the herbicide is disappointing from the wildlife viewpoint. No evidence, either in previous reports or in this study, indicated that herbicides stimulated the important legumes. The principal herbage response seems to be in the grasses *(30)*, which appear capable of responding to any decrease in woody competition *(18)*.

The repeated burning treatments were highly effective in top-killing understory hardwoods, in maintaining a succulent browse layer for white tailed deer (*Odocoileus virginianus*), and in stimulating herb species valuable for deer, bobwhite quail (*Colinus virginianus* L.), and wild turkey (*Meleagris gallopavo*). Winter-burning was particularly effective. The details have been reported previously *(12)*.

Where understory hardwoods are a problem in pine stands, herbicides, if used properly, should be superior to prescribed burning in complete killing of individual hardwoods. This means superior control of hardwood competition against pine regeneration after the current pine crop is harvested. On the other hand, prescribed burning produces superior quantities of wildlife foods, at the same time keeping the hardwoods small enough for future herbicide or mechanical treatment. Obviously, it should be possible in many stands to attain the best effects of both herbicide and burning treatments through incorporating both within a single system of understory control.

PESTICIDE PRECAUTIONARY STATEMENT

This paper reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State or Federal agencies before they can be recommended. Caution: Pesticides can be injurious to human, domestic animals, desirable plants, and fish or other wildlife — if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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Alabama's Agricultural Experiment Station System
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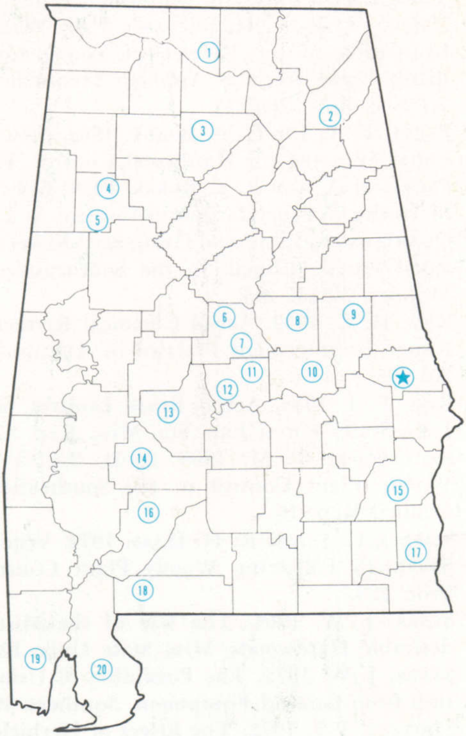
With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Ornamental Horticulture Field Station, Spring Hill.
20. Gulf Coast Substation, Fairhope.