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**PESTICIDE
APPLICATOR
CERTIFICATION
TRAINING**

**Manual 6
Right-of-Way
Pest Control**

EXTENSION DIVISION

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

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CAUTION

Rights-of-way maintenance problems may differ within a state or region, but the basic principles are similar in the eastern U.S. Most large rights-of-way applicators operate in ten or more states in one year and operators of ground application equipment frequently work in three or more states during a season. This publication is designed for Virginia, and applicators operating in other states should consult authorities in individual states for specific recommendations and regulations which prevail in that state.

ACKNOWLEDGMENTS

Portions of this manual were obtained from the following sources:

1. Vegetation Management Manual, Ohio Department of Agriculture. 1974.
2. Vegetation control Manual for Highways in Virginia. 1975.
3. Amchem Products, Inc. The Microfoil Boom ^(R) and 060 Nozzle ^(R).

DISCLAIMER

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RIGHT-OF-WAY PEST CONTROL

A Training Program for the Certification
of Pesticide Applicators

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RIGHTS-OF-WAY MAINTENANCE WITH CHEMICALS

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INTRODUCTION

GENERAL CONSIDERATIONS

More than 15 million acres of land in the U.S. are presently in use as rights-of-way for electric power lines, telephone lines, highways, railroads, pipelines, navigation channels, airport runway approaches, drainage and flood control canals, spillways, levies, and communications structures. All of these areas require periodic maintenance to control plant growth in order to assure their continued efficient usage. This maintenance can most economically be provided by proper chemical treatment. Treatment cycles range from two to five years depending upon the amount of regrowth that occurs and the degree of control required for efficient usage of the rights-of-way. Proper treatment and retreatment of wood poles can often double their useful life.

The objectives of a good industrial vegetation management program are:

1. Maintain rights-of-way roadsides, electric substations, pole yards, drainageways, and fence rows so that undesirable vegetation does not interfere with their intended use.
2. Eradicate poisonous plants, poison ivy, poison sumac, etc., and noxious weeds.
3. Accomplish the above in the most efficient, effective manner at the lowest practical cost.

There are also indirect benefits resulting from well-planned vegetation programs, which are of great importance in public relations. They include:

1. Safety - Elimination of weeds, trees, brush on rights-of-ways to improve visibility and eliminate allergy-producing vegetation, poisonous plants and reduce fire hazards.
2. Beautification - Release of desirable shrubs and trees by selective control of competing undesirable vegetation.
3. Wildlife - Conversion of areas from woody brush to shrubs and herbaceous plants by spraying provides better cover for nesting and feeding ares for birds and animals.

Proper treatment of R-O-W areas requires a basic knowledge of pesticides and expertise on methods of application. More than 50,000 people in the U. S. are involved either seasonally or fulltime in the application of the various pesticides required in rights-of-way maintenance. Persons responsible for rights-of-way management, all supervisory personnel, and at least one person with each treatment should have knowledge of the purpose of the treatment and possible hazards involved with the particular chemical being used. The following are areas in which the applicator should be knowledgeable:

- A. Federal and State regulations regarding pesticides, growth regulations and pole treatments on rights-of-way.
- B. Possible harm to the applicator from internal and external chemical exposure and necessity for protective clothing and equipment.
- C. Proper procedure to follow when accidental exposure occurs.
- D. Effect of chemicals on target and non-target plants and animals.
- E. Drift, volatility, and runoff potential of the materials being used.
- F. Influence of weather conditions on effectiveness and on pollution potential of the treatment.
- G. Proper mixing procedures and rates of application.
- H. Calibration, operation and care of equipment.
- I. Proper storage of chemicals in the warehouse, during transport, and on the job site.

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- J. Disposal of used containers and unused chemical according to federal, state, and local regulations.
- K. Procedures to follow in ingress to and regress from the rights-of-way.
- L. Preventing measures to control erosion that could result from use of heavy equipment on rights-of-way.
- M. A general knowledge of plants that could cause poisoning to animals in areas where rights-of-way cross pasture land.
- N. A knowledge of use restrictions when materials are applied near or on pasture or crop land.

CHEMICAL TOXICITY

The sprays we use in our everyday vegetation control work are relatively non-toxic. That is to say, at the concentrations we use, our sprays are relatively harmless. Common household materials, such as coffee, table salt, and aspirin can be more dangerous when measured by the LD₅₀ system.

Exhaustive tests over the past 25 years by the U. S. Department of Agriculture, independent laboratories, and the chemical manufacturers have proven that the proper use of herbicides constitutes no hazard to man, animal, or the environment.

As safe as our chemicals are, there are still several common sense safety precautions required with their use:

1. Only Labeled and Registered compounds should be used.
2. Read and understand the label.
- 3: Keep pesticides out of the reach of children. Dispose of empty container in approved manner.
4. Use proper protective clothing and equipment. Avoid chemical contact with eyes.
5. Use only approved and registered herbicides near lakes, streams, ponds, etc.
6. Spray pastured areas only if product is registered for that use.
7. Keep equipment in good operating order.
8. Keep accurate daily records of locations, quantity of material applied, approximate temperature, wind velocity and direction.
9. Add spray material to the tank in the exact amount specified while refilling with water. Make allowance for the material in the tank. Use an anti-siphon device when drawing water.
10. Operate pump with by-pass open, after filling for sufficient time to thoroughly mix material.
11. Spray pump should not be operated at pressure above the design capacity.
12. Keep containers closed and only store in original containers. Do not store herbicides with insecticides or fungicides to prevent contamination.
13. Do not apply in such a manner as to affect gardens, crops, or ornamentals.
14. Several materials are corrosive. Avoid spraying cars, buildings, etc.

TYPES OF PESTICIDES GENERALLY USED IN RIGHTS-OF-WAY MANAGEMENT

The largest group of pesticides used in rights-of-way are herbicides followed by growth regulators, insecticides, and fungicides, in that order.

HERBICIDES

Contact Herbicides - A contact herbicide kills any green foliage on contact. Paraquat is a widely used contact herbicide. It kills only the green foliage which it contacts and does not move within the plant. It will burn the tops of perennial plants, but does not affect the underground parts. However, repeated applications may eventually deplete the food reserve in underground plant parts and cause death. Paraquat kills the plant by destroying the cell membranes. Contact herbicides usually leave no residues in the soil and are relatively short lived.

Systemic or Translocated Herbicides - The phenoxy weed and brush killers, picloram, growth retardants, and glyphosate (Roundup) are of this type. They are absorbed through the foliage or roots of the plant and they move throughout the plant. They are extremely active in low quantities and spray drift becomes a major concern. They usually require that the plant be actively growing in order to be effective.

Soil Sterilant-Type Herbicides - These materials are primarily absorbed through the roots rather than the foliage. Once picked up by the plant roots, they are carried up into the plant with the upward movement of water. They usually can be applied at any time of the year and may remain effective for 1 - 3 years, depending upon the rate of application. Most are quite soluble in water and will leach down a slope. When applied at high rates under guardrails, they have resulted in excessive kill down the slope and severe soil erosion has resulted. A good stand of Ky 31 treated with growth retardant is considered to be superior to total vegetation control.

Preemergent Herbicides - Herbicides of this group are soil-applied and kill weeds prior to their emergence. They act by killing the tiny weed seedlings as they germinate, and generally have no effect on established vegetation. These materials usually remain effective for a few weeks to several months. They require moisture to carry them into the soil and must be put on in advance of weed seed germination. Certain preemergent weed killers, especially at higher rates, also have postemergent activity.

GROWTH REGULATORS OR INHIBITORS

These materials are used to reduce growth of grass on woody plants along rights-of-way. They are used to slow-down growth of ornamental plantings to reduce pruning costs and to improve sight at cross-roads, etc. They are also used in areas where "brownouts", that occur when herbicides are used, are unacceptable; such as major highways, urban and residential areas. They are effective for one season only and often must be repeated during a growing season. Examples of these growth regulators are Sustar, Maintain maleic hydrazide, and many others.

INSECTICIDES

Insecticides are used in rights-of-way mainly in ornamental plantings to control insects that remove foliage and render the plants unattractive. Other possible uses of insecticides are for gypsy moth, southern pine bark beetle, or other species reaching epidemic proportions.

Trees, shrubs, and other vegetation on highway rights-of-way are subject to population buildup and damage from insect pests. In some cases, trees and shrubs can tolerate insect damage without killing the plants. In others, the pests may constitute a reservoir of pest species that are a threat to neighboring residential areas or commercial nurseries. In other cases, the pest may be a species subject to state and/or federal quarantine and control laws. Highway Department personnel should be knowledgeable about common and potential insect pests and safe, effective methods for managing populations efficiently when necessary.

The major insect problems include: defoliators, such as cankerworms, tent caterpillars, sawflies, bagworm, Japanese beetle, and gypsy moth; leaf miners, especially locust leaf miner; pine tip moth; scale insects; white pine weevil; spider mites; and grasshoppers. Numerous other pests can be a problem locally in individual cases. In addition to existing infestations that occur on a rights-of-way, highways

and vehicles are critical in potential movement of quarantined and otherwise regulated pests, either into or out of rights-of-way. Most insect pest infestations along rights-of-way have been ignored or tolerated. In certain cases, such as pine tip moth, the insects have been permitted to go unabated as a natural means of maintaining reduced plant growth, although they constitute a serious threat to nearby ornamental pines in residential areas and commercial nurseries.

Each specific pest has its own characteristic life cycle and seasonal pattern of development; consequently, there is an optimum time for applying effective control measures for each. The proper insecticide at precise dilution rates must be applied thoroughly at the appropriate time to obtain control. Any use that is not consistent with uses and precautions specified on the pesticide is an illegal misuse of pesticides. Identification of insect pests, information on life history, habits, and hosts, and recommendations of effective, safe control measures may be obtained from local Cooperative Extension Service offices, state and federal brochures, highway department manuals, and technical data sheets from pesticide manufacturers.

Both insecticides and biological chemicals can be used in treating rights-of-way. Most insect pests encountered can be controlled with the insecticides carbaryl, malathion, diazionon, chlordane, or dimethoate; and the biological Bacillus popilliae (milky spore disease) and Bacillus thuringiensis (Dipel, Thuricide, etc.). These pesticides may be applied with large low-volume or high-volume sprayers (mist blowers or hydraulic pump sprayers), smaller power sprayers ("estate" - type sprayers) for individual small trees and shrubs, or back-pack mist blowers. For defoliators, mist spraying is very effective. For scale insects, spider mites, leaf miners, and pine tip moth, thorough, full-coverage sprays are essential. Mist blower applications are not adequate for pests requiring full coverage applications. The ultimate authority for any question on approved uses and application of pesticides is the label on the container. Be sure to read all precautions for proper storage, handling, mixing, application, and disposal.

Before using insecticides, contact the Virginia Extension Division and get recommendations for the proper insecticide and its proper usage.

Do not use sprayers for insect control that have been used for herbicides without proper cleaning.

FUNGICIDES

Fungicides are of limited use in rights-of-way management at present. The control of diseases in ornamental plantings is essential in some cases. Control measures are available from extension agents.

SURFACTANTS

Surfactant is a general term for wetting agents, spreader-stickers, and other materials that alter the physical and chemical characteristics of a spray solution. A surfactant may serve as an emulsifier, improve suspension and dispersion of insoluble powders in water, or improve wetting through the reduction of surface tension. A realization of the importance of these additives is increasing. The interaction between the surfactant and herbicide appears to be more important than the effect of the surfactant on the surface tension in some instances.

A good emulsifier must be soluble in both oil and water to prevent settling out. Wetting agents may increase greatly the entry of a spray into the leaf. They also prevent precipitation of calcium, magnesium, and iron salts of 2,4-D in hard water. Common concentration is about 0.1 percent of the spray. Spreader-stickers help sprays to stick, spread, and cover. Some household detergents have similar effects and have been used as wetting agents in the past.

FORMULATIONS OF COMMONLY USED PESTICIDES

A formulated pesticide contains the chemical in a form that can be:

1. Dissolved or suspended in a carrier and distributed in solution or suspension by sprayers.
2. Applied undiluted from original containers as dust, pellets, pastes, etc.

Usually an emulsifier, spreader, sticker, or other surfactant is added to facilitate dilution or increase wetting capacity. Frequently, formulations contain an inactive filler that serves as a diluent only. For example, there may be only 2, 3, 4, or 6 pounds of active ingredient in an herbicide formulation that has a total weight of 10 pounds per gallon.

Here are several types of formulations:

WATER-SOLUBLE CONCENTRATES

These are readily dissolved in water to make a spray. They are often sold as powders. TCA, dalapon, sodium salt of 2,4-D, and amitrole are examples. They are also formulated as liquids - amine salts of 2,4-D or MCPA and the sodium salts of PCP. These liquid formulations are prepared because some water-soluble chemicals cannot be handled conveniently unless they are diluted. Water-soluble concentrates are also available as pastes and slurries - sodium salts of DNC, PCP, and 2,4-D. They may or may not include wetting agents.

EMULSIFIABLE CONCENTRATES

These are usually liquids in which the chemicals are dissolved in one or more water-insoluble solvents such as oil or benzene and to which an emulsifier is added. When the emulsifiable concentrate is added to water and agitated, the mixture is broken into fine droplets of oil to be suspended in the water to form an emulsion. The esters of 2,4-D, 2,4,5-T and 2,4,5-TP are examples.

INVERT EMULSIONS

These formulations are water-in-oil emulsions in which every spray droplet is surrounded by oil instead of water. This results in a viscous material more difficult to apply, but less likely to drift. This formulation was the basis of early extensive non-drift aerial applications.

OIL-SOLUBLE CONCENTRATES

These are similar to emulsifiable concentrates, but they do not contain an emulsifier. They do not mix with water, but they can be diluted with fuel oil or kerosene or applied without dilution. These are used primarily in basal or timber stand improvement operations.

WETTABLE POWDERS OR WATER-DISPERSIBLE

These powders are generally formulated from chemicals that are insoluble or soluble with difficulty in oil or water. They are finely ground with or without a powdered diluent. A wetting agent is added to keep the particles from floating, and a dispersing agent is added to keep the material in suspension. Monuron, diuron, and simazine are examples.

GRANULES AND PELLETS

Forms of herbicides in which the chemicals is impregnated upon vermiculite, attaclay, or similar carriers. They can be prepared by spraying the herbicide on the carrier or by adding the core material, such as vermiculite, to the original dry powder. Then a pillrolling technique with binders is used to produce pellets; or the powder plus binders and water is extruded, chopped, and dried to produce grains or pellets. Fenuron, simazine, picloram, 2,4-D, and an increasing number of herbicides are formulated as pellets.

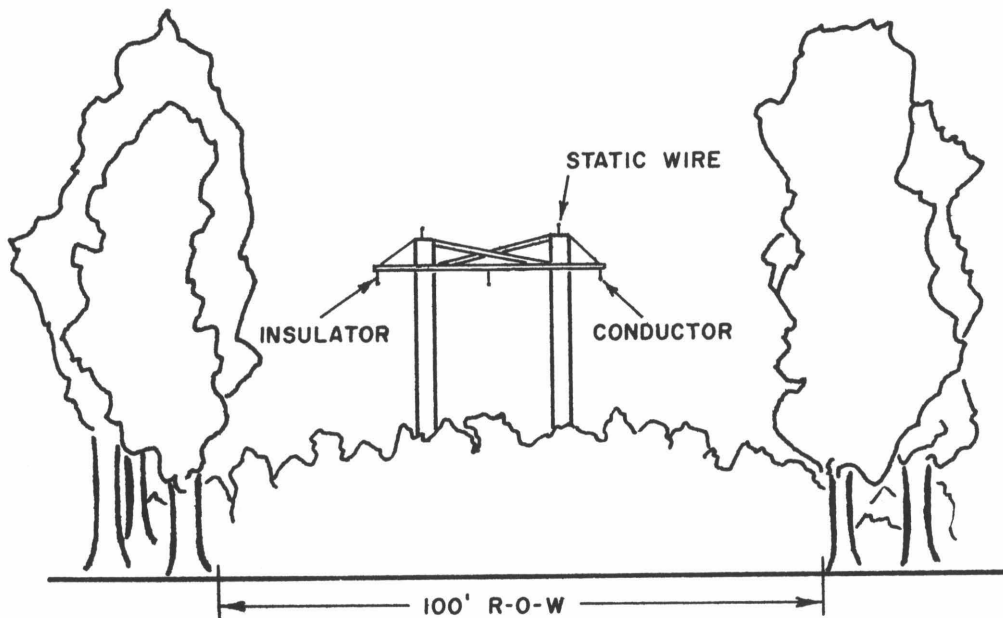
No water and no mixing are required, application equipment is less expensive than sprayers, there is no spray drift hazard, and they can be applied in areas awkward for spray equipment. If the chemical is effective only by root absorption, a granule or pellet intercepted by leaves is wasteful; grains or pellets that drop to the ground are more effective. However, the cost is higher per pound of active

ingredient applied per acre of herbicides formulated in this manner. They are not adapted for foliar applications but must be applied to the soil, they are generally less effective than sprays where moisture is limited, and distribution of small amounts is difficult except by hand. They may cause considerable off-the-right-of-way damage, however, and should be used with caution near desirable vegetation.

PASTES

These are usually applied directly as formulated. Pole treatment compounds are an example.

TYPICAL CROSS SECTION OF UTILITY LINE 44 KV OR HIGHER



MIXING PROCEDURES

Basically, the economic value of a pesticide depends upon the relative amounts of active chemical ingredient that is contained per pound or gallon. This is expressed in percent of active ingredient, acid equivalent, or pounds per gallon in the case of liquids.

Examples are: (1) a product containing 50 percent active ingredient is worth 2 1/2 times more than a 20 percent product pound-for-pound; and (2) an amine formulation of 2,4-D) containing 4 pounds per gallon, acid equivalent, is worth twice the value of a formulation containing 2 pounds per gallon.

The pounds of active ingredient (AI) or acid equivalent (AE) per gallon are given on the label of liquid herbicide. The percent is given on labels of powders, granules, and other dry materials.

CALIBRATION

To calculate the amount of liquid herbicide, required when the rate is expressed in pounds per acre, use the following formula:

$$(AE) \frac{\text{Rate in pounds per acre}}{\text{Pounds of herbicide per gallon}} = \text{gallons per acre}$$

Example: If the rate is 1 1/2 pounds per acre and the herbicide contains 4 pounds (AE) per gallon, the $\frac{1.5}{4.0} = 0.375$ gallon, or 8 pints X 0.375 = 3 pts.

Use the same formula to calculate gallons of herbicide per 100 gallons of spray.

Example: If the rate is 2.5 pounds (AI) per 100 gallons and the herbicide contains 2 pounds (AE) per gallon, than $\frac{2.5}{2.0} = 1.25$ or 1/4 gallons.

To calculate the amount of dry product required when the rate per acre is given, use the following:

$$\frac{100}{\text{percent active ingredient}} \times \text{rate per acre} = \text{pounds product}$$

Example: If the rate is 15 pounds of active ingredient per acre, and the percent of active ingredient is 75, then $\frac{100}{75} \times 15 = 20$.

Mixing. Never pour the concentrate directly into an empty tank. Either fill the tank half full, add the chemical, agitate, and complete the filling or start filling and add the chemical as the filling is continued. Operate the pump with the nozzles shut off, bypassing the spray through the tank for several minutes (at least six times) to insure thorough mixing.

SPRAY EQUIPMENT

Spray Nozzles - Spray nozzles are manufactured in a wide range of types to fit any spraying need. An excellent reference guide is the spray catalog from Spraying Systems*. One of the main types of nozzles used by the Highway Department is the off-center (OC) nozzle. It comes in a variety of sizes as shown in Figure 1. Nozzles have the numbers printed on them which indicate the pattern and volume.

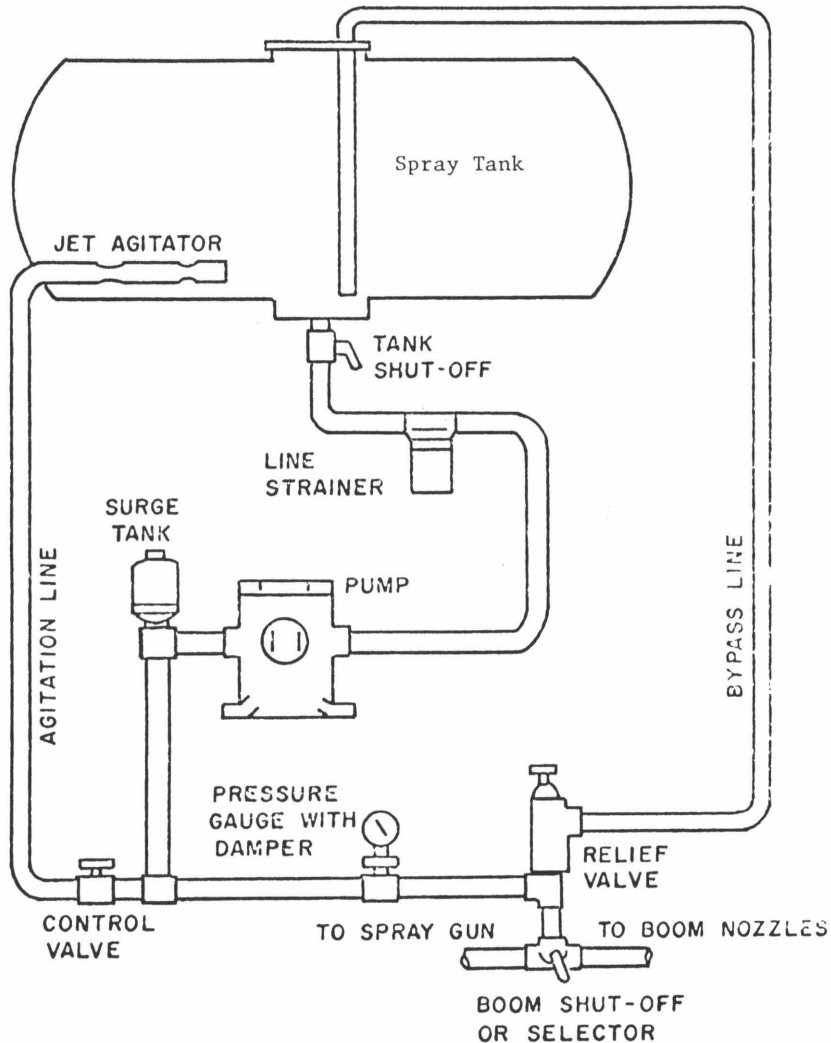
The diagram on page shows spray patterns obtained by different OC nozzles for spraying highway shoulders. Flat jet nozzles are suggested for guard rails that can be reached with the boom as shown on page

Spray Pumps - Pumps come in various types and price ranges.

Centrifugal Pumps - least expensive, develop relatively high volume and low pressure.

Roller Pumps, Nylon Roller, or Rubber Rollers - Nylon rollers are subject to excessive wear when wettable powders are used. The organic solvents in emulsifiable concentrates will cause the rubber rollers to swell.

Piston Pumps - These are the most expensive and most versatile types (See Figure 1). They will develop high pressure, are not subject to wear by wettable powders, or adversely affected by the organic solvents of the various formulations. They are quiet, durable and if properly taken care of, will last for long periods. They have the slight disadvantage that the pressure tends to pulsate each time the piston makes a stroke. This is overcome by the addition of a surge tank in the line leaving the pump.



BASIC COMPONENTS FOR GROUND SPRAY RIG

MAJOR PROBLEMS ASSOCIATED WITH PESTICIDE APPLICATION

APPLICATION PROBLEMS

Proper application is an absolute requirement in obtaining satisfactory results from any herbicide treatment. All treatments must be applied uniformly at the recommended rate over the area to be treated. Foliage-applied treatments (contact and translocated) must be applied with a sufficient volume of carrier (usually water) to assure adequate coverage.

Drift and volatility are frequently confused. They are somewhat similar in result but distinct in origin. "Drift" refers to the downwind drifting of droplets of spray at the time of application. If applied as a "fog" or "mist", such droplets can easily drift a half mile or even more. "Volatility" refers to the evaporation of the herbicides after application, and moving with the wind in vapor form.

Any chemical may cause difficulty from drift. When herbicides are applied as sprays, air currents acting on the moving spray droplets may carry them through the atmosphere beyond the intended target. The direction, distance, and amount of spray drift are influenced by the size of the droplets, type of spray (oil or water, for example), spray additives, application equipment (such as the type of nozzle), and direction and velocity of wind.

Drift is a major concern in right-of-way maintenance. It presents a potential hazard to sensitive vegetation (crops, gardens, ornamentals), wildlife, people, livestock and aquatic areas adjacent to rights-of-way.

The effect of droplet size on particle drift is illustrated in the following table:

SPRAY DROPLET SIZE AND ITS EFFECT ON SPRAY DRIFT*

Droplet Diameter in Microns	Type of Droplet	Time Required to Fall 10 ft. in Still Air	Distance Droplet Will Travel in Falling 10 ft. (3 mph. Breeze)
5	Fog	66 min.	3.0 miles
100	Mist	10 sec.	409.0 feet
500	Light Rain	1 1/2 sec.	7.0 feet
1,000	Moderate Rain	1.0 sec.	4.7 feet

*Ref: Weed Control As A Science - G. C. Klingman.

Particles of fog or mist size present the greatest drift hazard. These size particles are often generated by high-volume spraying equipment utilizing high pressures for foliage treatment of trees and brush.

Spray drift is usually greatest from aerial applications without special formulations or application equipment. Not only is the spray from aircraft applied at a greater distance from the surface being sprayed, but turbulent air currents produced by the moving plane or helicopter accentuate the effects of natural winds on the spray.

Attachments or modifications to spray equipment, especially to ground rigs, can often be employed to reduce spray drift. Shielded booms are frequently used for this purpose in agricultural spraying or using herbicides adjacent to desirable vegetation.

In recent years, new herbicide carriers, additives, and special spray nozzles have been produced that greatly reduce or eliminate spray drift. Invert emulsions (water in oil), particulating agents, and polymeric thickeners, for example, can be used in aerial applications, with significantly reduced drift.

Drift damage from contact herbicides will not be as serious as that from the hormone types, because only those parts of the plant which are directly wetted by the drifting droplets will be affected by a contact herbicide.

The following precautions can be taken to reduce drift:

1. Use as low a pressure as possible.
2. Switch to a larger tip; this produces larger droplets which will not drift readily.

3. Spray down the right-of-way, not across it.
4. Keep aerial spray nozzles below the horizontal as much as possible.
5. Do not spray adjacent to sensitive crops, change chemicals, application methods, or leave an unsprayed area.
6. Use a spray thickener.

Drift then, must always be guarded against as a hazard in applying chemicals in general. Extreme care--using trained operators, low pressures, and nozzles producing the largest droplets feasible for the particular job being done -- should be taken in all industrial vegetation control spraying.

Pressure should be set to obtain the largest droplet possible for the diameter of the disc. If the droplets are small, you may expect drift so by keeping the material in large droplets, most drift can be eliminated.

Ester formulations of the phenoxy-type herbicides (2,4-D;2,4,5-T; 2,4,5-TP; etc.) present the greatest potential for vapor drift. Amine formulations of these herbicides are essentially non-volatile and do not present a vapor drift hazard. ✓

Drift Control Agents: Adjuvants and application systems have been developed which help overcome certain inherent drift problems that exist in conventional spraying. Two of these systems are:

1. Invert emulsions
2. Spray additive stabilizers

Though different in method, there are similar advantages with both

- Better drift control by having uniform droplets
- More highly visible spray pattern that results in better placement

A brief description of each method is as follows:

1. Invert emulsions. The most common type of emulsion is an "oil-in-water" preparation. An invert emulsion is a "water-in-oil" type which involves preparing the herbicide in water solution and encapsulating these particles in oil to form spray particles of a mayonnaise consistency. This inversion requires a separation of the water and oil phases in separate tanks and a special mixing apparatus to combine the two phases before or during the spraying operation. The specific gravity (weight) of this emulsion is the heaviest of any. Extra equipment and preparation are involved in this process.
2. Spray additive stabilizers: There are additives, which affect particle size and viscosity of spray solutions, that give the same fundamental advantages described above but require no special equipment.

Important mixing instructions are on the labels of these products to minimize difficulty in their use. Contact the manufacturer for specific instructions and additional information.

These materials can be used in conventional spray equipment. However, screens (strainers) smaller than 50 mesh should not be used.

All of the above-described methods should be considered as drift aids under normal conditions. Extreme conditions such as high winds, very high temperatures, etc., cannot be overcome by these measures. Caution should be exercised and labels closely observed.

Lateral Movement: Caution must be exercised in use of herbicides (particularly bare-ground treatments) on slopes, sandy soils, and in areas that may be subject to erosion in heavy rains. All soil active herbicides can move laterally. Such movement may cause excessive destruction of vegetation and result in soil erosion or cause injury to desirable vegetation.

In areas where excessive vegetation destruction may result from bare-ground treatment, the use of contact foliage translocated or selective herbicides is recommended for vegetation abatement. Vegetation abatement entails knockdown of established vegetation and/or short-term residual vegetation control.

Excessive destruction of vegetation in sloping areas, resulting through herbicide use, may result in erosion. Treated soils from eroded areas can cause injury to adjacent areas if carried off the right-of-way. In sloping areas, use bare-ground treatments with caution. Allow a mulch or cover to be maintained by periodically skipping retreatment. If possible, use selective herbicides to maintain a vegetation cover while removing certain objectionable vegetation.

Volatility. Movement of herbicides in the atmosphere may also occur through the production of vapors and by wind action on vapors. Much has been learned about this problem since the late 1940's when vapors of certain herbicides, particularly the lower alkyl esters of 2,4-D, resulted in volatility damage to sensitive unsprayed crops such as cotton, grapes, and tomatoes.

Herbicide vapors in the atmosphere can arise from plant or soil surfaces. Physical and chemical properties of the herbicide and of the surfaces involved, and the temperature of the air and the amount of chemical influence the rate of vaporization. Vaporization potential increases as air temperature of the surface deposits increase. Absorption of herbicides to plant and soil surfaces, and penetration of the herbicide into foliage or soil, reduce or eliminate vapor losses.

Fortunately, most herbicides on the market today are of the low volatile type; their use greatly reduces the volatility hazard. Amine salt formulations will not volatilize. To reduce the danger of volatility damage: STOP OPERATION AT A SAFE DISTANCE FROM SUSCEPTIBLE CROPS OR USE NON-VOLATILE MATERIALS.

For your guidance, we list the more susceptible crops and suggested distances from these crops that you should take precautions when using volatile materials:

Grapes	1,000'	Peanuts	300'
Cotton	600'	Squash	300'
Tobacco	600'	Corn	100'
Tomatoes	300'	Wheat	100'
Beans	300'	Oats	100'
Peas	300'	Alfalfa	100'

If a wind is blowing toward the crops, these distances should be doubled. Even if no wind is blowing, the distance should be observed due to possible volatility damage several days later.

Areas left unsprayed because of the close proximity of crops, may be safely sprayed during the dormant season or with non-volatile materials.

Use Around People and Domestic Animals - The best guide is to handle all herbicides with care. Avoid splash or spray contact, and keep exposure to a minimum. Never keep herbicides in containers that are improperly labeled, nor easily accessible to children. Never dump unused herbicides where water supplies may be contaminated. Be sure to avoid direct contact of spray particles or herbicides with the applicator, or persons and domestic animals in or nearby the treatment area.

Oil or Chemical Spills. According to the Environmental Protection Agency, a spill is "any chemical or oil reaching the water." An oil spill is defined as any discharge that results in a film on, emulsion in, or sludge beneath, the water or shoreline.

The person responsible for an oil spill is liable to penalties on two counts, failure to report and failure to remove. The penalty for failure to report the spill can be a \$10,000 fine and a year in prison. Every oil spill must be removed.

Report the spill immediately. The U. S. Circuit Court of Appeals has prohibited criminal prosecution of companies that voluntarily acknowledge a pollution incident, as long as the company admits it has spilled before the spill is discovered by authorities.

If spills on land are noticed immediately, remove about 1 inch of the affected soil with a shovel or flat spade and dispose of it in areas where bare ground is desired. This should remove most of the herbicide. The trees should then be inspected periodically to determine whether any chlorosis develops. If in doubt as to complete removal, or as an extra-precautionary measure, seven pounds of activated charcoal per 1,000 sq. ft. should be spread evenly, then incorporated lightly with a roto-tiller.

Activated charcoal absorbs the herbicide from the soil (ties it up) and makes it unavailable to plants. By reducing the availability of the herbicide to plants, injury is minimized.

If spills are noticed after rain, the soil should be removed to a depth of 4 - 6 inches, then apply broadcast charcoal over the area and incorporate.

Residual herbicides are usually absorbed by clay and organic matter particles in the soil and disappear at the rate of about 80% per year. If a misapplication is noticed immediately, then most of the damage can be prevented by simply removing the upper layer of soil. However, the more time that elapses following the application, the greater the depth to which the chemical will penetrate into the soil, and the more difficult it will be to mechanically remove it with the soil. In some instances, root pruning has been effective in isolating the herbicide away from the root system, particularly when a portion of the root system is involved.

LIVESTOCK POISONING

Over the years, livestock deaths, at first attributed to herbicide poisoning following rights-of-way application have been diagnosed as actually due to one of the following:

1. Malignant catarrhal fever in cattle, 2, 3, 4, 5, 6.
2. Eperythrozoonosis in swine.
3. Internal parasites in sheep.
4. Anemia in horses.
5. Lead poisoning.
6. Poisonous plants.
7. "Hardware disease."
8. Arsenic.
9. Old Age.
10. Accidental shooting and others.

Unexplained livestock deaths may coincide with sprayings, but unexplained deaths in livestock were occurring in pastures long before pesticides were discovered.

Use Around Livestock - Herbicides sprayed on plants are generally not toxic to livestock. Livestock may be poisoned by eating unused herbicides left in open containers or by drinking water contaminated with herbicides.

Poisonous Plants. One possible connection between spraying and livestock poisoning is the fact that some plants, very shortly after being sprayed, become more palatable and hence are eaten more readily than before. A few cases of poisoning, apparently from this cause, are on record. Poisonous plants have no place in a pasture and livestock should be removed for a 2 week period if the presence of poisonous plants is suspected.

One of the most common poisonous woody plants is wild cherry, the leaves of which contain a glucoside which gives off hydrogen cyanide, or prussic acid, in breakdown. Wild cherry may be poisonous, green or wilted, if animals eat enough of it. We have no records of the hazard from wild cherry being increased by spraying, and experimental studies show that the cyanide content decreases steadily after spraying to only 10 to 20 percent within two weeks, of that originally present.

Johnsongrass, goldenrod, bracken fern, tomatoes, and acorns are common plants that have proven to be toxic to animals under certain situations. Spraying during the dormant season is the best procedure for eliminating false livestock poisoning claims.

CONTAINER DISPOSAL

1. Read the label on the pesticide container and follow instructions for disposal of the empty container or surplus material. These are the accepted methods of disposal and should be followed rather than supplemental instructions. If no instructions are given on the label, follow the supplemental instructions.
2. The Virginia Pesticide Law, Regulation No. 19, states - "Disposal: No person shall dispose of, discard, or store any pesticide or pesticide container in such a manner as may cause injury to humans, vegetation, crops, livestock, wildlife, pollinating insects or to pollute any supply of water or waterway."
3. Avoid the necessity to dispose of excess pesticide spray mix only enough to complete the job or the day's operation.
4. Use every precaution to avoid contaminating streams, ponds, lakes, or other sources of water when filling or flushing equipment.
5. Never dispose of any pesticide, pesticide spray mix, or pesticide containers in any stream, pond, lake or other source of water.
6. Store pesticides and empty containers in a secure place on all equipment during transportation to eliminate loss along the right-of-way.
7. Rinse empty pesticide containers that contain liquid materials at least three times, and dump this solution in the spray tank. The empty container shall be then rendered unusable for other purposes. Glass containers shall be broken, and metal containers shall be chopped full of hole (top, bottom and sides) crushed and disposed of according to label directions.
8. Paper bags or fiber containers that contain dry powders or granular materials shall be checked to see that they are free of all excess materials before disposal. These containers shall be rendered unusable for other purposes by punching holes in the paper bags; paper or fiber containers shall be punched full of holes, crushed and disposed of according to label directions.
9. The Virginia Department of Health does not recommend the disposal of metal pesticide containers as scrap metal for salvage.
10. If no instructions for disposal of empty containers are printed on the label, the following instructions are to be followed after the empty containers have been rendered unusable for other purposes.
 - a. Glass or metal containers, after being crushed, shall be buried at least 18 inches deep in a place where water will not be contaminated. Sanitary landfills may be used, provided the city, town, or county has given permission for such use.
 - b. Paper bags, paper or fiber containers, after being crushed, shall be buried at least 18 inches deep in a place where water shall not be contaminated. Sanitary landfills may be used for such purposes provided the city, town, or county has given permission for such use.
11. For information in case of fire and/or accident involving pesticides or where large quantities of pesticides are to be disposed of, contact the Division of Product and Industry Regulation, Virginia Department of Agriculture and Commerce, 203 N. Governor Street, Richmond, Virginia 23219 (Telephone - 804-770-3798).

BRUSH CONTROL

Control of brush or woody sprouts resulting from stumps of trees or seedlings in the right-of-way is the largest single cost of maintaining utility rights-of-way. It is also an important factor in maintaining railroad, pipeline, and highway rights-of-way. There are many ways of controlling brush. The most commonly used ones are:

1. Foliage spray treatment (ground or aerial)
2. Dormant spray treatment (cane broadcast or basal)
3. Granular or pellet treatment (grid or clump)

There are many variations in application methods which will be discussed in more detail under each of these three groups.

The height of brush is not a factor in treatment unless it is too small. Any plant can be treated regardless of height, although the height of brush may be controlled by the following factors:

1. Public Relations. Large dead brush will be very unsightly along public thoroughfares. This will lead to adverse criticism.
2. The treatment of large brush increases the possibility of drift to adjacent property where susceptible crops may be found.
3. On large brush it will be much more difficult to obtain the proper coverage.
4. The cost to treat large brush increases rapidly as the size of brush increases. The ideal height of brush to treat would be from four to eight feet. If the brush is higher, it should be cut.

FOLIAGE APPLICATIONS - GROUND RIGS:

Foliage treatment (or stem foliage) may be done successfully from the time the leaves are fully expanded in the spring until the foliage starts to turn color in the fall. However, it will be found that early treatment in the season will obtain better results. Increasing the concentration to overcome maturity of brush as the season advances is recommended. Foliage spraying should stop when leaves start turning color.

High-volume foliage treatment to the point of runoff is versatile, economical, and can be used in most areas where brush control is a problem.

Herbicides should be used at the rates and concentrations indicated on the label. Some common herbicides used for this application today are:

Phenoxys	2,4-D and 2,4,5-T or combinations sold as "Brushkillers"
Picloram	Tordon alone or applied with 2,4-D or 2,4,5-T
Dicamba	Banvel, usually applied with 2,4-D or 2,4,5-T
Glyphosate	Roundup, kills most vegetation
Fosamine	Krenite kills most woody plants
Silvex	Kuron, Weedone, 2,4,5-TP, etc. - can be used on ditch banks and other areas where 2,4,5-T cannot be legally used.

Thorough wetting of the leaves and stems to the point of runoff is essential for good foliage treatment. The sprayman will generally operate the gun from a ground position and with a sufficient length of hose to treat from a position close to the plant. The amount of material used per acre may vary considerably, depending on the height and density of brush. However, in foliage and treatments, the material is applied to the point of runoff. The cost of labor is such today that sufficient material should be applied to insure adequate control.

BASAL APPLICATIONS - GROUND RIGS

A basal application consists of a thorough wetting of the lower portion of individual stems of the plants to be killed. All exposed roots should be treated with no attempt to do anything with the top. Sufficient material should be applied to cause rundown to the root crowns. The emphasis on run-down is very important. The success of basal treatment depends on how well the applicator does his job. There must be a generous amount of concentrate applied. Normally No. 2 fuel oil or its equivalent is used as a carrier for the chemical and helps it penetrate the bark of most woody species.

Most chemicals, except those marked "OS", can be mixed with oil and diluted with up to 85% water. This helps conserve oil supplies and is almost as effective as using 100% oil as a carrier.

Basal treatment may be done at any time during the year; it will make very little difference whether the plants are dormant or growing. Satisfactory results will be obtained if the application is properly done. This type of treatment lengthens the season to a year-round operation. This is a good method for keeping experienced spray personnel. Basal treatment done during the dormant season can be used in treating areas close to susceptible crops such as legumes, grapes, etc. to reduce the possibility of damage. However, volatility from ester formulations of phenoxy herbicides can still be a problem from dormant applications. Generally, 16-20 lbs. of acid per 100 gallons of oil is suggested in basal treatments.

Another basal treatment is the Modified or Broadcast Basal method which is similar to the above, but is useful when the stems of the brush are numerous. Here, the lower 2-3 ft. are covered in a broadcast manner and individual stems are less likely to be missed during the spraying operation. This method is less time consuming than the regular basal stem treatment. A lower chemical concentration and higher volume of oil is recommended when using this method instead of the regular basal spray.

The solution most generally used in basal treatment is 2,4-D and 2,4,5-T combinations or 2,4,5-T alone mixed with #2 fuel oil or old transformer oil. In recent years, picloram mixed with oil for basal treatment is used to control the root suckering species which are not normally controlled by 2,4-D/2,4,5-T basal such as sassafras, black locust and sumac. Also, dicamba and karbutilate are being used increasingly in dormant applications on woody plants.

STUMP TREATMENT

Another method is to apply the basal treatment solution to the cut stump surface. The stumps must be well soaked on all sides, and particularly at the root crown to the point of runoff. Best results are obtained on stumps above three inches (3") in diameter - brush or smaller trees will waste too much material. Stumps should be treated soon after cutting, before the tissue in plants dries up.

Equipment for basal or dormant spraying may vary from the knapsack type suitable only for small basal or stump treatment to the large power rigs mounted on a suitable truck or tractor which would be designed for the terrain to be covered. This equipment may carry as much as 5,000 feet of hose with extra men and equipment. Piston type pumps, mounted on four-wheel-drive bombardier type vehicles or rubber-tired articulated log skidders, with special guns would be standard equipment for right-of-way brush control. Suction or filler hoses should be equipped with an anti-siphon or check valve to prevent spray mixture from contaminating water supply.

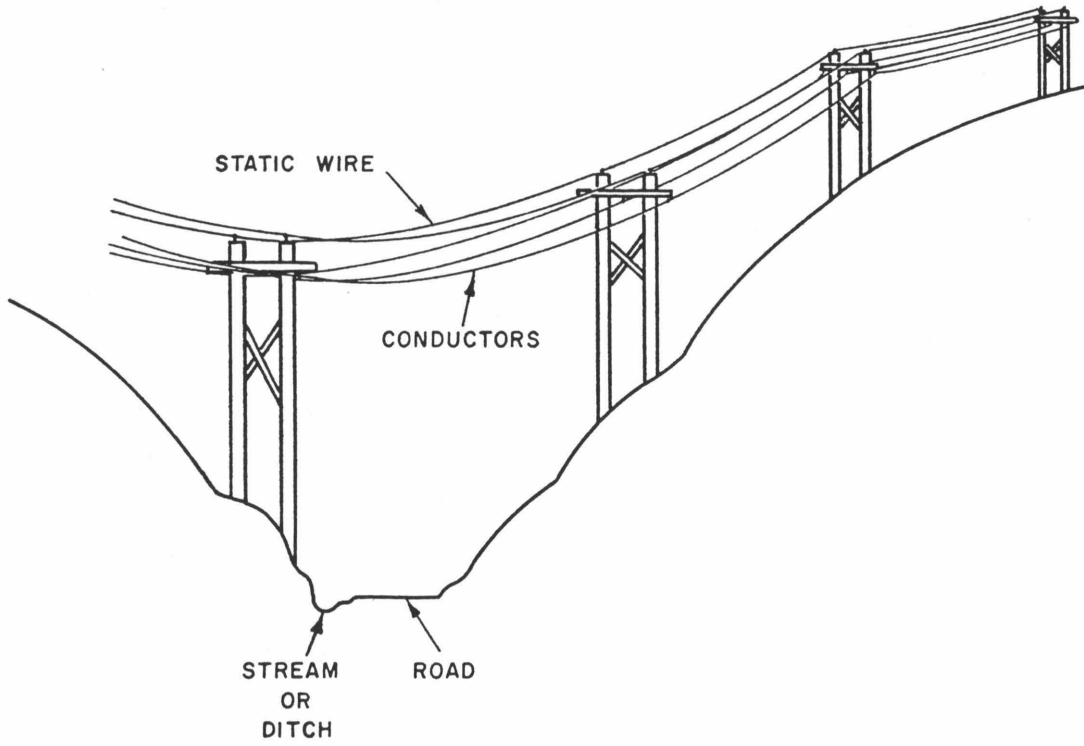
Portable mist blowers can also be used successfully for brush control. The pressure needed for basal treatment should be enough to produce a steady stream from the nozzle. Mist blowers should not be used within 500 ft. of greenhouses or other areas where succulent ornamental plants are kept. Oil-soluble thickeners are also recommended to cut down on drift.

DRY OR PELLETTED APPLICATIONS

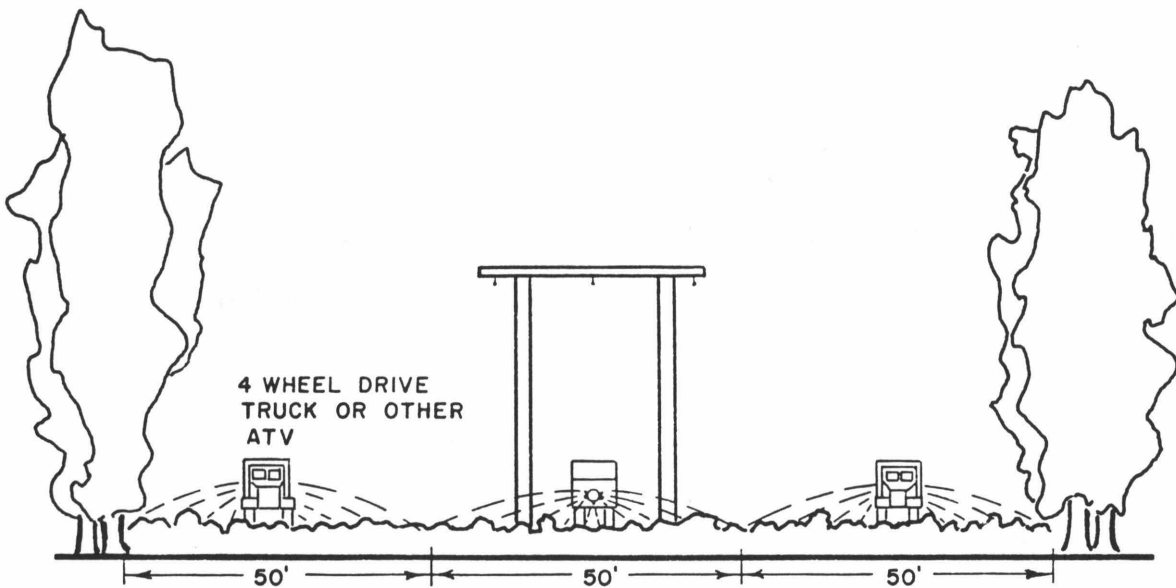
Pelleted materials of bromacil, dicamba, diruon, karbutilate, monuron and picloram are very effective as weed and brush killers. The pelletized materials are scattered on the ground around the base of the plant or applied on a grid system.

These materials are absorbed entirely through the plant roots and therefore must be soluble in water. This feature also makes them more likely to cause right-of-way damage to nearby crops and timber that results from surface or underground water carrying the soluble chemicals with it. An example is picloram which can be used as a foliage spray or in a pelleted form. Most of the chemical in spray is caught and held by the leaves of the brush and does not enter the soil, whereas the pelleted material all goes into the soil.

TYPICAL PROFILE OF CROSS COUNTRY LINE
44 KV OR HIGHER

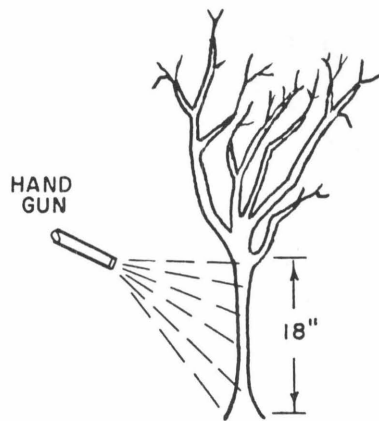


UTILITY LINE SPRAYING WITH FIXED NOZZLE



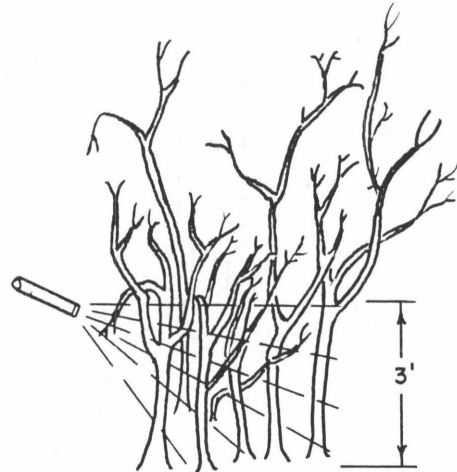
BASAL SPRAYING

USED FOR BRUSH UP TO
4" IN DIAMETER.
20-50 GALLONS/ACRE



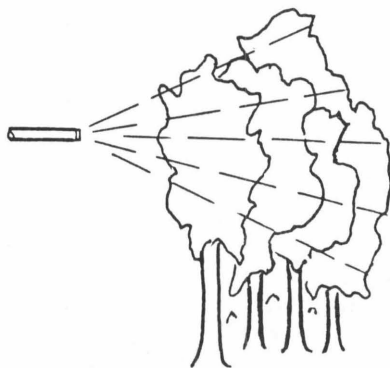
BROADCAST BASAL
SPRAYING

50-100 GALLONS/ACRE



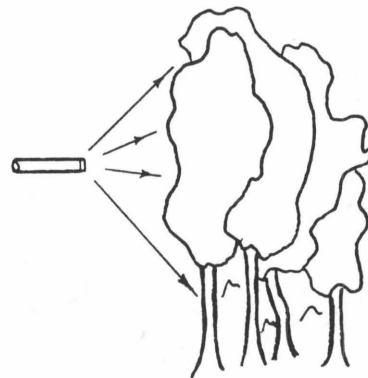
FOLIAGE SPRAYING

50-100 GALLONS/ACRE
BRUSH OVER 12-15' SHOULD
BE SPRAYED AERIALY.



STEM FOLIAGE SPRAYING

100 GALLONS/ACRE OR MORE
STEMS AND LEAVES ARE
WET TO RUNOFF.



Wettable powders such as tebuthiuron or hexazonine may be applied as a spray or in a slurry. Products of this nature are usually root absorbed and have little effect when applied to the tops of woody plants. They may be applied by hydraulic pumps, knapsack sprayers or other hand-type applicators. They are especially useful where spot treatments are required.

FOLIAR APPLICATIONS - AERIAL

Aerial application of herbicides to utility rights-of-way is a fast, efficient, economical method of controlling the growth undesirable woody vegetation.

Since most rights-of-way are restricted in width, and may run through a variety of terrain, it is imperative that the proper equipment and techniques be utilized. Most of the advancement in chemicals and applicator systems has involved the use of a helicopter as the aerial applying vehicle.

Because of its slow flying characteristics and maneuverability, the helicopter readily lends itself to this job. It is capable of flying at or below treetop level, therefore limiting the distance the chemical must fall before reaching the right-of-way, thereby reducing the possibility of wind drift. The pilot is afforded excellent vision from the helicopter, which further assists in controlling the application.

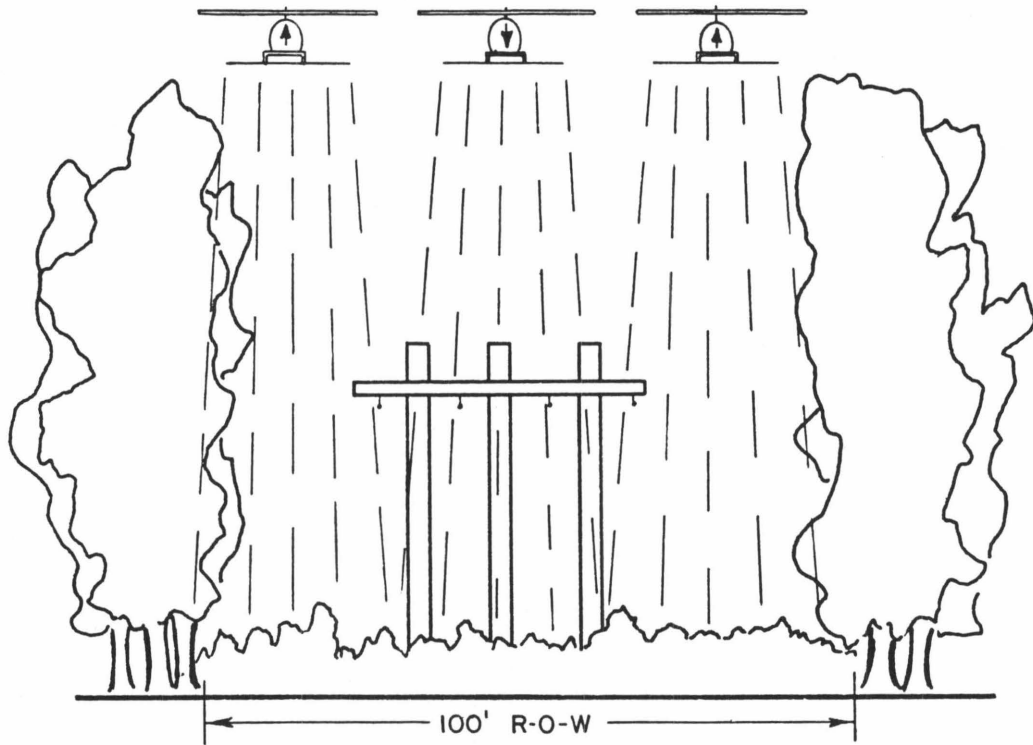
Aerial Applying Systems - There are several applying systems available for right-of-way spraying. Some are designed to handle a thickened material to reduce possible wind drift and resultant off right-of-way damage. But, more recent equipment is designed to control drift by delivering uniform large droplets.

1. Amchem Micro-Foil Boom. A method of applying non-thickened material, and still maintaining control of the chemical. The system consists of a boom with many small nozzles. Low pressure carries the material to the nozzles. The nozzles are trimmed into the airflow and the chemical is laid into the airstream and falls similar to a sheet of rain.
2. Amchem microfoil 060. This is a recent adaptation of the microfoil boom. Its name is derived from the orifice size of 0.060 inches. The large, uniform droplets formed with the nozzle penetrate the leaves of foliage and kills small brush at the ground level. Another advantage of the 060 boom is that more precise control is maintained on the swath enabling the pilot to adequately cover brush growing in ravines under a power line; it has proven adequate in drops of 200 ft. or more. The design of the 060 boom practically eliminates fine droplets in the spray pattern when used correctly.
3. Conventional Boom. A system utilizing pressure to force chemical through a number of nozzles. The chemical falls to the right-of-way as a mist of various size droplets. The lack of drift control greatly limits the use of a conventional boom for rights-of-way.
4. Amchem Spray Disk. This unit is used for the application of Amchem's Envert Emulsion. Properly mixed, the invert material reaches a consistency approximately that of heavily whipped cream. The material is pumped into the tanks of a helicopter and gravity fed to a rotating disk with nozzles. The material is dispensed in large heavy droplets allowing control and placement of the material on the rights-of-way.

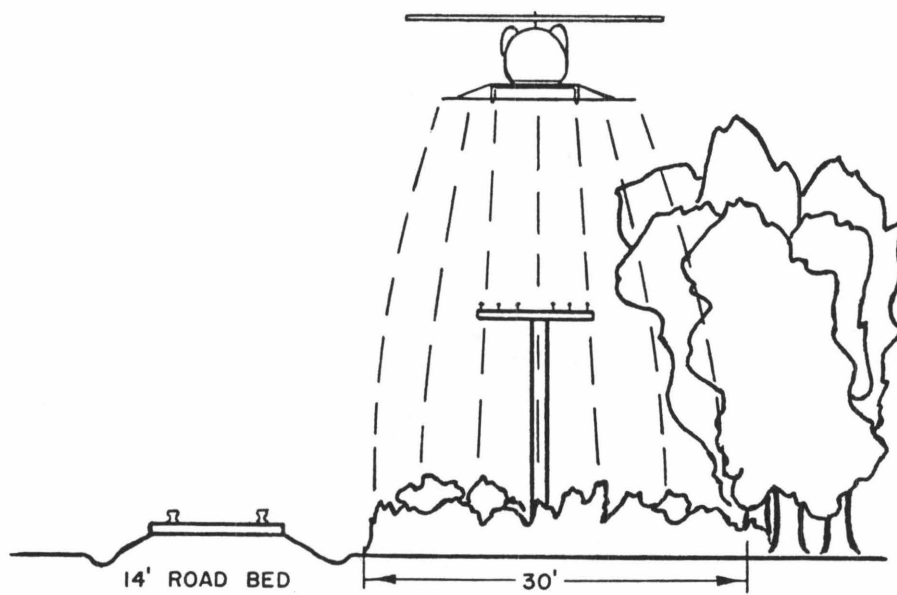
Aerial Application Techniques - Flying techniques will vary according to the pilot, his experience and capabilities. However, there are several methods or techniques that, if followed, will eliminate rights-of-way damage and reduce the number of complaints and damage claims. The following items are considered essential for safe and effective aerial spraying:

1. Reconnaissance of rights-of-way - A proper aerial reconnaissance of the right-of-way before spraying will give the pilot advance knowledge of the presence of homes, gardens, valuable crops, trees, or other areas that should not be sprayed. Known restrictions should be marked on rights-of-way maps.
2. Wind and other climatological factors - Since wind drift of chemicals is the major cause of rights-of-way damage, it is very important that the wind speed and direction be known at all times. Wind limits should be set for the chemical being used, application equipment, height of drop, and proximity and species of crops or plants next to rights-of-ways.

PROFILE OF AERIAL SPRAYING ON R-O-W ABOVE 40'



RAILROAD SIGNAL LINE SPRAYING WITH HELICOPTER



Herbicidal foliage spraying of woody vegetation by aircraft on right-of-way should be curtailed when the wind velocity exceeds five miles per hour at eye level.

In case of deep valleys requiring the chemical to be dropped long distances, it may be necessary to wait for periods when the wind is almost calm. There is also a temperature gradient between hills and valleys which may cause some air movement.

Normally, the wind is of lower velocity early in the morning (dawn) and early evening; therefore, most of the production is accomplished during these periods.

3. Continuous observation - The pilot should (1) constantly observe the spray pattern to see that it does not exceed the edge of the rights-of-way and to be sure that turn-on and turn-off points are well within spray-area limits, (2) search for the presence of valuable property or crops that may have escaped his vision on the advance reconnaissance and be ready to halt spraying at any point.
4. Sensitive crops and other areas - Certain crops -- tobacco, grapes, vegetables -- should not have the spray applied closer than 100 ft. even under ideal conditions. Never spray toward sensitive crops. These areas should be picked up in reconnaissance or be marked on a map prior to actual spraying.

Homes, parks, recreation areas and the like, should be avoided by several hundred feet, unless specific instructions to the contrary are given.

Avoid lakes, streams, ponds, and other water sites when applying most brush control chemicals. Drainage areas that go into irrigation water should be avoided by at least 500 ft.

Precautions in Aerial Spraying - In spite of the judgment and caution applied in aerial application, occasional damage claims or complaints may result, legitimate or otherwise.

There is no substitute for quick, personal response to these complaints. A rapid investigation of damage complaints can save many dollars in unwarranted claims, and can create good public relations for the rapid settlement of justifiable complaints.

The individual who suffers actual damage deserves fair treatment for his loss. The individual who believes he has been damaged deserves the consideration of a quick response to his complaint and an explanation of the facts.

Even though chemicals and application systems have been continuously improved to make aerial brush control of rights-of-way a practical method of control, with reduced possibility of off right-of-way damage due to wind drift, the equipment is only as good as the pilot that uses it. The pilot is the key to successful application. He must maintain the proper attitude towards aerial applications. He must be constantly aware of the serious problems that could result from improper techniques employed. He must be constantly alert for changes in weather or equipment that could affect the safe application of chemical to the right-of-way limits. Most of all, he must have a sincere desire to do the best possible job.

Due to inaccessible terrain and other factors, aerial application may often be a more practical method of controlling vegetation. However, aerial treatment has no place in urban and suburban areas, and it is very difficult to do aerial applications with 2,4,5-T and adhere to the restrictions of USDA, VDA, EPA, and OSHA as to application near ditch banks, lakes and streams, and close to buildings.

Because of the need for good public relations and the fact that the foliage of brush turns down after spray treatment, it is advisable that tall brush near road crossings not be foliage-sprayed with any material causing a "brownout" unless a "living screen" has been allowed to grow and hide the area. Tall brush near crossings should be cut and basal sprayed if it is visible from a road.

Calibration of Aerial Sprayers - Calibration of helicopter sprayers - Actual output per acre of aerial spray rigs is of utmost importance as with any method of pesticide application. The delivery at ground level of a predetermined amount of liquid per acre is not easy to accomplish, especially in uneven terrain where utility lines are at various heights from the ground.

Each type of aerial spraying equipment performs differently and the pilot should be thoroughly checked out with each type, as he would be with different types of aircraft. For instance the width covered by the Microfoil boom will be approximately double the length of the boom at 50' height using .028" orifices whereas the 060 boom will cover a width approximately double its length at a height of 125'. A calibration chart for the microfoil boom is shown below. As with calibrating other types of spray equipment, the following are of importance:

1. Air speed
2. Pressure
3. Swath width
4. Volume

Average Swath Widths With The Amchem Microfoil Boom^{1/}
STANDARD MICROFOIL, VARIABLE LENGTHS SWATH WIDTHS IN FEET (35 MPH*)

Boom Length	10 Feet		16 Feet		20 Feet		26 Feet		26 Feet 45 MPH		
Nozzle Size	.013	.028	.013	.028	.013	.028	.013	.028	.013	.028	
FLYING ALTITUDE IN FEET	10	16	12	29	21	37	27	40	30	34	25
	15	17	13	30	22	38	28	43	33	37	27
	20	18	14	31	24	40	30	45	34	39	29
	30	21	16	35	27	44	34	49	39	44	34
	40	24	18	38	29	47	37	54	44	49	38
	50	25	21	40	33	51	41	60	48	54	44
	60	27	23	43	36	54	44	65	54	59	48
	70	30	25	47	39	58	48	69	58	65	54
	80	32	27	50	42	62	52	74	63	69	58
	90	34	29	53	45	66	56	80	68	75	64
100	36	32	56	49	70	60	85	73	80	68	

* Note slight decrease in swath widths as speed increases to 45 MPH

^{1/} These are average widths that can be expected. Each pilot must do his own calibration. Other spraying equipment will have similar tables furnished.

MICROFOIL CALIBRATION OF THE .060 NOZZLES--DUAL FEED

.096" Brass Restricting Orifice				
Gallons Per Minute Delivered				
Boom Length				
Pressure	10 Feet	16 Feet	20 Feet	26 Feet
20 psi	19	30	37	46
25 psi	23	35	44	56
30 psi	24	39	48	61
35 psi	26	42	50	67
40 psi	28	44	54	68

.078" Aluminum Restricting Orifice

Pressure	Gallons Per Minute Delivered			
	Boom Length			
	10 Feet	16 Feet	20 Feet	26 Feet
20 psi	14	22	29	35
25 psi	16	25	33	39
30 psi	18	27	35	45
35 psi	20	30	39	47
40 psi	20	32	40	49

In addition, for aircraft calibration, the height from the ground is very important since the effective swath is largely governed by this factor. Charts are provided for proper speeds and height to cover given heights in aircraft manuals and by the spray equipment manufacturer.

In actual calibration, the pilot should first be sure that the air speed indicator is correct. This can be checked by flying over an automobile at low speeds (15-20-25-30 mph etc.) since aircraft air speed indicators are not very accurate on the low end of the speed range. Once the aircraft speed is known, the volume of spray delivered per minute should be determined in actual flight.

A 50' swath one mile long = 6 acres; a 100' swath one mile long = 12 acres (approx.). Consequently, if 10 gal/acre is desired, it would be necessary to deliver 10 gal/min at 60 mph, using a 26' microfoil boom at 50' height. If the height must be increased, and the swath width increases, then the aircraft must be slowed down or the pressure increased in order to apply the correct amount of spray. Raising the pressure is not advocated since this will often produce fine droplets that drift easily. In checking swath width, it should be measured in the right-of-way since the swath tends to become slightly narrow in areas where trees bound each side of the right-of-way as compared to an open area.

Other factors that influence the application rate - "crabbing" or flying slightly sideways to compensate for air movement will narrow the swath width and cause "streaking" in wide rights-of-way. In general, a pilot learns many of the fine points of spraying with experience and cannot become proficient until he has mastered the many different situations involved in aerial spraying.

Typical cross sections of rights-of-way are shown on pages 22 and 23. Diagrams of aerial spraying on low voltage or "distribution" lines, as well as high voltage or "transmission" lines, are also shown in the diagrams on page . As can be seen from these spraying diagrams with a helicopter is not only useful in controlling weeds and brush underneath the conductors; side trimming of adjacent trees is also accomplished in the same operation. This greatly reduces future trimming costs and aids in preventing electrical outages during wind and ice storms. In spraying operations, one pass is generally made to a given area regardless of the equipment being used on the helicopter. Better results can usually be obtained by flying in both directions, especially with the microfoil boom, but this increases costs/acre. With equipment that delivers higher gallonage with larger droplets one pass is sufficient.

GROUNDLINE RETREATMENT FOR UTILITY POLES

DECAY IN POLES

The decay of treated poles and their eventual failure results from various causes. The primary mechanism, however, is the gradual deterioration of the wood by fungi where the wood has insufficient preservative treatment. Damage by insect attack is usually considered jointly with decay since the preservative treatments are effective against both types of organisms.

By close observation, sounding with a hammer, probing with a blunt screwdriver, and a little practice, it is possible to recognize many of the signs of decay. The following are the most common ones: Deep checks, - Deep, open checks especially over one-half inch wide can signal possible trouble. They serve as entry ports for fungi and insects. Mechanical damage - Wood damaged by vehicles, animals, or by climbing also provides entry points. Fragile, soft outer surface - The wood, especially at the groundline, may be so decayed that it can be pushed in with a blunt screwdriver. Or, it may collapse under the impact of a hammer. Insect holes - Ants and termites may move in and out of poles through small holes or cracks. Ants use the pole for a homesite; termites use the wood for food. Insect damage is usually associated with decay. Large holes or hollows - Decay is usually associated with holes and hollows in the pole. A hammer can be useful in locating hollows. Upon impact, a hollow pole sounds dull producing a low pitch sound; a sound pole produces a higher pitch sound. Loose spongy fiber or charred appearance - This characteristic indicates decay.

Generally, treated poles are most susceptible to decay at or near the groundline where the conditions of moisture, temperature, and air are most favorable for the growth of fungi. Some of the factors that affect pole lie include: the species of wood, type and uniformity of preservative treatment, geographical location, and soil conditions.

PRESERVATIVE TREATMENTS

There are generally two major classes of preservatives: the oil-borne such as creosote or pentachlorophenol in a petroleum solvent and the water-borne such as the arsenates or copper.

GROUNDLINE INSPECTION

Fungi appear to operate best where there is a favorable balance of moisture and air. A lack of either will hinder their growth. Above the groundline, the moisture conditions are usually low most of the time. Therefore, it is more difficult for decay to become established and its development is slow. Far below the ground, air is less available due to soil compaction and higher moisture content. It is the groundline portion of the soil, usually the top 18-24 inches, where much of the decay action occurs. However, caution should be exercised. Under certain conditions, decay can occur at greater depths as well as above the groundline. Once established, decay spreads both up and down from the initial point of attack.

All inspections should be done by well-trained, experienced personnel. Poles to be examined should be excavated to a depth appropriate for the conditions, usually 18 inches or more. The entire surface of the pole should be exposed for viewing. Surface dirt is removed with a wire brush. Surface decay is readily visible to the eye and to the touch by the crumbly nature of the wood. Internal decay may be present without any surface indications. Internal decay can be detected by sounding with a hammer, the use of sonic detectors, and by making increment borings. All borings should be plugged with a tight-fitting, treated dowel and the hole flooded with a preservative prior to plugging.

GROUNDLINE TREATMENTS

Excavated poles should be groundline treated with a supplementary preservative. These supplementary preservatives are of three basic types: Penta - petroleum greases, Water - soluble salts, Penta - petroleum greases combined with water-soluble salts. The major active agents in these preservatives are pentachlorophenol, creosote, sodium fluoride, borate, or arsenates of copper.

For groundline treatment, all possible externally decayed wood should be removed. Apply the paste, gel, or grease as directed by the manufacturer. The preservative is then covered with a wrap of polyethylene coated Kraft paper. The wrap should extend from the bottom of the excavation to about six inches above the ground. The wrap is then stapled or fastened to the pole. There are also commercially prepared bandages.

All precautions should be observed in handling the supplementary preservatives. The directions on the label should be followed closely regarding the handling, storage, and application of the material. Disposal of the empty containers should be in accordance with the label directions.

SAFETY PRECAUTIONS

Use all chemicals products only with adequate ventilation. Do not get the chemical in eyes, on skin, or on clothing. Wash thoroughly with water after handling. Appropriate protective clothing and rubber or other suitable gloves should be used when handling the chemicals or freshly treated wood.

Avoid contamination of feed or food. Keep all chemicals out of lakes, streams, or ponds. Do not contaminate water or soil by improper cleaning of equipment or disposal of wastes. Do not reuse chemical containers; they should be disposed of in accordance with label instructions.

HIGHWAY ROADSIDE VEGETATION MANAGEMENT

Roadside vegetation is necessary for both the proper functioning and protection of the highway installations, as well as the safety of the traffic. Roadsides must be kept in a safe, relatively smooth, erosion free condition. Roadside vegetation should not be permitted to grow to such a size or be in such a location as to block sight distances for the highway user, or grow to such a size as to become an obstacle endangering a vehicle out of control. Grass has proven to be the quickest and most easily established roadside vegetation fulfilling these needs. Some degree of skill is required, however, to produce a tight cover, free of weeds and brush on a low maintenance program.

BENEFITS FROM CHEMICAL CONTROL ON HIGHWAYS

To hold costs within funds available, a minimum of highway mowing is necessary. Many slopes too steep and dangerous to mow, and areas beyond the view of the highway user, are not mowed at all or very sparingly. And yet, such areas, if left unattended for a period of time, will revert to weeds, soon to be followed by briars and brush, then by tree seedlings and trees. In some instances, this regeneration, may be acceptable. In others, it may cause a blocking of sight distances, endanger the safety of traffic, or be aesthetically undesirable. Therefore, if mechanical control of roadside vegetation is to be kept to a minimum, some other means must be employed to prevent the spread of noxious weeds, allergy producing plants, and the development of unwanted brush. Chemical control of vegetation has been successfully adapted to the highway roadside maintenance program with these resulting advantages:

1. Fewer mowings each year, reducing hazard to workmen.
2. Reduction or eradication of poison ivy, ragweed, and other toxic or allergy-producing weeds.
3. Reduction of mosquito breeding places.
4. A contribution to motorist safety by eliminating brush and tall weeds and improving sight distances on curves and at intersections.
5. Grass on the roadside reduces snow drifting on the traveled highway.
6. Elimination of weeds that spread onto adjoining crop areas - important contribution to farm weed control.
7. Removal of cover that lures animals to roadside nesting and resulting traffic traps.

CONTROL OF WEEDS IN WOODY ORNAMENTAL PLANTINGS

Woody plants have deeper and stronger root systems than most flowers and will tolerate the use of stronger weed killer. The three products discussed under flower beds may also be used around various woody plants. Again the label will provide a list of plants for which the product has been tested.

In addition to the above materials, various other preemergent and postemergent herbicides have label clearance for use around woody plants. These products are more generally intended for commercial use. They are usually packaged in larger containers and not as readily available at garden stores as the products mentioned for use in flower beds.

These materials are recommended on the basis of active ingredient. Various formulations differ in their percentage of active ingredient. Granular materials often contain only 5% active ingredient while wettable powders may range from 50 to 80%. It is essential that you apply the correct amount of active ingredient per unit area. Use this formula to convert from active ingredient per acre:

$$\frac{100}{\% \text{ active}} \times \text{Recommended rate of active ingredient per acre} = \text{Product per acre}$$

SPRAYING BY UTILITY COMPANIES NEAR HIGHWAYS

Public Utility Companies will be permitted to spray under their lines on highway right-of-way provided:

1. Spraying is limited to growth which will ultimately grow into the utility lines.
2. Such spraying is approved by the Department.

PROBLEMS IN HIGHWAY SPRAYING

Many miles of state, county, and township roadsides in Virginia has been sprayed for a number of years. Some of the roadsides today, are relatively weed free, and some of the previously mentioned advantages of roadside spraying have been gained. In other instances, patches of certain species of troublesome weeds such as thistles, wild carrot, milkweed, chicory, wild parsnip, kudzu, poison ivy, and ragweed are of concern. Briars (in variety), poplars, and willows are the most bothersome brush items.

The application of herbicides to highway roadsides requires a high degree of skill and alertness from the spray operator. Immediately beyond the right-of-way limits is a constantly changing variety of valuable agricultural and horticultural plant life. Some are highly susceptible to herbicide damage and vary from home flower and vegetable gardens to large acreages of sensitive farm or truck crops. In some instances, the areas beyond the right-of-way are not visible and knowledge of the area being sprayed is highly desirable for the person directing the spray.

No spraying should be done when the wind is more than 5-7 mph, or, in other words, when the breeze is strong enough to blow paper, debris and dust about, or when there is more than a gentle movement of leaves of small twigs of trees.

Booms, off-center nozzles and other points of discharge should be close to ground level. At no time should the spray be discharged when the mixture is drifting or blowing off the right-of-way. Speed of travel should not be so great that the spray pattern is distorted; usually not over 10 miles per hour. Drift control methods discussed earlier are helpful but not a cure for drift problems.

PRECAUTIONS TO BE OBSERVED IN HIGHWAY SPRAYING

No spray should be applied to areas planted with erosion control planting, or to shrubs and trees planted for screen or beautification purposes, or any desirable individual tree or group of trees growing along the roadside. One exception is chemically trimming overhanging branches of multiflora rose or other plants growing over guardrails or delineators.

While it is desired to spray as much as possible of the roadside within the limits described above, it is in the interest of good public relations to prevent damage to crops and plantings on abutting property. Therefore, no spray should be applied on either side of the road bordering:

- a. Homes
- b. Flower Gardens
- c. Vegetable gardens or vegetable crops
- d. Tobacco
- e. Tomatoes
- f. Sugar beets
- g. Grapes

Medians and shoulders of interstate routes can be sprayed with proper equipment at times when primary and secondary roads cannot since these areas are not normally in proximity to sensitive crops or home sites.

EQUIPMENT AND OPERATING PROCEDURES FOR HIGHWAYS

CALIBRATION

Method 1.

Spray volume per acre can be determined by spraying an acre, or known fraction of an acre, at the same pressure and speed under which the sprayer will be operated. The spray discharge is collected during this test run and converted to an acre basis. A 1/10 acre calibration run should be adequate. The following table gives the length of run needed for various spray pattern widths. If the rate of speed is known, this determination can then be done by collecting the spray volume for the length of time required to make the calibration run. The time required to make the 1/10 acre run at 7 mph is also given in the table.

Sprayer Calibration Table

Width of Spray Pattern	Length Needed for 1/10 acre	Time to Make Run at 7 mph
4 ft	1089 ft	1 min. 46 sec.
6 ft	726 ft	1 min. 10 sec.
8 ft	544 ft	53 sec.
10 ft	435 ft	42 sec.
15 ft	290 ft	28 sec.
20 ft	217 ft	21 sec.

Method 2.

The four factors that determine the rate of the herbicide application are: strength of solution, pressure, nozzle used, and speed of the vehicle.

Since the solution is generally mixed according to directions on the label, and the pressure adjusted to be not more than 30 psi, then only the width of the spray pattern and the amount of the mixture delivered in one minute are needed to determine the speed at which to drive the vehicle.

One formula for determining the speed to be used is:

$$\text{MPH} = \frac{\text{GPM} \times 495}{\text{GPA} \times \text{W}}$$

MPH = miles per hour.

GPM = gallons per minute delivered by the nozzle being used.

495 = result of multiplying minutes in hour (60) by width of pattern for one mile which is equivalent of an acre (8.25 ft).

GPA = designated gallons per acre.

W = width of spray pattern as determined by actual trial.

An example is as follows:

Assume that the spray pattern for the nozzle being used is 20 feet wide and the recommended rate of application is 25 gallons per acre. Place the nozzle in a container and, using the normal pressure which will be used in spraying, measure the amount of solution delivered in one minute.

Assuming that five gallons were delivered in one minute, the computation would be:

$$\text{MPH} = \frac{5 \times 495}{25 \times 20} = \frac{2475}{500} = 5 \text{ MPH}$$

In this illustration, the spray vehicle must travel at a speed of approximately 5 MPH in order to deliver 25 gallons per acre to an area twenty feet wide.

Generally, speeds should not be in excess of 6 mph.

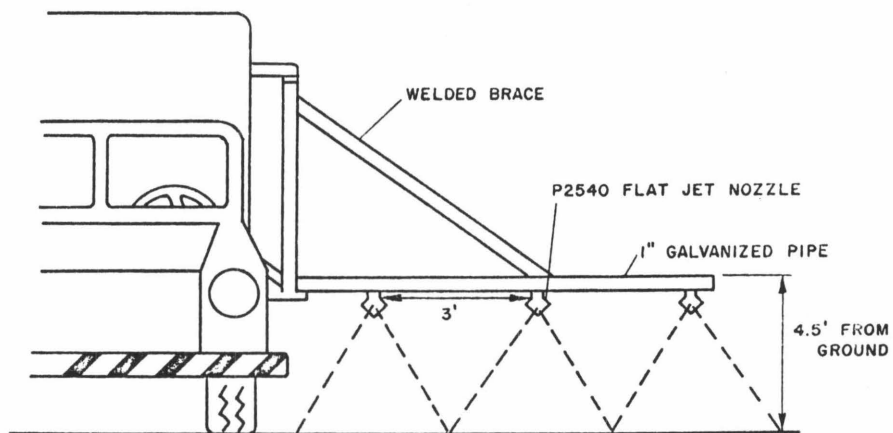
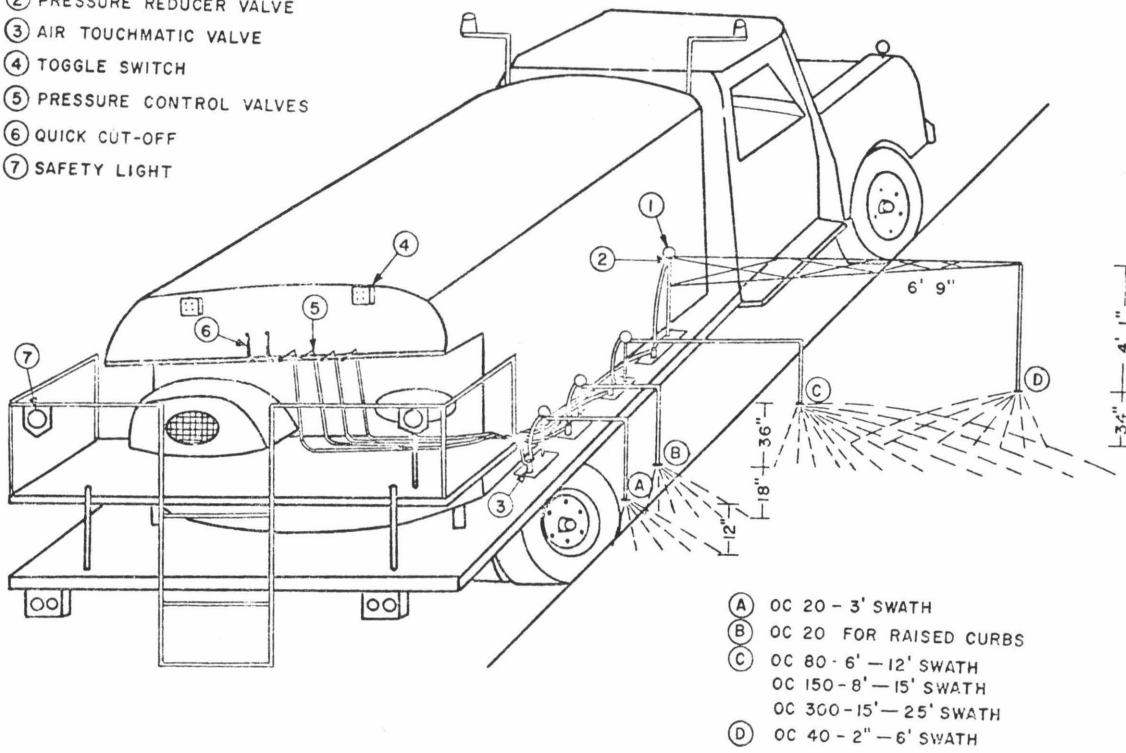
<u>MPH</u>	<u>DISTANCE</u>	<u>TIME</u>
4.00	500 ft	85 seconds
4.25	500 ft	80 seconds
4.50	500 ft	76 seconds
4.75	500 ft	72 seconds
5.00	500 ft	68 seconds
5.25	500 ft	65 seconds
5.50	500 ft	62 seconds
5.75	500 ft	59 seconds
6.00	500 ft	57 seconds
6.25	500 ft	55 seconds
6.50	500 ft	53 seconds
6.75	500 ft	51 seconds
7.00	500 ft	49 seconds

ARRANGEMENT OF PUMPS AND NOZZLES

There are many ways to arrange sprayers on mobile units. An arrangement that has proven satisfactory in Virginia is shown on page with the component parts on page

In general, all control switches, etc. should be in a location where they can be reached easily by an operator standing in one position on the spray rig. For safety, a duplicate control panel should be mounted in the cab of the truck so that major controls can be operated by the driver or another person in case of an emergency.

- ① PRESSURE GAUGE
- ② PRESSURE REDUCER VALVE
- ③ AIR TOUCHMATIC VALVE
- ④ TOGGLE SWITCH
- ⑤ PRESSURE CONTROL VALVES
- ⑥ QUICK CUT-OFF
- ⑦ SAFETY LIGHT



BOOM ARRANGEMENT

PERENNIAL GRASS CONTROL ON HIGHWAYS

ELIMINATION OF PERENNIAL GRASS

Grass control materials find their greatest use on the roadside in the control of Johnsongrass. This plant is a serious menace to agricultural land use, especially in the rich bottom-land areas. It spreads rapidly by seed and can take over an area within a year or two from scattered infestations so that control efforts are necessary if a field is not to be abandoned to it.

Two types of chemicals are used on Johnsongrass. One is a non-selective, the other a systemic type. They may be used in combination. They also may be used for bermudagrass and quackgrass control.

Application is most effective when applied by a spray thoroughly covering, to the point of runoff, Johnsongrass when it is in a rapidly-growing condition, usually in late spring and early summer. Also, applications can be effectively made again in the fall after the plants have been mowed and are making regrowth. Johnsongrass cannot be eliminated from an area with one or two sprays. A program extending over several years is necessary because of the hard seed which has the ability to remain dormant in the soil for years before germinating. Seed formed by the plant after an early summer spraying, on the other hand, has proved to be nonviable.

Another use of these chemicals on the roadside is in the treatment of cattails. Ditches which are nearly flat or in otherwise slow drainage areas often become infested with cattails which further clog the system and add to the problems. The same material or combinations used on Johnsongrass have proven most effective in the control of cattails.

Precautions to be followed in the use of grass control materials:

1. Because these materials are effective on all grasses, they must be directed only on the target species. Desirable roadside grasses will be killed by the spray. Therefore, direct the spray on plants to be killed and shut off spray before moving to another location. Do not trail spray from one spot to another.
2. Do not direct spray into water standing in the ditch or that which may drain into another location.
3. Agricultural crops related to the grasses will be affected by these herbicides. Do not direct the spray or allow it to drift on corn, wheat, oats, rye, or pasture land.
4. Read and follow the instructions and precautions on the label.

Glyphosate is a new herbicide, first granted clearance for industrial use in 1974. It is extremely effective on grasses, but, at higher rates, will kill broadleaf weeds and trees.

Glyphosate enters through the plant leaves and is then carried throughout the plant. It kills slowly and 7-10 days may be required for grass to turn brown. It is water-soluble and, if rain occurs within 8 hours of application, partial loss of effectiveness will occur. A follow-up treatment may be required for complete control. Bermudagrass requires higher rates (3-4 lb/A) for control than Johnsongrass.

Glyphosate has no soil activity and treated areas can be reseeded after one week. In 1974 tests, Johnsongrass infested areas were sprayed with Roundup and seeded with Ky 31 grass into the dead Johnsongrass mulch. No problem was encountered with seedling establishment.

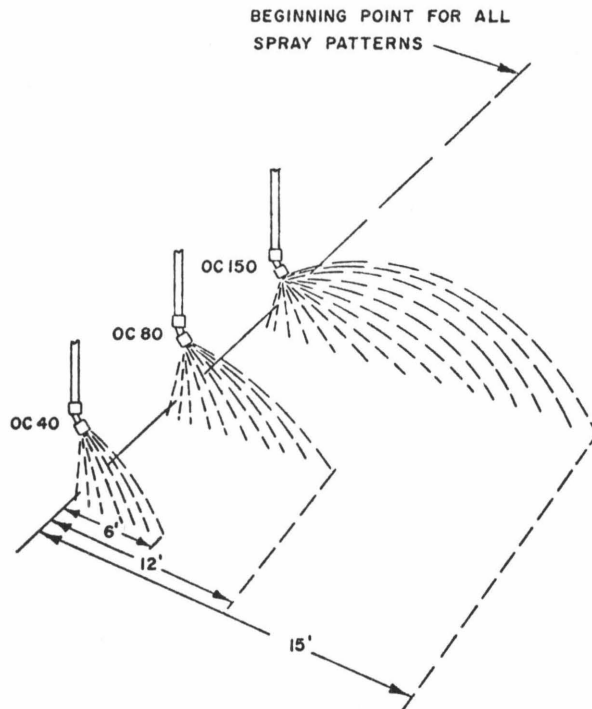
INHIBITION OF PERENNIAL GRASSES

Many grassy areas along highway roadside such as medians and guardrails, are difficult and hazardous to mow. Growth retardants are an excellent way of maintaining healthy roadside vegetation with reduced maintenance. A successful application of growth retardant applied in the early spring will hold Kentucky 31 fescue to a very slow rate of growth and prevent seed head formation. Broadleaf herbicide can be added to the spray mixture to eliminate broadleaf weeds. In many cases, one application of growth regulator and broadleaf herbicide has maintained an acceptable appearance throughout the entire growing season.

Timing of application seems to be rather critical for successful results. If too much growth occurs prior to application, results are only marginally effective. Also, mowing of the treated area tends to shorten the effective life of the retardant. If significant growth has occurred, it is best to mow the area prior to application of the inhibitor. Presence of grass clippings on a mowed area will block a subsequent spray and result in erratic results.

Fall applications of growth inhibitors have given fair results but generally are not as satisfactory as spring applications. Fall applications require increased rates and often give increased browning of the turf.

The two growth inhibitors presently recommended are maleic hydrazide and melfluidide (Embark). Maleic hydrazide has been manufactured for several years and is now sold under a variety of trade name. Both materials are water soluble and must be absorbed through the foliage. Rainfall within 8 hours of application may wash the material from the foliage and cause loss of activity. Rates of application are given in the recommendation section.



NON-SELECTIVE VEGETATION CONTROL ON HIGHWAYS

Non-selective vegetation control is often necessary around substations, pole yards, storage areas, guardrails, buildings, parking areas, railroads, petroleum storage areas, etc. Vegetation in these areas could constitute a fire hazard, public nuisance, health hazard, and breeding area for rodents, as well as reduce public safety and facility security.

Non-selective herbicides are chemicals which eradicate all vegetation and may leave the soil non-productive for a year or more, depending on the chemical selected and the rate used. The material, in most cases, must have the ability to knock down existing vegetation and also prevent or discourage regrowth and germination for a time. The material to be used must be non-corrosive or not detrimental to the materials stored in the area. Likewise, the material selected should have the properties of not moving laterally in the soil. Applications must be in an even pattern at prescribed rates to prevent surface movement and damage to abutting areas and plant life.

FACTORS AFFECTING NON-SELECTIVE HERBICIDE APPLICATIONS

Soils - Herbicides react differently with different soil types. Light soils tend to hold herbicides less; heavy soils retain chemicals more readily.

Sandy soils have the least ability to tie up herbicides; thus, herbicides are available to control weeds faster. However, duration of effective weed control is usually shorter.

Certain heavy soils, or soils high in adsorptive materials, such as charcoal, cinders, or sawdust hold chemicals more readily, causing a reduction in immediate weed killing effect. Therefore, more herbicide is usually required to produce weed control, although a longer period of weed control can be expected. However, these factors are only rarely limiting when careful consideration is given to an overall program.

Moisture - Water is important in chemical weed control. It is a vehicle for application of herbicides to weeds and the soil. Non-selective-type chemicals must be in solution in water before they can enter the root system of plants. If heavy rainfall prevails, water can leach most of the chemical from the upper surfaces of the soil and reduce its effectiveness. In lower rainfall areas, less chemical is usually required.

Vegetation Types - The type and species of vegetation also influence the selection of the chemical because of the tolerance of certain plants to certain chemicals. Annual weeds and grasses originate from seeds in the surface of the soil, and can be controlled with low rates of residual-type herbicides. Perennial vegetation has root systems which live from year to year in the soil so that either translocated specific herbicides or non-selective chemicals at higher dosages are required for control.

It may be necessary to add other chemicals, such as contacts, systemics or surfactants to give rapid control where existing vegetation is present.

Soil Microorganisms - Bacteria and fungi in soils which feed on vegetation control chemicals and shorten their period of effectiveness. However, this is not exceptional since it is normal for microorganisms to attack organic matter as a source of food. This means that annual application under most circumstances is more effective.

APPLICATION METHODS

Spray volumes - For initial weed control and elimination most recommendations are for a minimum of 100g of solution per acre. If extremely tall or heavy vegetation is to be treated, it may be necessary to use as much as 400 gallons of water per acre. Application with a boom usually required less material than application with a hand gun. Each job should be inspected before making any application to determine the type of vegetation to be controlled, the size and density of the vegetation, the type of equipment required, etc.

Granules or Pellets can be applied by hand or mechanical means.

MATERIALS DESIGNED TO BE APPLIED WITH WATER

Water soluble materials do not require mechanical agitation. Wettable powders normally do require mechanical agitation. Since most sterilants are applied to the ground rather than the foliage, it is not necessary to use high pressure. Nozzle sizes large enough to give large spray droplets in a coarse spray should be used. Pressure should be adjusted to give a uniform, even pattern. (Normally 30 to 60 lbs.) Calibrate equipment to apply the correct amount of material per acre. Over-application can result in damage to adjacent areas; under-application may not give adequate control. Pressure, the size and number of nozzles, and speed all affect the quantity of liquid to be applied per acre. After adjustment, make a trial run with water only. Spray a measured area and convert the gallons used to gallons per acre. Make any necessary adjustments and proceed. This should insure correct calibration.

If the equipment being used to apply sterilants is to be used for applying other type herbicides, it should be thoroughly cleaned and flushed several times with clean water.

VEGETATION IN PAVEMENT CRACKS AND JOINTS

Herbicides may be used on vegetation growing in pavement cracks, joints, curbs and land dividers. The growing plant roots can exert great force in causing pavement cracks to widen, then also allow moisture to enter and contribute to deterioration. Before pavement cracks can be sealed, or a watertight bond made between pavement and shoulder, vegetation must be removed. A combination of materials are generally used for this purpose. Generally, a nonselective knock down, a broadleaf herbicide, and possibly a grass control material are combined for this purpose and applied a sufficient time ahead of the intended pavement work so that the vegetation has completely disappeared.

Precautions to be followed in this work would be to make sure they are not applied in such a volume so as to drain from the pavement surface onto adjacent vegetation or so that the material may leach through the roadbed drains into the ditch or onto desirable roadside cover.

Paraquat or Roundup and a residual type herbicide such as diuron, is a good combination for this purpose.

SOME OF THE DO'S AND DON'TS IN APPLICATION OF STERILANTS

Do not apply near trees or shrubbery where their root systems may extend into treated area.

Do not apply to frozen ground. The material will not be absorbed into the soil and most often will be carried to an area where it is not desirable.

Be extremely careful in applying material on slopes. Heavy rain may cause lateral movement and damage adjacent areas. Non-selective herbicides should not be allowed to move or leach into streams, rivers, etc. This can result in severe damage to adjacent lands.

Use low pressure - High pressure applications often result in severe damage due to drift.

RAILROAD SPRAYING

RAILROAD ROADBEDS

Signal control areas, switching and car storage yards are usually sprayed with special on-track equipment using complete vegetation control materials. Brush control along rights-of-ways is also done with on-track equipment since most of the rights-of-way are inaccessible to surface vehicles. Signal lines and power lines can be sprayed by aerial equipment if desired.

Roadbeds and yards can be sprayed with any of the non-selective materials mentioned elsewhere, in this manual. In general the chemicals used should:

1. Be effective against annual and perennial weeds and grasses and give control of these plants for at least one season.
2. Be relatively stable and resist leaching onto adjacent desirable vegetation.
3. Be non-poisonous to livestock and to aquatic animals.
4. Be relatively inexpensive.

In order to control a wide variety of species herbicide mixtures are generally used. Combinations generally used contain contact and residual type herbicides. Residual type chemicals often used are diuron, various triazines, bromacil, monuron, and boron. Contact chemicals available are various weed oils, paraquat, and cresol-based chemicals. Mixtures also may contain 2,4-D, 2,4,5-T, picloram, dicamba, and silvex for controlling broadleaf annual and perennial weeds.

Roadbeds, yard, etc. are usually sprayed fairly early in the season before extensive growth takes place and the residual herbicides in the mixture can prevent new seedlings from germinating. This procedure is designed to keep vegetation growth at a minimum all season so that operation of maintenance equipment will not be hampered.

Not only do weeds and grass in roadbeds and yards hinder normal operation of personnel and equipment, but the roots penetrate the supporting aggregate and cause poor drainage which softens the roadbed and greatly reduces the amount of weight the rails and cross ties can support.

Spraying roadbeds is usually accomplished by mounting a boom on the rear of a spray car with the nozzles spaced at the desired height and width to cover the determined volume of spray. Calibration of such equipment is relatively simple since the height remains fairly constant and constant speed and pressure can be easily maintained. Large tank cars can easily be carried along thus assuring a constant supply of chemical. The application of this type of spray is diagrammed on page

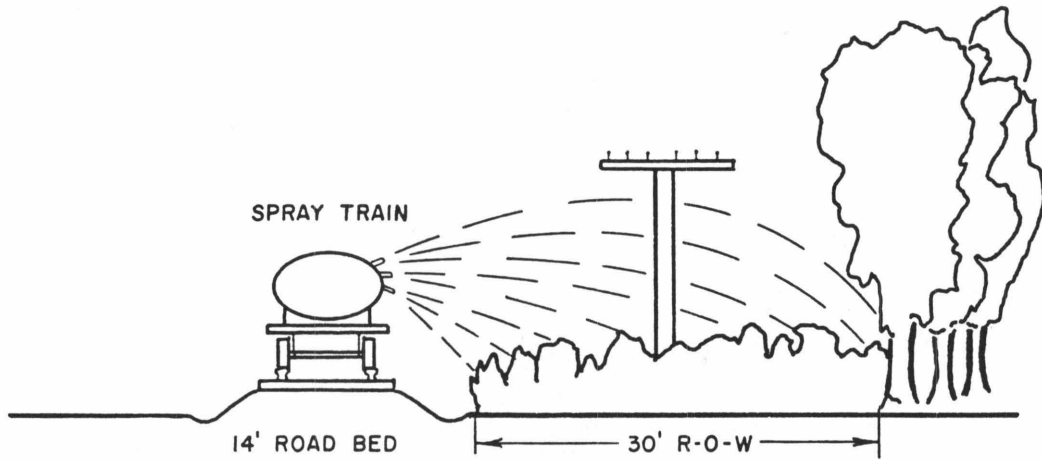
Dry or granular applications are sometimes used and can be applied by a spreader attached to the rear of a flat car or other suitable on-track equipment. Dry applications should be made during the winter or early spring in order to control grass and weed seedlings as they germinate. As with spray mixtures, two or more dry herbicides are usually mixed together in order to control a wider variety of weeds and grasses.

SIGNAL LINES, CUTS, FILLS, AND OTHER AREAS

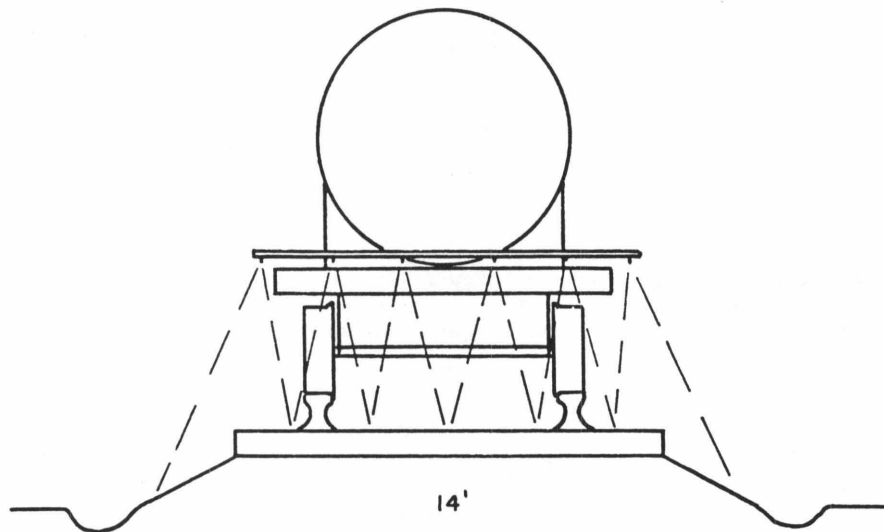
In the railroad right-of-way are sprayed with selective herbicides so that a grass cover can be maintained to prevent soil erosion. Woody plants or brush are the major plants to be controlled since they grow rapidly and reach a height that reduces sight and interferes with signal and power line operation. The area in which brush must be controlled varies considerably but often is 100' or more on each side of the track, depending on the degree of slope. Most of this area can be reached with high pressure sprayers operated from on-track equipment. High cuts and fills, tunnels, etc., must be treated with off-track equipment. Diagrams on pages and shows methods of treating railroad rights-of-way.

Chemicals used for brush control are the same as mentioned earlier on other types of right-of-way brush control. The same precautions are necessary as with other types of ground spraying. Since extremely high pressures are used with on-track brush spraying equipment, it is wise to use some type of drift control additive in the mixture.

TYPICAL RAILROAD R-O-W
SPRAYING WITH ON TRACK EQUIPMENT



SPRAYING ROADBED WITH SOIL STERILANTS



ABBREVIATIONS OF TERMS USED IN PLANT GROWTH CONTROL

A	acre(s)	min	minute(s)
ae	acid equivalent	ml	milliliter(s)
ai	active ingredient	mm	millimeter(s)
ec	emulsifiable concentrate	mph	miles per hour
ft (')	foot or feet	oz	ounce
g	grams(s)	ppm	parts per million
gal	gallon(s)	psi	pounds per square inch
gpa	gallons per acre	pt	pint(s)
pgm	gallons per minute	qt	quart(s)
hr	hour(s)	rpm	revolutions per minute
ht	height	sq	square
in (")	inch(es)	tech	technical
L	liter(s)	temp	temperature
lb	pound(s)	wt	weight
lve	low volatile ester	wp	wettable powder
mg	milligram(s)		

CONVERSION FACTORS FOR ENGLISH AND METRIC UNITS

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
<u>Length</u>			
0.621	kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in	2.54
<u>Area</u>			
0.336	kilometer ² , km ²	mile, ² , mi ²	2.590
247.1	kilometer ² , km ²	acre, acre	0.00405
2.471	hectare, ha	acre, acre	0.405
<u>Volume</u>			
0.00973	meter ³ , m ³	acre-inch	102.8
3.532	hectoliter, hl	cutic foot, ft ³	0.2832
2.838	hectoliter, hl	bushel, bu	0.352
0.0284	liter	bushel, bu	35.24
1.057	liter	quart (liquid), qt	0.946
<u>Mass</u>			
1.102	ton (metric)	ton (English)	0.9072
2.205	quintal, q	hundredweight, cwt (short)	0.454
2.205	kilogram, kg	pound, lb	0.454
0.035	gram, g	ounce (avdp), oz	28.35
<u>Pressure</u>			
14.50	bar	lb/inch ² , psi	0.06895
0.9869	bar	atmosphere*, atm	1.013
0.9678	kg (weight)/cm ²	atmosphere*, atm	1.033
14.22	kg (weight)/cm ²	lb/inch ² , psi	0.07031
14.70	atmosphere*, atm	lb/inch ² , psi	0.06805

CONVERSION FACTORS FOR ENGLISH AND METRIC UNITS

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<u>Length</u>			
0.621	kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in	2.54
<u>Area</u>			
0.336	kilometer ² , km ²	mile ² , mi ²	2.590
247.1	kilometer ² , km ²	acre, acre	0.00405
2.471	hectare, ha	acre, acre	0.405
<u>Volume</u>			
0.00973	meter ³ , m ³	acre-inch	102.8
3.532	hectoliter, hl	cubic foot, ft ³	0.2832
2.838	hectoliter, hl	bushel, bu	0.352
0.0284	liter	bushel, bu	35.24
1.057	liter	quart (liquid), qt	0.946
<u>Mass</u>			
1.102	ton (metric)	ton (English)	0.9072
2.205	quintal, q	hundredweight, cwt (short)	0.454
2.205	kilogram, kg	pound, lb	0.454
0.035	gram, g	ounce (avdp), oz	28.35
<u>Pressure</u>			
14.50	bar	lb/inch ² , psi	0.06895
0.9869	bar	atmosphere,* atm	1.013
0.9678	kg (weight)/cm ²	atmosphere,* atm	1.033
14.22	kg (weight)/cm ²	lb/inch ² , psi	0.07031
14.70	atmosphere,* atm	lb/inch ² , psi	0.06805
<u>Yield or Rate</u>			
0.446	ton(metric)/hectare	ton(English)/acre	2.240
0.891	kg/ha	lb/acre	1.12
0.891	quintal/hectare	hundredweight/acre	1.12
1.15	hectoliter/ha, hl/ha	bu/acre	0.87
<u>Temperature</u>			
$\frac{9}{5} \text{ }^{\circ}\text{C} + 32$	Celsius	Fahrenheit	$\frac{5}{9} (\text{ }^{\circ}\text{F} - 32)$
-17.8C		OF	
OC		32F	
20C		68F	
100C		212F	

ENGLISH VS. METRIC UNITS

<u>English System</u>			<u>Metric System</u>
Linear Measure			
1 inch	=	2.54	centimeters
1 foot	=	3.048	decimeters or
		0.3048	meters
1 yard	=	0.9144	meters
1 mile	=	1609.35	meters or
		1.6094	kilometers
Liquid Measure			
1 fluid ounce	=	29.573	milliliters
1 quart	=	0.9463	liters
1 gallon	=	3.7856	liters
Square Measure			
1 square inch	=	6.452	square centimeters
1 square foot	=	9.29	square decimeters or
		0.0929	square meters
1 square yard	=	0.8361	square meters
1 square mile	=	2.59	square kilometers
Cubic Measure			
1 cubic inch	=	16.3872	cubic centimeters
1 cubic foot	=	0.0283	cubic meters
1 cubic yard	=	0.7646	cubic meters
1 cubic mile	=	4.1782	cubic kilometers
Dry Measure			
1 peck	=	8.8096	liters
1 bushel	=	35.2384	liters
1 gallon	=	268.8	cubic inches
1 cubic foot	=	6.42	gallons
1 cubic foot	=	1728.00	cubic inches
1 cubic yard	=	46656.00	cubic inches
1 gallon	=	.005761	cubic yards
Weights			
1 grain	=	0.0648	grams
1 avoirdupois	=	28.3495	grams

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
0.446	ton (metric)/hectare	ton (English)/acre	2.240
0.891	kg/ha	lb/acre	1.12
0.891	quintal/hectare	hundredweight/acre	1.12
1.15	hectoliter/ha, hl/ha	bu/acre	0.87
$\frac{9}{5} (^{\circ}\text{C} + 32 \text{ Celsius})$		Fahrenheit	$\frac{5}{9} (^{\circ}\text{F}-32)$
-17.8C		0F	
0C		32F	
20C		68F	
100C		212F	

CHEMICALS COMMONLY USED ON RIGHTS-OF-WAY

HERBICIDES

Material	Trade Name	Description
Amitrole	Amitrole, ATA Weedazol, Cytrol	Postemergence, non-selective herbicides, readily absorbed by leaves and stems, very effective on poison ivy, grasses. Short residual.
Ammonium sulfamate	Ammate X, AMS Ammate X, Ni	Contact herbicide for weeds and grasses, water soluble, very corrosive. Non-volatile. Non-inhibited ammonium sulfamate for use around reservoirs.
Atrazine	Various	Selective, post and preemergence, controls broadleaf weeds and grasses, shorter residual than simazine.
Bromacil	Hyvar X	Pre- and postemergence, non-selective, controls wide range of weeds, long residual, rainfall required. Particularly effective on grass.
Dacthal	Dacthal	Preemergence, non-soluble, incorporation increases efficiency, controls crabgrass. Seed beds and around ornamentals.
Dalapon	Dowpon, Radapon	Systemic grass control agent, use with wetting agent, short residual, compatible with other herbicide.
Dicamba Dicamba + 2,4-D Dicamba + 2,4,5-T Dicamba + 2,4-D + MCP	Banvel D Banvel 720 Banvel 510 Trimec	Pre- and postemergence, selective, slightly water soluble, use on perennial weeds in turf, compatible with other herbicides. Effective on woody vegetation.
Dichlobenil	Casoron	Preemergence, selective, incorporation increases residual, not compatible. Used mainly on ornamental plantings.

Material	Trade Name	Description
Diphenamid	Dymid, Enide	Preemergence, selective on grasses and some broadleaf weeds, 6 months residual. Used mainly on turf areas and seed beds.
Diquat	Ortho Diquat	Non-selective, contact, water soluble, inactivated on contact with soil, avoid drift and use near crops and animals, do not mix with wetting agents. Mainly for aquatic weeds.
Diuron	Various	Non-selective herbicide, use on crabgrass foxtail, etc. Long residual, slow working, needs continuous agitation in water.
Erbon	Baron	Non-selective, pre- and postemergence, translocated.
Fenavar	Fenavar	Combination of amitrole, fenac and bromacil, non-selective, long residual, industrial use on deep rooted perennial weeds, water soluble.
Glyphosate	Roundup	Perennial grass control - also kills all vegetation at higher rates.
Karbutilate	Tandex	A non-selective herbicide effective on annual, perennial, and woody vegetation by a systemic root action. May be applied as granules or spray.
Monuron	Telvar	Selective preemergence or non-selective with long residual. Requires agitation.
Paraquat	Ortho Paraquat	Non-selective, contact, inactivated upon soil contact, use with surfactant.
Phosamine	Krenite	Postemergence for woody plants. Kills most species. Has little or no residual properties.
Picloram	Tordon 101, Tordon 155, Tordon 10K, Amidon 101	A translocated herbicide very effective on root suckering species. Ash and oak show resistance. Short residual in soil, avoid use around tobacco, soybeans, etc.
Silvex	Kurosol, Weedone	Selective, pre- and postemergence, use on broadleaf weeds and brush, longer residual than 2,4-D.
Simazine	Various	Preemergence, selective, use on broadleaf weeds and grasses in ornamentals, one year residual.
Sodium arsenate	Atlas "A"	Non-selective, very soluble in water, not for home use, very poisonous to man and animals, take all precautions when using.
Sodium TCA	Various	A contact grass killer which acts as a temporary soil sterilant at high rates. Effective on weedy perennial grasses.
Tebuthiuron	Spike	Non-selective - relatively short lived in soil.
2,4-D Dichlorophenoxy- acetic acid	Various	This herbicide is in many ways an ideal vegetation killer. It is effective at small concentrations on many plants, highly selective, non-toxic to man, livestock or wildlife, non-corrosive to equipment, inexpensive, and easy to apply. In this climate, 2,4-D will not accumulate in the soil or affect it unfavorably. The heaviest doses are decomposed in the soil in 15-60 days. In dry soils and climates it may last all season. It has no unfavorable effect on soil bacteria or other microorganisms. Farm or game animals (including fish), insects and man are unaffected by 2,4-D except in doses far above those received through any herbicide use.

Material	Trade Name	Description
2,4-D + 2,4-DB	Brush Killer-170	LV ester of 2,4-D and 2,4-DP containing two pounds of each per gallon. For use where 2,4,5-T is considered hazardous such as on irrigation ditch banks or near potable water supplies. It is an effective brush killer on all species except maple when applied as a foliage spray.
2,4,5-T Trichlorophen- oxyacetic acid (Banned 2/28/79)	Various	There are many other compounds similar to 2,4-D, with similar general properties as just described and similar in control of vegetation. The most important of these is 2,4,5-T. It differs from 2,4-D only in having three chlorine atoms in its molecule instead of two, hence tri- instead of di-chlorophenoxyacetic acid. This compound is much more effective than 2,4-D on many woody plants and so is of major importance in woody plant control. On the other hand it is less effective than 2,4-D on some plants and has about the same effect as 2,4-D on many other plants. These two compounds, 2,4-D and 2,4,5-T, are today the most important in brush control and are often still further abbreviated to D and T. They are frequently sold and used in mixtures of the two, which are often called "brush killers." Vendor should certify that material contains 0.5 ppm or less of the dioxin tetrachlorodibenxoparadioxin.
Weed oils	Various	General contact herbicide, flammable, some types can be made selective, combination with oil-soluble herbicides are good, short residual.

POISON CONTROL INFORMATION

VIRGINIA'S POISON CONTROL CENTERS

City	Name and Address	Telephone	Director and Assistant Director
STATE COORDINATOR	State Department of Health	770-4706	Raymond D. Bath, M.D.
ALEXANDRIA	Poison Control Center Alexandria Hospital	931-2000 Ext. 555	James D. Mills, M.D. William J. Weaver, Jr., M.D.
ARLINGTON	Poison Control Center Arlington Hospital 5129 N. 16th St. 22205	524-5900 Ext. 662, 751	William D. Dolan, M.D.
BLACKSBURG,	Poison Control Center Montgomery County Community Hospital Route 460 S. 24060	951-1111 Ext. 120	J. T. Showalter, M.D. C. M. Caldwell, M.D.
CHARLOTTESVILLE	Poison Control Center University of Virginia Hospital Box 307 Pediatric Clinic 22903	924-2231	W. G. Thurman, M.D. William T. Neikirk, M.D.

City	Name and Address	Telephone	Director and Assistant Director
DANVILLE	Poison Control Center Danville Memorial Hospital 142 S. Main St. 22201	793-6311 Ext. 257	James F. Burch
FALLS CHURCH	Poison Control Center Fairfax Hospital 3300 Gallows Road 22046	698-3111	R. Leidelmeyer, M.D.
HAMPTON	Poison Control Center Dixie Hospital Vicotria Blvd.	722-7921 Ext. 258, 259	Thomas W. Sale, M.D. Frank Freda, M.D.
HARRISONBURG	Poison Control Center Rockingham Memorial Hospital	434-4421 Ext. 225	Charles C. Powel, M.D. Robert L. Miller, R.Ph.
LEXINGTON	Poison Control Center Stonewall Jackson Hospital 22043	463-3131	F. A. Feddeman, M.D.
LYNCHBURG	Poison Control Center Lynchburg General Marshall Lodge Hospital, Inc. Tate Springs Road 24504	846-6511	Frank Daniel, M.D
NASSAWADOX	Poison Control Center Northampton-Accomac Memorial Hospital 23413	442-2011	Blaine S. Daugherty, R.PH. Elizabeth F. Shrieves, R.N.
NORFOLK	Poison Control Center Office of Chief Medical Examiner 427 E. Charlotte St. 23510	625-1306 Ext. 4 627-3238	Ramon A. Morano
PETERSBURG	Poison Control Center. Petersburg General Hospital Mt. Erin & Adams Sts.	732-7220 Ext. 327, 328	Barbara Bolte, Hospital Pharmacist
PORTSMOUTH	Poison Control Center U.S. Naval Hospital 23708	397-6581 Ext. 425, 426, 427	James Hughes, M.D. Joseph Boudreaux, R.Ph.
RICHMOND	Poison Control Center Medical College of Virginia 1200 E. Broad St. 23219	770-5123	Gordon Kellett, Resident
ROANOKE	Poison Control Center Roanoke Memorial Hospital Bellevue & Lakes Avenues 35025	981-7000 Ext. 229, 228	Andrew C. Shapiro William H. Flannigan
STAUNTON	Poison Control Center King's Daughters' Hospital 1410 N. Augusta St. 24401	885-0361 Ext. 247, 289	Gerald L. Selph, R.Ph. John F. Knapp, R.Ph.

City	Name and Address	Telephone	Director and Assistant Director
WAYNESBORO	Poison Control Center Waynesboro Community Hospital 501 Oak Avenue	942-8355 Ext. 436, 440	William C. Kappes, M.D. R. David Anderson, R.Ph.
WILLIAMSBURG	Poison Control Center Williamsburg Community Hospital Mt. Vernon Avenue, Drawer H 23185	229-1120 Ext. 65	John S. Fletcher, M.D

In addition to the Poison Control Centers located in Virginia, other sources of information may be helpful.

The Pesticide Coordinator at VPI & SU is Dr. Norman Lau (phone 961-6543). He has considerable pesticide information on file, but the information available through his office is not intended to be of an emergency nature.

In case of highway accidents involving spills of pesticides, there is a Pesticide Safety Team Network that can be reached by dialing 800-424-9300. This network does not supply general toxicology information and is designed only to handle major spills or fires involving pesticides.

Several chemical companies maintain a specialist to handle emergency calls relating to the use of their product.

REPORTS AND RECORDS

Daily and even hourly records should be kept on all commercial pesticide applications. These are very important for checking on rate of chemicals applied, effects of weather conditions on results, and most important of all, to provide factual information in the event of damage claims.

Reports of damage claims should be prompt and complete. All claims should be investigated by the person in charge of the spraying operation upon receipt of a claim and reported promptly to his supervisors. Most claims can be settled amiably if handled promptly and efficiently.

CHEMICAL DAMAGE CLAIM REPORT

CLAIMANT	Name _____ Phone _____ Complete Address _____
TIME PLACE EQUIPMENT CREW	Date _____ Time _____ a.m., p. m. Route _____ County _____ Truck & Type Spray Equipment _____ Driver _____ Spray Operator _____ Foreman _____
THE DAMAGE	Nature and extent of damage: Describe fully, to include name of plants, trees, livestock, etc. for which damage is claimed. Use reverse side for sketches, distances from spraying operation, additional information.
INVESTIGATION	Made by: _____ Name _____ Should investigation also be made by an expert in this field? _____ Should samples of damaged plant materials be collected as evidence? _____
ACTION TAKEN DATE	Date _____
DATE CLOSED	Date _____

CHEMICAL APPLICATION REPORT

LINE OR ROUTE _____ COUNTY _____ DATE HERBICIDE APPLIED _____

LOCATION FROM: (Town) _____ TO: (Town) _____

CONTRACTOR OR JOB NO. _____

WHERE APPLIED (Median, guardrail, pole or structure no., milepost) _____

SPRAY OBJECTIVE (Grass, Broadleaf Weeds, Brush, Insect Control) _____

NUMBER MILES TREATED _____ NUMBER ACRES TREATED _____

WIDTH OF SPRAY APPLICATION _____ FEET _____

CHEMICAL USED (2,4,-D, 2,4,5-T, Bromacil, Maleic Hydrazide, or other) _____

TRADE NAME FROM LABEL (Retard, D-Cut, Slo-Grow, Hyvar X, Dacamine, etc.) _____

MANUFACTURER _____

TYPE OF SPRAY EQUIPMENT USED (Myers 1000 gallons with off-center nozzle, Handgun, Helicopter) _____

APPLICATION RATE PER ACRE (Pounds, Gallons) _____ MPH, PRESSURE _____ PSI

AMOUNT OF HERBICIDE MATERIAL USED (Pounds, Gallons) _____

DATE EQUIPMENT WAS CALIBRATED _____ NUMBER GALLONS OUPUT WHEN CALIBRATED _____

WEATHER CONDITIONS AT APPLICATION (Temperature, Cloudy, Rain, Bright, Wind, etc.) _____

BRIEF DESCRIPTION OF WEATHER CONDITIONS FOR SEASON PRIOR TO APPLICATION _____

REMARKS FOR FUTURE USE: DESCRIBE RESULTS AFTER CHEMICAL WAS APPLIED (Did chemical give desired control?) _____

EQUIPMENT OPERATOR _____

APPLICATION SUPPERVISED BY _____

GLOSSARY OF TERMS RELATING TO BRUSH AND WEED CONTROL

- Abrasion - The process of wearing away by rubbing.
- Abscission - Natural separation of fruit, leaves, or stems from a plant.
- Absorption - Pesticide entrance into a plant, animal, or soil.
- Accumulative Pesticides - Those chemicals which tend to build up in animals or the environment.
- Acid Equivalent - The amount of active ingredient in a herbicide expressed in terms of the parent acid.
- Activate - To cause the herbicide to have toxic effects upon plants, usually done by rainfall or mechanical incorporation carrying the herbicide into the soil solution where it is available for root absorption.
- Active Ingredient - The chemicals in a product that are responsible for killing the pest.
- Activator - A chemical added to a pesticide to increase its activity.
- Acute Oral Toxicity LD₅₀ - In toxicity studies, it is the dosage required to kill 50% of the test animals when given a single dosage by mouth. The dose is represented by the weight of the chemical per unit of the body weight. Low LD₅₀ = more than 5000 mg/kg, moderate LD₅₀ = 500 to 5000 mg/kg, moderately high LD₅₀ = 50 to 500 mg/kg, highly toxic LD₅₀ = less than 50 mg/kg. The lower the LD₅₀ value, the greater the toxicity.
- Adherence - Sticking to a surface.
- Adhesive - A substance that will cause a spray material to stick to the sprayed surface, e.g., sticking agent.
- Adjuvants - Products combined with spray materials to act as wetting or spreading agents, stickers, penetrants, emulsifiers, etc., aiding in the action of the toxic materials.
- Adsorption - The adhesion by dissolved or suspended material to the surface of a solid (the soil micelle or organic matter).
- Adulterated - Any pesticide whose strength or purity falls below the quality stated on its label. Also, a food, feed, or product that contains illegal pesticide residues.
- Aerobic - Living in air. The opposite of anaerobic.
- Aerosol - An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulation used to produce a fine mist.
- Amine - An organic compound containing hydrogen derived from ammonia by replacing one or more hydrogen atoms by as many hydrocarbon radicals.
- Amine Salt - An amine salt is prepared by the neutralization of 2,4-D, 2,4,5-T or similar compounds with an amine. These are usually liquid formulations.
- Agitation - The process of stirring or mixing in a sprayer.
- Alkaloids - Chemicals present in some plants. Some are used as pesticides.
- Annual - A plant that completes its life cycle from seed in one year.
- Antagonism - The loss of activity of a chemical when exposed to another chemical.
- Antidote - A practical treatment for poisoning, including first aid.
- Aqueous - A term used to indicate the presence of water in a solution.
- Arsenicals - Pesticides containing arsenic.

Glossary (Cont'd.)

- Band Treatment - A treated strip extending a few inches on each side of a guardrail or similar structure.
- Basal Treatment - An application to the stems of plants at and just above the ground line and including application to root collar and exposed roots.
- Biennial - A plant that completes its life cycle in two years. The first year it produces leaves and stores food. The second year it produces flowers and seeds.
- Boot Stage - When the seed head of a grass begins to emerge from the earth.
- Broadleaf Weeds - Generally dicotyledenous plants having netting-veined leaves with a distinct blade and petiole and with cambium and phloem near the circumference of the stem.
- Carcinogenic - Can cause cancer.
- Carrier - The liquid or solid material added to a chemical compound to facilitate its application.
- Chlorinated Hydrocarbon - A synthetic organic pesticide that contains chlorine, carbon, and hydrogen. Same as organochlorine.
- Chlorosis - The yellowing of a plant's green tissue.
- Chronic Toxicity = Prolonged illness caused by a poison; it may be mild or eventually fatal, depending on the amount of poison absorbed. Chronic toxicity may be caused by a single dose or by repeated doses, depending mainly on what compound is involved.
- Common Chemical Name - A well-known, simple name of a pesticide accepted by the Pesticide Regulation Division of the Environmental Protection Agency. Examples: carbaryl, atrazine, benomyl.
- Compatible - When two or more chemicals can be mixed without affecting each other's properties or harming the target, they are said to be compatible.
- Concentration - The amount of active ingredient or acid equivalent in a given volume or liquid or in a given weight of dry material.
- Contact Herbicide - An herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.
- Contaminate - To make impure or to pollute.
- Corrosion - The process of wearing away by chemical means.
- Creeping Perennial - A perennial plant that reproduces by both seeds and asexual means (rhizospores, stolons, etc.).
- Deciduous Plants - Perennial plants that lose their leaves during the winter.
- Defoliant - A compound which causes the leaves, or foliage, to drop from the plant.
- Degradation - The process by which a chemical is reduced to a less complex form.
- Dermal - Of the skin; through or by the skin.
- Dermal Toxicity - Ability of a chemical to cause injury when absorbed through the skin.
- Desiccant - A compound that promotes dehydration of plant tissue.
- Detergent - A chemical (not soap) having the ability to remove soil or grime. Household detergents can be used as surfactants in herbicide sprays.
- Dilute - To make a pesticide thinner or weaker by adding water, oil, or other materials; to "water down."
- Directed Application - Applying of a pesticide to a restricted area, such as a basal brush spray.

Glossary (Cont'd.)

- Dissolve - Usually refers to getting solids into suspension and/or solution necessary for uniform application.
- Dormant - State of inhibited growth of seeds or other living plant organs due to internal causes.
- Dormant Spray - Pesticide application made before trees and other plant life begin to leaf-out in the spring.
- Dose, Dosage - Quantity of a pesticide applied.
- Drift - The movement of material outside the intended target area, usually as fine droplets.
- Emergence - Refers to the time when the first leaves of the plant appear above the soil surface.
- Emulsifiable Concentrate (EC) - A formulation produced by dissolving the toxicant and an emulsifying agent in an organic solvent. The resulting mixture can then be sprayed with either water or oil as a diluent.
- Emulsifier - A chemical which aids in suspending one liquid in another.
- Emulsifying Agent - A surface active material which facilitates the suspension of one liquid in another.
- Emulsion - The suspension of one liquid as minute globules in another liquid; for example, oil dispersed in water.
- Epinasty - Distortion of stems and leaves from sublethal herbicide applications, drift, or volatility.
- Eradication - Complete elimination of a living organism from a specified area.
- Ester - An ester is a combination of inorganic acids such as 2,4-D or 2,4,5-T and an alcohol.
- Ethers - Organic compounds in which the two hydrocarbon radicals are jointed through an atom of oxygen.
- Extender - A material added to an herbicide formulation to extend its activity. This usually results in quicker activity, greater activity, and a broader range of activity. Example: oil added to foliage sprays.
- Foliar Application - Pesticides which are applied to the stems, leaves, needles, or blades of a plant.
- Formulation - Refers to the form in which the herbicide is used. Herbicides are formulated to be applied as (1) solutions of water -- liquid concentrates of soluble powders; (2) solutions of oil -- liquid oil concentrates; (3) emulsions -- emulsifiable liquid concentrates; (4) suspension -- wettable powders; (5) dry -- granules or dust.
- Fungistat - A chemical that keeps fungi from growing.
- Germination - Process of beginning vegetative growth, often referring to the beginning of growth from a seed.
- GPA - gallons per acre.
- GPM - gallons per minute.
- Granules - Pesticide formulation in which the active ingredient is impregnated on small particles of clay, corn cob, wheat stalk, or other carrier. Usually more expensive than equivalent liquid.
- Grassy Weeds - Weeds belonging to the grass family, characterized by round jointed stems, sheathing leaves, which are parallel veined, and flowers borne in spikes.
- Growth Regulator - An organic substance effective in minute amounts for controlling or modifying plant processes.
- Hard Water - Water which contains certain minerals, usually calcium and magnesium sulfates or carbonates in solution, to the extent of causing a precipitate rather than a lather when soap is added. Very hard water may cause objectionable precipitate to form in some herbicidal sprays.

Glossary (Cont'd.)

Herbaceous Plant - A vascular plant that does not develop woody tissue.

Herbicide - Any compound used to kill or inhibit the growth of a plant.

Hormone - A growth regulating substance occurring naturally in plants or animals. Also, refers to certain man-made or synthetic chemicals with growth regulating activity.

Humidity - Refers to the moisture in the air. Weed killers often are comparatively more effective under moderately humid conditions.

Immune - Not susceptible to a disease or poison.

Impermeable - Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot.

Infestation - Any pests found in an area or place where they are not desirable.

Inhibit - To hold in check or stop, i.e., to check or stop seed germination or plant growth with herbicides.

Invert Emulsions - One in which the water is dispersed in oil rather than oil in water. Oil forms the continuous phase with water dispersed forming the discontinuous phase. Usually a thick mayonnaise-like mixture.

kg. - The abbreviation for kilogram which is a metric measurement of weight equivalent to 1000 grams or approximately 2.07 pounds.

Label - All written, printed or, graphic matter on or attached to the pesticide or the immediate container.

LC₅₀ - The concentration of an active ingredient in air which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas, or vapor. It is generally expressed as micrograms per liter as dust or mist but in the case of a gas or vapor as parts per million (ppm).

LD₅₀ - The dose of an active material taken by mouth or absorbed by the skin which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD₅₀ of 10 milligrams per kilogram (mg/kg) it is more toxic than one having an LD₅₀ of 100 mg/kg.

Leaching - Downward movement of a material in a solution through the soil.

Mammals - Warm-blooded animals that nourish their young with milk. Their skin is more or less covered with hair.

mg - Abbreviation for milligram - 1/1000 of a gram.

Miscible Liquids - Two or more liquids that can be mixed and will remain mixed under normal conditions.

Monocotyledon - A plant having a single cotyledon or seed leaf. Includes most grass plants.

MPH - Miles per hour.

Necrosis - Localized death of living tissue such as the death of a certain area of a leaf.

Necrotic - Showing varying degrees of dead areas or spots.

Non-cropped Land - Land not in crop production or used for pasture.

Noxious Weed - A plant arbitrarily defined by law as being especially undesirable, troublesome, and difficult to control. Definition of the term "noxious weed" will vary according to legal interpretations.

Oils - Usually refer to aromatic or paraffin oils used in formulation products as herbicide carriers or for direct use. Light, unsaturated oils cause a rapid burning of leaves called acute toxicity. Heavy oils injure the growing plant and cause a chlorosis. This slower type injury is called chronic toxicity.

Glossary (Cont'd.)

Oral - Of the mouth; through or by the mouth.

Oral Toxicity - The degree of toxicity of a compound when it is ingested through the mouth.

Orifice - An opening or hole in a spray nozzle.

Overall Treatment - Applied uniformly over the entire area.

Pathogen - Any disease-producing organisms.

ppm - (parts per million) - The number of parts by weight or volume of a given compound in one million parts of the final mixture. ($\text{ppm} = \% \times 10,000$; $\% = \text{ppm} \div 10,000$).

Penetration - The act of entering or ability to enter.

Percent Concentration - Similar to parts per million but expressed as a percentage.

Perennial - A plant that lives for more than two years.

Pesticide - Any substance or mixture of substances that are used to control plant and animal life.

Phloem - A live conducting tissue in the plant which usually takes manufactured food from the leaves downward.

Photodecomposition - Destroyed by light.

Photosynthesis - A process by which carbohydrates are formed in the chlorophyll-containing tissues of plants exposed to light.

Phytotoxic - Poisonous to plants.

Pollutant - An agent or chemical that makes another substance impure or dirty.

Postemergency - After emergence of specified weed or crop.

PPB - Parts per billion. A way to express the concentration of chemicals in foods, plants, and animals. One part per billion equals 1 pound in 500,000 tons.

PPM - Parts per million. A way to express the concentration of chemicals in foods, plants, and animals. One part per million equals 1 pound in 500 tons.

Prevention Control - Stopping a given species of pests from contaminating an area before they become established.

PSI - Pounds per square inch.

Pubescent - Hairy pubescence affects the ease of wetting of foliage and also retention of spray on foliage.

Rate - The amount of active ingredient or acid equivalent of an herbicide applied to a unit area.

Registered Use - The USDA registers the use of pesticide rates and times of application. All products intended for cropland use must be cleared and registered with the USDA.

Residue - That amount of chemical that is on or in plants in soil at the time an analysis is made.

Resistance - The ability of an organism to suppress or retard the injurious effects of a material.

Rhizome - An underground stem, growing on some perennial plants, used on reproduction.

Root Suckering - Sprouts from roots which extend laterally from the root cellar.

RPM - Revolutions per minute.

Glossary (Cont'd.)

- Safener - A chemical added to a pesticide to keep it from injuring plants.
- Salt - The compound formed when an acid is reacted with a metal.
- Seedling Stage - Usually refers to the early stages of growth of plants within a few days or weeks after seed germination and seedling emergence.
- Selective Herbicide - An herbicide that will kill some plant species when applied to a mixed population without serious injury to other species.
- Sensitive - A plant not capable of withstanding herbicidal effect.
- Soil Application - Application of chemical made primarily to the soil surface rather than to vegetation.
- Soil Incorporation - Mechanical mixing of the herbicide with the soil.
- Soil Persistence - Refers to length of time that an herbicide application to the soil remains phytotoxic.
- Soil Sterilant - An herbicide that prevents the growth of plants when present in the soil. Soil sterilization effects may be temporary or relatively permanent.
- Soluble - Will dissolve in a liquid.
- Solution - A preparation made by dissolving a material in another substance, usually water. Once solutions are formed, they tend to be stable as opposed to emulsions, which will settle-out.
- Solvent - A liquid which will dissolve a substance to form a solution.
- Spot Treatment - Application limited to only a small restricted area of infestation.
- Spray Drift - The movement of airborne spray particles from the intended area of application.
- Spreader - A chemical which increases the area that a given volume of liquid will cover on a solid or in another liquid.
- Spreading Agent - A substance used to improve the wetting, spreading, or possible adhesive property of an herbicide.
- Sticker - A compound which, when added to spray solutions, tends to give a greater deposit, particularly in conjunction with wettable powder formulations.
- Stolon - An above-ground stem or runner on many perennial plants which is adapted to reproduction by developing roots at the tips or at the nodes.
- Stump Collar Sprouting (Coppice) - New sprouts produced by a stump following cutting.
- Summer Annuals - Plants which germinate in the spring, make most of their growth in the summer, and die in the fall.
- Surfactant - Materials used in pesticide formulations to impart emulsifiability, spreading, wetting, dispersibility, or other surface-modifying properties.
- Susceptible - Capable of being diseased or poisoned; not immune.
- Susceptible Species - A plant or animal that is poisoned by moderate amounts of a pesticide.
- Suspension - A system consisting of very finely divided solid particles dispersed in a solid, liquid, or gas.
- Synergism - The joint action of two or more pesticides that is greater than the sum of their activity.
- Systemic - A compound which, when taken up by the plant, is made effective throughout its whole system. Usually refers to insecticides that kill insects which eat the juices of treated plants.

Glossary (Cont'd.)

Systemic Chemical Name - Naming an herbicide compound according to the system developed by the International Union of Chemistry.

Systemic Herbicide - One which is absorbed by the leaves and stems of plants and moves (is translocated) to another part of the plant where it has a lethal effect.

Target Pest - The pest at which a particular pesticide or other control method is directed.

Tolerance (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides. (2) The amount of pesticide that may safely remain in or on raw farm products at time of sale.

Toxicant - A poisonous chemical.

Toxicity - Degree to which something is poisonous.

Trade Name - Same as brand name.

Translocated Herbicide - An herbicide which is moved within the plant from the point of entry.

Translocation - Transfer of food or other materials such as 2,4-D or 2,4,5-T from part to another in plants.

Vapor Drift - The movement of herbicidal vapors from the area of application.

Vapor Pressure - The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Viscosity - A property of liquids that determines whether they flow readily. Viscosity usually increases when temperature decreases.

Volatile - Refers to substances that evaporate or vaporize (change from a liquid to a gas) at ordinary temperatures on exposure to air.

Water Solubility - Capable of being homogeneously mixed with water.

Weed - A plant growing where it is not desired.

Weed Control - The process of limiting weed infestations so that operation can be conducted effectively.

Wettable Powder - A compound that, when added to a spray solution, causes it to contact plant surfaces more thoroughly.

Wetting Agent - A chemical which causes a liquid to contact surfaces more thoroughly.

Winter Annual - A plant that germinates in the fall or winter, matures seed and dies in the spring or early summer.

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