

SIX BRUSH CONTROL TREATMENTS were applied in the spring of 1953 to a 3-mile section of a Penelec right-of-way in central Pennsylvania (1). This line had been given an initial clearance in the winter of 1951-52 through a typical upland oak forest. The major objectives of research carried out in conjunction with these tests have been, (1) to determine the effects of chemical spraying on game food and cover plants, (2) to study game usage of the various treatment areas, and (3) to study the effectiveness of the sprays in controlling woody brush while producing a low plant cover that will be resistant to invasion by tree species.

A distinctive feature of the experimental layout has been that the spraying was carried out by a regular commercial crew using standard equipment. Also, the treatment areas were large enough for use of commercial techniques, a step found necessary in converting research plot data into practical recommendations. One major difference between the spray applications in the tests and similar techniques commercially applied is that in the tests very thorough applications were made in which larger volumes of spray were used than is usual in commercial applications. This was done intentionally in order to produce a maximum kill of brush and to cause a maximum disturbance of ground cover for each technique. The net result has been a brush kill which is above usual commercial standards at the present time. Details on the experimental design may be found in a previous report (1).

A line of research supplementary to the original tests has been application of a follow-up basal spray to one-half of each original treatment area. This was done to test the effectiveness of a quick follow-up basal as a brush control tool to get a right-of-way into the best possible condition for subsequent light maintenance sprays.

The original treatments and follow-up sprays were:

A — Unsprayed

B — *Broadcast foliage spray* of 2,4-D plus 2,4,5-T butoxy ethanol esters, half and half, at a concentration of 4 pounds combined acid equivalent per 100 gallons of water. Applied June 1953.

C — *Oil-water, semi-basal spray* of emulsifiable acids of 2,4-D plus 2,4,5-T, half and half; 3 gallons of spray material to make a concentration of 6 pounds of combined acid equivalent per 100 gallons spray in an oil-water carrier consisting of 10 gallons of No. 2 fuel oil in 87 gallons of water. Applied June 1953.

D — *General summer basal spray* of emulsifiable acids of 2,4-D plus 2,4,5-T, half and half, at a concentration of 12 pounds of combined acid equivalent per 100 gallons of spray, No. 2 fuel oil being used as a carrier. Applied June, 1953.

Effects of Certain Common Brush Control  
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On Game Food and Cover  
On a Power Line  
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E — *Selective winter basal spray* of 2,4,5-T butoxy ethanol esters at a concentration of 12 pounds of acid equivalent per 100 gallons of spray, No. 2 fuel oil being used as a carrier. Applied February 1954.

F — *Broadcast foliage spray* of Ammate at a concentration of  $\frac{3}{4}$  pound per gallon of water; 4 ounces of DuPont sticker-spreader were added per 100 gallons of spray. Applied June 1953.

B-D, C-D, D-D, E-D, F-D — A *follow-up basal spray* (D) applied in July, 1954 (June, 1956 for E-D) to one-half of each replication of treatments B, C, D, E, and F. The follow-up consisted of a summer basal spray using the ACP formula 1054-E and techniques as in D. The 1054-E concentrate contained 2 pounds of 2,4-D and 2 pounds of 2,4,5-T per gallon and was diluted at the rate of 4 gallons in 96 gallons of No. 2 fuel oil.

## EFFECT OF SPRAYS ON WOODY BRUSH

### Top Kill

An acceptable top kill was obtained with all chemicals used owing to thorough applications of high volumes of spray. In all cases, a top kill of 94 per cent, or more, was obtained on woody plants on the treatment areas by the end of the second growing season after spraying (2).

### Resurge

As a comparison of the relative effectiveness of the various spray applications in control of woody brush, data is given, table 1, on the number of woody plants

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FIG. 1. — Unsprayed control area, five years after cutting. Growth of tree sprouts has reached 14 feet in height in some places and is crowding out the ground layer.



FIG. 2. — Broadcast foliage spray area, four years after spraying. A dominant Sedge-Grass cover has been present for two years.

Table 1. — Number of living woody plants and stems attaining a height of 3 feet or more, 4 growing seasons after spraying.

Treatment Replication	Woody Plants with Living Stems						Living Woody Stems Per Acre Over 3 Feet in Height	Average Height, Living Woody Stems Over 3 Feet
	Scrub Oak	Other Oaks	Red Maple	Sassafras	Other Hardwoods	Total Per Acre		
	No./A	No./A	No./A	No./A	No./A		Number	Feet
A I	80	960	720	80	480	2320		
II	0	280	0	0	120	400		
III	0	200	40	6000	360	6600		
IV	160	280	40	680	280	1440		
	Treatment Average					2690	5980	7.3
B I	0	8	0	0	0	8		
II	8	8	0	0	0	16		
III	0	24	0	0	0	24		
IV	48	8	0	0	0	56		
	Treatment Average					26	316	4.5
C I	0	0	0	0	0	0		
II	0	8	0	0	0	8		
III	0	0	0	0	0	0		
IV	0	8	24	0	24	56		
	Treatment Average					16	60	4.3
D I	0	0	0	0	0	0		
II	0	0	0	0	16	16		
III	24	0	0	0	0	24		
IV	24	0	0	200	0	224		
	Treatment Average					66	112	4.6
E* I	8	0	0	0	0	8		
II	0	0	0	0	0	0		
III	0	0	0	224	0	224		
IV	8	0	0	64	0	72		
	Treatment Average					76	144	4.2
F I	0	0	0	0	0	0		
II	0	0	32	0	0	32		
III	0	0	8	0	0	8		
IV	0	0	0	0	0	0		
	Treatment Average					10	106	5.2

\* Three growing seasons for E.

that have stems extending above the ground layer of herbs and grasses which reaches about 3 feet in height on this area. These taller plants are the forerunners of the resurgence that may require subsequent treatment in a few years.

As shown in table 1, a high degree of brush control has been maintained for the four years following spraying on all sprayed areas. In no case does the sparse woody brush extending above the ground layer merit retreatment, either on the basis of brush density or height, at this time.

Indicative of the relative effectiveness of the various sprays, however, is a notable difference in the number of stems per acre for the various treatments. The broadcast treatment with 2,4-D + 2,4,5-T has been the least effective in controlling the plants which are dominant in this forest type, it has been standing in the control of suckering species such as sassafras. Foliage sprays also have been found to be effective in controlling other suckering species, such as black locust, and where follow-up sprays were made one year after the original sprays, they have been effective in controlling and eliminating black locust for five years (4). Ammate foliage spray gave excellent control on the oak species, but red maple showed a notable resurgence and will need a follow-up treatment. Complete brush control is to be maintained.

The oil-water, semi-basal sprays gave good results on this oak-maple brush, and, when properly applied, can be expected to give maximum control on brush of either high or low density. To get the best of kill with an oil-water spray, however, it is necessary to use the proper formulation, the right mixture of oil, water, and the right technique of application. As a result of these will give increasingly inferior results.

The basal sprays, both summer and winter, gave an excellent kill of oak and maple with very few resurging. The only areas where resurgence was noted was in locations where sassafras thickets occurred. These were scattered along the right-of-way to a minor proportion of the total cover. In the case of basal spraying, considerable difficulty was encountered.

FIG. 4. — Summer basal spray area, four years after spraying. The original Bracken-Sedge-Herb-Blueberry cover has persisted for four years.





FIG. 3. — Oil-water, semi-basal area, four years after spraying. Bracken-Sedge-Herb cover has been dominant for two years.

in finding all low seedlings and suckers in the ground layer during the winter season. Summer basal has proved to be superior to winter applications both in the matter of finding smaller plants and efficiency of application.

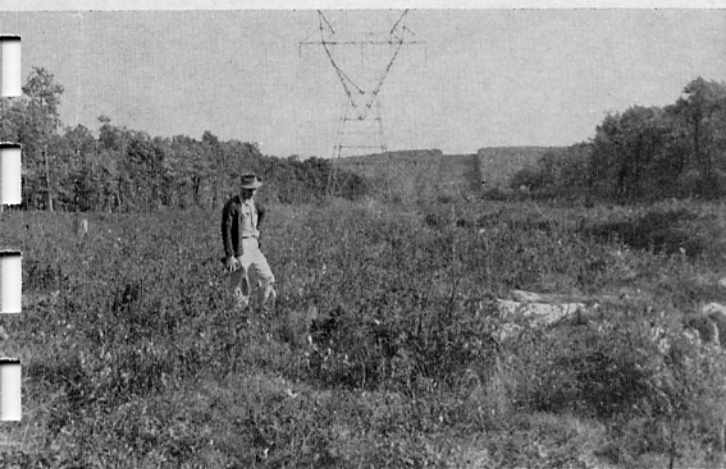
When the follow-up, summer basal sprays were applied one year after application of both broadcast and basal sprays, marked reduction of brush was obtained, table 2. These follow-up basal sprays were particularly effective following broadcast applications where they were successful in eliminating some of the hard-to-kill species such as the various oaks and the red maple not killed by the original broadcast foliage spray. A com-

Table 2. — Comparison of single sprays (B, C, D, E, F) with similar sprays to which a follow-up summer basal was applied one year after original sprays (B-D, C-D, D-D, E-D, F-D); data taken three growing seasons after the follow-up basal.

Treatment	Living Woody Plants per Acre Over 3 Feet in Height	Living Woody Stems per Acre Over 3 Feet in Height
	Number	Number
A—Unsprayed	2,690	5,980
B—Broadcast foliage	26	316
C—Oil-water	16	60
D—Summer basal	66	112
E—Winter basal*	76	144
F—Ammate	10	106
Treatments as Above Followed by a Summer Basal		
B-D	0	0
C-D	2	2
D-D	2	2
E-D	1	2
F-D	0	0

\* One growing season for E.

FIG. 5. — Winter basal spray area, three years after spraying. The original Bracken-Sedge-Herb-Blueberry cover has persisted for four years.



bination of high volume, broadcast foliage sprays, which were effective on such species as sassafras and scattered seedlings, with a quick follow-up basal has been markedly successful.

### EFFECTS OF SPRAYS ON PLANT COVER OF THE GROUND LAYER

During the 4 years following the various chemical treatments, several major differences were brought about in the ground layer as a result of spraying. The low cover on the broadcast foliage spray areas underwent sudden and drastic changes following spraying as a result of heavy killing of low shrubs, herbs, and grasses. This was in contrast with a slight disturbance of the ground layer on basal spray areas, table 3. The most

Table 3. — Changes in dominant species and in area covered by ground vegetation, under 3 feet in height, as a result of chemical spraying.

Treatment, June 1953	Dominant Plants in Late Summer, Aug.-Sept.				
	1953	1954	1955	1956	
A Unsprayed	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	
Ground Cover (per cent)	79	96	84	80	
B Broadcast Foliage	Bracken Sedge Herb Blueberry	Sedge Grass Herb	Sedge Grass	Sedge Grass	
Ground Cover (per cent)	10	79	88	96	
C Oil-Water	Bracken Sedge Herb Blueberry	Fireweed Bracken Grass Sedge	Bracken Sedge Herb	Bracken Sedge Herb	
Ground Cover (per cent)	25	79	91	95	
D Summer Basal	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	
Ground Cover (per cent)	75	95	96	98	
E* Winter Basal	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	Bracken Sedge Herb Blueberry	
Ground Cover (per cent)	75	95	95	97	
F Broadcast Foliage Ammate	Bracken Sedge Herb Blueberry	Fireweed Sedge Grass	Fireweed Sedge	Sedge Fireweed Bracken	
Ground Cover (per cent)	10	71	84	85	

\* E treated in February 1954.

FIG. 6. — Ammate foliage spray area, four years after spraying. The plant cover is still in a state of rapid change and Sedge-Fireweed-Bracken is now the dominant cover.



striking changes that occurred were the sudden development of a solid fireweed cover after broadcast foliage spraying with Ammate and the development of sedge-grass on the D + T broadcast spray areas.

A major trend in plant cover after the initial disturbance by spraying was the gradual progression on the broadcast areas towards a stable community. From fireweed as a dominant, the change in the succeeding three years has been towards a cover dominated by sedge, grasses, and bracken fern. It is probable that eventually the ground layer on these areas will develop into the Bracken-Sedge-Herb-Blueberry community which has persisted on the basal spray areas since 1953. However, it is important to emphasize the current instability created by the broadcast sprays for the period immediately following spraying, and to contrast this with the stability of cover on the basal spray areas.

A major development on the unsprayed control areas has been the gradual suppression of the ground layer by tree sprouts as they have grown larger and increased in density. This suppression has not affected the species composition of the ground layer, but it has reduced its density and will probably change it into the sparse ground layer typical of the surrounding closed forest stands, if the brush is not cut. It is expected that the unsprayed brush will need recutting in 1957 at the end of the fifth year following cutting.

#### USAGE OF TREATMENT AREAS BY GAME SPECIES

The effect of chemical spraying upon game food plants and usage by game animals has been followed closely (2 and 3), and continues to be a point of major interest in the tests, table 4. Usage of all treatments by deer has continued. While this game species commonly bedded down in sedge or grassy spots of sprayed sections in other seasons, it concentrated upon the brushy unsprayed areas in the winter when snow covered the ground. Rabbits also used the control areas heavily in winter months. During the early spring and summer, however, the deer browsed heavily in the sprayed areas upon young shoots of bracken fern, and upon herbs such as the whorled loosestrife.

Ruffed grouse used all but one of the chemical treatments, while turkey usage was observed on Ammate spray areas. These latter birds used open spots for dusting and probably also found the insect life of the open right-of-way attractive. Young turkey poults, in particular, are known to feed upon insects such as grasshoppers in the early summer months. Squirrels crossed and used the right-of-way adjacent to the timber edges in all but one treatment without any particular pattern of usage being evident.

Table 4. — Number of times common wildlife species or signs were observed on treatment areas from October 1, 1955, through October 1956.

Wildlife Observed	A	B	C	D	E	F	Total
Deer	47	8	17	26	33	24	155
Rabbit	38	2	1	5	16	1	63
Grouse	0	0	2	3	1	4	10
Turkey	0	0	0	0	0	9	9
Squirrel	2	1	0	4	1	8	16

#### SUMMARY

Four years after spraying a power line right-of-way with herbicides, a comparison of five techniques indicates that by use of basal sprays a stable ground cover can be maintained with minimum disturbance. Such cover has proven useful to several important game species. On the other hand, broadcast spraying resulted in drastic alterations of the low plant cover which has been slowly progressing towards a more stable condition. The broadcast spray areas are used by several important wildlife species.

All techniques produced a 94 per cent or higher top kill of woody brush owing to thorough applications of high volumes of spray. Summer basal spray proved to be effective on hard-to-kill mixed oak and maple brush and produced a maximum control of brush coupled with minimum disturbance of low plant cover. It also preserved several valuable wildlife shrubs that were nearly eliminated by broadcast and semi-basal sprays. Winter basal spraying gave excellent kills on oak and maple brush, but was difficult to apply effectively on scattered single stems in the winter months.

Oil-water, semi-basal spray and the broadcast Ammate spray proved to be highly effective treatments that produced minimum resurgence on all woody brush. Ammate and D + T broadcast foliage sprays were particularly effective when coupled with a follow-up summer basal spray made the year after the broadcast applications.

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Indicative of the relative effectiveness of these sprays, however, is a notable difference in the number of stems per acre for the various treatments. Although the broadcast treatment with 2,4-D + 2,4,5-T (B) has been the least effective in controlling the upland oaks which are dominant in this forest type, it has been outstanding in the control of suckering species such as sassafras. Foliage sprays also have been found effective in controlling other suckering species, such as black locust, and where follow-up sprays were made within a year after the original sprays, they have been effective in controlling and eliminating black locust for at least five years (4). Ammate foliage spray gave excellent control on the oak species, but red maple showed considerable resurge and will need a follow-up treatment if complete brush control is to be maintained.

The oil-water, semi-basal sprays gave good all-around results on this oak-maple brush, and, when properly applied, can be expected to give maximum kill on brush of either high or low density. To get this kind of kill with an oil-water spray, however, it is necessary to use the proper formulation, the right mixture of oil and water, and the right technique of application. Anything short of these will give increasingly inferior results.

The basal sprays, both summer and winter, gave excellent kill of oak and maple with very few plants resurging. The only areas where resurge was troublesome was in locations where sassafras thickets occurred. These were scattered along the right-of-way to form a minor proportion of the total cover. In the case of winter basal spraying, considerable difficulty was encountered