Torbert Slack:

What maximum height of brush would you recommend spraying in order to eliminate or alleviate drift?

W. C. Bramble:

The lower the brush, the less hazard there would be of drift, as the spray can be directed down on the foliage. A 5- to 6-ft. height should be about the maximum for spray in order to reduce drift and to get efficient application.

W. H. Simonson:

Are the hormone sprays as recommended for roadside use a hazard to animal life?

Iurka:

Exhaustive studies by S. N. Fertig, College of Agriculture, Cornell University, show that in all cases which have been carefully surveyed, even though the herbicide has been associated with the trouble, it has in no case been directly or indirectly related to the deaths reported.

W. J. Garmhausen:

What is the effect of herbicides on bees? Does it kill them when they come in contact with the spray? Does the herbicide that clings to their bodies affect the young in the hive or produce other undesirable effects?

Iurka:

The Entomology and Agronomy Departments of Cornell University have never found any evidence to show that the hormones of either D or T form will directly affect bees or bee larvae when used at the concentrations normal for roadside or other spraying purposes.

A COMPARISON of the EFFECTS of CHEMICAL BRUSH-CONTROL TECHNIQUES on PLANT COVER

William C. Bramble
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In the spring of 1953, a large-scale test of common brush-control techniques was instituted on a 3-mile section of a power-line right-of-way paralleling US 322 in central Pennsylvania. In the winter of 1951-1952 this line had been given an initial capital clearance through an upland oak forest containing species typical of the extensive oak-chestnut forest region of the northeastern United States.

The six treatments applied originally in this study were selected as brush-control techniques commonly employed in right-of-way maintenance. A commercial power sprayer and crew applied the spray. One year following the initial treatments, a follow-up basal spray was given to one-half of each area of four of the original treatments. Original treatments and follow-up sprays may be briefly described as follows:

A. No spray: to be compared, as a control, with sprayed areas and not to be

treated in any way until in need of cutting to maintain the right-of-way. Original clearance of the right-of-way was completed in the winter of 1951-1952.

B. Broadcast foliage spray of 2,4-D + 2,4,5-T in a water carrier. In this treatment, Weedone industrial brush killer, 4 lb. per gal. of the butoxy ethanol esters of 2,4-D and 2,4,5-T, half and half, was mixed at the rate of 1 gal. per 100 gal. of water. The spray was applied at 300-lb. pressure by a No. 8 nozzle tip. This tip size and the high spraying pressure were necessary to secure thorough coverage of all stems and foliage, especially the dense brush clumps. Spray also was broadcast on all existing ground cover.

C. Semi-basal spray of 2,4-D + 2,4,5-T in an oil-and-water carrier. For this treatment, ACP formula L-182A was used, containing 2 lb. per gal. of the emulsifiable acid of 2,4-D and 2,4,5-T, half and half. Three gal. of L-182A, 10 gal. of No. 2 household fuel oil, and 87 gal. of water were mixed to obtain 100 gal. of spray material. This spray also was applied at 300-lb. pressure by a No. 8 nozzle tip for good penetration. The spray was applied at the stumps, bases, and lower two-thirds of stems and foliage of woody brush. Complete encirclement of each stem and run-down to the root crown were secured. Only woody brush was sprayed.

D. General summer basal spray of 2,4-D + 2,4,5-T in an oil carrier. For this treatment 6 gal. L-182A were mixed with 94 gal. of No. 2 household fuel oil to obtain 100 gal. of spray material. The application was a combination of stump and basal treatment. No. 5 nozzle tips were used, the spray being applied with approximately 50-lb. pressure to the basal 12 in. of each stem and to the exposed bark area of each stump. Sufficient material was applied to encircle completely the base of each stem and to run down to the root crown. All the brush species which attain a mature height of more than 6 ft. were sprayed. The low shrub and herbaceous ground cover were not sprayed.

E. Selective winter basal spray of 2,4,5-T in an oil carrier. Application was made in January 1954. Although the sum application techniques and equipment were used as in treatment D, it was a very different type of spray. In the first place, Weedone 2,4,5-T (4 lb. acid equivalent per gal.) alone was used in a concentration of 3 gal. in 97 gal. of No. 2 fuel oil. Secondly, it was a more selective spray in that sweet fern was not sprayed at all, while on marginal strips about 18 feet wide neither witch hazel nor bear oak were sprayed. Also, it was not found practical to attempt to spray all seedlings, because of the almost impossible task of finding them in the winter among the low shrubs.

F. Broadcast foliage spray of Ammate in a water carrier. For this treatment 80 percent ammonium sulfamate was mixed with water at the rate of 3/4 lb. per gal. Du Pont sticker-spreader was added to this mixture, 4 oz. per 100 gal. The Ammate spray was applied with 300-lb. pressure by a No. 8 nozzle tip to ensure thorough coverage of all stems and foliage of the existing brush.

B-D, C-D, D-D, F-D. A follow-up basal spray applied on one-half of each replications of treatments B, C, D, and F. The follow-up consisted of a summer basal spray using the same technique as in D. The chemical used was ACP formula 1054-E, which contained 2 lb. of 2,4-D and 2 lb. of 2,4,5-T per gal. of concentrate. This was used at the rate of 4 gal. per 96 gal. of No. 2 fuel oil.

The general design of the tests was kept as simple as possible. Each treatment was repeated in each of four randomized blocks, thus giving four replications per treatment. The blocks were selected so as to include a uniform plant community within each block, while blocks were allowed to vary somewhat from each other in plant-community composition. The treatment areas varied from 1.9 to 3.9 acres in

size, covering from 460 to 940 ft. of a 180-ft. wide right-of-way.

Within each treatment area two types of sample plots were taken for detailed analysis of the vegetation. One type consisted of a randomly located plot on each treatment area, the plot being 33 ft. wide by 165 ft. long extending perpendicular to the right-of-way and subdivided into five 33-by-33-ft. subplots. The entire plot is a transverse belt transect on which the combined estimate of Braun-Blanquet (3) was used for community analysis. In addition, counts were made of all stumps and stump sprouts on the plots for the purpose of determining the effect of sprays on tree and tall shrub species.

Additional 33-by-165-ft. belt transects were placed at several points in the forest adjacent to the right-of-way to get information on the species composition of the various layers of the uncut forest in the area.

The second series of plots in each treatment area consisted of five 100-ft. line transects mechanically spaced to divide the treatment area into equal parts, each extending from the edge of the right-of-way past the center. The method of Canfield (4) was followed in taking data on the cover value of species by layers on these line transects and consisted essentially of measuring the ground space occupied by the base of each plant on the line.

CONTROL OF WOODY BRUSH

The first objective of all the techniques used was the control of woody brush on the right-of-way. In this connection, it has been important to differentiate between top kill, or the killing of the tops of plants back to the ground level, and total kill of stem and roots.

Heavy and thorough spray applications were used in these tests so that the spraying would be the best that could be reasonably achieved with the various techniques (1). As a result of such applications, a highly acceptable top kill was obtained with all the sprays. It may be noted in Table 1 that the top kill after two growing seasons varied from 94.1 to 99.7 percent. The top kill of 94.1 percent for the broadcast foliage spray of 2,4-D + 2,4,5-T was significantly lower than the kill obtained by the other sprays when tested by the analysis of variance; the other differences were not significant.

TABLE 1

TOP KILL BY VARIOUS SPRAYING METHODS

Treatment	Percent Top Kill for All Species Combined	
	After One Growing Season	After Two Growing Seasons
A. Unsprayed	--	--
B. Foliage	45.5	94.1
C. Oil-water	53.8	99.0
D. Summer basal	90.7	98.9
E. Winter basal	94.0	98.3
F. Ammate	33.4	99.7

The number of stems and plants per acre that grew to be more than 3 ft. in height at the end of three growing seasons has been used as a basis for comparing the resurge of woody brush which followed various treatments. These are presented in Table 2. The 3-ft. height is that to which woody stems must grow before they

emerge from the herbaceous ground layer. In Table 2 it may be seen that the oil-water, the summer basal, and the Ammate sprays have been most effective in keeping woody brush under control. The 26 stems per acre coming from five plants, found in the oil-water treatment, for example, are in striking contrast to the 228 stems and 34 plants in the foliage spray. However, all the spray treatments greatly reduced the number of stems below the 6,620 per acre found on the unsprayed areas. Differ-

TABLE 2

RESURGE* AFTER TREATMENT

Treatment	No. of Living Stems per Acre over 3 feet in Height			No. of Plants** per Acre with Living Stems over 3 Feet in Height
	Sassafras	Other Species	Total Stems	
A. Unsprayed	2,680	3,940	6,620	712
B. Foliage	2	226	228	34
C. Oil-water	0	26	26	5
D. Summer basal	4	62	66	10
E. Winter basal	108	25	133	57
F. Ammate	0	80	80	14

*Three growing seasons after spraying; two growing seasons for treatment E. Data given are averages of four replications.
**Refers to distinct sprout clumps and single stems; number of stumps used for treatment A.

ences in resurge between sprays appear to be primarily due to their failure to control a few species. For example, red maple sprouts form the majority of the stem resurging after the Ammate spray, sassafras sprouts predominate after the winter basal spray, and scrub-oak sprouts dominate the resurge following summer basal sprays. The broadcast foliage spray was the least effective in controlling the oaks, so that those species form the bulk of the resurging stems. There appears to be no one species dominating the resurge that followed the most efficient spray of the lot, the oil-water spray.

One of the more difficult problems that eventually comes up following an initial spray is: "What to do as a next step and when to do it?" Although none of the test spray areas were in absolute need of treatment within the three-year period following the initial sprays, it was deemed advisable to try a quick follow-up basal spray to test if this would have the effect of a "one-two punch" previously noted in other cases, and thus be more effective in controlling brush in the long run than if one were to wait until the brush had grown to a height where respraying became a "must."

Following out this idea in the early summer of 1954, one year after the original spraying, a summer basal spray was applied as a follow-up on one-half of the area of each of the replications of treatments B, C, D, and F. The general effect of this follow-up after two growing seasons is given in Table 3. There is no doubt that the follow-up type of treatment has resulted in holding back the woody brush to a lower height than would be the case if it were given only one spray. There is also no doubt that the follow-up had the effect of considerably reducing the number of resurging stumps and stems as compared with single spray treatments. These follow-up basals had the greatest effect in the cases of treatments that had the most resurge following the original spray (namely, the broadcast foliage spray and the

Ammate spray, where a reduction of living stump sprouts per acre of from 90 to 95 percent was effected). Their most important effects will not be seen for several years when evidence should be obtainable as to the effectiveness of quick follow-up spraying in keeping brush under control, as compared with single sprays.

TABLE 3

EFFECT OF FOLLOW-UP BASAL SPRAYS

Spray Type	No. Stumps per Acre with Living Sprouts	No. Living Stump Sprouts per Acre
B. Foliage	258	2,926
B-D. Foliage-summer basal	24	142
Percent difference	91%	95%
C. Oil-water	168	1,570
C-D. Oil-water-summer basal	20	74
Percent difference	88%	95%
D. Summer basal	100	970
D-D. Summer basal-summer basal	26	136
Percent difference	74%	86%
F. Ammate	250	3,562
F-D. Ammate-summer basal	46	352
Percent difference	82%	90%
A. Unsprayed	712	7,558

DEVELOPMENT OF LOW PLANT COVER

Several characteristics of the low plant cover which developed after the various treatments are of special interest with respect to roadside development and maintenance in wooded areas. Aesthetic appearance of sprayed areas following spraying is of first concern, and in this characteristic the sprays differ greatly. Broadcast foliage sprays of 2,4-D + 2,4,5-T (B) and of Ammate (F) produced an unsightly brown strip which persisted until the second growing season. This was caused by a 100 percent top kill on common herbs such as loosestrife, a 90 to 100 percent kill on bracken fern, and an 80 to 100 percent kill on vernal sedge. During the second growing season, low cover began to reappear, and about three-quarters of the ground area became covered. By the end of the third growing season, 84 to 88 percent of the ground area was covered, mostly with grasses and herbs.

The basal sprays (D and E), at the other extreme, retained the general green appearance of the right-of-way even in the year of spraying. After the first growing season, a nearly complete plant cover was developed; and by the end of the second season, 95 to 96 percent of the ground area was covered by low vegetation.

The oil-water spray (C) was intermediate to the foregoing types, with about three-quarters of the strip browned as a result of spraying. By the third growing season, about 91 percent of the ground area was again covered with vegetation.

An important characteristic of ground-cover development has been the strikingly different types of plant communities developing after the various sprays. The basal sprays (D and E) produced a community characterized by bracken, sedge, herbs, and blueberries, similar to that of unsprayed areas. This community has been rel-

atively stable for three years and shows little signs of change except for an increase in bracken fern. On the other hand, the low plant cover on semibasal and broadcast spray areas (B, C, and F) has been affected markedly by spraying and in the third year is still in the process of rapid change. Broadcast foliage spray of 2,4-D + 2,4,5-T has produced a sedge-grass community. Broadcast spraying of Ammate resulted in development of a temporary fireweed community, still in the process of rapid change to some more stable mixture. Shrubs are lacking in broadcast area, although sweet fern and blackberry are invading and are now present as scattered small seedlings. The oil-water semibasal spray has produced a mixture dominated by bracken, sedge, and loosestrife which is also still in the process of rapid change.

The characteristics of the low vegetation of a sprayed right-of-way also affect a most important third characteristic; namely, stability of resistance to invasion by tall-growing shrubs and trees. It would appear that the more stable tight cover maintained by the basal sprays should be most resistant, whereas the unstable changing cover of the broadcast and semibasal areas should be more easily invaded. At the present time, however, there is no clear-cut evidence to support this obvious assumption. Valid conclusions are obscured by many factors, and no attempt will be made at this time to settle this point. However, it may be pointed out that bracken fern is well known as a ground cover that resists tree invasion. It can form a dense vegetative cover in the summer, while in the spring it forms a mat of dead leaves and stems in which it is difficult for tree seedlings to become established. Bracken is a dominant plant on basal-spray areas.

Labor, equipment, and materials involved in the initial and follow-up spraying treatments are summarized in Table 4.

TABLE 4

Summary of Labor and Spray Volume for Original Treatments Applied on the Penelec Power Line Right-of-way, June 9 to July 1, 1953, and for Follow-up Sprays Applied July 13 to 19, 1954

Treatment	No. of Replications	Total Acreage Treated	Average Gals. per Acre	Average Man-Hours per Acre	Average Spray-Truck Hours per Acre
A. No spray	4	8.60	-	-	-
B. Foliage	4	8.43	460	7.23	2.41
B-D. Foliage + summer basal	4	3.48	48	5.20	1.30
Total			508	12.43	3.71
C. Oil-water	4	10.08	345	7.11	2.37
C-D. Oil-water + summer basal	4	4.06	20	3.26	.81
Total			365	10.37	3.18
D. Summer basal	4	9.82	140	11.61	3.87
D-D. Summer basal + summer basal	4	4.15	21	3.13	.78
Total			161	14.74	4.65
E. Winter basal	4	10.05	137	16.90	3.30
F. Ammate	4	12.65	415	7.05	2.35
F-D. Ammate + summer basal	4	4.25	40	4.33	1.08
Total			455	11.38	3.43

SUMMARY

A large scale test of common brush-control techniques was begun on a 3-mile section of a right-of-way in central Pennsylvania in the spring of 1953. The commonly used control techniques employed in this test were a broadcast foliage spray of 2,4-D + 2,4,5-T (B), an oil-water semibasal spray of 2,4-D + 2,4,5-T (C), a summer basal spray of 2,4-D + 2,4,5-T (D), a winter basal spray of 2,4,5-T (E), and a broadcast foliage spray of Ammate (F). In addition to these original treatments, one-half of each of the four replications of treatments B, C, D, and F were given a summer basal spray one year after the original spray applications. As a control for the test, one set of four replications was left unsprayed.

Because of a thorough and efficient application of the spray, all techniques gave an adequate top kill that varied from 94.1 to 99.7 percent of the total number of stems. When the resurge of woody brush that followed the initial spraying was compared three growing seasons after spraying, the oil-water, the summer basal, and the Ammate spray techniques were the most effective in keeping woody brush under control. Certain plant species were not well controlled by specific techniques and accounted for the bulk of the resurge on the particular treatments. Most striking of these was the lack of control of red maple by Ammate, scrub oak by the summer basal spray, and sassafras by the winter basal spray. The quick follow-up summer basal spray had the effect of giving more adequate control of woody brush and of keeping the stems below a 3-ft. height on the right-of-way.

Broadcast foliage sprays and semibasal sprays produced an unsightly brown strip during the growing season following spraying. This was caused by a high top kill of ground cover. After three growing seasons, the broadcast spray areas had regained an 84 to 88 percent plant cover of a sedge-grass or herb type. The basal sprays retained the original plant community of bracken-sedge-herb-blueberry that was present at the time of spraying and preserved a tight cover that appeared to be resistant to reinvasion through the third growing season. This plant community covers from 95 to 96 percent of the ground area and aesthetically has been a very desirable feature of the basal sprays.

Although no one spray technique can be said to be the best under all conditions, the basal sprays offer the best opportunity for controlling woody brush while at the same time maintaining an attractive roadside appearance. However, where the brush is very dense, such as it often is after repeated hand cutting, a broadcast type of spray may be the more efficient treatment, with a basal follow-up used to complete the initial control program.

REFERENCES

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3. Braun-Blanquet, J., "Plant Sociology." 430 pp. McGraw-Hill Company, New York, N.Y. (1932).

4. Canfield, R. H., "Application of the Line-Interception Method in Sampling Range Vegetation." J. Forestry, Vol. 39, pp. 388-394 (1941).

COMMENTS

W. J. Garmhausen:

At what height of cut are stumps most effectively controlled by herbicides?

Bramble:

Brush 3 to 4 in. in diameter or larger should be cut low; i.e., below 12 in. Smaller brush should be cut higher, say 2 to 3 ft., so that stumps can be located easily and the spray applied properly. In both cases the spray should be put on in high volumes so as to wet the sides and base of the stumps to assure run-down.

Torbert Slack:

What is the cost per acre of the several methods of herbicidal control of vegetation you report over a period of several years?

Bramble:

The answer to this is indicated by the percentage of control reported by each of the several methods and by the data in Table 4 of the report.

Frank H. Brant:

Is high pressure necessary for basal spray or would the low pressure of a knapsack sprayer be effective?

Bramble:

High pressure is not necessary for basal spraying. However, knapsack tanks are not as efficient as power equipment, with the possible exception of some locations which are entirely inaccessible for power equipment, and where follow-up spraying of brush is done on scattered plants. Commercial operators have used extremely long lines of hose from power equipment rather than depend on knapsack equipment where brush is moderate to heavy in density.

ROADSIDES as LIVING MUSEUMS of NATURAL HISTORY

Richard H. Pough, President
The Nature Conservancy

The United States covers a vast area, each climatic region of which has its own characteristic native plants and animals. Within each region local variations in soil, degree of wetness, slope, and other factors gave rise to many different plant-animal communities and produced a varied landscape. As the country was settled and the land was put to use raising crops, feeding livestock, or growing timber, these natural plant-animal communities were greatly altered or completely destroyed.

Were it not for the network of rights-of-way that spans the country from coast to coast, biologists would not, in many areas, know very much about the original character of the soils and vegetation. Fortunately rights-of-way, as they cut here and there across the country, invariably intersect samples of each local soil and each local plant-animal community, providing for the biologist a set of samples of unplowed soils and relatively little disturbed plant communities.

The importance of natural areas to the biological sciences is just beginning to be fully appreciated. As a result, there has been a rapid increase in the num-