ENGINEERING BULLETIN

HIGHWAY EXTENSION AND RESEARCH PROJECT FOR INDIANA COUNTIES

Roadside Weed And Brush Control With Chemicals

PURDUE UNIVERSITY—ENGINEERING EXPERIMENT STATION
in cooperation with
THE COUNTY COMMISSIONERS OF INDIANA

COUNTY HIGHWAY SERIES—No. 2

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Highway Extension and Research at Purdue

The Highway Extension and Research Project for Indiana Counties was organized in July 1959 to carry on extension and research programs specifically for County Highway Departments throughout the state of Indiana. The Project was organized as a result of legislation designating Purdue University through its Engineering Experiment Station and School of Civil Engineering as the agency to perform this service. The intent of the legislation was that the University through the School of Civil Engineering should extend its existing highway research and extension program at the county level to assist and guide county highway officials in their problems of planning, design, operation, and management of the county departments throughout the state.

The Highway Extension and Research Project for Indiana Counties (HERPIC) operates as a cooperative effort between the county commissioners of Indiana and Purdue University. As a relatively new organization the HERPIC program is still being developed. However, initial effort is directed toward providing guide manuals that set forth recommended procedures on important topics. In addition regional workshop conferences are held in various parts of the state, and at these conferences typical county road problems of the specific area are reviewed.

An older and more widely known highway research and extension organization is the Joint Highway Research Project which has operated since 1936 as a cooperative effort between the Indiana State Highway Department and Purdue University. Since its inception the Joint Highway Research Project has made many significant contributions toward the improvement of highway design and operational procedures at both state and local levels. In addition the Joint Highway Research Project sponsors the Annual Purdue Road School, an activity that brings together people from all segments of the highway industry and provides an opportunity to develop better relationships through discussion of mutual problems.

COUNTY HIGHWAY SERIES

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Roadside Weed and Brush Control with Chemicals

INTRODUCTION

Roadside weed and brush control on rural county roads is one of the major maintenance responsibilities of all Indiana county highway departments. During the past decade, roadside maintenance has been greatly simplified through the development and use of herbicides or plant-killer chemicals.

Herbicides are used to improve highway safety, drainage, and appearance and to eliminate poisonous weeds. The proper use of chemicals on roadsides will reduce mowing and brush cutting costs and promote good public relations with the community and the highway user.

This bulletin, developed primarily for the highway engineer and the county road supervisor, describes the more important herbicide materials available for roadsides, their recommended use, and application methods. Information is also provided to help county road officials develop better weed and brush control programs for county road systems. The last part of the bulletin covers details of planning a county-wide weed and brush control program.

CHEMICAL WEED AND BRUSH CONTROL

Purpose and Use of Herbicides

Since the development of a chemical called 2,4-D about 15 years ago, the use of chemicals to control weeds and brush on roadsides has steadily increased. The chemicals, called herbicides, can be used to improve highway safety. Safety is improved by increasing sight distance through the elimination of tall-growing weeds and brush at road intersections, railroad and truck crossings, driveway entrances, in front of bridge and culvert heads, pedestrian crossings, and on the inside of curves.

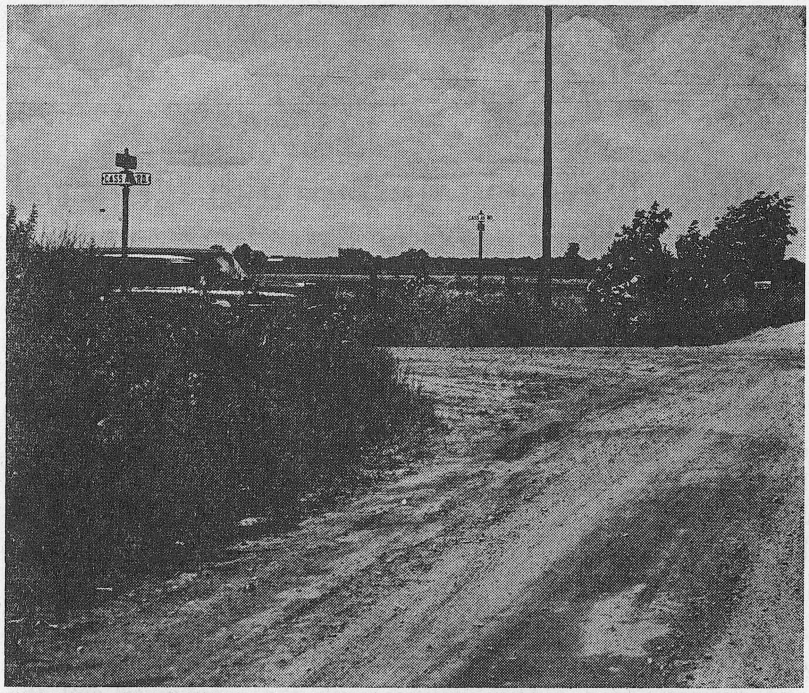

Fig. 1. Herbicides can be used to improve highway safety by increasing sight distance. Observe the partially hidden truck approaching the intersection.

Chemicals are used to treat areas where weeds and brush are causing a drainage problem. By keeping the brush back from ditches there will be a minimum of twigs and branches to block inlets.

Chemicals are used to kill poison ivy, oak, sumac, and weeds causing hay fever and other allergies. Working conditions are improved for highway maintenance personnel and roadside conditions are made more attractive and pleasant for the highway user. Killing roadside weeds also reduces weed growth in adjacent crop fields and orchards.

The ultimate objective of chemical weed and brush control is to produce a roadside of low-growing, mature, native grass, free of weeds and brush. A mature stand of grass makes a satisfactory appearance, and does not require mowing on most county roads. Also the use of chemicals for weed control improves the economy of roadside maintenance by reducing mowing and brush cutting costs.

Problems, Precautions, and Public Relations

One undesirable feature, often associated with the use of herbicides, is called "brown-out." It is the discoloration of foliage after the application of herbicides in the spring or summer. The higher and denser the weeds and brush, the more "brown-out," and the greater possibility of adverse public reaction.

There is also a possibility that certain sensitive crops and ornamental plants may be damaged by wind-drift of sprayed herbicides. Spray droplets, or the vapor of some herbicides, can drift across the right-of-way on windy or very hot days and damage certain crops or plants. However, certain precautions, discussed later, can be taken to eliminate or minimize damage to desirable vegetation.

A county highway department, planning an extensive herbicide program, should consider using advance publicity for the purpose of informing and educating the public. Articles in local newspapers should point up the advantages of chemical treatments and explain

Fig. 2. Herbicides may be used to expose bridge and culvert heads, sign posts, guard rails, and other highway structures or obstacles near the road edge.

that "brown-out" is a temporary condition which exists only until the weeds are brought under control. The public should also be advised that every precaution against crop damage in the chemical control program will be taken.

Herbicide Materials and Application Methods

The herbicide 2,4-D, primarily for weeds, and the herbicide 2,4,5-T, primarily for brush, probably make up more than 90 per cent of all herbicides used on roadsides. The two chemicals are most generally mixed with water and applied as foliage sprays as illustrated in Fig. 3. Occasionally, 2,4-D and 2,4,5-T are mixed with oil and applied to the base or stumps of trees and brush to effect the kill.

Fig. 3. Here is an efficient spraying operation on a county road. A mixture containing 2,4-D and 2,4,5-T is being sprayed from a fixed nozzle and a spray gun.

Some herbicides, known as soil sterilants, are applied to the soil to kill vegetation. These chemicals depend on rain water for transportation to the root zone of the unwanted vegetation. A relatively new, temporary soil sterilant, fenuron, in a dry, pellet form is applied to the soil to kill brush. Other soil sterilants, in the form of wettable powders, are sprayed on the soil to kill and prevent the growth of weeds and grass under guard rails, around bridge and culvert heads, sign posts, and other highway structures. Some of the wettable powders discussed are diuron, dalapon, and simazine. For certain hard-to-kill weeds and brush, the nonvolatile foliage sprays, ammate and amitrol are safe to use.

FOLIAGE SPRAYS OF 2,4-D AND 2,4,5-T

2,4-D and 2,4,5-T Materials

Herbicides 2,4-D and 2,4,5-T are used extensively and there are various formulations which are different in volatility, safety, effectiveness, and costs.

The chemicals, 2,4-D and 2,4,5-T are originally produced as acid materials, dichlorophenoxyacetic acid and trichlorophenoxyacetic acid. There is usually 4 lb of acid equivalent in each gallon of 2,4-D or 2,4,5-T. The acid solutions are relatively unstable; therefore, to make them easier to handle, the manufacturer converts them to ester or salt formulations. By mixing the acid materials with alcohols, the esters are formed as emulsions. The acids are also frequently reacted with amine bases to make salt solutions.

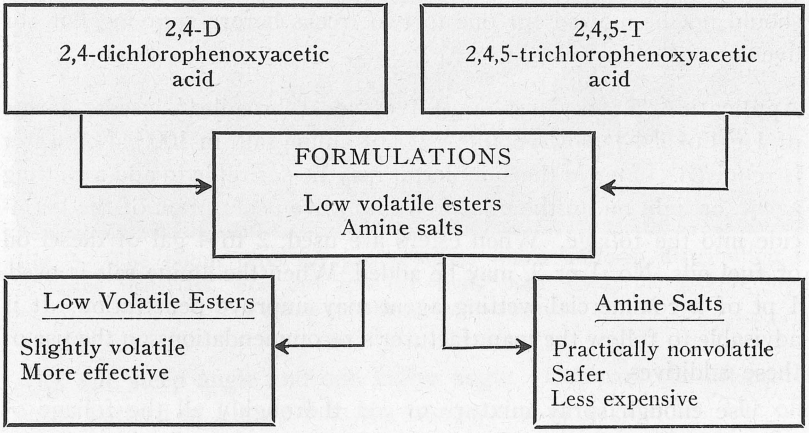

Fig. 4. This diagram shows the formulations of 2,4-D and 2,4,5-T recommended for use in Indiana and lists some features of each formulation.

Amine salts are essentially nonvolatile, safer to use, and less expensive than the low-volatile ester formulations. However, the esters are significantly more effective in killing weeds and brush and are recommended for use whenever possible. When spraying near sensitive crops or ornamental plants, it is suggested that nonvolatile amine salt formulations be used for greater safety. Standard or high-volatile formulations are not recommended—there is too much danger of vapor drift.

Foliage Spraying for Weed Control

The herbicide, 2,4-D, is primarily a broadleaf weed killer but it will also kill many easy-to-kill species of brush. The chemical is mixed with water and applied as a foliage spray. When there is considerable brush growing with the weeds, it may be necessary to use a mixture of 2,4-D and 2,4,5-T as described in the next section. Appendix C lists common weeds in Indiana and their susceptibility or resistance to 2,4-D.

Time to Spray Foliage spraying for weed control may begin any time in the spring after the weeds are up and actively growing. Normally, spraying is stopped by the latter part of August, because it is much less effective in reducing the weed population next year. In areas where sensitive crops are grown, every effort should be made to spray before these crops break through the soil surface.

To be certain that weeds receive a lethal dose of herbicide, areas should not be mowed for one to two weeks before spraying nor for five days after spraying.

Application Rates For control of most broadleaf weeds, a rate of 1 gal of 2,4-D, low volatile ester or amine salt, in 100 gal of water is required. Later in the summer, it may be desirable to add a wetting agent, or light oil, to the mixture to improve penetration of the herbicide into the foliage. When esters are used, 2 to 4 gal of diesel oil or fuel oils, No. 1 or 2, may be added. When the amine salt is used, 1 pt of a commercial wetting agent may improve penetration. It is advisable to follow the manufacturer's recommendations on the use of these additives.

Use enough spray mixture to wet thoroughly all the foliage of the weeds. Thorough wetting is more important for effectiveness than increasing the concentration or strength of the spray mixture. For a roadside width of about 10 ft containing primarily young low weeds, 50 gal of spray mixture may be sufficient to cover one mile of road on one side.

Field Spraying The use of power spraying equipment mounted on a truck moving slowly and continuously down the roadside, is the most efficient method of weed spraying. Figures 5, 6, and 7 illustrate various types of equipment and how they are used.

Figure 5 shows a boom type sprayer which provides uniform distribution of a minimum of material; however, the boom must be raised for each mail box, sign, bridge, and other obstruction. Figure 6 shows one fixed nozzle for spraying near the pavement and one

moveable nozzle for spraying low brush and weeds beyond the shoulder. Figure 7 shows the use of a single, fixed, off-center nozzle for shoulder spraying. The off-center nozzle produces a spray pattern

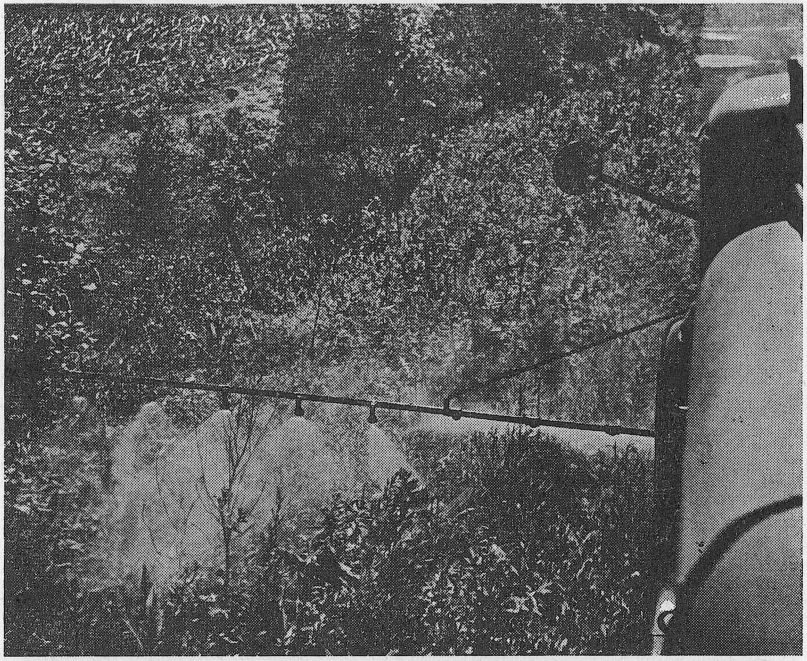

Fig. 5. The boom type sprayer provides for a uniform distribution of herbicide materials. For one mile of road, both sides, 100 gal or more of spray mixture may be required.

with one steep angle and one flatter angle. Compare the off-center spray pattern in Figure 7 to the fan pattern in Figure 5. The off-center nozzle usually sprays larger drops and tends to clog less than a nozzle spraying a fan pattern.

To minimize atomization and wind-drift of the spray, use the lowest pressure that will produce a thorough coverage of the foliage. Low tank pressures are around 40 psi. Nozzle pressures are always somewhat less than tank pressures. Weed sprays may be applied at a truck speed up to 5 to 10 mph. The amount of spray material applied per unit of area depends on pressure, nozzle setting, and truck speed.

Use every precaution to prevent damage to crops and ornamental plants. Low volatile ester formulations should not be used within ¼ mile of sensitive crops. Spray and vapor drift can be kept to a minimum by spraying when the wind velocity is less than 10 mph and the temperature is less than 85 F.

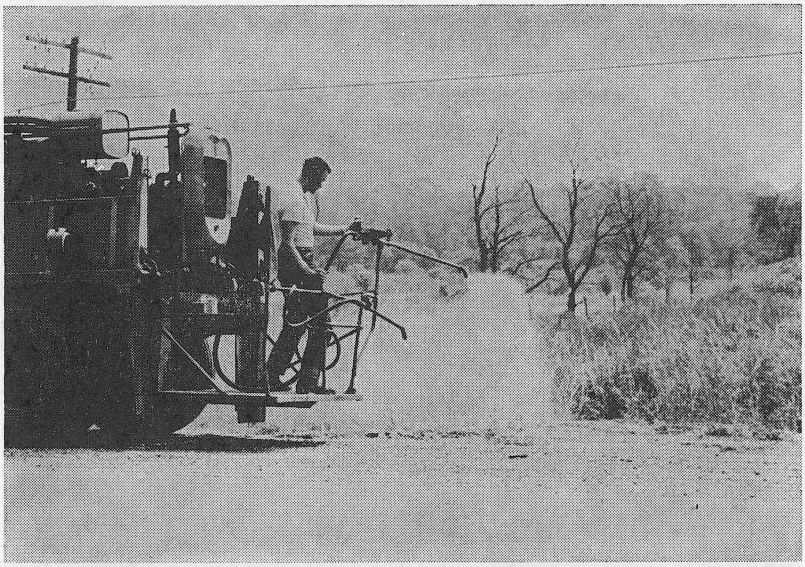

Fig. 6. Counties may rig equipment for specific needs. Note the fixed nozzle and the nozzle mounted on a long gun-like barrel.

Do not spray the right-of-way on either side of the road bordering tomatoes, grapes, vegetable crops, tobacco, and homes. Amine salts of 2,4-D can be used on the opposite side of the road from soybean fields and orchards, provided the wind is not blowing toward these plants. Next to fields of legumes, such as clover and alfalfa, salt formulations can be sprayed with an off-center berm nozzle but not with a hand-gun. Spray next to fields of corn, wheat, oats, and all other grains with care and do not direct the spray into the fields.

Number of Applications One spray application per season will not usually kill 100 per cent of the weeds. For effective weed control, specialists recommend at least two applications per season for two or three seasons, after which, only one application per season may be required.

For two applications per season, apply the first one in late May or early June and the second during August. If one treatment per season is planned, application time should be varied for best results, because various weed types mature at different times during the season.

Foliage Spraying for Brush Control

The herbicide, 2,4,5-T—primarily a brush killer—is used extensively for roadside brush control by foliage spraying. It is most generally used in combination with 2,4-D as a brush and weed killer.

The combination of the two herbicides is effective against most brush and common weed types. The cost of the 2,4-D is less than half the cost of 2,4,5-T, and use of the herbicide combination decreases the overall materials costs and increases the effectiveness of foliage spraying. Appendix D lists common brush species in Indiana and their susceptibility to 2,4-D and 2,4,5-T.

Time to Spray In Indiana, the spraying of brush foliage may be done in May (in southern Indiana), June, July, August, and early September. The herbicides, however, are most effective in the spring immediately after the plants have reached full leaf stage development. At this time, food reserves are low, and large leaf surfaces provide more area for absorption of the herbicide. Foliage spraying of brush should be discontinued in the fall two or three weeks before the first frost.

Height of Brush The height of brush is not important in killing woody plants, but it is important from a public relations viewpoint. The unsightliness of foliage "brown-out" increases as the height and density of the brush increases. Cutting the tall brush and then spraying the new sprouts the following summer is one method of eliminating "brown-out". When stumps are sprayed, shortly after cutting, resprouting is minimized. See the following section on stump and

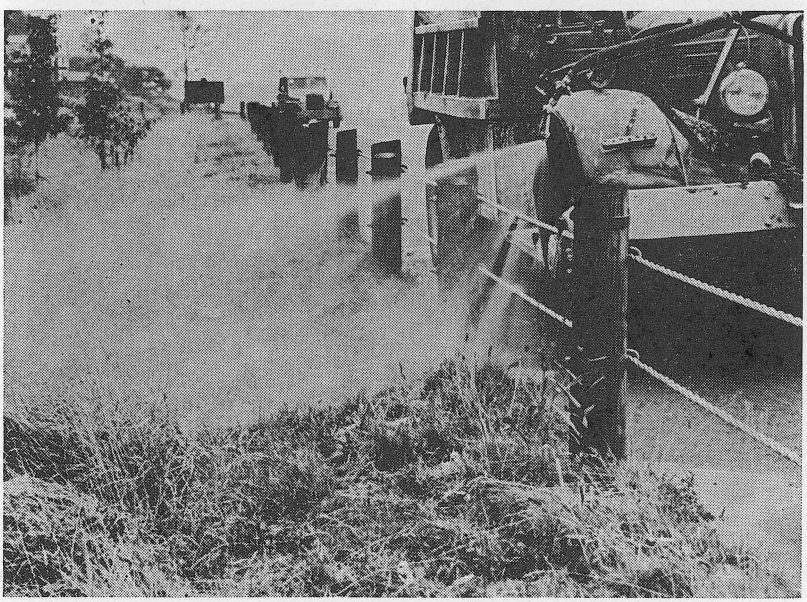

Fig. 7. For spraying weeds along the shoulder, a single off-center type nozzle may be used as illustrated.

basal spraying. Some state highway departments require that brush over 3 ft, except poison ivy, poison oak, and some thorny plants, be cut before spraying.

Application Rates Most brushy plants and weeds can be killed with a mixture of 2 qt of 2, 4-D plus 2 qt of 2, 4, 5-T in 100 gal of water. However, as resistance to brush kill increases, the proportion of 2,4,5-T in the mixture should be increased. For maximum strength against hard-to-kill woody brush such as oak, maple, sassafrass, osage orange, and brambles, use 1 gal 2,4,5-T in 100 gal of water.

Later in the summer, after the leaves have become somewhat tougher and perhaps dust coated, it may be desirable to use a wetting agent to aid penetration of the herbicide into the leaves. For amine salt mixtures, some manufacturers recommend the addition of ½ to 1 pt of a commercial wetting agent or the addition of 2 to 4 gal of light weight oil, usually diesel or fuel oil—No. 1 or 2, to 100 gal of a mixture containing a low volatile ester formulation. Follow the manufacturer's recommendation on the use of these additives. Thoroughly agitate the mixtures, before and during spraying, by mechanical means or recirculation.

Fig. 8. Tall dense foilage, as shown here, may require several hundred gallons of herbicide mixture for both sides of a mile of road.

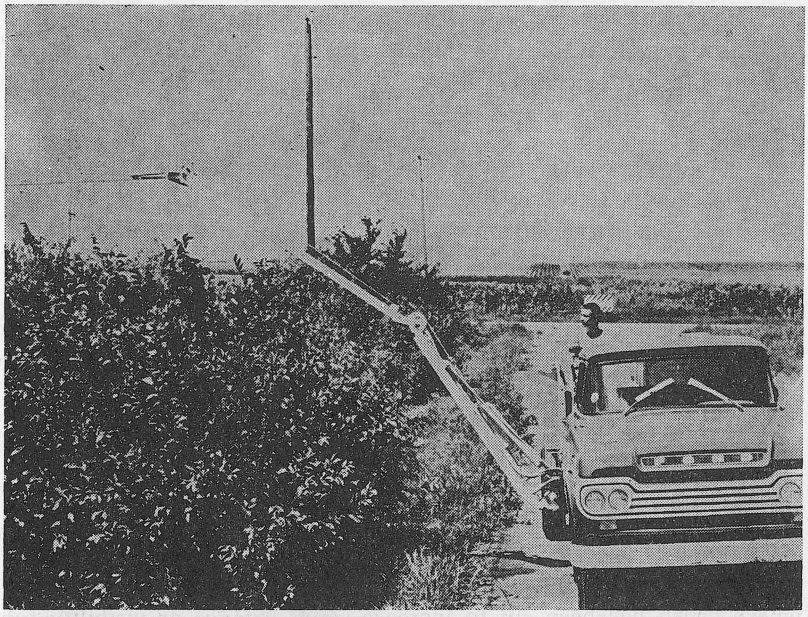

Fig. 9. Highly flexible boom sprayers of the type shown can be adjusted to fit the shape or contour of low growing brush and tall weeds.

Use enough of the herbicide mixture to wet thoroughly all the leaves of the brush. For tall, dense brush, as illustrated in Fig. 8, the amount of liquid spray required for an effective kill may range from 100 to 200 gal per acre or from 250 to 500 gal per mile for both sides of a road with a 40-ft right-of-way. There are approximately 2.5 acres of roadside per mile of road. For brush and weed conditions as illustrated in Fig. 9, both sides of a mile of roadway may require 150 to 300 gal of spray mixture.

Number of Applications As in weed spraying, two or three spray applications of brush killer per season for the first two or three years is more effective than one application per season, particularly where the brush is high or dense at the start.

Field Spraying Truck-mounted power sprayers should be used for both weed and brush spraying. Figures 3, 8, and 9 show efficient spraying operations. For extensive brush spraying programs, tanks of 500 to 1000 gal capacity should be used. The use of nurse tank trucks or trailer tanks are feasible or desirable especially where water hauls may be relatively long.

The pressure required in order to spray brush of various heights and distances from the boom or gun can range up to 100 to 250 psi. As the pressure increases, nozzle openings should be adjusted for optimum size droplets and to reduce misting and fogging.

Foliage spraying of brush requires the same precautions as weed spraying. Crops sensitive to 2,4-D are also affected by 2,4,5-T. Special care must be taken not to spray near orchards, shrubs, or ornamentals. Ester and salt formulations should be used near growing crops in the same manner recommended for weed spraying. In using hand-operated spray-guns, apply only enough spray solution to thoroughly cover the foliage, and never point spray guns into cultivated fields.

STUMP AND BASAL SPRAYING WITH 2,4-D AND 2,4,5-T

Stump Spraying for Brush Control

After cutting brush in the right-of-way, stumps may be sprayed to kill the roots and prevent resprouting. This is especially important where brush has been cut to increase sight distance or visibility for highway safety.

Fig. 10. Stump spraying is done to prevent resprouting.

When there are a large number of relatively small stumps or stems, it may be easier and less costly to spray the foliage of new shoots or sprouts the following spring or summer.

Time to Spray The most effective time to spray stumps is immediately after cutting during any time of the year. Some hardy species resprout vigorously and may require follow-up treatments.

Procedure Use only ester formulations of 2,4-D and 2,4,5-T in oil, diesel fuel, kerosene or fuel oil, No. 1 or 2, with 1 gal of equal portions of 2,4-D and 2,4,5-T mixed with 20 gal of oil. For resistant species, use 1 gal of straight 2,4,5-T in 20 gal of oil.

Make applications with a knapsack sprayer or power sprayer and a small handboom. Remove leaves, debris or snow to expose the stumps down to ground level before spraying, and spray all exposed surface areas to saturation and run-off. Where brush cutting will leave an excessive amount of debris over the base of the stumps, basal spraying before cutting, and instead of stump spraying, should be considered.

Fig. 11. Basal spraying may be done as a follow-up operation to foliage spraying.

Basal Spraying for Brush Control

Basal spraying is the same as stump spraying except brush is not cut previously. Basal and stump sprays provide a more positive kill than foliage sprays, and are highly effective on durable trees such as red maple, ash, oak, hickory, and basswood. The method as shown in Fig. 11 is often used as a follow-up treatment for foliage spraying or for spot treating. Plants may leaf out normally in the spring following a treatment, but they will die eventually.

Time to Spray Basal spraying can be used at any time of the year, and is especially effective for killing brush in farming areas during the dormant season.

Procedure Use the same procedures as for stump spraying except spray the base of the brush to a height of about 2 ft above the ground. For trees with a diameter greater than 6 or 7 in., make overlapping, nearly-vertical axe cuts through the bark and thoroughly saturate the cut with herbicide. While the cut alone should kill the tree, the herbicide will minimize resprouting.

SOIL STERILANTS

General

Soil sterilants are herbicides applied to the ground to kill plants and prevent new growth. Rain water carries the chemicals to the root zone to effect the kill, which is slow compared to foliage spraying. However, effectiveness depends on solubility of the chemical, the amount of rainfall, permeability of the soil, and amount of chemical applied. Rapid advancements are being made in the development of soil sterilants and presently there are many on the market. The soil sterilants considered herein are fenuron, diuron, and simazine. These are the common chemical names, but the products are sold under various trade names.

Fenuron Pellets for Brush Control

Fenuron, 3-phenyl-1, 1-dimethylurea, in a dry pellet form, is a temporary brush control soil sterilant. Pellets, about the size of large peas, are hand-scattered, at the base of the brush, as illustrated in Fig. 12. The pellets are applied at the rate of about 65 lb per acre.

The brush will die some weeks or months after application of the pellets. Weeds and grass are killed more quickly, but they also return more quickly. Do not apply pellets on steep slopes where erosion is, or may be, a problem. Some relatively flat slopes, however, contain dense root systems which may give the slope sufficient protection for a year. Also, do not use pellets near, or up-slope, from desirable shade trees.

The advantages of pellets over foliage sprays are: 1, no spray equipment is needed; 2, application is easy; and 3, there is no danger of spray or vapor drift. However, large scale use is more costly than that of foliage sprays. Pellets are excellent for small areas, or spot treating at road intersections, or on the inside of curves, or where a safety hazard exists.

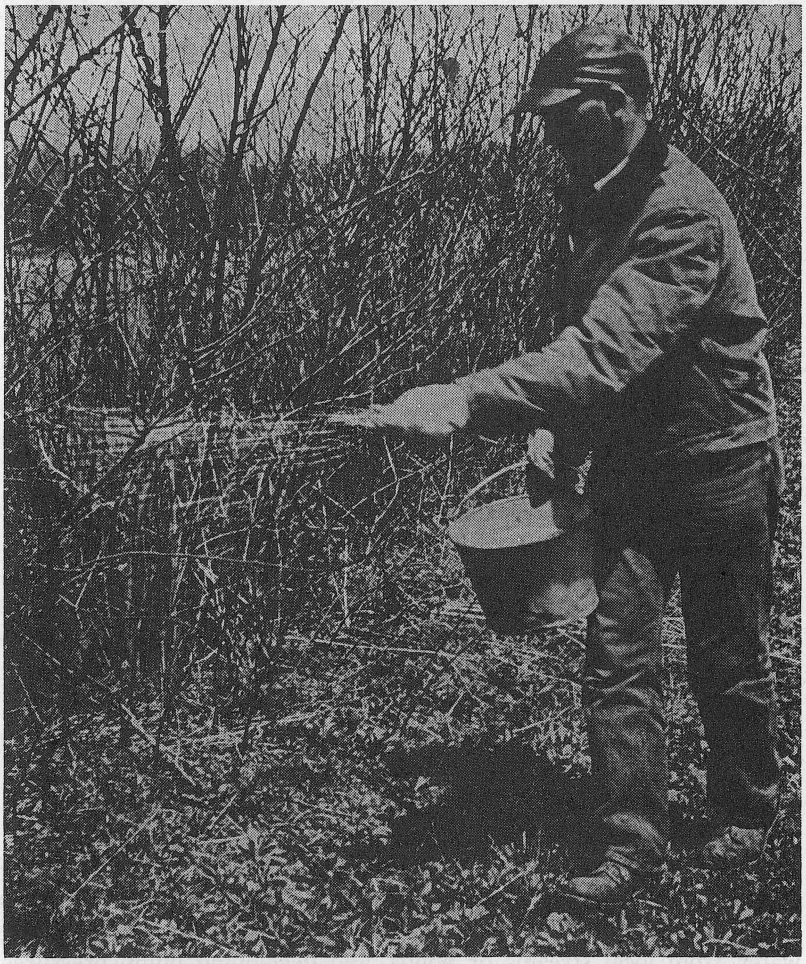

Fig. 12. The primary advantage of using fenuron pellets to kill brush in small areas is ease or simplicity of application.

Diuron and Simazine Used to Expose Highway Structures

There are a number of soil sterilants which will kill and prevent growth of vegetation for one year and possibly longer. These chemicals are effective for use under guard rails, around bridge and culvert heads, sign posts, and on stabilized road shoulders where safety is also an important factor.

Diuron, 3-(3, 4 dichorophenyl)-1, 1-dimethylurea, and simazine, 2-chloro-4, 6-bis(ethylamine)-s-triazine, are two wettable powder soil sterilants. They are usually applied in water sprays, which must be kept agitated mechanically during spraying to keep the powder in sus-

pension. After application, sometimes the treated areas are sprayed with a bituminous material to minimize washing and lateral movement of the herbicide.

Diuron is very effective for killing and preventing the growth of vegetation around highway structures. It is usually applied at the rate of 20 to 40 lb per acre. Mix 1 lb of diuron in 4 to 6 gal of water.

Simazine, which is only slightly soluble in water, penetrates the soil in such small concentrations that it is only effective on shallow root systems. It is applied at the same rate and in the same manner as diuron. At very low application rates, it will control weeds in areas containing desirable trees and shrubs.

SPRAY EQUIPMENT

General

The character of vegetation and requirements of the site determine the type of equipment to be used in spraying roadsides. High-pressure and large-volume spraying equipment are used for large areas where control of the spray is not important. Low-pressure, less than 75 psi, equipment may be used where careful control of the spray and drift are important and spraying distance is short. Knapsack spray equipment or herbicide pellets may be used for spot treating and in areas not easily reached by power machines.

Power Sprayers

For an overall spraying program on rural county roads, power sprayer units should be self-contained, skid-mounted, gasoline motor operated units. The power sprayer units should have a tank capacity of 500 to 1000 gal, and be capable of pumping mixing water from local streams or ponds, and developing pump pressures between 40 psi and 300 psi. For the normal spraying with 2,4-D and 2,4,5-T, a high volume output is seldom needed.

Normally, the skid-mounted units are operated from flat-bed trucks. After the spraying season is over, the power sprayers can be stored and the trucks made available for other work. Other important equipment features of the power sprayer units include the pumps, agitators, and nozzles.

Pumps

Power units are equipped with piston, centrifugal, or rotary pumps. Piston pumps are relatively low volume units, but can produce pressures of 400 psi and above. They are usually long-lived, heavy, relatively expensive, and give good service where sprays containing wettable powders are used in large volumes.

Centrifugal pumps are usually low pressure pumps with high volume capacity, but pressures usually do not exceed 80 psi. They are well adapted for handling sprays containing wettable powders.

Rotary pumps are relatively low cost, compact units which include the nylon roller and rubber impeller types. They operate at low speeds and provide satisfactory service when used for the application of 2,4-D sprays. They will be relatively short-lived when used for the application of large volumes of sprays containing abrasives or wettable powders.

Agitators

Chemical spray materials are obtained from the manufacturer in the forms of solutions, emulsions, or wettable powders and must be mixed or diluted in water or oil before they can be applied properly. To insure a uniform mixture in spray solutions it is therefore necessary that all power sprayer units be equipped with agitators.

Only mild agitation in the spray tank is required for solutions and emulsions containing adequate emulsifiers, but wettable powders settle out rapidly if not agitated continuously. Also emulsions without emulsifiers, such as mixtures of oil and water, will separate if not agitated.

Solutions may be agitated in spray tanks by either mechanical paddles or hydraulic means. Many power sprayers are equipped with mechanical agitators which consist of a series of paddles mounted on a shaft running through the spray tank. Hydraulic agitation forces a part of the spray mixture, at boom pressure, through openings or jets in a pipe laid in the bottom of the tank. Adequate agitation requires a return volume of 10 to 15 gal per minute for each 100-gal of tank capacity.

Nozzles, Pressures, Discharge Rates

Interchangeable nozzles and tips, for a wide range of discharge rates and spray angles, are available to fit all types of spray equipment from low-volume 2,4-D sprayers to high volume soil sterilant sprayers. The volume of spray mixture applied to a specific area of roadside depends on the nozzle size, pressure, and travel speed during application.

Changing the nozzle size is the most convenient way to make a significant volume output change. When the diameter of the nozzle opening is increased two times the volume output increases four times. Changing the pressure produces only a relatively small change in volume output. To increase the volume output two times the pressure must be increased four times. Increasing the speed of travel

of the spray truck reduces the volume of material applied per unit area. Increasing the speed two times reduces the amount of material applied to one-half per unit area.

Spray equipment manufacturers supply charts showing the capacities of nozzle sizes in gallons per minute at different pressures. Some charts also convert this to gallons per acre at different speeds. Manufacturers also supply calibration instructions for spray equipment when an accurate check of the volume output is needed. In foliage spraying, however, the primary objective is to wet thoroughly the foliage, with minimum run-off using a specified strength of spray mixture.

HERBICIDES FOR SPECIAL PROBLEMS

General

Certain species of weeds, brush, and all grasses are resistant to 2,4-D and 2,4,5-T foliage sprays. See Appendices C and D. Plants, which are not killed, or which are difficult to kill, with 2,4-D and 2,4,5-T, may be destroyed with other specific herbicides. Usually, these are used only when resistant plants exist in concentrations. These herbicides are nonvolatile. They are safe to use near sensitive crops, provided there is no wind-drift of the spray.

Dalapon

Dalapon, 2, 2-dichloropropionic acid, can be used to control cattails, tules, and undesirable annual and perennial grasses. This herbicide is effective on tall perennials, such as Johnson grass, quack grass, and foxtail. From a safety standpoint, tall grasses are highly objectionable around guard rails and culvert headers. However, the control of cattails and rushes in ditches and drainage ways is an equally important highway application for this material.

Dalapon is basically a water-mixed foliage spray herbicide. It may act as a temporary soil sterilant upon coming in contact with the ground. It is most effective when applied to actively growing green foliage before the formation of seed heads. Dalapon may be sprayed in combination with 2,4-D, where control of both grasses and broadleaf weeds is desired.

Amitrol

Amitrol, 3-amino-1, 2,4-triazole, in water is used as a foliage spray. It is effective on grasses, Canada thistle, whitetop, leafy spurge, milkweed, Russian knapweed, cattails, horsetail rush, poison oak, poison ivy, and tules.

Ammate

Ammate, ammonium sulfamate, is used as a water-borne foliage spray, or the crystalline powder can be applied dry to tree stumps. As a foliage spray it kills most types of weeds, brush, and grasses—it is nonselective. However, it will corrode spray equipment and metal highway structures if they are not cleaned shortly after the application.

PLANNING A COUNTY-WIDE WEED AND BRUSH CONTROL PROGRAM

General

Planning a county-wide herbicide program is basically a matter of surveying existing needs and working out annual programs which do the greatest good with the funds available.

Each Indiana county should plan its individual weed and brush program on the basis of local conditions and needs. Fixed, inflexible plans should not be considered. Some counties may have a partial weed and brush control program already, while others may have neglected roadside maintenance, and therefore must overcome heavy accumulations of tall, dense weeds, and brush. Some counties also have a faster weed and brush growth, because of soil and climate conditions. Other counties have heavy weed growth with only light, spotty brush, or vice versa. Therefore, the problems of each county must be approached differently.

In working out an annual program, however, there are three or four basic steps the county road officials should take:

1. Review or survey the overall weed and brush conditions in the county.
2. Estimate the amount of money which can be budgeted for an annual brush and weed program.
3. Plan a short range program.
4. Plan a long range program.

Survey of Weeds and Brush

A good county road map, a notebook, and a county-wide survey of weed and brush conditions are an important part of developing a good herbicide spray program. However, the amount of detail and method of recording the information is an individual matter, but some decisions should be made in the field. The following is a suggested list of pertinent information which might be helpful in making a survey:

1. Rate those road sections where roadside weeds and brush constitute a road maintenance problem on a mile-to-mile basis of heavy, light, or spotty.
2. Determine and note road sections where weeds are the primary problem and where brush, or weeds and brush together, constitute the main difficulty.
3. Note the location of susceptible crops, ornamental plants, and desirable shade trees. Locate trees and brush that serve as snow fences, safety barriers, headlight glare barriers, and screen unsightly views or objects. Discuss the roadside spraying program with nursery owners, because they may object to having adjoining roadsides sprayed with herbicides.
4. Visualize the "brown-out," or poor appearance, a herbicide treatment might produce where there are dense stands of brush along more heavily travelled roads and contemplate public reaction.
5. Note locations where brush should be cut first and stump or subsequent foliage spray applied.
6. Locate steep slopes which should not be treated, because of the hazard of creating or increasing an erosion problem.
7. Note locations where normal foliage spraying of 2,4-D and 2,4,5-T should be supplemented with other herbicide treatments such as dalapon or fenuron.
8. Make notes on special problems or conditions to be discussed with spray crews.

Priority Road Sections and Locations

Many counties cannot afford to spray treat all its roadside mileage in any one year. Therefore, determine road sections and locations which should be treated first. The following priority list is suggested as a planning guide.

Safety Hazards Treat road sections where tall weeds or brush reduce visibility or sight distance, including road intersections, railroad and truck crossings, driveway entrances, front of bridge and culvert heads, pedestrian crossings, and the inside of curves.

Drainage Treat areas within the right-of-way where weeds and brush cause a drainage problem. Spray grown-over ditches and drainage inlets. Use selective herbicides on steep gradients to retain grasses and prevent erosion.

Health Treat all known concentrations of poison ivy, poison oak, noxious weeds and allergy producing weeds. The elimination of these

plants will improve working conditions for highway maintenance personnel and promote better public relations in the community.

Primary Roads Treat sections of heavily travelled county roads with heavy concentrations of weeds and brush, giving first attention to the tallest and densest stands.

Secondary Roads Treat sections of the lightly travelled county roads which have heavy concentrations of weeds and brush, giving first attention to locations where the tallest stands occur.

Selection of Herbicides

Because of the general overall effectiveness, the ease of application, and the relatively lower material costs, foliage spraying of 2,4-D and 2,4,5-T should be the main part of a county highway program. However, to kill plants resistant to 2,4-D and 2,4,5-T, or to produce barren ground under or around highway structures, or to make spot treatments, other herbicides are available. To help select the most suitable herbicide and application method for a particular roadside weed or brush condition, refer to Table 1 and study the section in this bulletin which discusses the recommended herbicide.

TABLE 1.
VEGETATION, HERBICIDES, AND APPLICATION METHODS

Roadside Vegetation Condition	Herbicide and Application Method
Weeds	2,4-D foliage spray
Brush	
Easy-to-kill	2,4-D plus 2,4,5-T foliage spray
Hard-to-kill	2,4,5-T foliage spray
Weeds and brush growing together	2,4-D plus 2,4,5-T foliage spray
Brush, spotty or in small areas	fenuron pellets spread by hand
Brush, spotty or in small areas	2,4,5-T basal spray
Brush, previously cut in small areas	2,4,5-T stump spray
Weeds and grass around highway structures	diuron, simazine, or mixture of simazine and amitrol sprayed on the soil
Grasses, tall and undesirable, growing in concentrations	dalapon foliage spray
Aquatic plants in drainage ditches	dalapon foliage spray
Weeds, brush, and grass resistant to 2,4-D and 2,4,5-T	amitrol and ammate foliage sprays
Weeds in shrub areas	simazine at low rates; spray on the soil or apply granules

Estimating Costs

The cost of spraying one mile of county road will vary considerably and depends on the size, density, and species of the weeds and brush. It also depends on water-haul distance, type and quantity of herbicide applied, and the efficiency of the spraying operation. For fairly extensive programs, current applied costs of a low-volume foliage spray application of a mixture of 2,4-D and 2,4,5-T, to both sides of a mile of road, ranges from about $13 to $17. High-volume spray applications may range from two to three times this amount depending on the height and density of the brush.

The following information will help compute costs. Forty-foot right-of-ways with 18 or 20-ft roads have roadside areas of 2.6 and 2.5 acres, respectively. One acre contains 43,560 sq. ft. In the use of soil sterilants, a strip under a guard rail 2 ft wide and 21,780 ft long, measures 4.1 miles, and is equal to one acre.

Cost of power spray equipment, including a pump, a 500 gal tank with a mechanical agitator, high pressure oil-resistant hose, and a quick-shut-off type of spray gun is about $3000.

One of the early decisions which should be made before the highway department makes any major investments in spray equipment is whether the spraying will be done by the county highway personnel or by a contractor on an applied materials basis.

The advantages of contract work are worth considering. Contractors usually: 1, have better equipment; 2, have more experienced personnel who can do the job faster; 3, are responsible for all damage claims; and 4, can relieve overburdened highway personnel for other duties in the spring.

The advantages of force account work claimed by one state highway department are: 1, closer control of the operation; and 2, better application and higher percentage of kill.

Spray Crews and Operating Precautions

Dependable, trained, and experienced spray crews are essential to a successful weed and brush spraying program. Preferably these men should have a native knowledge of the local species of weeds and brush as well as local crops and shrubs, and have a genuine interest in local community affairs.

The county road supervisor should train his spray crews in the care and maintenance of sprayer equipment. Knowing what herbicides are, how they act, where and how they should be used, and where they should not be used, is also an important part of the crew's

training. Spray crews should become thoroughly familiar with and follow carefully the precautions listed here:

1. Keep nozzles and spray guns pointed down when spraying. Never direct spray outside the right-of-way limits.
2. Keep spray nozzles and valves clean and in good working order at all times.
3. Do not operate sprayer at a pressure higher than is necessary to get coverage, or at a high pressure which will cause the spray to mist or fog.
4. Do not spray when there is more than a gentle breeze. When the wind is strong enough to blow paper, debris, and dust about, or when there is more than a gentle movement of the leaves and small twigs on the trees, do not spray.
5. Do not spray within the limits of any village, town, or city.
6. Do not spray during the rain. Usually an application made one hour before a rain is sufficient time for the material to enter the system of a plant.
7. Do not spray the right-of-way on either side of the road bordering homes, vegetable gardens, vegetable crops, tobacco, tomatoes, sugar beets, or grapes.
8. Do not spray the roadside next to soybeans or orchards. The opposite side can be sprayed in these places if the breeze is not blowing toward the fields or trees.
9. When spraying brush near sensitive crops, it is safer to use only the amine salt formulation of 2,4,5-T in water rather than a mixture containing both 2,4-D and 2,4,5-T.

SELECTED REFERENCES

1. Astrup, M. H., "Oregon's Herbicide Program," *Report of Committee on Roadside Development,* Pub. 419, pp. 37-40, 1956.
2. Boyd, W. J., Poulos, P. L., "Brush Control with Spot Applications of Fenuron in the Northeast," *Paper,* Northeastern Weed Control Conference, New York, N. Y., Jan. 1960.
3. Eckert, E. C., "Chemical Weed Control Program in Michigan," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 419, pp. 30-32, January 1956.
4. Garmhausen, W. J., "Motor Operated Equipment in Roadside Development," *Report of Committee on Roadside Development,* Highway Research Board, pp. 113-119, 1949.
5. Garmhausen, W. J., "Chemical Weed Control on Ohio's Highways," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 419, pp. 34-37, January 1956.

6. Garmhausen, W. J., "Report of Special Task Committee on Mowing and Herbicides," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 318, 1954.

7. Garmhausen, W. J. "Progress Report of Committee on Mowing and Herbicides," *Report of Committee on Roadside Development,* Pub. 356, pp. 35-48, 1955.

8. Goldstein, H. E., "Herbicide Toxicity," *17th Short Course on Roadside Development,* Department of Landscape Architecture, Ohio State University and OSHD, pp. 92-94, October 1958.

9. Hagemeister, H., "Chemical Weed Control Along the New Jersey Turnpike," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 356, 1955.

10. Iurka, H. H., "Herbicides for Roadsides," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 419, pp. 3-11, January 1956.

11. Iurka, H. H., "Progress in Use of Herbicides," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 496, 1957.

12. Iurka, H. H., "Herbicide Work on New York State Highways," *Report of Committee on Roadside Development,* Highway Research Board, Pub. 419, pp. 32-37, January 1956.

13. Gonzolez, F. E., "Industrial Brush Control with Fenuron Pellets," *Paper,* Southern Weed Conference, Biloxi, Miss., January 1960.

14. Kosesan, W. H., "Spray Manual," *Technical Bulletin No. 25,* Oregon State Highway Department, Revised 1960.

15. Lee, O. C., "Brush Control by Chemicals," *Extension Leaflet 358,* Agricultural Extension Service, Purdue University, April 1955.

16. Lee, O. C., "Killing Weeds with 2,4-D," *Extension Bulletin 389,* Agricultural Extension Service, Purdue University, April 1959.

17. Martin, S. C., et al., "Controlling Woody Plants with 2,4,5-T; 2,4-D and Ammate," *Bulletin 615,* Agricultural Experiment Station, University of Missouri, January 1954.

18. McCambridge, J. R., "Use of Chemicals for Controlling Highway Vegetation," Proceedings of the Kentucky Highway Conference, University of Kentucky, Mar. 1958.

19. Rudolf, P. O., Walt, R. F., "Chemical Control of Brush and Trees in the Lake States," *Station Paper No. 41,* Lake States Experiment Station, Forest Service, U. S. Department of Agriculture, St. Paul, Minn. October 1956.

20. Smith, R. N., "Application of 'Dybar' Fenuron Weed and Brush Killer to a Right-of-Way in Northern Maine," *Paper,* Northeastern Weed Control Conference, New York, N. Y., January 1960.

21. Weed Society of America, "Report of the Terminology Committee," *Weeds,* Vol. 6, No. 1, January 1958.

APPENDIX A

GLOSSARY OF TERMS

(Adapted from *Technical Bulletin* No. 25, Oregon State Highway Dept.)

Annual A plant that completes its life cycle in one year.

Basal Treatment A spray application to the stem or trunk of plants from the ground line up a distance of 24 to 36 in.

Biennial A plant that completes its life cycle in two years. It germinates and produces leaves the first year and fruits and seeds the second.

Broadleaf Plants Those that produce broad leaves, as contrasted with narrow-leaved grasses.

Brush A thicket of shrubs and small trees.

Carrier The liquid or solid material added to a chemical to aid its application in the field or for storage or shipment.

Concentration Refers to the strength of a solution or mixture; the amount of active material in a given volume of solution. Example: 4 qt of 2,4-D concentrate per 100 gal of water.

Contact Herbicide A chemical which kills only the parts of plants actually contacted or sprayed.

Deciduous Plants which lose their leaves during the winter.

Diluent Any liquid or solid material used as a diluting agent. One which serves to dilute or carry an active ingredient, as water, oil, or sand.

Dissolve Refers to the property of a solid material to pass into solution; such as sugar in water.

Dormant Spray One which is applied during the time plants are dormant, or not growing, in winter or early spring.

Drift The movement by wind currents of a chemical in droplet or vapor form from the point of application to adjacent areas.

Emulsifying Agent A material that aids in the dispersion of fine particles or globules of one liquid in another liquid.

Emulsion A mixture in which one liquid is suspended in fine particles or minute globules in another liquid. Example: 2,4-D ester in water.

Herbicide Any chemical material used to kill or retard the development of plants.

Hormone A substance occurring naturally in plants or animals which is transported in the organism and produces an effect remote from its source; often called a growth regulator.

Leach Usually refers to the movement of chemicals or plant foods down through the soil with water.

Nonselective Herbicides Chemicals which are toxic to plant life in general without regard to species. Examples: fenuron and diuron.

Noxious Weed A plant that is harmful to humans, animals or agriculture, and often difficult to control.

Oils Refers to diesel oil, kerosene, or other oils used for direct application or as a carrier to aid in the application of herbicides.

Perennial A plant that lives from year to year. Examples: Morning glory and Canada thistle.

Phytotoxic Refers to products which are poisonous or injurious to plants.

Precipitation Rainfall (or snowfall).

Rate or Dosage Refers to the amount of active ingredient of a material applied to a unit area of land. Example: 2 qt. of 2,4-D (concentrate) per acre.

Residual Refers to the length of time herbicides remain effective, particularly soil sterilants which have a killing effect over a long period of time.

Resistant Refers to or describes plants which are not killed by a specified herbicide at a given rate. Plants capable of withstanding the effects of a certain chemical are said to be resistant to its effects.

Selective Herbicide A herbicide which is toxic to certain plants and less effective on others.

Sensitive Describes plants which are killed or affected by a herbicide. Plants are sensitive if they are unable to withstand the effects of a specified herbicide.

Soil Sterilant A material applied to the soil that kills existing growth of plants and all new growth for a period of time varying from a few months to a year or more.

Spot Treatment Selective application of spray to a localized or small area rather than a complete or overall application.

Spray Drift The movement of spray in small droplet form from the point of application to adjacent areas.

Suspension A liquid or gas in which fine solid particles are dispersed, but not dissolved.

Systemic Refers to a herbicide which is absorbed into the plant to which it is applied and is then translocated to other parts.

Tolerant Same as resistant; plants are tolerant when capable of withstanding the effects of a chemical.

Toxic Injurious or poisonous to animals or plants.

Translocation Movement or transfer of food or other materials from one part of a plant to another. 2,4-D is readily translocated in plants.

Volatility or Volatilization This is the ability of a compound to change into a gas.

Weed Any plant growing where it is not wanted.

Wettable Powder A formulation of a material as a powder which forms a suspension when added to water.

Wetting Agent A material which, when added to a spray liquid, causes the spray to spread over plant surfaces and wet them more thoroughly.

Woody Plants Those which have woody fibrous tissue.

APPENDIX B—INDIANA WEED LAW

Indiana Acts 1939, Chap. 140, pp. 674-675 (also Burns' Statutes Sec. 36-714).

AN ACT requiring the cutting down and destroying by the county highway supervisors or the county surveyors and boards of county commissioners of all briars, thistles, burrs, tree sprouts, docks, willows, sumac and other noxious weeds within the limits of any county highways, and repealing all laws in conflict therewith.

(H. 57, Approved March 9, 1939.)

County Highways—Cutting of Weeds, Etc.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That each and every county highway supervisor and the county surveyor and boards of county commissioners of the counties where the county surveyor is charged by law with the supervision and maintenance of county highways, shall cut down or cause to be cut down, and removed from all county highways, by the highway department of the several counties of the state, all briars, thistles, burrs, tree sprouts, docks, willows, sumac, reeds, cat-tails, tall grass, marijuana, Indian or wild hemp or loco weed, shrubs and all other obnoxious growth within the limits of the county highway rights-of-way between the fifteenth of June and the first day of September in each year.

Expenses—Payment.

SEC. 2. All expenses for carrying out the provisions of this act, shall be paid out of funds derived from the motor vehicle highway account.

Repeal.

SEC. 3. All laws and part of laws in conflict herewith are hereby repealed.

Other References:

Burns' Statutes Sec. 10-3547 Destruction of marijuana by township trustee.

Burns' Statutes Sec. 15-905 Removal of Canadian thistles.

APPENDIX C—COMMON INDIANA WEEDS AND THEIR SUSCEPTIBILITY TO 2,4-D

(Adapted from "Killing Weeds with 2,4-D" by O. C. Lee, *Extension Bulletin 389*. Agricultural Extension Service, Purdue University, April 1959)

Weeds	Resistant	Susceptible
Artichoke, wild		S
Aster, fall		S
Barnyardgrass	R	
Bedstraw, cleavers		S
Beggarstick		S
Bermudagrass	R	
Bindweed, field		S
Bitter winter cress, yellow rocket		S
Bladder champion		S
Bouncing bet	R	
Broom sedge	R	
Buckhorn plantain		S
Buckwheat, wild	R	
Buffalo bur	R	
Bull or pasture thistle		S
Burdock		S
Buttercup, wild		S
Canada thistle		S
Cane, wild	R	
Carpet weed		S
Carrot, wild		S
Catchfly	R	
Catnip		S
Cheat, chess	R	
Chickory, blue flowering		S
Chickweed, common		S
Chickweed, mouse ear		S
Cinquefoil		S
Climbing milkweed	R	
Cockle, white or corn	R	
Cocklebur		S
Corn spurry	R	
Crabgrass	R	
Cucumber, wild	R	
Cup plant, square stem		S
Dandelion		S
Dodder	R	
Docks, curled and yellow		S
Dogbane, red stem milkweed	R	
Dog fennel, mayweed		S
Downy or bromegrass, wild oats	R	
Dragonhead		S
Evening primrose		S
False flax		S
Fanweed, pennycress		S
Flower-of-an-hour		S
Foxtail, giant, yellow and green	R	
Garlic, wild		S
Goatsbeard		S
Goatweed		S
Golden rod		S
Goosegrass	R	
Ground cherry	R	
Ground ivy, creeping Charlie		S
Hemp, marijuana		S
Hemp, nettle		S
Henbit		S
Hoary cress		S
Horse nettle, bull nettle	R	

Weeds	Resistant	Susceptible
Iron weed		S
Jimson weed		S
Joe-Pye weed		S
Johnsongrass	R	
Knotweed, doormat		S
Lettuce, wild		S
Lambsquarter		S
Mallow, butter print		S
Marestail, horseweed		S
Medic, black		S
Milkweed, common	R	
Millet, wild	R	
Morning glory, annual		S
Morning glory, perennial		S
Motherwort		S
Mullin		S
Mustards		S
Nettle, stinging or fire		S
Nightshade	R	
Nimblewill	R	
Nutgrass	R	
Oats, wild	R	
Onion, wild		S
Oxeye daisy		S
Parsnip, wild		S
Peppergrass, annual		S
Perennial sow thistle		S
Pigweeds		S
Plantain, common		S
Poison Hemlock		S
Pokeberry, pokeweed		S
Prickly pear cactus	R	
Purslane		S
Quackgrass	R	
Ragweed, common		S
Ragweed, giant, horseweed		S
Sandbur	R	
Shepherd's purse		S
Sloughgrass, watergrass	R	
Smart weed, annual		S
Smart weed, perennial	R	
Snakeroot, white		S
Sorrels	R	
Spanish needles		S
Speedwells		S
Spiny cida		S
Spurge	R	
Squirrel-tail grass	R	
Stick tight		S
Strawberry, wild	R	
St. Johns wort, klamath weed	R	
Sunflower, wild		S
Sweet potato, wild		S
Teasel		S
Thoroughwort		S
Vervain		S
Vetch, wild		S
Violets, wild	R	
Water hemlock		S
Water hemp		S
White top		S
Yarrow		S

APPENDIX D—SUSCEPTIBILITY OF COMMON WOODY PLANTS TO HERBICIDES

Species	Chemical	Reaction*
Alder	2,4-D	II
Ash	2,4-D/2,4,5-T	II
Barberry	2,4-D	II
Basswood	2,4-D/2,4,5-T	III
Birch	2,4-D	II
Blackberry	2,4,5-T	I
Blueberry	2,4-D	II
Box Elder	2,4-D	I
Greenbriar	2,4-D/2,4,5-T	II
Buckbrush	2,4-D	II
Buckeye	2,4-D/2,4,5-T	II
Catalpa	2,4-D/2,4,5-T	I
Cedar	2,4-D/2,4,5-T	IV
Chaparral	2,4-D/2,4,5-T	II
Cherry	2,4-D/2,4,5-T	I
Chestnut	2,4-D/2,4,5-T	II
Cottonwood	2,4-D/2,4,5-T	I
Cranberry	2,4-D	II
Virginia Creeper	2,4-D/2,4,5-T	II
Cucumber Tree	2,4-D/2,4,5-T	II
Currant	2,4-D	I
Dewberry	2,4,5-T	II
Dogwood	2,4-D	II
Elderberry	2,4-D/2,4,5-T	II
Elm	2,4-D/2,4,5-T	II
Gooseberry	2,4,5-T	I
Wild Grape	2,4-D/2,4,5-T	I
Gum	2,4,5-T	II
Hackberry	2,4,5-T	III
Hawthorn	2,4,5-T	II
Hazel	2,4-D	II
Hickory	2,4-D/2,4,5-T	I
Honeysuckle	2,4-D	II
Poison Ivy	2,4,5-T	II
Pine	2,4,5-T	IV
Locust	2,4-D/2,4,5-T	I
Maple	2,4,5-T	III
Mesquite	2,4,5-T	II
Mulberry	2,4-D/2,4,5-T	II
Myrtle, Wax	2,4,5-T	II
Oak	2,4,5-T	II
Osage Orange	2,4,5-T	II
Poplar	2,4-D	II
Redbud	2,4-D/2,4,5-T	I
Wild Rose	2,4,5-T	II
Sagebrush	2,4-D	II
Sassafras	2,4-D/2,4,5-T	I
Spruce	2,4,5-T	IV
Sumac	2,4-D	I
Tree of Heaven	2,4-D	I
Walnut	2,4-D/2,4,5-T	II
Willow	2,4-D	I
Witch Hazel	2,4-D/2,4,5-T	II

*DEFINITIONS OF REACTION

I Very sensitive: Normally, 100 per cent kill achieved with one spray. Recommended application rate is 3 qt of chemical per 100 gal of water.

II Sensitive: Some regrowth may occur following first spraying. Second treatment usually gives complete kill. Recommended application rate is 4 qt of chemical per 100 gal of water.

III Semiresistant: Plant usually defoliated, but regrowth may normally be expected. Retreatment usually necessary. Recommended application rate is 4 qt of chemical per 100 gal of water.

IV Resistant: Reaction ranges from slight to none. Plants usually can survive repeated treatments at normal spray concentrations. Recommended application rate is 4 qt of chemical per 100 gal of water.

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