COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Training Manual for Right-of-Way Vegetation Management

Preface

This publication was prepared by a committee of specialists in the University of Kentucky Cooperative Extension Service, personnel in the Vegetation Management Association of Kentucky and members of the Division of Pesticides of the Kentucky Department of Agriculture. When used in conjunction with the EPA Core Manual, "Applying Pesticides Correctly," this manual will provide information to meet minimum EPA standards for certification of commercial applicators in Category 6, Right-of-Way Pest Control. Additional helpful information for Right-of-Way applicators may be obtained from the Cooperative Extension Service, regulatory agencies, pesticide labeling, pesticide dealers and industry representatives, and utility rights-of-way company personnel involved in vegetation management.

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Training Manual For Right-of-Way Vegetation Management

Introduction

Rights-of-way are the areas involved in common transport. They are essential for the proper functioning of a modern society and include:

• federal, state, county and township highways and roads,
• public airports,
• railroads,
• electric utilities (including substations, switching stations, transmission lines and distribution lines)
• pipelines (including pumping stations),
• public surface drainageways,
• public irrigation waterways,
• banks of public bargeways and areas around locks and dams,
• bicycle, bridle and other public paths or trails (outside established recreational areas).

Rights-of-way may be found everywhere and are placed in every type of terrain, soil, climate, vegetation complex and land-use area. Vegetation management on rights-of-way is desirable and necessary for a number of reasons, both aesthetic and practical, including:

• safety due to improved visibility on transportation rights-of-way,
• reduced fire hazard by the encouragement of less fire-prone plants,
• soil erosion control,
• assured continuity of utility services,
• promotion of the health and comfort of the public,
• ornamental values enhanced by control of nuisance vegetation.

Figure 1.—Railroad Right-of-Way

Rights-of-way generally must be kept free of large brush or trees—that is, maintained in an early stage of plant community succession which means that vegetation must be continually managed. In addition, maintaining land in an early stage of plant community succession often encourages the growth of persistent vines such as kudzu which can be as undesirable as large woody plants. The type of vegetation management necessary will depend on the function of the right-of-way, as well as its topography, biology and ecology. Of paramount consideration is the type of vegetation encountered. Undesirable vegetation includes those plants that:

• create a safety hazard or nuisance,
• impede the normal operation or functional activities of the right-of-way,
• are considered "noxious,"
• repress desirable vegetation,
• cause damage to rights-of-way structures, such as road surfaces, railroad ballast, utility wire poles or supports, and pipelines and pumping stations,
• provide harborage for undesirable wildlife,
• constitute a detriment to crops and cropland if allowed to spread.

Vegetation management is necessary and in most cases desirable; but since most rights-of-way are long and narrow, they often touch the property of many landowners. Neighbor conflicts may become magnified especially if vegetation management efforts are not contained within rights-of-way boundaries.

Public relations problems between rights-of-way users and their neighbors are minimized when the public is informed of the vegetation management needs and methods and when vegetation management personnel know and execute a program with definite goals and plans.

Goals

The principal goal of vegetation management is to ensure the protection, operation, stability, continuance and safety of the common transport involved. Other goals of a well-planned vegetation management program may be to:

• naturalize the right-of-way using indigenous plants, where possible, to make the right-of-way blend in with the surrounding landscape,
• reduce maintenance costs,
• reduce erosion or water quality problems,
• provide feed or shelter for wildlife.

Planning Requirements

Successful right-of-way vegetation management requires good planning which incorporates stated goals and objectives into a rational, comprehensive and practical program. This planning must include recognition of the environmental requirements of desirable plants and the incorporation of methods that will accomplish the goals and objectives in the most economical, environmentally sound and practical fashion.

A properly planned and executed vegetation management program will use a variety of vegetation control techniques and strategies that will be dictated by economics, terrain, vegetation type and public relations. The program should have options for

alternative management methods, such as cropping and grazing, as well as chemical weed and brush control. Good planning and execution can result in:

- *increased public acceptance of the right-of-way facility,*
- *fewer complaints about the right-of-way,*
- *reduced maintenance cost,*
- *decreased damage to facilities and structures,*
- *fewer operational interruptions,*
- *increased safety,*
- *improved public relations and less legal difficulty with public action groups and right-of-way neighbors,*
- *reduced erosion and water pollution,*
- *improved cost planning and control,*
- *better utilization of equipment and reduced work load fluctuation.*

Topography

Rights-of-way are basically composed of a series of narrow strips of land that are used for different types of common transport. For example, electric utility rights-of-way vary in width from 30 feet to 200 feet and have been set aside for the erection of poles and guys, towers and electrical conductors necessary for carrying electrical current to utilization points—that is, from the point of electrical generation to the individual customer's premises. The electric company usually acquires these rights-of-way from property owners through an easement which grants the utility company the right to install and maintain the facilities necessary for the transmission and distribution of electrical current. The utility company does not normally purchase the land for the rights-of-way; rather, it simply acquires permission or easement from the property owners to install needed facilities. In many instances, one or more types of rights-of-way are combined. For example, a highway right-of-way is often built next to a utility right-of-way.

Terrain

The terrain over which these rights-of-way pass is just as varied as the material being transported. The terrain crossed will vary from farmland used for annual crops or pasture through gently rolling hills to rugged and almost inaccessible mountainous terrain. Rights-of-way also pass over streams, rivers, lakes, ponds and roads.

Vegetation

A variety of vegetation is encountered along a right-of-way. Areas devoid of unwanted vegetation, such as land used for agricultural purposes, give way to pastures, low-growing shrubs and brush, as well as fully grown trees. The level of vegetation management necessary depends on the type of right-of-way and the sections within that right-of-way.

Levels of Vegetation Management

Highways and railroads obviously need absolute vegetation control in the roadbed. The shoulder of the road or rail line is usually maintained free of vegetation to facilitate drainage. The remainder of the right-of-way may be maintained in grass or low growing shrubs. The type of vegetation allowed to grow

Figure 2.—Highway Right-of-Way (Photo by A. D. Luscher)

will be limited to those materials that do not interfere with the movement of vehicles or the vision of vehicle operators.

Electrical transmission lines through forested areas may have the following sections of the right-of-way:

- *a central path or road for inspection and/or maintenance crews,*
- *an area of low-growing shrubs or grasses under the wires,*
- *an area kept cleared of large trees 25 to 75 feet on either side of the centerline (greater clearance required for EHV),*
- *edge of easement or area off easement having dangerous trees removed as necessary (depending on easement description).*

Electrical distribution lines are often virtually surrounded by vegetation, but continual efforts are made to clear vegetation to eliminate power outages. Sometimes mature trees that pose a dangerous threat to electrical facilities must be completely removed.

Figure 3.—Utility Right-of-Way

Gas pipelines are somewhat different in the area of rights-of-way because the soil is disturbed when the pipe is laid. Generally, the soil is laid bare until grass or other vegetation re-

invades the right-of-way. Pipeline rights-of-way are usually kept mowed. Grasses and low- growing broadleaf plants are the predominant vegetation.

Biology and Ecology of Weeds

The biology of weeds is concerned with the establishment, growth and reproduction of weeds as well as the influence of environment on these processes. The ecology of weeds is primarily concerned with the effects of climatic, physiological and biological factors on these plants.

Classification

There are many ways to classify weeds. For weed control purposes, weeds can be divided into two major groups: grasses and broadleafs. Broadleaf weeds can then be divided into herbaceous and woody plants.

Grass Weeds (Monocots) have one cotyledon or seed leaf. The principal veins of the leaf run parallel. The flower parts are in groups of three or multiples of three. Vascular bundles of stems are scattered throughout a cylindrical mass of tissue. Vascular cambium is lacking in grasses.

Broadleaf Weeds (Dicots) have two cotyledons or seed leaves. The principal veins of the leaf form a network rather than being parallel. The flower parts are typically in groups of four or five. The vascular bundles of stems are usually arranged in the form of a cylinder and vascular cambium is present.

Woody plants include trees, shrubs and woody vines.

Herbaceous plants are plants that naturally die to the ground without persistent stems above ground (without a definite woody structure).

Life Cycle

The life cycle or growth habits of weeds present in a right-of-way determine the vegetation management method necessary for the most effective weed control.

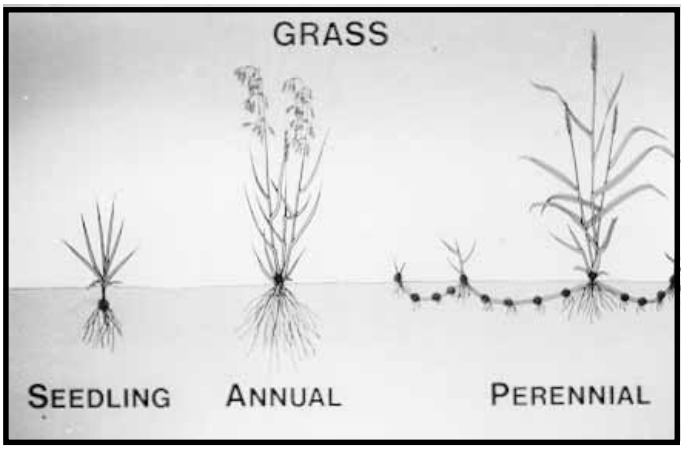

Figure 4.—Grass Weeds (Monocots)

Annuals—Annual weeds are plants that develop from seeds, mature, produce seed and die in one growing season. **Winter annual** plants germinate from seeds in the fall, overwinter, mature, produce seed and die in the spring or early summer. Examples of winter annuals are chickweed, henbit, cheat and Shepherd's purse. **Summer annual** plants germinate from seed in the spring, grow through the summer, produce seed and die in the fall. Examples of summer annuals are crabgrass, foxtail, fall panicum, pigweed and lambsquarters.

Annual weeds can frequently be controlled with residual type herbicides applied pre-emergence to the weeds. Foliar herbicides, either contact or translocated, are also effective in controlling annual weeds. Usually a combination of a foliar herbicide plus a residual herbicide will provide the most dependable weed control.

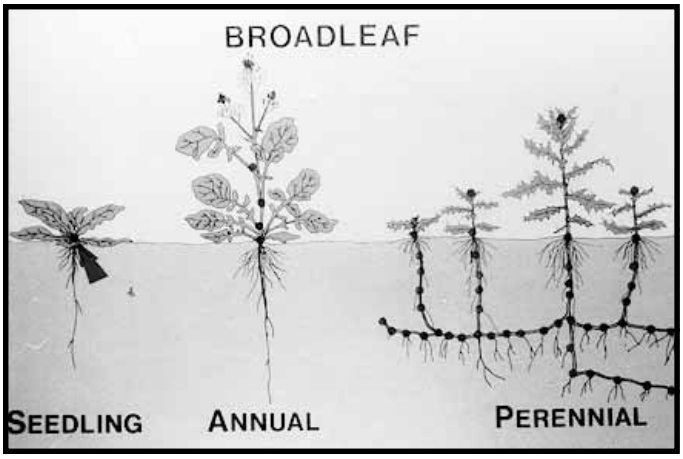

Figure 5.—Broadleaf Weeds (Dicots)

Biennials—Biennial weeds complete their life cycle over a two-year period (two growing seasons). They frequently develop from seed and form a rosette (a low-growing cluster of leaves) during the first year. During the second growing season, the stems elongate, flowers and seeds develop, and the plant then dies. Examples of biennial weeds are poison hemlock, Queen Anne's lace (wild carrot), common mullein and musk (nodding) thistle. Biennial weeds usually can be controlled using the same methods that are effective on annual weeds. They are best controlled during the first year of growth.

Perennials—Perennial weeds live for three or more seasons and reproduce by seed and/or vegetative parts. They are often more persistent than annuals or biennials and for the best control may require repeated applications of foliar translocated herbicides. Soil-applied herbicides may have to be applied at high rates for perennial weed control. Examples of perennial weeds are johnsongrass, quackgrass, Canada thistle, brush, shrubs and trees.

Simple perennial weeds ordinarily reproduce solely by seed. Vegetative reproduction occurs only when roots or crowns are cut by tillage implements. Cut pieces may then send out feeding roots and stems to become new plants. Examples of simple perennials are dandelion, curly dock and plantain.

Bulbous perennial weeds reproduce by bulbs and bulblets as well as by seeds. Both aerial bulblets and seeds may be produced in the flower heads while below ground, secondary bulbs develop at the base of the old bulb. An example of a bulbous perennial is wild garlic.

Creeping perennial weeds spread by lateral extension of the stems (stolons) along the soil surface, by stems (rhizomes) beneath the soil, by roots or by seeds. Examples of creeping perennials that spread by creeping stems along the soil surface are mouse ear chickweed, knotgrass and pennywort. Those

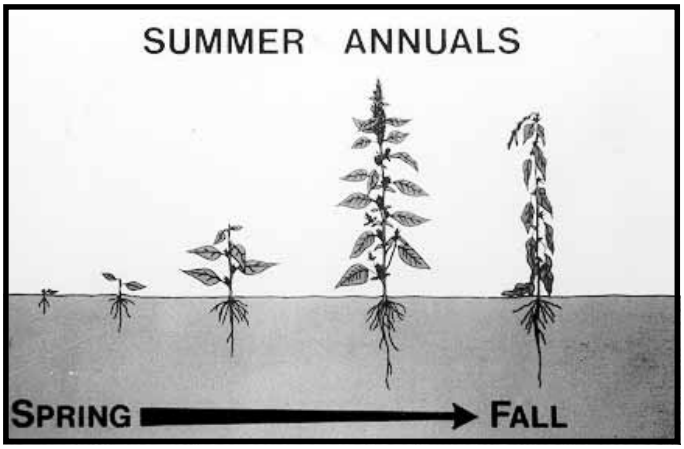

Figure 6.—Life Cycle of Summer Annuals

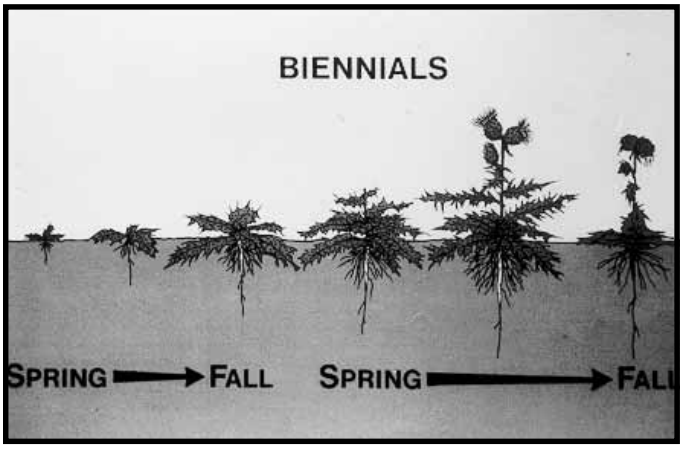

Figure 7.—Life Cycle of Biennials

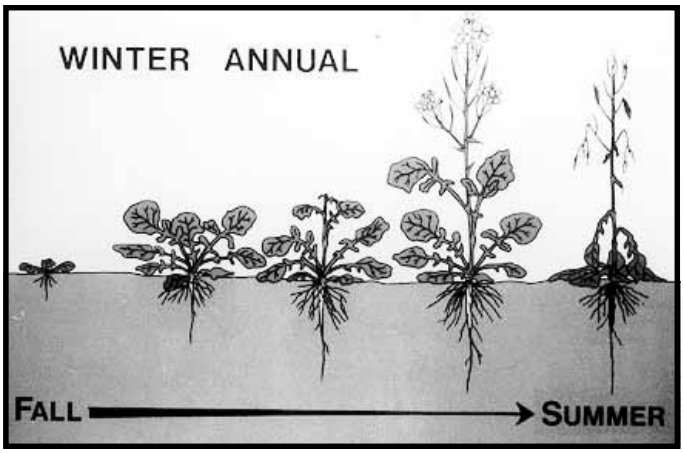

Figure 8.—Life Cycle of Winter Annuals

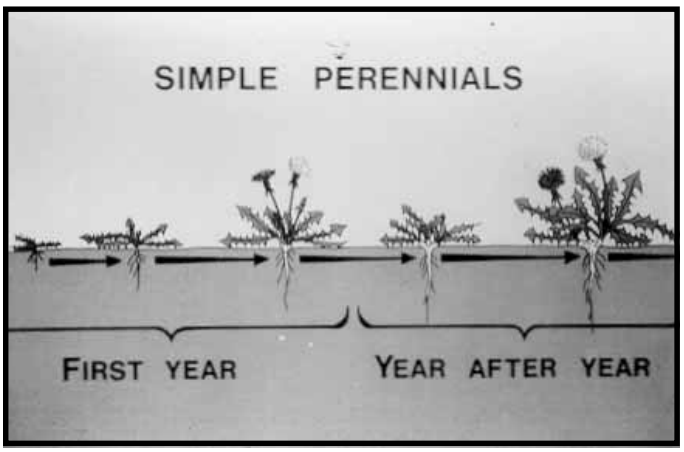

Figure 9.—Life Cycle of Simple Perennials

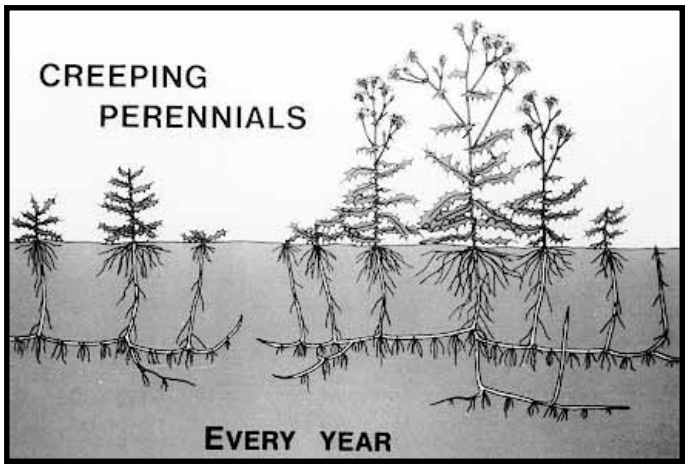

Figure 10.—Life Cycle of Creeping Perennials

spreading by rhizomes include quackgrass. johnsongrass and hedge bindweed. Those that spread by creeping roots are perennial sowthistle and red sorrel.

Dissemination and Persistence

Weeds spread through the dispersal of their sexual (seed) and asexual (rhizomes, stolons, tubers, roots and bulbs) reproductive parts. Annuals and most biennials spread by seed. Wind, water, animals, machinery and crop seed are a few of the mechanisms that facilitate the spread of these weeds. Some perennial weeds spread primarily by asexual means, whereas others are spread by both asexual and sexual methods. The spread of perennials is slow, especially in noncultivated land that may occur in rights-of-way.

The persistence of annual and biennial weeds depends mainly on their ability to re-infest the soil with their seed. The introduction or infestation of perennials into an uninfested area depends on seed. Therefore, controlling the production of seed would prevent further spread of many species.

The length of time that weed seeds remain viable may depend on the particular species involved and the environmental conditions to which they are exposed. In general, seeds that are viable but do not germinate within a few days or months will remain in a dormant or resting stage. Dormancy may determine the time of year when weed seed germinates, or it may delay germination for years, thereby guaranteeing a source of viable seed in subsequent years.

Stages of Vegetation Succession

Vegetation succession refers to the orderly development of different types of vegetation on land from which the original vegetation has been removed. Annual weeds such as ragweed and pigweed are generally the first to appear in cleared areas left abandoned. Grasses, grass-like plants and biennial or perennial herbaceous broadleaf weeds are the next plants to come into the area. The next plants to succeed are shrub-like plants. Trees are introduced in the final stage of vegetation development. Regardless of which stage of vegetation development is found in a right-of-way initially, the trend is for it to develop into a forest.

The type of vegetation that is desirable for a particular right-of-way will depend on its function, as well as safety, wildlife and soil conservation considerations. As a general rule, annual weeds and forests are considered to be undesirable cover for rights-of-way. A community of certain grasses, grass-like plants, certain perennial herbaceous broadleaf weeds or shrubs is suitable for most rights-of-way.

Vegetation Management Control Methods

There are three methods of control used in rights-of-way vegetation management: biological, mechanical and chemical.

Biological Methods

Animals, birds and competing plants are used in biological control of vegetation. This method can be very inexpensive if a stable plant community is established on the right-of-way. However, it requires an intimate knowledge of the ecology of the area and the manipulations necessary to foster a stable system. When rights-of-way cross pasture land, grazing is usually sufficient maintenance, thus eliminating the need for vegetation control methods.

Mechanical Methods

Mechanical control is the oldest vegetation management method and includes hand-pulling, hoeing, blading, mowing, cutting, pruning, carefully controlled burning, flooding, bulldozing and cropping. Mechanical control methods are usually very labor intensive and thus extremely expensive.

There are situations where mechanical controls can be the least expensive method of vegetation management for the right-of-way company. Areas that are being cropped or residential and industrial areas maintained by the landowners are often maintained in superb condition at no cost to the right-of-way company. In some cases, desirable vegetation is deliberately introduced onto the utility right-of-way. Maintenance and cultivation of this desirable vegetation ensures that unwanted vegetation is controlled. Such is the case when Christmas tree farms or tree nurseries are maintained on utility rights-of-way. The desirable vegetation is harvested or removed before it reaches the size where it presents a problem to the utility company.

Unfortunately, many areas cannot be maintained by the landowner's normal cultural practices. Many of these areas cannot be managed with less expensive methods, so mechanical controls are necessary.

Mowing is used extensively in the maintenance of pipeline and highway rights-of-way. Although cropping, i.e., the removal of hay, is used in some states, it is not practical in Kentucky, and mowing crews are used to maintain roadsides on virtually all our highways and secondary roads.

Cutting or pruning by utility arborists is often the only acceptable management method for trees and brush that invade utility rights-of-way. Trees that grow around electrical and telephone wires are often considered to have ornamental value and must be selectively pruned. Special care must be taken to use "Natural Target Pruning" techniques to avoid extensive damage to trees. In Kentucky, utility arborists who are also "Certified Arborists" can be relied on to use appropriate pruning methods. Tree topping along utility rights-of-way is not appropriate.

Railroad and highway rights-of-way also use cutting or pruning methods for brush and tree control. Large mechanical brush cutters are used on these rights-of-way to eliminate brush and small trees. Chainsaws, brush hooks, hand saws and axes are necessary equipment when working in areas where large mechanized brush cutters are impractical.

Burning is used in some states to control rights-of-way vegetation. This method is usually cheap and effective, but it is not practical in Kentucky because of legal and environmental complications.

Flooding provides an effective way to control vegetation along the edges of canals and navigable rivers or lakes. The Corps of Engineers uses this method effectively to maintain vegetation and reduce mosquito breeding along the shorelines of the waterways it administers.

Mechanical control methods are very expensive and therefore most rights-of-way operators would rather use less

costly methods of vegetation control if possible. For instance, hand clearing of utility rights-of-way can be as much as four times more expensive on a per acre basis than chemical control of the same vegetation. Also, some situations such as hand cutting of hillsides, may be more hazardous to workers.

Chemical Methods

Terrain often makes regular maintenance using mechanical methods impractical. In situations where rights-of-way cross rugged, mountainous terrain, chemical control is often the only practical vegetation control method.

Tree Growth Regulators

Tree growth regulators (TGRs) such as paclobutrazol (Profile) can be used to slow the growth of trees, allowing more effective management of pruning cycles. TGRs have been shown to reduce the amount of biomass removed from trees and, in doing so, reduce the amount of time needed to prune and clip treated trees.

Classification of Herbicides

Herbicides are commonly grouped according to such common characteristics as methods of application, selectivity or chemistry.

Method of Application

Herbicides may be applied to the soil or to the foliage of emerged weeds. Soil-applied herbicides depend on uptake by seeds or underground vegetative plant parts for control. For optimum results, they must remain in the soil in an active or available form for a certain period of time. The length of time that a herbicide remains in the soil is referred to as its soil persistence or soil residual life. Although these terms are generally used in reference to soil-applied herbicides, they may apply to certain herbicides that are primarily applied post-emergence but may also leave some "active" residue in the soil.

The estimated persistence of some of the herbicides used in rights-of-way is as follows:

Common Name	Trade Name	Average Persistence* (months)
bromacil	Hyvar-X	12-36
chlorsulfuron	Telar	6-36
clopyralid	Transline	6-12
dicamba	Banvel Vanquish	1-3
2,4-D	(various)	1
fosamine ammonium	Krenite	less than 1
hexazinone	Velpar	12-24
imazapyr	Arsenal	6-24
metsulfuron	Escort	6-24
picloram	Tordon	6-36
prometon	Pramitol	12-24
sulfometuron	Oust	6-24
tebuthiuron	Spike	12-36
triclopyr	Garlon	1-2

* *The length of time may vary depending on the rate of herbicide applied and environmental conditions*.

Herbicides applied to the foliage are commonly referred to as post-emergence herbicides. Herbicides control weeds either by direct contact of the plant tissue treated or by translocation to other plant parts. Weeds sprayed with contact herbicides usually die within a few hours or days and have very little, if any, residual control. Contact herbicides are used primarily to control annual weeds. Examples of contact herbicides are paraquat (Paraquat) and MSMA (Ansar). Weeds treated with translocated herbicides generally require several days before dying. These herbicides are often capable of controlling annuals, biennials and perennials. Glyphosate (Accord, Roundup), 2,4-D (several trade names) and dicamba (Banvel, Vanquish) are just a few of the translocated herbicides.

Selectivity

Herbicides may be classified as selective or non-selective. Also, herbicide selectivity is rate dependent. At low rates, some herbicides are selective, whereas at high rates they become non-selective.

Selective herbicides kill some plants and have little or no effect on other plants. The selective nature of herbicides allows the removal of unwanted weeds from desirable crops. A good example of a selective herbicide is 2,4-D, which will remove broadleaf weeds while causing no injury to desirable grasses such as corn or wheat.

Non-selective herbicides kill all vegetation regardless of species. Examples of non-selective herbicides are paraquat (Paraquat), bromacil (Hyvar) and glyphosate (Roundup, Accord).

Chemistry

Herbicides having similar chemical characteristics are grouped into **herbicide families**. Following are summaries of some of the common herbicide families used in rights-of-way:

The **phenoxy herbicides** are usually applied to the foliage for control of annual and perennial broadleaf weeds. Although these herbicides are applied to the foliage, they also are capable of being taken up into the plant through its roots. Drift in the form of spray or vapor may injure desirable broadleaf plants near areas being sprayed. Some examples of phenoxy herbicides are 2,4-D and MCPA.

The **picolinic acid herbicides** control many annual and perennial broadleaf weeds. They are readily absorbed by roots and foliage. These herbicides move readily within the plant to the growing points of stems and leaves. This results in a variety of growth regulator type effects. These herbicides have a moderate to high leaching potential since they are weakly adsorbed to soil. Examples of picolinic acid herbicides include clopyralid (Transline) and picloram (Tordon).

The **sulfonylurea herbicides** control many annual and perennial broadleaf and grassy type weeds. These herbicides can be applied to the foliage of plants or to the soil. With foliar applications a surfactant is used to enhance absorption into the leaves. Injury symptoms are typically slow and may not be apparent for two to three weeks after application. Examples of sulfonylurea herbicides include chlorsulfuron (Telar), metsulfuron (Escort), and sulfometuron (Oust).

In general, most **triazine herbicides** are taken up into the plant through the roots; however, certain members of this family can also

be absorbed through the foliage. When used as a foliar treatment, a surfactant or an oil is generally used to enhance absorption. Triazines are capable of providing non-selective control of various grasses and broadleaf weeds when used at rates recommended for non-cropland. Regardless of whether they are applied pre-emergence or post-emergence, the triazine herbicides generally accumulate in the leaves where they inhibit photosynthesis. Prometon (Pramitol) is an example of a triazine herbicide.

The **uracil herbicides** are more readily absorbed by the roots than by the shoots of plants. The addition of a surfactant does, however, enhance their foliar activity. After being absorbed by the roots, uracil herbicides move to the leaves of plants where they inhibit photosynthesis. The effects of uracil herbicides on perennial weeds are generally slow and may take several months. Bromacil (Hyvar X) is an uracil herbicide.

The **urea herbicides** are most effective when applied as a pre-emergence treatment; however, their post-emergence activity can be enhanced when they are applied with a surfactant. Like the triazine herbicides, the ureas do not prevent germination of weed seed. Rather, they accumulate in the leaves of emerged plants where they inhibit photosynthesis. Although the urea herbicides provide control of both grasses and broadleaf weeds, they are considered to be more effective on broadleaf weeds. Diuron (Karmex) and tebuthiuron (Spike) are examples of urea herbicides.

The following are **other herbicides** not included in the above families:

Dicamba (Banvel, Vanquish) is used to control woody plants as well as many broadleaf herbaceous plants. At label rates it has very little, if any, effect on grasses. Dicamba is absorbed by the leaves, stems and roots and translocates throughout the plant. It is relatively mobile in the soil.

Fosamine ammonium (Krenite) is used in controlling woody plants. It should be applied during a two-month period prior to fall coloration. When applied to deciduous plants at this time of the year, there is little or no effect until the following spring when bud development is prevented or limited. Pines, however, show a response shortly after application.

Glyphosate (Accord, Roundup) is used for control of many annual and perennial weeds including grasses, broadleafs, brush and certain trees. It can be applied to the foliage of actively growing plants where it is absorbed by the leaves or as a tree injection or cut stump treatment. Glyphosate is rapidly and tightly adsorbed by soil.

Imazapyr (Arsenal) controls many annual and perennial weeds including certain grasses, broadleafs, vines, brush, and trees. Plant growth is inhibited within a few hours after application, but injury symptoms may not be apparent for two to three weeks after application. Arsenal can be applied to the soil or to the foliage of plants.

Triclopyr (Garlon) is a growth regulator type selective herbicide for control of many woody plants and broadleaf weeds. Most grasses are tolerant to Garlon. It can be applied as a ground or aerial foliage spray or as a basal or tree injection application. Garlon is absorbed by both foliage and roots and translocates throughout the plant. Some leaching may occur in light soils under high rainfall conditions.

Herbicide Application Methods and Equipment

The equipment used for vegetation management on rights-of-way is of two general types—that for ground application and that for aerial spray. Ground applications may include foliar spray treatment, basal bark treatment, stump treatment, tree injection and soil treatment with pellets. Airborne equipment is carried by helicopter.

Ground Application

High and low volume foliar sprays may be applied from a backpack sprayer or a truck-mounted pump sprayer in which the herbicide is mixed at a predetermined amount with water and applied at a specific pressure and rate per acre. For best control, foliar treatments must be applied to the point of runoff in a sufficient volume of water to ensure adequate coverage.

Basal bark treatment consists of a thorough coverage of the lower 18 inches of the stem and the root crowns of a woody plant. Herbicides mixed with oil are used for basal treatment. Basal treatment can be done at any time of the year; if done during the dormant season, less damage will result to susceptible crops nearby.

Stump treatments or cut stubble treatments are also employed on cut stumps or stems to prevent suckering or re-sprouting in species such as maple, black locust or sassafras. Best results are obtained when stumps are treated with a herbicide immediately after cutting, before the tissue hardens and dries around the cut.

Pelleted products can be applied in very small amounts by hand broadcasting or specific placement around the stems of unwanted shrubs (e.g., multiflora rose) or brush.

Figure 11.—Cut Stump Treatment (Photo by A. D. Luscher)

Banding or strip spraying is useful when treating only strips of vegetation.

A hypo-hatchet or tree injector can also be used to inject pre-measured amounts of herbicide directly into the growing woody stem.

Aerial Application

Helicopters, rather than fixed wing aircraft, are often used for aerial application of herbicides on rights-of-way. Three distinct types of application methods may be used: microfoil boom, invert emulsion and spray disc.

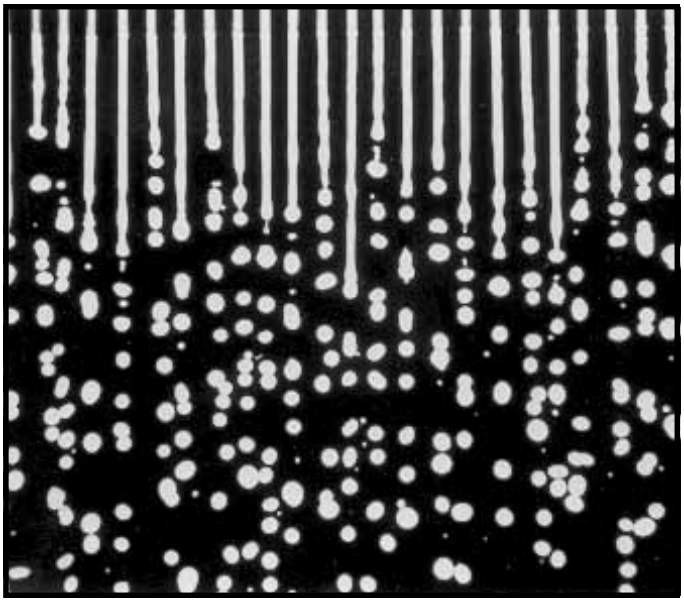

Figure 12.—Spray Droplets from Microfoil Boom (Photo by Richard Lubic)

The microfoil boom employs a specially designed nozzle, often referred to as a .060 nozzle, which combines the herbicide mixture and air at a given pressure to form large, viscous spray particles and minimize drift. The spray then falls on the right-of-way in the form of light rain.

An invert emulsion system involves preparing the herbicide in a concentrated water solution and encapsulating these particles in oil to form spray particles of a "mayonnaise" type consistency. The inversion requires a separation of the water and oil phases in separate tanks and a special mixing chamber to combine the two phases as spraying goes on.

Figure 13.—Invert Emulsion—Preparing the Constituents (Photo by David McDonough)

The disc method involves a revolving spray disc mounted underneath the spraying ship whereby the herbicide mixture is spread across the right-of-way by centrifugal force from the revolving disc. Coverage and width of spray can be changed by varying the speed of the revolving disc. The spray mixture consistency from the disc is similar to that from the microfoil boom.

Soil Factors That Influence Herbicides

Soil texture, organic matter, pH and moisture content are some of the major soil properties that influence the efficacy of a soil-applied herbicide.

Soil Texture

The relative amount of clay, silt and sand in a soil can determine the availability of certain herbicides in the soil. Usually as the clay content of the soil increases, the availability of the herbicide for uptake in the plant decreases. Clay particles are primarily negatively charged and therefore they tend to attract or adsorb positively charged particles. Herbicides which tend to be positively charged in the soil (e.g., prometon) are adsorbed to a greater extent by clay particles than herbicides which are negatively charged (e.g., picloram). This is why the rates of certain herbicides vary with soil texture.

Organic Matter

The organic matter or humus content of the soil is primarily negatively charged and therefore reacts in a similar manner with herbicides as do clay particles. In general, however, herbicides are more strongly adsorbed to humus than to clay particles. A small increase in the organic matter content of the soil can greatly enhance the absorption of a herbicide.

Soil pH

The pH of the soil can influence the effectiveness and persistence of certain herbicides. For example, metsulfuron (Escort) degrades rapidly by chemical hydrolysis when soil pH is less than 6.0, whereas when soil pH is above 6.0, degradation rates are slower and more dependent on microbial processes.

Soil Moisture

In order for a soil-applied herbicide to be taken up in the plant, there must be a certain amount of moisture present in the soil. Generally, soil-applied herbicides do not perform as well under drought conditions as they do when the soil moisture is adequate.

Soil moisture may also indirectly affect the persistence of various herbicides by influencing microbial degradation or certain chemical reactions. Soil-applied herbicides usually persist longer when the soil is dry rather than moist or wet.

Environmental Factors That Influence Herbicides

Results achieved from herbicides may be quite variable. This variability (or more specifically the lack of control) may be due to

improper application (e.g., improper choice of herbicide, poor equipment, incorrect calibration, lack of agitation or ineffective product). Many of these problems can be prevented or corrected by the operator. However, a large part of the variability in results obtained from herbicides is due to factors over which the operator has no control, such as environmental conditions, variation of soils and differences in susceptibility of various plant species.

Before considering the effect of environmental factors on the performance of herbicides, it is essential to consider how the herbicide is applied. Herbicides may be applied as soil, foliage, stump or basal bark treatments. The influence of a given environmental factor may be quite different, depending on the type of application. Environmental conditions have very little effect on stump or basal bark treatments. However, environmental conditions may have a considerable effect on soil and foliage applications.

Soil-applied Herbicides

From the practical viewpoint, rainfall (soil moisture) and temperature are two environmental factors that most influence the performance of soil-applied herbicides.

Rainfall is as important for chemical weed control as it is for plant growth. Herbicides applied to the soil surface must be moved into the root zone of the plants to be controlled by rainfall soon after the application is made. Herbicides generally do not perform as well during periods of drought as they do when adequate moisture is present.

The amount of rainfall necessary to move a herbicide depends on its water solubility. For example, picloram (Tordon) is considered to be highly water soluble; thus, it has a higher potential to move in soil with water compared to many other herbicides. It is important to remember that leaching of water-soluble herbicides is greatest under heavy rain that falls in a short period of time. Excessive movement of herbicide in the soil may cause injury to desirable plants close to the rights-of-way that have been treated.

The influence of rainfall on the efficacy of herbicides is interrelated with additional environmental factors, as well as soil texture and soil structure. Temperature influences the performance of soil-applied herbicides by affecting chemical reactions in the soil, microbial activity and plant growth processes. Decomposition of herbicides by chemical reaction and microbial activity in the soil occurs more rapidly at high temperatures; therefore, herbicides are less persistent under these conditions.

Temperature has a profound effect on the absorption, translocation and metabolism of soil-applied herbicides by plants. Other factors being constant, the effects of these processes increase with increasing temperatures within a range conducive to plant growth. The interrelationships of these processes among themselves and with other factors often determine the toxicity and selectivity of the herbicide, but these interrelationships are too complex to be discussed here. However, it should be noted that herbicides usually perform best under temperatures at which plants grow rapidly. Under conditions of extremely high or low temperatures, the toxicity and selectivity may be altered dramatically due to the influence of temperature on these physiological processes.

Foliarly-applied Herbicides

It is quite probable that environmental factors have a greater effect on the efficacy of foliarly-applied herbicides than on that of soil-applied herbicides.

Factors affecting plant growth in general, such as soil moisture and temperature, discussed in the section under soil-applied herbicides, have the same effect on foliarly-applied herbicides. Rapidly growing succulent plants are generally more susceptible to post-emergence herbicide treatments than are plants in any other condition.

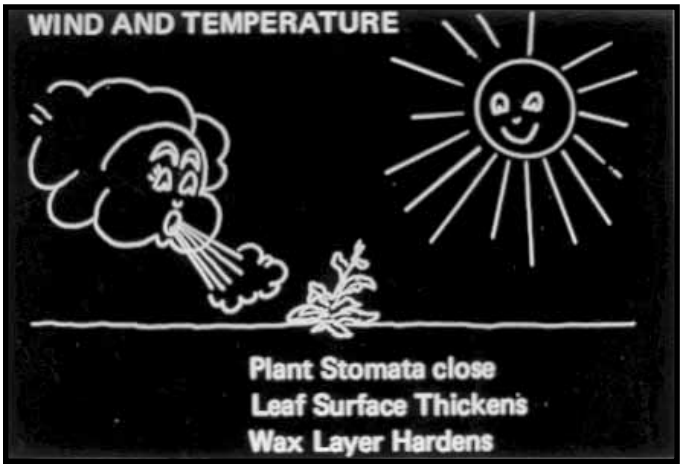

Figure 14.—Wind and Temperature Effects (Photo courtesy of Dow Chemical Co.)

In order for a herbicide applied to the foliage to be effective, it must be absorbed into the plant through the cuticle of the leaf. Plants grown under drought stress develop a thicker cuticle than those grown under more favorable conditions. This thicker cuticle limits absorption of the herbicide. The translocation of systemic herbicides may also be limited in plants grown under such drought stressed conditions.

Foliarly-applied herbicides usually perform best when applied during a period of high relative humidity, which greatly enhances foliage absorption by delaying drying of spray droplets and hydrating the cuticle, making it more permeable. High relative humidity may also enhance translocation of systemic herbicides. Very light rainfall, such as a drizzle, dew or fog, increases absorption and effectiveness by remoistening the dry herbicide on the leaf surface. However, heavy rainfall shortly after application may wash the herbicide off the plant. The amount of the herbicide washed from the plant will depend on the quantity of precipitation, the rate of herbicide application, the chemical characteristics of the herbicide and the use of an additive. Water-soluble herbicides such as salt formulations of 2,4-D are washed off more easily than oil-soluble herbicides such as ester formulations of 2,4-D.

In addition to the effect of temperature on the plant's physiological processes, temperature also influences foliar absorption of herbicides. Plants grown under high temperature frequently develop a thicker cuticle which restricts herbicide absorption. Due to the interaction of these physiological processes, the effect of the temperature at the time of application on herbicide performance depends on the herbicide being

applied. In general, best results can be expected from foliar herbicides applied during warm weather to actively growing plants and followed by a period of several hours with no rainfall.

Sunlight is an additional environmental factor that influences the performance of many soil and foliarly-applied herbicides. It is essential for the activity of certain herbicides, but it is seldom a limiting factor in their performance. However, the herbicide paraquat kills plants more rapidly on clear, sunny days and more slowly on cloudy days.

Public Relations Concerns

Adherence to label directions and proper application are absolute requirements to obtaining satisfactory results from any herbicide treatment. All treatments must be applied uniformly at the recommended rate over the area to be treated. Foliar treatments must be applied in a sufficient volume of carrier, usually water, to ensure adequate coverage.

When treating rights-of-way, it is very important to keep the spray mixture within the treated area during and after the actual spray application. There are two characteristics of herbicides which account for the majority of instances in which herbicides sprayed on rights-of-way reach non-target locations and result in damage complaints. These characteristics are drift and volatilization of the herbicide.

Drift refers to the movement of spray particles or droplets through the air to areas not intended for treatment. The amount of drift which can occur will depend on the particle or droplet size and the amount of air movement at the time of spraying. Herbicide spraying should not be done if the wind speed is greater than 5 miles per hour. The following table shows that particles of fog or mist size present the greatest possibility for drift to occur. These size particles are generated readily by high pressure spraying equipment.

Spray Droplet Size and Its Effect on Spray Drift

Droplet diameter (microns)	Type of droplet	Time required to fall 10 ft in still air	Distance droplet will travel in falling 10 ft (3 mi/h breeze)
5	Fog	66 minutes	3 miles
100	Mist	10 seconds	409 feet
500	Light Rain	1 ½ seconds	7 feet
1000	Moderate Rain	1.0 seconds	4.7 feet

From Weed Science: Principles and Practices, G.C. Klingman

Volatilization of herbicides is a chemical process whereby the herbicides change from a liquid to a gas. The herbicide, in the form of a gas or vapor, can move with the air currents for a mile or more to injure sensitive crops.

Drift and volatilization are problems of major concern in rights-of-way maintenance. They represent potential hazards to sensitive crops, gardens and ornamentals, and may have harmful effects on wildlife, people, livestock and aquatic areas near rights-of-way.

In many cases, movement of herbicides off right-of-way areas results in complaints from the public or property owners. Any complaints arising from herbicide application should be answered expeditiously and settled rapidly in a fair and amicable manner.

The general public is often not knowledgeable about the reason for and the nature of herbicide applications to rights-of-way. Applicators and operators can do much to alleviate public fear through a rational approach to effective communication with the public. The utilities should be above board and totally honest in their communications in order to bring about the needed education of the public concerning herbicide use.

Environmental Concerns

Groundwater Advisories

The potential for contamination of groundwater is an important consideration when choosing pesticides. Several products have groundwater advisory statements on their label. Such statements advise not to apply these products where the water table (groundwater) is close to the surface and where the soils are very permeable (well-drained soils such as loamy sands). Refer to these statements and observe all precautions on the label when using these products.

Endangered Species Act

The Endangered Species Act (ESA) is intended to protect and promote recovery of animals and plants that are in danger of becoming extinct due to the activities of people. Under the Act, the Environmental Protection Agency (EPA) must ensure that the use of pesticides it registers will not result in harm to the species listed by the U. S. Fish and Wildlife Service as endangered or threatened, or to habitat critical to those species' survival. To accomplish this, the EPA has implemented "Interim Measures," including county bulletins showing the area(s) within the county where pesticide use should be limited to protect listed species. Pesticide active ingredients for which there are limitations are listed in table form in the bulletins. The limitations on pesticide use are not law at this time, but are being provided for use in voluntarily protecting endangered and threatened species from harm due to pesticide use.

Laws, Regulations and Guidelines

Laws

Pesticide use and application in Kentucky is governed by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended, and by Kentucky Revised Statutes (KRS) 217B, the Pesticide Use and Application Act of 1972, as amended. The law is administered by the Department of Agriculture, Frankfort, Kentucky.

Regulations - General Provisions

Department of Agriculture Regulation KAR 31:005 sets forth the general provisions which apply with regard to definitions, compatibility, conflicting provisions, severability, record-keeping, storage and handling of restricted-use pesticides, supervisory requirements, certification denial, suspension, modification or revocation, and private applicators. Sections of this regulation are reprinted here:

Section 1. Definitions.

(5) "Certification" or "certified" means recognition by the Department that a person has demonstrated at least a minimum acceptable level of competence by examination or otherwise, and is authorized to use or supervise the use of restricted-use pesticides in the area of this certification.

(6) "Commercial applicator" means a certified applicator (whether or not the person is a private applicator with respect to some uses) who uses or supervises the use of any pesticide which is classified for restricted use for any purpose or on any property other than as provided by subsection (2B) (see below).

(13) "Environment" means water, air, land, plants, man and other animals living therein, and the interrelationships which exist among them.

(14) "Faulty, careless or negligent manner" means any act or omission which has or may have a deleterious effect on any person or property or which any person recommending or applying pesticides knows or should know is unnecessary or will not effectively accomplish the end sought and also means any application or use of pesticides inconsistent with the standards established by this regulation.

(26) "Pesticide" means any substance or mixture of substances intended to prevent, destroy, control, repel, attract or mitigate any pest.

(27) "Practical knowledge" means the comprehension of and ability to see pertinent facts in dealing with specific problems and situations.

(28) "Private applicator" means a person certified to use or supervise the use of any pesticide which is classified for restricted-use for purposes of producing any agricultural commodity on property owned or rented by him or his employer or (if applied without compensation other than trading of personal services between producers of agricultural commodities) on the property of another person.

(41) "Under the direct supervision of" means the act or process whereby purchase, use or application of a pesticide is made by a competent person acting under the instructions and control of a certified applicator who is responsible for the actions of that person and who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is used or applied.

Section 7. Supervisory Requirements. When a person purchases, uses or applies restricted-use pesticides under the direct supervision of a person with certification, the availability of the person with certification shall be directly related to the hazard of the situation.

Section 5. Record-keeping Requirements.

(3) Commercial applicators. All commercial applicators who purchase, use or apply restricted-use pesticides shall maintain the following records:

(a) Name and address of person requesting services;
(b) Kind and amounts of pesticides applied;
(c) Date of use or application;
(d) Purpose of application;
(e) Area of land treated, where applicable;
(f) Crop or type of area treated;
(g) Name of person with certification to purchase, use or apply restricted-use pesticides;
(h) Pesticide dealer where restricted-use pesticides were purchased; and
(I) Street address or site of use or application.

(4) Retention. All persons required to maintain records under subsection (3) of this section shall retain the records for a period of three (3) years from the date of use or application. Duplicate records need not be maintained. When a use or application of a restricted-use pesticide is made in the name of a person or business entity, then only one (1) set of records for each job or use need be maintained by that person or business entity, even though more than one (1) person may have made the use or application.

(5) Availability. Records required under this section shall be made available to the Department upon written request.

Regulations - Certification

Department of Agriculture Regulation KAR 31:015 establishes a system of certification for persons who purchase, use, or apply restricted-use pesticides pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act of 1972, as amended.

Sections of this regulation that apply to right-of-way certification are reprinted here:

Section 1. Applicability. No person may purchase, use or apply restricted-use pesticides unless that person is certified in a category consistent with such purchase, use, or application, as provided in this regulation or is acting under the direct supervision of a person so certified.

Section 2. Certification. Certification under this regulation may be obtained from the Department in the following categories of restricted-use pesticide use or application:

(6) Right-of-way pest control. This category includes persons using or supervising the use of restricted-use pesticides in the maintenance of public roads, electric power-lines, pipelines, railway rights-of-way, or other similar areas.

Section 3. General Requirements. To obtain certification, a person shall pay an application fee of twenty-five dollars ($25), submit a completed application form specifying the category or categories in which certification is requested, and satisfactorily demonstrate competence in the use and handling of pesticides in those categories. Competency in the use and handling of pesticides shall be determined on the basis of written examinations, and, as appropriate, performance testing, based upon standards set forth below. Such examination and testing shall include the general standards applicable to all categories and the additional standards specifically identified for each category or subcategory in which a person desires to be certified.

Section 4. General Standards of Competency. All persons shall demonstrate practical knowledge of the principles and practices of pest control and safe use of pesticides, including standards for the supervision of noncertified persons as established by regulation.

Section 5. Specific Standards of Competency. In addition to

meeting the requirements of Sections 3 and 4, persons requesting the certification for a specific category must demonstrate competence related to that category as follows:

(6) Right-of-Way. Persons requesting right-of-way certification shall demonstrate practical knowledge of a wide variety of environments, since rights-of-way can traverse many different terrains, including waterways. They shall demonstrate practical knowledge of problems of runoff, drift and excessive foliage destruction and the ability to recognize target organisms. They shall also demonstrate practical knowledge of the nature of herbicides and the need for containment of these pesticides within the right-of-way area, and the impact of their application activities upon the adjacent areas and communities.

Section 6. Aerial Certification. Persons desiring to apply restricted-use pesticides using aircraft shall obtain aerial certification in addition to certification in the appropriate category of pesticide use. Additional standards shall include possession by aerial applicators of special knowledge of aerial application equipment and of particular expertise with regard to calibration of that equipment. Their knowledge shall extend to such areas as spray efficiency testing, field flight patterns, swath marking, turning procedures and subsequent considerations, awareness of obstacles and obstructions, and personal safety to pilot, flagman, and ground crew. Knowledge should also include information that is commonly on pre-flight checklists of spray personnel.

Section 8. Certification Maintenance. To maintain certification, each person certified to purchase, use or apply restricted-use pesticides, other than a private applicator, shall in any five (5) year period, attend at least two (2) training programs approved by the Department in the use and application of pesticides, with the exception of seed treatment applicators who shall attend one (1) training course. Training received before the promulgation of these rules and regulations will be eligible for retroactive credit toward certification maintenance.

Section 9. Credentials.

(1) When a person meets all the requirements to obtain a license to do business under KRS 217B.010 to 217B.260 or under KRS 217B.500 to 217B.585, the Department shall issue that person a document signifying that the person is licensed to do business in the category for which a person qualifies.

(2) When a person meets all the requirements to obtain certification to purchase, use or apply restricted-use pesticides, then the Department shall issue that person a document signifying that the person is certified to purchase, use or apply restricted-use pesticides in the categories for which the person qualifies.

(3) When a person qualifies for certification incident to qualification for a license to do business, then the Department shall issue that person two (2) documents. One (1) document shall be the license to do business. The other document shall be the certification to purchase, use or apply restricted-use pesticides.

(4) A certification to purchase, use or apply restricted-use pesticides issued under this regulation is separate and distinct from any licenses to do business issued under KRS 217B.010 to 217B.260 or under 217B.500 to 217B.585. A certification may be granted or denied, or modified, suspended, or revoked independent of the grant or denial, modification, suspension, or revocation of any license to do business. In a like manner, any license to do business may be modified, suspended, or revoked independent of the grant or denial, modification, suspension, or revocation of any certification.

Guidelines—Environmentally Conscious Recommendations for Aerial Right-of-Way Applicators

• No aerial applications of any pesticide should be made on rights-of-way when the wind velocity is greater than 5 miles per hour.

• All rights-of-way to be sprayed should be inspected prior to spraying by the pilot of the aircraft that is to conduct the spraying operation. This inspection should be conducted immediately prior to the application and should not exceed 2-½ miles of line.

• Pesticide spraying equipment should be shut off in areas where potential for damage to humans, crops, animals or water contamination exists. Pesticide cut-off limits for aerial right-of-way applicators should be listed on pesticide labels.

• It is the responsibility of the utility company to inform applicators of previously damaged areas, areas requested by owner not to be sprayed, water reservoirs or other high-risk areas, and to mark these areas on the map to be used by the applicator.

Calculating Rates

Basically, the economic value of a herbicide depends on the relative amounts of active chemical, toxic to plants, that is contained per pound or gallon. This is expressed in percent of active ingredient, acid equivalent or pounds per gallon for liquids.

Thus, a solid containing 80 percent of the weed killing ingredient is worth more than a 20 percent granular product pound for pound, and an amine salt formulation of 2,4-D containing four pounds per gallon, acid equivalent, is of more value than the same formulation containing 2 pounds per gallon. Actually, since mixing charges and cost of containers, freight and handling have to be paid on twice as much material for a 2-pound-per-gallon formulation as a 4-pound formulation, the cost per pound of active material is less in the 4-pound formulation than in the 2-pound formulation although the cost per gallon of product is more.

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.

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

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

Example: If the rate is 1½ pounds per acre and the herbicide contains 4 pounds (AE) per gallon, then

$\frac{1.5}{4.0}$ = 0.37 gallon, or 8 pints x 0.37 = 3 pints

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, then

$$\frac{2.5}{2.0} = 1.25 \text{ or } 1\frac{1}{4} \text{ gallons}$$

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 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 spray 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 sprayer with the nozzles shut off, bypassing the spray through the tank for several minutes to ensure thorough mixing.

Glossary

Absorption—Uptake (in this context, of a pesticide) by plants, animals including humans, micro-organisms or soil.

Acid Equivalent—The amount of active ingredient in a pesticide formulation (e.g., an ester) expressed in terms of the acid from which it is derived; this figure is used in determining application rate.

Active Ingredient—The chemical in a pesticide product that is responsible for the pesticidal effects.

Adjuvant—A material added to a pesticide formulation to increase its effectiveness or aid in the application process.

Adsorption—The binding of a pesticide to surfaces (e.g., soil particles) by physical or chemical action.

Amine Salt—A pesticide formulation in which an acid is neutralized by an amine, a basic compound.

Annuals—Plants that live only one growing season, reproduce by seed and die.

Application Rate—The amount of pesticide applied to a site; usually expressed as a liquid or dry measure per unit area; for example, pounds or pints per acre.

Basal Bark Treatment—An application to the woody stems of plants at and just above the ground line and including the root crown.

Biennials—Plants that live for two growing seasons; in the first season, they form a low vegetative "rosette"; in the second, they flower, produce seed and die.

Biological Control—Suppression of a pest population by its own natural enemies such as predators or parasites.

Certification—Recognition by the regulatory agency that a person has demonstrated at least a minimum acceptable level of competence and is authorized to use or supervise the use of restricted-use pesticides in this area of certification.

Chemical Control—Suppression of a pest population by use of a pesticide.

Commercial Applicator—A certified applicator, whether or not a private applicator with respect to some uses, who uses or supervises the use of restricted-use pesticides on any property other than as a private applicator.

Contact Herbicide—A herbicide that kills plants primarily by contact with plant tissues rather than as a result of translocation; only the part actually touched by the herbicide is affected.

Dicot (Dicotyledon)—A plant with two cotyledons or seed leaves; a broadleaf plant with net-like venation.

Emulsifying Agent—A material which helps suspend one liquid in another with which it would not mix otherwise.

Emulsion—A dispersion of fine particles of oil in water.

Ester—An organic salt; an acid neutralized with an alcohol.

Extender—A material added to a herbicide formulation to extend its activity and effectiveness.

Foliar—Relating to the leaf or foliage of plants; e.g., a foliar spray is applied to the foliage.

General Use Pesticide—A pesticide that can be purchased and used by any responsible person.

Herbaceous Plants—Plants that do not form a woody stem.

Herbicide—A phytotoxic chemical used for killing or inhibiting the growth of plants.

Hypo-Hatchet—An instrument used to inject a pre-measured amount of herbicide directly into the growing woody stem.

Invert Emulsion—A dispersion of water in oil having a mayonnaise-like consistency.

Leaching—The movement of pesticides downward through soil with water.

Mechanical Control—Control of vegetation by hand-pulling, hoeing, blading, mowing, cutting, pruning, burning, bull-dozing, cropping or other non-chemical and non-biological methods.

Microfoil Boom—A boom that has a specially designed nozzle that forms large, viscous spray particles to minimize drift.

Monocot (Monocotyledon)—A plant having a single cotyledon or seed leaf and narrow leaves with parallel veins.

Perennials—Plants that live for three or more seasons and reproduce by seed and/or vegetative parts such as bulbs, tubers, rhizomes, stolons or roots.

Persistence—In this context, a measure of how long a pesticide remains in an active form at the site of application or in the environment.

Pesticide—Any substance or mixture of substances intended to prevent, destroy, control, repel, attract or mitigate any pest.

pH—A value expressing the acidity or alkalinity of a solution on a scale of 1 to 14; the neutral point is 7.0, below 7 is acid and above 7 is alkaline.

Phenoxy—A chemical class of herbicides including 2,4-D.

Phytotoxicity—Injury to plants due to exposure to a chemical.

Restricted-Use Pesticide—A pesticide that can legally be purchased and used only by or under the supervision of a certified applicator.

Rhizomes—Lateral extensions of plant stems beneath the soil.

Right-of-Way—An area involved in common transport.

Safener—A substance which prevents objectionable changes

when two or more substances must be mixed which otherwise would not be compatible.

Selectivity—The characteristic of herbicides whereby certain plant species are killed while others are injured little if at all.

Soil Sterilant—A chemical that prevents the growth of any organism in the soil—plants, animals or microorganisms; the effect may be temporary or long-lasting, depending on the chemical.

Spray Disc—In aerial application, a revolving disc mounted under the spraying ship whereby the herbicide mixture is spread across the right-of-way by centrifugal force of the revolving disc.

Spray Drift—The physical movement of spray particles off the target area at the time of application.

Stolons—Lateral extensions of plant stems along the surface of the soil.

Stump Treatment—Herbicide applied to cut stumps or stems to prevent suckering or re-sprouting.

Sulfonylurea—A chemical class of herbicides which includes chlorsulfuron, metsulfuron and sulfometuron.

Surfactant—An adjuvant which improves the emulsifying, dispersing, spreading and/or wetting properties of a pesticide.

Translocated Herbicide—Herbicide which when applied to one part of a plant (leaves or roots) can be taken up by the plant and moved internally to another part of the plant.

Tree Growth Regulator (TGR)—A chemical which in small amounts alters the growth habits of trees.

Triazine—A chemical class of herbicides which includes atrazine and prometon.

Uracil—A chemical class of herbicides which includes bromacil.

Urea—A chemical class of herbicides which includes diuron.

Volatilization—The movement of particles of a liquid pesticide after it has been converted into a vapor; usually occurring at some time after application.

Woody Plants—Plants that live longer than two years and have a thick, tough stem or trunk covered with cork.

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