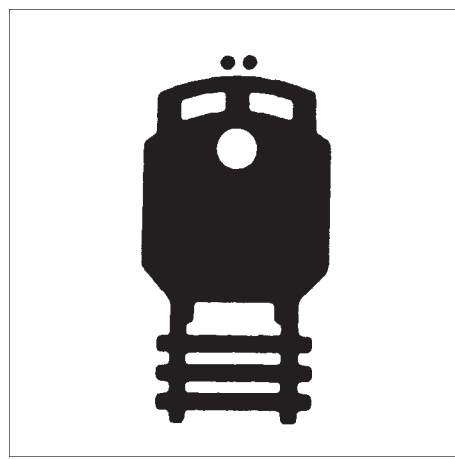
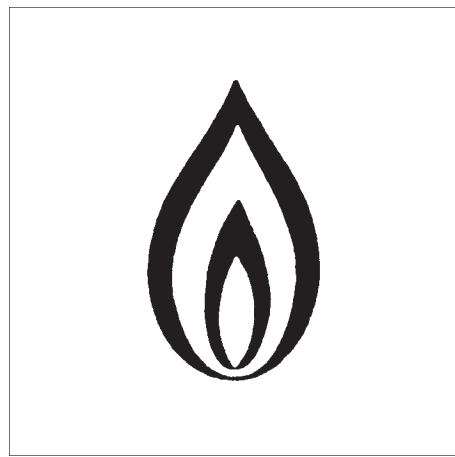
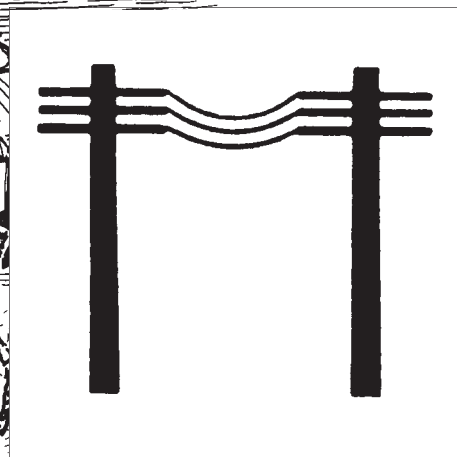




Rights-of-Way Pest Control



Directions for using this manual

This is a self-teaching manual. At the end of each major section is a list of study questions to check your understanding of the subject matter. By each question in parenthesis is the page number on which the answer to that question can be found. This will help you in checking your answers.

These study questions are representative of the type that are on the certification examination. By reading this manual and answering the study questions, you should be able to gain sufficient knowledge to pass the Kansas Commercial Pesticide Applicators Certification examination.

Preface

This manual is intended as a self-training guide for commercial rights-of-way treatment applicators. It is designed to complement the General Manual (publication S-12). The General Manual contains important additional information on types of pests, pesticide use, labels, regulations, safety, etc.

The purpose of this manual is to provide general information on how to select, apply, handle, and dispose of rights-of-way treatments in a safe and effective manner. It is hoped that this information will benefit commercial applicators and ultimately, consumers. Specific recommendations are not included because available products change frequently. Consult your local K-State Research and Extension office for current recommendations.

Table of Contents

Introduction	5
What Are Rights-of-Way?	6
Reasons for Rights-of-Way Vegetation Management	7
Pesticide Usage Considerations	7
Designing Vegetation Management Programs	8
Soil Characteristics	8
Texture	8
Organic Matter	8
pH	8
Slope	8
Herbicide Characteristics	8
Herbicide Absorption to Soil	8
Persistence	8
Environmental Factors	8
Soil Moisture	8
Temperature	8
Humidity	8
Precipitation	8
Wind and Temperature	9
Specialized Area Considerations	9
Aquatic Areas	9
Desirable Vegetation	9
Sloping Areas	9
Metal Surfaces	9
Use of Herbicides Around People and Livestock	9
Weed Identification	9
Monocots	10
Dicots	10
Life Cycles of Weeds	10
Annual Weeds	10
Summer Annuals	10
Winter Annuals	10
Biennials	10
Perennials	11
Noxious Weeds	11
Herbicide Classification	11
Selective Herbicides	11
Nonselective Herbicides	11
Contact Herbicides	11
Systemic Herbicides	11
Bare-ground or Soil-sterilant Herbicides	12
Pesticide Application Equipment	12
Components of Pesticide Application Equipment	12
Phytotoxicity	15
Damage to Fish and Wildlife	15

Table of Contents

Nonselective Vegetation Control: Guide Rails, Posts, Storage Areas	19
Reasons for Nonselective Vegetation Control	19
Planning the Control Program	19
Equipment	19
Vegetation in Pavement Cracks and Joints	19
Tree and Shrub Management	20
Methods Used	20
Planning the Management Program	20
Equipment for Woody Vegetation Management	20
Problems and Precautions in Woody Vegetation Management	21
Utility Rights-of-Way Vegetation Management	22
Telephone and Electric Power Lines	22
Transformer Stations and Substations	22
Pipelines	22
Railroads	22
Reasons for Vegetation Management Along Railroad	22
Areas for Railroad Vegetation Control	22
Problems Common to Railroad Vegetation Management	23
Evaluating Results	24
Using Pesticides to Control Insects and Rodents	25
Resistance to Pesticides	27
The Development of Resistance	27
Important Factors That Influence the Development of Resistance:	27
Herbicide-resistant Weeds	28
Resistance Management	28
Pesticide Spills and Fires	31
Pesticide Spills	31
Pesticide Fires	31
Public Relations	33
Differences in perception	33
Carelessness	34
Other Areas of Concern	35
Glossary	37




Weeds can be unsightly and pose a safety hazard on rights-of-way properties. Herbicides and mowing have been the main methods of controlling vegetation on rights-of-way and industrial sites for many years. Traditionally, herbicides have been cost-effective, but that is changing. Vegetation management is now becoming more complex and less reli-

ant on herbicides, due to increasing herbicide costs, off-site damages, and environmental pressures.

Pesticides must be used properly to avoid health and environmental problems. The objective of this manual is to educate the reader about pesticide application along Kansas' rights-of-way.

What Are


Rights-of-Way?

 Rights-of-way are defined as areas involved in common transport.

Examples include:

- Federal, state, county and township highways and roads;
- Electric utility lines, including transformer stations and substations;
- Pipelines, including pumping stations;
- Public airports;
- Railroads;
- Public-surface drainage systems, or ditches;
- Telephone and other communication networks; and
- Bicycle, hiking, bridle and other public paths or trails outside established recreational areas.

Reasons for Rights-of-Way Vegetation Management



The objectives of a well-planned vegetation-management program are to safely, efficiently and effectively maintain rights-of-way and rights-of-way facilities so that vegetation does not interfere with their intended use.

More than 15 million acres of land in the United States currently are 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, levees and communications structures. All of these require periodic vegetation management to assure they continue to be safe and efficient. One way to provide this management is with herbicides. Apply herbicides only as they are needed for safe and efficient use of the rights-of-way.

The aesthetic, economic and environmental benefits of a good vegetation-management program include:

- Improved highway pavement management: Properly managed roadside vegetation improves air circulation and increases the amount of sunlight that reaches the pavement, which keeps it dryer and extends its life.
- Improved highway safety: Drivers have better visibility of signs, curves, intersections, traffic signals and driveways. Maintain a safe shoulder area and keep the deflection area behind guardrails free of trees and vegetation. In addition, manage vegetation to maintain a free-draining road surface, which reduces the potential for hydroplaning or skidding on ice.
- Preservation and enhancement of scenic resources: This includes planting, encouraging natural plant growth and selectively restricting plant growth to screen, preserve, create or enhance views.

- Providing wildlife habitat: Improving existing conditions (i.e., woods, woody vegetation, open turf, bare ground, unshaded streams, etc.) with shrubs and herbaceous plants may provide wildlife with cover, nests and food.

Pesticide Usage Considerations

Licensed, certified applicators can quickly and efficiently improve the appearance and function of rights-of-way. Clearing brush and herbaceous weeds from rights-of-way is time consuming and labor intensive. However, herbicides and plant growth regulators can control vegetation to improve visibility, landscape beauty, safety and the function of rights-of-way. The applicator must match the pesticide to the pests and the conditions of control.

Urban and rural areas, waterways and adjacent farmland used for crop and animal production pose diverse and special problems when using pesticides in rights-of-way upkeep. Special cases of pest invasion may require insecticides or fungicides. However, most pesticides used on rights-of-way are herbicides and/or plant growth regulators.


Always plan the use of pesticides in advance. Include practices that minimize spray drift, runoff, washoff and other types of off-site pesticide movement.

Because of the wide variety of areas that rights-of-way traverse, review the pesticide label for special environmental and safety hazards. A principal concern when using chemicals in rights-of-way is containing the treatment within the rights-of-way themselves. In all cases, take steps to avoid or minimize the effect of treatments on areas adjacent to the rights-of-way.

The objectives of a well-planned vegetation-management program are to safely, efficiently, and effectively maintain rights-of-way and rights-of-way facilities so vegetation does not interfere with their intended use.

Designing Vegetation Management Programs

Persistence of a herbicide in the soil depends on its chemistry, rate of application, soil texture, organic matter, precipitation, temperature, and movement.



The goal of a well-designed vegetation management program is to produce the type of vegetative cover required. This can usually be done without a total reliance on herbicides by combining the use of herbicides with mowing and other management practices.

Critical considerations in planning a vegetation management program include:

- type of vegetative cover desired
- species of vegetation present
- species of vegetation absent
- soil characteristics and topography
- off-site vegetation
- herbicide characteristics
- available control and management options

Soil Characteristics

Texture. Soil texture refers to the relative amounts of sand, silt, and clay particles in a particular soil. Soil particles have exchange sites which are negatively charged. Clay, the smallest particle, has the most exchange sites. Silt and sand have fewer exchange sites and are generally not considered a factor in herbicide movement.

Organic Matter. As with clay particles, organic matter has exchange sites. However, organic matter has many more exchange sites than the smallest clay particles. Therefore, its ability to attract other particles is much greater.

pH. The effectiveness of some herbicides is affected by pH. Certain pH ranges or extremes may reduce or enhance the effectiveness. When herbicide labels have cautions involving soil pH, observe them.

Slope. Slope has a major influence on the fate of herbicides. As slope increases, water runoff potential increases. Herbicides can be moved off-site by surface runoff or internal soil drainage, potentially damaging or killing non-target species.

Herbicide Characteristics

Herbicide absorption to soil.

Herbicides are chemicals that have positive or neutral charges. Positive-charged particles can be attracted to negative-charged sites on soil particles. Whether the herbicide particles will be absorbed on soil particles is determined by the size of the charge on both particles, the distance between the particles (amount of water in the soil), concentration of herbicide and other salts in the soil solution, and the rate of movement of water through the soil. The unabsorbed particles are moved through the soil by a process known as leaching.

Persistence. Persistence of a herbicide in the soil depends on its chemistry, rate of application, soil texture, organic matter, precipitation, temperature, and movement. Herbicides can move with surface flow or leach through the soil profile (diluting effect).

Environmental Factors

Soil moisture. Soil-applied herbicides must be in moist soil to be taken up by plant roots. This requires water in the form of precipitation or irrigation.

Temperature. Temperature determines the rate at which plants grow, absorb, and translocate herbicides. At low temperatures, plant roots may not be active and will not take up the herbicides, or the plant roots may be so inactive that the herbicide works very slowly. At high temperatures, the herbicide may evaporate (volatilize).

Humidity. A foliar-applied herbicide will enter the leaf more easily and rapidly at high humidity than at low humidity. At low humidity, plant leaves have denser cuticles or wax layers, which restrict herbicide absorption.

Precipitation. Rainfall soon after a foliar-applied herbicide treatment may decrease effectiveness if the herbicide is washed off the leaf. Rain increases soil moisture, so soil-

Designing Vegetation Management Programs

applied herbicides can be more readily absorbed by the weeds. However, excessive rainfall may move the herbicide too deep, past the root zone of the weeds. A hard rain may move surface-applied herbicides out of the target area. This is especially true if the soil surface is packed or sloping.

Wind and temperature. A hot, dry wind will cause the stomates (openings on the plant leaf surface) to close, the leaf surface to become thicker, and /or the cuticle layer to harden. These factors make it harder for herbicides to penetrate the leaves. Wind also increases the risk of herbicide drift to non-target sites.

Specialized Area Considerations

Aquatic areas. When treating areas adjacent to aquatic sites, such as ponds, use herbicides that are labeled for that purpose. Avoid drift and vaporization, and keep spray out of the water. Avoid lateral movement or runoff from the treated area into the aquatic habitat.

Desirable vegetation. These areas include gardens, crops, ornamentals, etc. Do not apply herbicides to areas where the roots of desirable plants may absorb the chemical. Desirable plants located off the rights-of-way often have much of their root systems under the rights-of-way.

Sloping areas. These areas, if stripped of vegetation by the use of herbicides, will be subject to soil erosion. Maintain a cover or mulch on the areas by occasionally skipping retreatment or use selective herbicides that leave desirable vegetation growing.

Metal surfaces. Certain herbicides are corrosive. When you apply herbicides, avoid spraying automobiles, buildings, and other metal surfaces, either directly or through drift.

Use of Herbicides Around People and Livestock

All pesticides must be handled and applied with care. Avoid splash or spray contact, and keep exposure

to a minimum. Wear the appropriate personal protective equipment as directed on the labels. Keep herbicides in containers that are properly labeled and keep them properly stored and secured. Never dump unused herbicides where they can contaminate water supplies. Mix just enough spray solution for the job.

It is better to spray excess solution over an area at the treatment rate than to dump excess mix onto a small area. Avoid spraying herbicides or particles on yourself or other people and domestic animals that are in or near the treatment area.

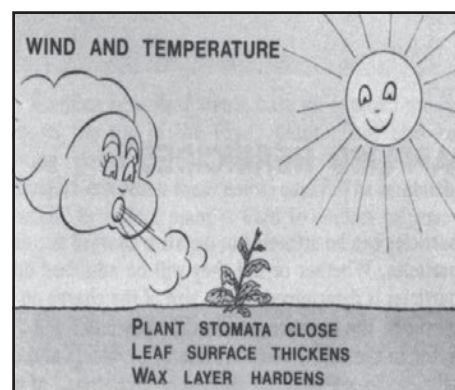
Herbicides sprayed on plants are generally not toxic to livestock, although labels should always be read prior to purchase and use. However, livestock may be poisoned by eating unused herbicides left in open containers or by drinking water contaminated with herbicides. Consult pesticide labels for any grazing restrictions on rights-of-way where livestock are allowed to graze.

Certain unpalatable or poisonous plants may become more palatable to livestock after being treated with herbicides. Be sure that livestock cannot have access to poisonous plants that have been treated with herbicides. Observe grazing and hay-cutting restrictions where pastures are to be treated.

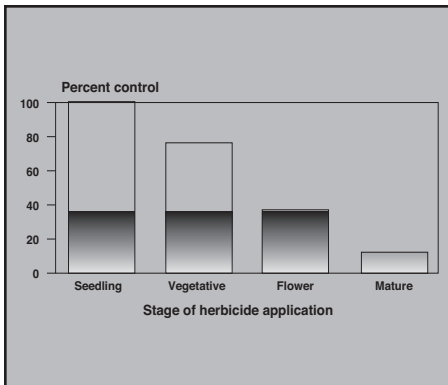
Weed Identification

Accurately identifying undesired vegetation, or weeds, is the first step in developing an effective management program. This is particularly true if planning to use herbicides since many herbicides only control certain plant species. Plant identification manuals are available through various agencies, including university, government and private companies. If unable to identify a plant, send or take specimens, including flowers if possible, to your local Research and Extension office.

Weeds include any undesired plants that are unsightly, potentially harmful, or hazardous to animal or



Designing Vegetation Management Programs



Weed control of annuals.

human health. A weed may be simply defined as a plant "out of place."

Weeds can be grouped into two categories, according to the manner of their growth habit and life cycles.

Monocots (grasses or grass-like plants): When monocots germinate, they have a single cotyledon. The cotyledon does not emerge above the soil surface, and the first leaves seen are true leaves. All monocots have narrow leaves with parallel veins, and they usually have a fibrous root system. Monocots most commonly reproduce by seed, stolons (creeping stems above the soil surface) or rhizomes (creeping stems below the soil surface). The growing point in monocots is at or below the soil surface, until reproductive structures develop. Monocots include grasses, sedges and cattails. These plants often are desirable in rights-of-way sites.

Dicots (Broadleaf plants): Dicots have two cotyledons that generally are pulled out of the soil following germination. The cotyledons are sometimes called seed leaves and often don't look like the later true leaves. Dicots usually have broad leaves (thus, the term broadleaved plants) with veins that form a netlike pattern; the plants generally have a tap root. All species can reproduce by seed, but some have vegetative buds either in the crown or on the taproot, and still others reproduce by spreading rootstocks.

Dicots are either herbaceous or woody plants. Woody dicots include brush, shrubs and trees. Brush and shrubs have several stems and are usually less than 10 feet tall at maturity. When trees are present, the brush and shrubs are considered understory. Trees usually have a single stem and are more than 10 feet tall at maturity. Woody plants may be evergreens or deciduous. Some woody plants can spread vegetatively as well as by seed (e.g., sumac). In contrast to monocots and herbaceous dicots, woody plants can be controlled at any time of year if appropriate methods are selected.

Life Cycles of Weeds

Weeds are also categorized according to how long they live and the season in which they grow. The categories often are mentioned on herbicide labels and are important in determining how best to control a particular weed.

Annual weeds live less than 12 months. Annual weeds can produce a multitude of seeds during a single growing season, and generally are most troublesome in newly planted areas and in cultivated soil. Many seeds of annual weeds will germinate during the following year, but some seeds may remain dormant in the soil for 50 years or more before they germinate and emerge as plants.

Summer annuals germinate from seed in the spring, flower and produce seed during the summer and die in the late summer or fall. They are best controlled in the seedling stage. Redroot pigweed, common lambsquarters and common ragweed are examples of broadleaf summer annuals. Grassy summer annuals include foxtails and crabgrass.

Winter annuals usually germinate from seed in the late summer and fall, overwinter as low-growing plants, flower and produce seed the next spring and then die. Winter annual weeds occasionally germinate in early spring and still produce seed by early summer. These weeds are easiest to control in the seedling or rosette stage of growth. Shepherds purse and pennycress are broadleaf winter annuals, and downy brome and cheat are winter annual grasses.

Biennials are weeds that live for two growing seasons and have tap roots. They germinate from seed in the spring or summer and produce a rosette of leaves on the soil surface. Biennials overwinter in the rosette stage and require a cold period to flower. The following year, they flower, produce seed and then die. They are most serious in pastures, roadsides and neglected areas. Control of biennials is best achieved when they are in the seedling or rosette stage the

Designing Vegetation Management Programs

year they germinate or in the rosette stage the second year. Once the flower stalk is formed (known as the bolting stage), biennials are difficult to control with herbicides. Examples of biennials include musk thistles, common mullein and wild carrot. There are no biennial grasses, brush or trees.

Perennials are weeds that live for more than two years and may live almost indefinitely. Perennials can reproduce by seed only (e.g., dandelion) or by spreading vegetatively from:

- Stolons (e.g., ground ivy),
- Rhizomes (e.g., cattails),
- Spreading rootstocks (e.g., Canada thistle and field bindweed), and
- Tubers (e.g., nutsedge).

Perennials may germinate from seeds in spring or summer but normally don't flower during the season they are established from seed. Their top growth becomes dormant each winter and their survival depends on underground structures. Non-woody perennials resume growth the following year from buds on the crowns, roots or tubers. They flower and set seed that year and each year thereafter. Perennial weeds are the most persistent and difficult to control. However, not all perennials are undesirable in rights-of-way, particularly if a permanent ground cover is desired.

Noxious Weeds

Noxious weeds are competitive with desirable vegetation and may spread to adjacent properties. Noxious weeds are weeds that must be controlled, according to state law. For a list of the current noxious weeds, contact either your local County Noxious Weed Department or the Kansas Department of Agriculture, Plant Protection and Weed Control Program, 785/862-2180.

Herbicide classification

Herbicides may be placed into groups by chemistry, the way they are applied, mode of action, or the type of formulation. A simple classification scheme is as follows:

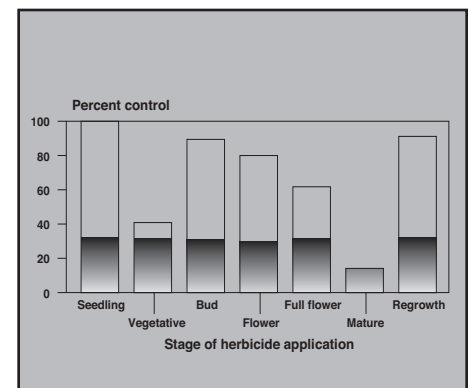
Selective herbicides have true physiological selectivity if they are applied to a mixture of plant species growing on the same site. Selective herbicides control only certain species while causing little, if any, significant injury to others. Selective control allows the desired plants to grow normally as the affected plants are controlled. For example, 2,4-D can be used to control broadleaf weeds without adversely affecting grass growth and seed production.

Nonselective herbicides damage all plants they contact. They can be applied selectively by directing their placement. For example, johnsongrass may be controlled in a stand of crownvetch by applying Roundup with a rope-wick type of applicator when the johnsongrass grows higher than the crownvetch around it.

Contact herbicides are not translocated and affect only the leaf or stem tissue that is sprayed. They usually affect plant functions rapidly after application, causing leaf burn symptoms. Contact herbicides can control annual weeds, but established perennial plants will regrow. Examples of contact herbicides are MSMA and paraquat.

Systemic herbicides are absorbed into the foliage or roots and translocated to other parts of the plants. Because these processes are slow, it may be days before the herbicide reaches its site of action and inhibits growth. The target site of action may be an enzyme, cell membrane or the chloroplast where a plant traps carbon dioxide for sugar production. Systemic herbicides are effective for control of perennial weeds that may regenerate new growth from buds on shoots, roots, rhizomes, or stolons.

Bare-ground or soil-sterilant herbicides are applied to prevent all plants from growing on the site for six months or more. These herbicides are frequently used to control vegetation around buildings, in fence rows and areas where a fire hazard exists. Because herbicide rate influences persistence, several herbicides may serve as temporary sterilants if high rates are



Weed control of perennials.

Designing Vegetation Management Programs

applied. Avoid herbicides with high water solubility or vapor pressure because of the possibility of leaching into ground water and off-site movement.

Pesticide Application Equipment

The equipment used to apply pesticides depends on the target organism, the type of application, and the pesticide formulation. No matter which type of equipment is used, there is one requirement: it must apply the proper amount of pesticide uniformly over the target area. The rate of pesticide being applied must be known. The details of calibration are addressed in the General Manual, S-12.

Components of Pesticide Application Equipment

The tank is a major component of the sprayer. It should be large enough to avoid frequent refilling, but small enough to provide maneuverability. Stainless steel, fiberglass, and polypropylene are considered the best tank materials because of their corrosion resistance. Stainless steel is the most expensive, and buyers must weigh their need for durability against cost. Every tank should have shut-off valves on all outlets so that any liquid in the tank can be held without leaking out of the pump, strainers or other parts of the system that are serviced most frequently.

The amount of agitation needed depends on the type of pesticides applied. Liquid concentrates, soluble powders, and emulsions require little agitation; usually the flow from the bypass hose is enough. Wettable powder (WP) suspensions require vigorous agitation to prevent settling. Tanks with square corners require more specialized agitation than round tanks. Two methods exist for agitating spray material in the tank: (1) paddles or a propeller to provide mechanical agitation; or (2) the use of return flow of material from a pump to provide hydraulic agitation. When

hydraulic agitation is used, a simple bypass line from the relief valve is not enough. There should be a separate agitator line from the pressure side of the pump to the bottom of the tank with appropriate valves to control the amount of agitation.

Strainers are used to prevent scales, rust flakes and other foreign material from plugging nozzles or other working parts of the sprayer. They are installed as necessary on the intake line, pressure line or as a part of the nozzle.

A good spray pump must deliver the required pressure and volume within its normal working capacity plus have reserve capacity to allow for wear. If abrasive materials are used, it must be able to pump them over a long period of time without loss of performance. Metal parts must resist corrosion if corrosive materials will be used. Seals should be compatible with the types of materials to be used. Common pump types include roller, centrifugal, and diaphragm. Care should be taken to make sure proper plumbing methods are used for the chosen pump type.

Pressure control is one of the most important aspects of proper application. Pressure determines the quantity of spray material delivered by the nozzles. Pressure control protects pump seals, hoses and other sprayer parts due to damage from excessive pressure and bypasses any excess spray material back to the tank.

Relief valves and pressure unloading valves are two types of pressure controls. A relief valve simply bypasses spray material not needed by the booms directly back to the tank. This then requires the pump and engine to keep working as though one were spraying, even when the booms are turned off. However, unloading valves maintain working pressure on the discharge end of the system, but move the overflow back into the tank at lower pressure, reducing strain on the engine and the pump. Bypass or unloading valves are used with positive displacement pumps, including roller and diaphragm. Centrifugal

No matter which type of equipment is used, it must apply the proper amount of pesticide uniformly over the target area.

Designing Vegetation Management Programs

pumps do not require bypass or unloading valves as pressure is controlled by throttling the pump output to the appropriate level. When selecting the appropriate pressure control, be sure that the flow capacity matches that of the pump being used.

A pressure gauge is essential on any sprayer. Without one, it is impossible to tell how the sprayer is functioning. If pressure does not remain constant, the amount of liquid coming out of the nozzles will vary. Mount the gauge so that it can be seen easily. Pressure gauges often fail because they become clogged with solid particles or are allowed to freeze in winter. A glycerin-filled diaphragm-type gauge is more expensive, but will last much longer.

Consider four main points when selecting sprayer hoses: composition, construction, working pressure and size. High-quality hoses and fittings may be expensive, but are cost-effective when used over a long period of time. The hose should be resistant to chemical action of the spray solution. The working pressure of the hose should be greater than the maximum pressure that the pump delivers. Hose size should be matched to the flow volume and pressure requirements. If the hose in the pump suction line is too small, the pump may not get enough pesticide mixture or may cavitate, causing low pressure or pump damage. If the hose in the pressure line is too small, volume at the nozzle(s) will drop because of severe pressure drop through the line.

A nozzle is an atomizing device that meters the liquid, breaks the liquid into droplets, and forms a pattern of distribution. A complete nozzle assembly consists of the body, screen, cap and tip. The function of the nozzle body is to attach the screen and tip to the boom. Several different nozzle body designs are available. All designs perform adequately, but each design has advantages for specific spraying jobs. Nozzles accommodate a variety of replaceable tips or discs to meet

spraying requirements. Manufacturers of sprayer nozzles can supply data sheets for the delivery rate, usually in gallons/minute at different pressures for their nozzles. The application rate of any tip is dependent on the sprayer speed, nozzle tip spacing, and operating pressure of the tip.

Warning: Never operate nozzles at high pressures to compensate for selecting the wrong nozzle size. High pressures increase the rate of nozzle wear and increase the drift hazard.

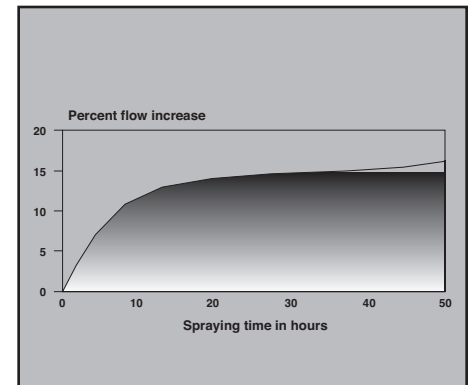
Nozzle tips and discs are made of aluminum, brass, ceramic, plastic, stainless steel or tungsten carbide. Tungsten carbide, ceramic, and stainless-steel tips are more resistant to abrasive wettable powders and are more expensive than brass tips, but provide the most economical long-term value. Nozzle tip types commonly used to apply herbicides to rights-of-way with ground equipment include flat fan, off-center (OC), boomless and whirling disc.

Note: When using wettable powders, calibrate the sprayer frequently. As a nozzle wears, the quantity of spray material delivered increases.

The flat-fan nozzle is normally used for broadcast spraying, such as broadleaf weeds in turf. The deposition pattern is elliptical with tapered edges. Flat fans require 30 to 50 percent overlap to provide even distribution. At 15 to 30 psi, the flat fan delivers small to medium droplets. Newer flat fan type nozzles designed to reduce drift problems include the turbo flat fan, drift guard flat fan, and raindrop flat fan.

The most commonly used flat-fan nozzles have a spray angle of 65, 80, or 110 degrees. Use of the 110-degree tip allows the operator to keep the boom relatively low to reduce the drift hazard, and give a uniform distribution of spray material over the entire length of the boom.

Low-pressure sprayers with specialized booms or off-center nozzles are widely used for roadside and



Nozzle wear.

Designing Vegetation Management Programs

railroad-yard maintenance. Specialized booms include those used to spray under guardrails and around other obstructions. Many variations exist, and their use depends on maintenance requirements.

Off-center nozzles produce a wide, flat fan spray deposition pattern, distorted to one side. Thus, a properly equipped spray or hyrail truck can uniformly apply herbicides to a wide roadside rights-of-way or multiple railroad tracks in a yard-maintenance program.

The Radiarc sprayer is a precision, boomless, low-volume application device that will apply pesticides in a uniform pattern. Its large droplet size and narrow droplet spectrum provide precise targeting with accurate, sharp edges to the spray swath. The spray device oscillates to make a uniform mechanical distribution of pesticide sprays at low-volume applications while reducing drift. The Radiarc sprayer is specifically designed to disperse particulates, suspensions, wettable powders and emulsifiable concentrates.

Boomless sprayers, a modification of OC nozzles, have a central nozzle or cluster of nozzles that produce a wide spray pattern that results in a wide swath similar to that laid down by a boom-type sprayer. Deposit is fairly uniform over the swath.

(carrier), release height, aircraft speed, and others.

Swath displacement, or the shifting of the applied material, will occur if there is a cross wind during application. Pesticide spray particles moving off target are generally considered as drift. Minute amounts of drift are unavoidable with many types of applications. The key is to manage drift and keep it at a level that is low enough to cause no adverse effect. Some problems of drift are: (1) the loss of pesticide, (2) crop damage and possible unwanted residues on crops, (3) destruction of beneficial insects, (4) detectable movement into human and domestic animal habitats, and (5) movement into and damage to wildlife environments.

Many drift effects are not large or long-lasting, but the threat of drift can be highly significant to the general public. Bad publicity from drift can be escalated by adverse TV, radio, and newspaper coverage, and stressful relations with neighbors. Where drift-loss from pesticide application cannot be eliminated, proper management can significantly reduce potential problems.

One of the best tools for controlling drift is spray droplet size management. Spray nozzles produce a range of droplet sizes rather than one uniform droplet size. This droplet size range is usually described by its volume median diameter (VMD). VMD is the diameter at which half the spray volume is made up of droplets larger and half is made up of droplets smaller than the VMD. This median measure is a convenient and useful method of describing a spray but gives no indication of the range of droplet sizes present.

Spray droplets less than 100 micrometers (1 micrometer = approximately 1/25,000 of an inch) in diameter at the nozzle, and larger droplets that become smaller than 100 micrometers in diameter before reaching the target, are generally considered to represent the drift potential of applied sprays. Small droplets may provide the best coverage and enhance effica-

The key is to manage drift and keep it at a level that is low enough to cause no adverse effect.

Factors Affecting Spray Drift

The term physical drift or drift-loss may be defined as the movement of airborne liquid, in the form of small droplets, from the target area at the time of application. Vapor drift, or volatilization, may also occur and should be minimized through product selection, and by observing meteorological restrictions on the application. Drift is complex and involves several factors such as particle size, air movement and temperature gradient, humidity, type of terrain, vegetation being treated and non-target elements (trees, structures, roads, bodies of water), as well as pesticide formulation, diluent

Designing Vegetation Management Programs

One of the best tools for controlling drift is spray droplet size management.

cy of some products, but large droplets reduce the potential of drift. Since both large and small droplets cannot be effectively produced at the same time, some reasonable and acceptable tradeoff must be developed to achieve reasonable pest control while controlling drift.

Select application equipment that will produce the largest droplet sizes consistent with the mode-of-action requirements of the pesticide. Set nozzles as low as possible to diminish wind effects, but not so low as to induce streaking from improper overlap. Use low spray pressures to minimize the amount of small driftable fines produced by the nozzle tip. Spray during periods of light wind from a direction that will cause potential drift to move away from sensitive areas. Consider the use of drift-suppressing additives to the spray material to reduce the amount of driftable fines produced. Avoid spraying during periods of high temperatures and low relative humidity, which will increase evaporation rates and drift potential of the spray material.

Effects on Nontarget Organisms

Pesticides on nontarget organisms may cause direct, immediate injury or, if used in the same place over a long time, may cause harm to the environment. The following sections will discuss the effects of pesticides on nontarget plants, bees and other beneficial insects, livestock, fish and wildlife, and endangered species.

Phytotoxicity is injury to plants because of exposure to a chemical. Phytotoxic injury can occur on any part of a plant: roots, stems, leaves, flowers or fruits. Nearly all pesticides can cause plant injury, particularly if applied at too high a rate, at the wrong time or under unfavorable environmental conditions.

As expected, the most phytotoxic injury is caused by herbicides designed specifically to kill plants. All herbicides kill plants by interfer-

ing with one or more of the vital processes of plant life. These processes include germination, cell division, photosynthesis, respiration and protein synthesis.

Herbicides may damage desirable plants they are meant to protect or other plants on adjacent land. Injury to desirable plants occurs most frequently when the chemical has a narrow range of selectivity between those plants and the target weeds. Damage to plants in adjacent areas primarily occurs because of drift or over spray. Damage sometimes is caused by surface runoff, particularly from sloping areas.

Persistent herbicides may injure succeeding plants at the site long after the original application. Injury to succeeding plants is particularly common when abnormally cold or dry weather inhibits degradation of the herbicide or when application rates are unusually high.

Damage to fish and wildlife can result. The potentially harmful effects of pesticides on fish and wildlife have been the focus of widespread concern, particularly since the early 1960s. There is, without question, valid cause for concern.

Damage to fish and wildlife may be either a direct and immediate consequence of improper pesticide application (e.g., direct fish kills resulting from overapplication or drift into an aquatic environment), a result of contamination of wild plants used as a food source or a result of indirect pollution of fish and wildlife habitats, principally through soil erosion, surface runoff and leaching. In the case of pollution, pesticides with longer persistence are a significantly greater hazard. Those that are both persistent and cumulative pose the greatest risk.

Pesticides may either kill fish and wildlife or, at sublethal doses, cause harm, including reduced growth, behavioral changes and decreased reproduction. Sublethal effects may be the most serious problem for wildlife; many of the highly publicized effects of the chlorinated hydrocarbons on wildlife, notably on fish-eating and

Designing

Vegetation

Management

Programs

raptorial birds, have been linked to reduced reproduction.

Pesticides have been implicated in the decline of numerous species of native plants and animals. To minimize the harm pesticides can do to federally endangered and threatened species, and to ensure that these species and their habitat will no longer be jeopardized, the EPA is developing a new program of use restrictions

under the Endangered Species Act. In the new program, pesticides harmful to native plants and animals will have a warning statement about their use within the geographic range of any endangered or threatened species. The statement will instruct users as to what actions they need to take to safeguard endangered and threatened species.

Study

Questions

Pages 7–16

1. (7) How often should herbicides be applied to rights-of-way?
 - a. Every 30 days from May through November
 - b. Every 90 days from May through November
 - c. Only as needed for safe use of the rights-of-way
 - d. Herbicides should never be applied to rights-of-way
2. (7) Most pesticides used on rights-of-way are:
 - a. herbicides
 - b. insecticides
 - c. fungicides
 - d. rodenticides
3. (8) Which of the following is NOT referred to as a soil texture characteristic?
 - a. sand
 - b. pH
 - c. silt
 - d. clay
4. (8) Movement of unabsorbed herbicide particles through the soil is a process called:
 - a. soaking
 - b. erosion
 - c. leaching
 - d. drifting
5. (9) Special consideration must be given to:
 - a. aquatic sites adjacent to rights-of-ways
 - b. sloping areas
 - c. desirable vegetation
 - d. all the above
6. (9) The first step in developing an effective management program is:
 - a. accurately identifying the weeds
 - b. selecting the herbicide
 - c. determination of soil characteristics
 - d. being sure it will rain within two weeks
7. (10) Dicot plants usually have:
 - a. narrow leaves
 - b. fibrous roots
 - c. growing point above soil surface
 - d. broad leaves with net-like vein pattern
8. (10) Summer annual weeds:
 - a. germinate from seed in the spring
 - b. germinate from seed in the fall
 - c. live for over two years
 - d. are cheat and downy brome grasses
9. (11) Weeds that live for more than two years are
 - a. annuals
 - b. biennials
 - c. perennials
 - d. multiannuals
10. (11) 2, 4-D is an example of a:
 - a. non-selective herbicide
 - b. selective herbicide
 - c. contact herbicide
 - d. nondrift herbicide
11. (12) The one requirement of application equipment is:
 - a. it must be made of aluminum
 - b. it must have its own power source
 - c. it must apply the proper amount uniformly over the target area
 - d. it must be replaced every two years
12. (12) Vigorous agitation is required during the use of ____ formulations.
 - a. emulsions
 - b. wettable powders
 - c. liquid concentrates
 - d. soluble powders
13. (13) The four main considerations in sprayer hoses are, composition, construction, working pressure, and ____.
 - a. length
 - b. color
 - c. size
 - d. end fittings
14. (13) Nozzle tips that are more resistant to abrasive wettable powders are made of:
 - a. aluminum
 - b. plastic
 - c. brass
 - d. stainless steel

Study

Questions

Pages 7–16

15. (14) Flat-fan nozzles with a ____ degree tips are best to reduce drift and give uniform coverage.
- 65
 - 80
 - 110
 - 150
16. (14) Movement of small airborne droplets off-target is called:
- physical drift
 - vapor drift
 - swath displacement
 - volatilization
17. (14) One of the best tools for controlling drift is:
- spray only on totally calm days
 - use very high pressure to penetrate the foliage
 - spray droplet size management
 - spray only when drift will blow back on the target
18. (15) The most phytotoxic pesticides are the:
- insecticides
 - fungicides
 - herbicides
 - rodenticides
19. (15) Indirect pollution of fish and wildlife habitats can occur through:
- leaching
 - soil erosion
 - surface runoff
 - all the above
20. (16) The U.S. EPA is developing a new program to protect certain fish and wildlife under what law?
- Food Quality Protection Act
 - Worker Protection Standards Act
 - Endangered Species Act
 - Pesticide Registration Act

Nonselective

Vegetation Control:

Guard Rails, Posts,

Storage Areas



Reasons for Nonselective Vegetation Control

Nonselective weed control reduces the need to trim by hand around signs, guard rails, posts, fences, etc. The bare-ground result of spraying around guard rails and other highway structures enhances visibility for motorists and highway crews responsible for maintenance. Keeping yards and storage areas cleaner and safer with complete weed control is desirable. Pretreating stabilized shoulders with a nonselective residual herbicide can extend the life of the shoulder substantially.

Guard rail and shoulder weeds collect winter sand and runoff from the road pavement. Eventually, the sand builds up dikes or berms that slow water runoff from pavement, creating large puddles and ice patches. On fill slopes, trapped runoff is channeled against these berms, building up velocity before finding a discharge point over the slope. A concentrated discharge usually causes erosion and slope failure.

Although machine grading can remedy this problem on open shoulders, guard rail sections are another matter. Mowing weeds under guard rails by hand is dangerous to workers as well as time consuming and expensive. Applying soil-residual herbicides gives complete control of all guard rail weeds. One treatment usually will last a growing season.

Planning the Control Program

With a nonselective weed-control program, it is necessary to plan ahead to make the best use of personnel and equipment. Regular site monitoring should be done. Usually, the best results from soil residuals comes when applied before the weeds emerge or when they are small. This means early spring. If experience has shown there has been lateral movement of residual herbicides in previous years, apply lower rates later in the season with a

contact herbicide to minimize further movement. Some areas that have been treated for several years may not need treatment at all.

Equipment

By adjusting boom and nozzle combinations, the same type of low-pressure equipment used for other types of weed control also can be adapted for use along guard rails. Generally, it is sufficient to treat a 3-foot strip under the guard rail. This can be done with a single hand-held spray bar with a single nozzle, or a spray bar with one nozzle may be placed high enough to clear the rail posts on a fixed mount on the truck. Equipment that automatically adjusts to obstacles is available, making hand-held spray bars unnecessary.

A nozzle arrangement that can be useful in this situation is the mounting of two smaller, off-center nozzles approximately 18 inches apart and 15 inches above ground level, on a bar in line with the direction of travel. By adjusting the nozzles so that the forward nozzle is angled in the direction of travel and the other toward the rear, shadowing is eliminated. The pattern width is determined by adjusting the nozzle angle.

Vegetation in Pavement Cracks and Joints

Herbicides can substantially reduce damage to pavement from vegetation growing in cracks and joints. Vegetation can expand the crack, which then collects silt and moisture and encourages more growth and further pavement deterioration. A systemic herbicide such as glyphosate (Roundup) is ideal for control in this situation. Soil-residual herbicides could extend the life of an application to cracks, etc. However, consider this option carefully because rain can move a residual herbicide from the joint or pavement surface and carry it to nearby nontarget sites.

If experience has shown there has been lateral movement of residual herbicides in previous years, apply lower rates later in the season with a contact herbicide to minimize further movement.

Nonselective

Vegetation Control:

Guard Rails, Posts,

Storage Areas

Tree and Shrub Management

Trees and shrubs are controlled along roadsides to maintain visibility, particularly along curves, at corners, intersections and in advance of signs. Suppressing trees and woody vegetation along roadsides can reduce shading as well as uneven thawing and pavement drying in the winter. Woody vegetation also impedes the functioning of ditches and drainage ways. Timely spraying of woody vegetation generally controls poison ivy in planned work locations and near homes, schools and playgrounds, which may otherwise be untreated because of the lack of time and funds.

Methods Used

Several methods of managing woody vegetation are available to roadside managers and certified pesticide applicators. Most of these combine mechanical cutting with pesticide treatment of stumps and/or regrowth.

Ideally, identify and chemically treat areas of woody-plant invasion before the plants become so mature that they require cutting. This often can be accomplished by spraying in a manner similar to broadleaf weed control, with the spray directed from the edge of the pavement. A variation of this is cutting extensive areas of woody vegetation in one operation and scheduling a foliar treatment of the regrowth for the following spraying season.

In areas where brownout or standing dead vegetation can be tolerated, foliar treatment of larger plants is an alternative. Always cut large trees at the ground level in areas and treat the stumps with a basal herbicide.

After woody species are under control, control extensive regrowth with periodic mowing, spot spraying of regrowth, low-volume basal applications or combinations of methods to avoid extensive cutting and broadcast spraying.

Planning the Management Program

Follow a woody-vegetation management program of cutting and treating stumps annually, except during spring, when upward sap flow makes this application less effective. Timing is not as important as in broadleaf or guard rail treatment. However, depending upon the area, planning what pesticides to use is important. Residual pesticides should not be used on slopes where avoiding injury to downhill vegetation is required. When brownout is a concern, time foliage treatments toward the end of the summer, thereby reducing the duration of a brownout.

Fosamine (Krenite) might be the herbicide of choice because it prevents growth the following season, but does not cause brownout of the foliage at the time of treatment. Fosamine also can eliminate brownout problems if the woody vegetation is cut and sprayed at the end of the first growing season after it has resprouted. The amount of herbicide used is significantly reduced in this type of treatment.

Equipment for Woody Vegetation Management

For stump treatment on a moderate scale, backpack sprayers will probably suffice. Large-scale treatment may require the use of a hose and handgun supplied by a power sprayer. Low pressures are sufficient. Use the same sprayers as those used for guard rail application. This equipment can be used to apply herbicides to poison ivy.

If a water-based spray for foliage spray is used, a high-pressure sprayer with hose and handgun will be faster and give better coverage than low-pressure equipment. Remember that these are for special uses only.

Ideally, identify and chemically treat areas of woody-plant invasion before the plants become so mature that they require cutting.

Problems and Precautions in Woody Vegetation Management

Foliar brownout is unsightly and may cause criticism from the public, so it is imperative that this work be performed with professionalism and sensitivity.

Wear waterproof foot gear and cover for the legs when ground spraying in tall grass and woody vegetation. Also, generally, applicators should wear long sleeved shirt, gloves, and protective eyewear. This prevents excessive exposure to the herbicide. When leaving these areas, avoid walking through valuable plantings to prevent damage caused by residues on clothes.

Nonselective

Vegetation Control:

Guard Rails, Posts,

Storage Areas

Utility

Rights-of-Way

Vegetation

Management

More than 4 million acres of transmission line rights-of-way in the United States represent a substantial wildlife habitat.



Telephone and Electric Power Lines

Vegetation management is necessary along telephone and electric power line rights-of-way for two reasons: to control tall woody plants that could interrupt overhead transmission line performance, and to improve accessibility for maintenance, emergencies and routine and aerial inspections. A well-managed rights-of-way increases both food and protection for wildlife and other animals.

More than 4 million acres of transmission line rights-of-way in the United States represent a substantial wildlife habitat. Rights-of-way that cut through forest areas, with the subsequent growth of herbaceous plants, bushes and young trees, support more animal life than the original tree cover. Wildlife such as rabbits, deer, fox and birds that normally live along the forest edge find food and shelter along rights-of-way.

The soil beneath telephone and electric power lines should not be bare. This area often is planted with perennial grasses that provide erosion control, support maintenance equipment and compete with tall or vining brush that should not be allowed to grow onto the lines. Control of most undesirable vegetation in established turfgrass can be obtained with occasional mowing or treatment with a selective herbicide.

Transformer Stations and Substations

Total vegetation control (TVC) is required in these areas. They must be kept free of vegetation to prevent short circuits and to alleviate fire hazards that could result from dead vegetation. These sites are usually covered with gravel. Treat the soil periodically with nonselective herbicides that have a relatively long soil-residual activity that prevents weeds from growing through the gravel. Be aware of the potential for herbicide movement off-site.

Pipelines

Pipelines do not require TVC, but brush should be kept to a minimum to allow for maintenance and aerial inspection. Establishing perennial grass after the pipes are laid will help control erosion. Mechanical removal or periodic treatments with selective brush herbicides help maintain these areas.

Railroads

Railroads are similar to other rights-of-way in that they pass through a variety of privately and publicly owned lands with all the vegetation control problems, such as drift and public relations, that may result. Vegetation control on railroads is different than other utility rights-of-way in that most of the area treated is owned by the railroad. The treatment can be more easily planned and managed. Herbicides are primarily applied with ground equipment.

Reasons for vegetation management along railroad

- Allowing inspection of track, ties and roadbed;
- Improving working conditions;
- Increasing safety;
- Reducing the potential for track-side fires;
- Conforming with state, city and local laws;
- Reducing the source of weed seeds to farmers' fields;
- Preventing overgrowth and noxious weeds in urban and suburban areas;
- Improving the appearance of the railroad; and
- Maintaining visibility at road crossings.

Areas for Railroad Vegetation Control

- *Ballast section:* Maintains drainage; allows inspection of ties, fastenings and switches, increasing the life of ties; keeps weed seeds out of traction motors on diesel engines; and prevents wheel slippage.

Utility

Rights-of-Way

Vegetation

Management

- *Shoulder adjacent to ballast section:* Promotes drainage and reduces potential for track-side fires.
- *Shoulder:* Allows unrestricted vision and train inspection.
- *Bridges, buildings and other structures:* Maintains fire safety.
- *Yards:* Maintains safety, convenience and appearance.
- *Low switch stands and dwarf signals:* Assures visibility.
- *Inside of curves:* Allows for train inspection.
- *Under communication lines:* Maintains uninterrupted service.
- *Area adjacent to tracks:* Helps keep trains from fouling.
- *Highway grade crossings:* Allows unrestricted view for both autos and trains.
- *Signs (mile posts, whistle boards, etc.):* Assures optimal view.

Problems Common to Railroad Vegetation Management

Drift. As with any other type of herbicide application, drift that can injure ornamentals and crops adjacent to the rights-of-way must be avoided. Precautions include using low-pressure, low-mounted booms and nozzles, special application devices coupled with drift-control adjuvants and stopping operations

when pesticide begins to drift from the rights-of-way.

Brownout. Brownout is not as big a problem as it is along highways because the area along the railroad is not as visible. Alternative treatments in visually sensitive areas should be considered. These could include basal applications or pesticide substitution.

Encroachment of hard-to-kill species. When the same ground is treated year after year with the same herbicides, certain vegetation may not be controlled and may become the predominant species in time. When this happens, switch herbicides to a different herbicide family. Long-range planning can help avoid this problem.


Logistics. Railroad vegetation-management programs must work with and not impede regular rail traffic using the same rails. In other rights-of-way application, there is little if any restriction on the normal use of the highway or utility line. In railroad vegetation management, know train schedules, plan for track delays (a good time to check equipment) and be alert and prepared to stop at road crossings. In areas of high vehicle traffic, spray at night. Normally, the sprayer should be off the tracks before dark.

Drift that can injure ornamentals and crops adjacent to rights-of-way must be avoided.

Evaluating

Results

Know the objectives of the control program when evaluating the results.




After using any vegetation-management practice, inspect the area to evaluate the results. Keep in mind the type and species of vegetation treated together with the soil type and weather conditions during and after application. Know the objectives of the control program when evaluating the results. In some cases, it is sufficient to suppress treated vegetation. In other cases, selective control is required. In still other cases, TVC is desired. In most cases, determine initial herbicide activity, and possible injury to adjacent desirable vegetation two to four weeks

after application. Evaluate the results of TVC treatments after about two months and subsequently through the end of the season. Evaluating the effectiveness of brush and perennial weed control measures should be done at least 12 months, and sometimes 24 months, after treatment.

Evaluation must be constant. Evaluations may result in rate adjustments, a change of products or timing of herbicide applications, and consideration for adding or adjusting nonchemical controls.

Using Pesticides to Control Insects and Rodents



The majority of rights-of-way pest-control situations include controlling vegetation with machinery and/or herbicides. At times, under certain conditions, migratory insects and rodents also might present problems. Insect pests include grasshoppers, armyworms, and mosquitoes. Rodent pests include field mice and woodchucks.

Control insect pests with any insecticide registered for such appli-

cations. As with herbicides, make sure that insecticides do not drift into off-target areas. Humans, pets, and livestock can be very sensitive to many insecticides. Rodent problems may be reduced by mowing or clipping to remove cover, by trapping or by using registered rodenticides.

Remember, the Kansas Department of Wildlife and Parks requires a permit before using any chemical to control wildlife.


Study

Questions

Pages 19–25

1. (19) Non-selective vegetation control is practiced:
 - a. where complete weed control is desirable
 - b. to control plant diseases
 - c. to prevent soil erosion
 - d. to make it possible to locate seedling noxious weeds
2. (19) To control vegetation in pavement cracks and joints, a ____ is ideal.
 - a. soil residual herbicide
 - b. systemic herbicide
 - c. contact herbicide
 - d. systemic insecticide
3. (20) Methods of controlling roadside woody vegetation include:
 - a. cutting
 - b. herbicides
 - c. mowing
 - d. all the above
4. (20) For stump treatment on a moderate scale, ____ sprayers will probably suffice.
 - a. backpack
 - b. air blast
 - c. boom
 - d. boomless
5. (22) Total vegetation control around transformer and substations involves:
 - a. only short residual, foliar herbicides
 - b. only long residual, foliar herbicides
 - c. non-selective, long soil residual herbicides
 - d. highly selective, short soil residual herbicides
6. (22) Vegetation control on railroads is different than other utility rights-of-way in that:
 - a. most of the area treated is owned by others
 - b. railroads seldom have to control vegetation
 - c. most of the area treated is owned by the railroads
 - d. the treatments are very difficult to plan and manage
7. (23) Which of the following are problems for railroad vegetation management?
 - a. drift
 - b. brownout
 - c. encroachment of hard-to-control species
 - d. all the above
8. (24) When evaluating the results of TVM treatments, the first evaluation should be ____ after application.
 - a. 1 week
 - b. 3 week
 - c. 1 month
 - d. 2 months
9. (25) An example of an insect that may need control along rights-of-way are ____.
 - a. butterflies
 - b. mosquitoes
 - c. leafhoppers
 - d. aphids

Resistance to Pesticides



As living organisms, pests must adapt to and overcome adverse conditions in order to survive. Plant pests must be able to survive harsh winters, and resist attack by parasites and predators. They have succeeded remarkably well. It is no surprise that pests also can adapt to control measures used against them.

Pesticide resistance is the inherited ability of a weed or other pest to tolerate the toxic effects of a pesticide. As pest populations develop resistance, increasing the rate or frequency of pesticide application may be needed, but not beyond label recommendations. Eventually, it will be impractical or impossible to control the pests with the pesticide to which they have become resistant. In some cases, other acceptable pesticides may not be available.

Hundreds of pest species, mostly insects, have become resistant to one or more pesticides. Keep in mind that not all populations of these pests are resistant. Any population of pests has the potential to develop pesticide resistance.

The Development of Resistance

Where does pesticide resistance come from? The answer lies in the natural genetic diversity within a plant population. When organisms reproduce, offspring receive copies of the “parent” genetic material. Those copies are not always perfect. Mistakes, analogous to misspelled or missing words, may appear. Those are called mutations. Because the parent was already fine-tuned to its environment, most such mistakes are either harmful or of no consequence.

Sometimes a mutation benefits an organism. This includes mutations that confer pesticide resistance. Because pest populations are so large, it is likely that within a population, a small percentage of individuals will develop resistance to a particular pesticide. These resistant individuals

survive when a pesticide is applied, and at least some of their offspring inherit the resistance.

Because the pesticide kills most of the nonresistant individuals, the resistant pests will make up a larger percentage of the surviving population. Each time a pesticide is used, the percentage increases.

In most cases, pest populations that have become resistant to one pesticide also become resistant to other, chemically related pesticides. This is called cross-resistance. This occurs because closely related pesticides kill pests in the same way (e.g., all organophosphate insecticides kill by inhibiting the same function that is vital for insect survival). If a pest resists the toxic action of one pesticide, it usually can resist other pesticides that act in the same way, even pesticides from other chemical families that have the same mode of action.

Given that pesticide resistance is an ever-present threat, the need to understand what influences its development is important. This knowledge can allow one to recognize or predict the likelihood of pesticide resistance.

Important Factors That Influence the Development of Resistance:

- The frequency of pest resistance before use of the pesticide in question. Resistance may be absent from a pest population, or it may be present in a few or many individuals. Obviously, the absence of resistance is best.
- The chemical diversity of the pesticides used. Using the same pesticide, or family of pesticides, won't kill pests that are resistant, and the proportion of resistant pests likely will increase.
- Persistence and frequency of use of the pesticide. Resistance often develops against pesticides that are applied often, and that have greater persistence.

Pesticide resistance is the inherited ability of a weed or other pest to tolerate the toxic effects of a pesticide.

Resistance to Pesticides

In developing a pest management program, assume that the pests can develop resistance to any pesticide used against them.

- Specific mode of action: Pest populations are more likely to develop resistance to pesticides that attack a single structure or mechanism than those pesticides that attack several vital life processes.
- The proportion of the population exposed to the pesticide: When an entire pest population is exposed to a single pesticide application, most nonresistant individuals are killed, which increases the proportion of resistant pests among the survivors. Weeds, however, emerge sporadically and, at any one time, many seeds lie dormant in the soil. As a result, many susceptible weeds are not exposed to a herbicide and, thus, continue in the population.
- The length of the pest's life cycle: As with any other inherited trait, pesticide resistance will increase faster if the pest has a short life cycle and many generations in a single season. This explains why insect populations show resistance faster than weed populations.

Herbicide-Resistant Weeds

Many weed species have biotypes resistant to herbicides. Most of these biotypes resist triazine herbicides, such as hexazinone (Velpar), and occur in cropland, not rights-of-way.

A recent concern is that within several weed species there are already biotypes resistant to the new chemical groups of sulfonylurea and imidazolinone herbicides. Some of these herbicides are used on rights-of-way. One such herbicide is metsulfuron methyl (Escort). Herbicides in these chemical groups have a precise mode of action: they prevent a specific enzyme (ALS) from functioning. This enzyme is essential for the production of three amino acids, and protein synthesis stops and plants die when this enzyme is blocked. In resistant biotypes, plants develop normally and the enzyme is unaffected. Farmers often use herbicides in these chemical groups for crop production. Thus, farmers and rights-of-way personnel could

cause resistance problems for each other. Both sides should practice resistance management to avoid further resistant-weed problems.

Resistance Management

In the past, pesticide resistance was managed by switching herbicides. This was possible because new products continually became available. Today's new pesticides are more complex, difficult to synthesize and more expensive to develop and use; and, even these products may become ineffective because of pesticide resistance. Obviously, switching products is no longer enough.

In developing a pest-management program, assume that the pests can develop resistance to any pesticide used against them. This means that greater emphasis must be placed on resistance management. This may seem like more work in the short run, but losing the use of a pesticide because of resistance could be more of a problem in the long run.

Resistance management attempts to prevent, delay or reverse the development of resistance. This complex task involves more than just herbicides. Incorporate the practices described below into a resistance management plan:

- Use an integrated pest-management program. Combine cultural, mechanical and chemical controls into a practical pest-control program.
- Use pesticides with different modes of action. Where a pest must be controlled more than once a year, use pesticides with different modes of action. This way, pests resistant to the first pesticide will be killed by the second.
- Use pesticides only when needed, and use only as much as necessary. A pest population develops pesticide resistance only when the pesticide is used. Therefore, using the pesticide when not needed may unnecessarily increase the number of resistant pests. Likewise, don't apply more pesticide than needed to keep the pest population below

damaging levels. If more is applied to try to eradicate the pests, it wastes not only money (because eradication is usually impossible),

but will also kill an even larger proportion of susceptible pests. As a result, even more resistant pests among the survivors can result.

Resistance to Pesticides

Pesticide

Spills and Fires

It is a legal responsibility to clean up and decontaminate any pesticide spill that occurs during mixing, applying, or storing pesticides.

Pesticide spills occur and sometimes pesticide storage facilities burn. Preparing a plan for handling spills and fires should be done in advance. Part of the planning process will involve who, what, why, and when of dealing with the situation. Assigning responsibilities for taking action, proper notification procedures for local and state agencies, and location and availability of equipment and supplies are some of the items that need to be covered. Spills require a different approach than fires. The following sections outline the general requirements to be met.

Pesticide Spills

It is a legal responsibility to clean up and decontaminate any pesticide spill that occurs during mixing, applying or storing pesticides. When a spill occurs, take immediate action.

- Attend to anyone exposed to the pesticide. Administer first aid and obtain medical care, if necessary.
- Clear the area of all people who are not helping to handle the spill. Be sure that everyone is wearing protective clothing and equipment to minimize exposure.
- Promptly confine the spilled pesticide to keep it from spreading and contaminating a larger area or body of water. Large spills of pesticides or spills of specific products require notification of state and federal agencies. The General Manual (S-12) provides emergency telephone numbers to call if the spill is too large to handle without help or if notification is required. Notification of local officials is required if the spill contaminates a body of water, a well, a drainage ditch or other similar area, or if the possibility exists that these water sources could be contaminated.
- Absorb a liquid spill on concrete or other solid surfaces with absorptive clay, vermiculite, pet litter, sweeping compounds, sawdust or sorbent products designed for absorbing liquid spills. Do not use

sawdust or sweeping compounds on strong oxidizing pesticides because this presents a fire hazard. Absorb as much liquid as possible into the material. Then sweep or shovel the contaminated material into a leak-proof drum, and properly dispose of the drum as a pesticide waste.

- Cover the spill area with a material that neutralizes the pesticide. Examples of appropriate chemicals are hydrated lime, a solution of lye, ammonia, sodium hypochlorite (bleach), or strong detergent and water. Contact the chemical manufacturer to determine which of these materials to use.
- Contact the chemical manufacturer before rinsing the area with water. Collect this rinse water and hold for proper handling. Ideally, apply this rinsewater on an area that is labeled for use of the pesticide while taking care not to exceed the labeled rate. If the pesticide rinsewater cannot be used in this way, then it must be disposed of as a pesticide waste.

Emergency telephone number of the pesticide manufacturers and local emergency-response personnel should be readily available. Also include the telephone numbers of the Kansas Department of Health and Environment spill response program (reporting 785-296-1679 [8 a.m.–5 p.m.] or 785-296-0614 [after hours], Kansas Division of Emergency Management (785-296-3176), the Kansas Department of Health and Environment, Bureau of Waste Management for disposal guidance (785-296-1600), National Spill Response Center (800-424-8802); Environmental Protection Agency (913-281-0991), National Pesticide Telecommunications Network (800-858-7378), and Chemtrec (800-424-9300).

When a pesticide (especially a herbicide) spills on the soil, the area may be unsuitable for plant growth unless

the contaminated soil is removed or the pesticide deactivated. Dig up the contaminated soil and distribute it over a large area that is labeled for the pesticide, taking care not to exceed the label rate. Otherwise, the soil is considered a hazardous waste, and must be disposed of at a hazardous-waste landfill. Removing contaminated soil may not be feasible except for small amounts of soil.

One option for small, localized spills, is the use of activated charcoal. Activated charcoal (carbon) deactivates many pesticides, including organic herbicides. Some herbicides, however, are formulated with inorganic components, such as chlorates or borates. Charcoal does not deactivate these inorganic components. The product's composition is listed on the label's statement of ingredients. Consult the herbicide manufacturer for specific guidelines in handling spills of herbicides with inorganic components.

Activated carbon, now widely used in diverse industries, is manufactured by heating or chemically treating organic matter to achieve a porous structure. This process produces a large surface area within a relatively small volume. Most activated carbons are purified by acid washes and water washes to remove impurities. They are available in both granular and powder form. The charcoal used with outdoor grills cannot be ground up to achieve the same pound-for-pound pore structure that is characteristic of activated charcoal.

Activated carbon can usually be purchased from a local pesticide dealer, who either carries the product or is able to find it. If activated carbon is not available locally, contact a chemical company supply house. Activated carbon is available in quantities from 1 to 50 pounds, depending on the supplier.

Before applying activated carbon, determine the approximate pesticide concentration in the contaminated area. Only be concerned with the amount of active ingredient, not with the total amount of product.

For example, if the spill was 1 pound of a 50WP product, deactivating 0.5 pounds of active ingredient is needed. As another example, if the spill was 1 gallon of an 8E product, the need is to deactivate 8 pounds of active ingredient.

The most accurate method to determine the chemical concentration in an area is to run a chemical analysis on the contaminated soil. Sample the soil to the depth that the pesticide moved. A 3-inch sample is usually sufficient unless the spill occurred a considerable time before sampling, heavy rains fell before sampling or the soil is coarse and porous.

Some charcoals are formulated as powders to be applied dry. Others are treated so that they can be added to water and applied as a spray. Evenly distribute the carbon over the contaminated area. Using a rototiller or some other incorporating tool, thoroughly mix the charcoal to the depth that the soil is contaminated. Water the area thoroughly every day for at least three or four days before replanting. If possible, wait for several more days. The treatment's effectiveness depends upon the soil texture and organic matter content, the properties of the herbicide and the sensitivity of the plant species to be grown in the area. Before replanting the area, test it by spot planting to determine the effectiveness. If the plants die or are injured, water again for three or four days. This additional watering is usually sufficient for deactivation, but occasionally you'll need to add more carbon.

Pesticide Fires

Although the majority of pesticide-active ingredients are not flammable and do not by themselves constitute a fire hazard, many of the solvents used in liquid formulations are highly flammable. For this reason, consider all liquid pesticides as potential fire hazards. The risk of fire from a stored liquid pesticide is based on its flash point. Flash point is the minimum temperature at which a liquid gives off sufficient vapor in

The majority of pesticide active ingredients are not flammable and do not by themselves constitute a fire hazard; but, many of the solvents used in liquid formulations are highly flammable.

Pesticide

Spills and Fires

the surrounding air to form an ignitable mixture. Liquids are classified by the National Fire Protection Association as flammable (flash point below 100 degrees) or combustible (flash points above 100 degrees). Whenever large quantities of pesticides must be stored, install fire-detection devices, and place a dry-chemical fire extinguisher near the storage entrance.

Prepare a fire plan for each storage facility, and outline the appropriate measures to take should a fire occur. Indicate the proximity of pesticide wastes (e.g., surface water, sewers, wells) and how you will prevent contaminated runoff water from fire fighting from entering such waters. It is, in fact, sometimes better to let a fire burn to avoid what are often massive problems with contaminated water. Be sure to discuss the proper way to deal with a fire with the pesti-

cide manufacturer, insurance carrier and local fire department.

Be sure the plan contains the emergency telephone number of the pesticide manufacturers and local emergency-response personnel. Also include the telephone numbers of the Kansas Department of Health and Environment spill response program (reporting 785-296-1679 [8 a.m.–5 p.m.] or 785-296-0614 [after hours], Kansas Division of Emergency Management (785-296-3176), the Kansas Department of Health and Environment, Bureau of Waste Management for disposal guidance (785-296-1600), National Spill Response Center (800-424-8802); Environmental Protection Agency (913-281-0991), National Pesticide Telecommunications Network (800-858-7378), and Chemtrec (800-424-9300).



Rights-of-way operations are highly visible to the public. Because of this, they may be unusually open to criticism. However, much of the criticism may be avoided if you are considerate of public concerns, are knowledgeable and informed, and use extra care in applying pesticides.


Differences in Perception

Different groups will see pesticide applications in different ways. As an example, a brownout from a properly applied herbicide on an electric powerline rights-of-way may be the destruction of an adjoining property owner's landscape and view. The property owner may appreciate the need for rights-of-way maintenance, but not at the expense of his or her own landscape. Also, the potential

for herbicide damage on the property owner's side may enter into the perception. The property owner may fear both a diminished landscape view and damage to plants on his or her property.

The best way to deal with many of the concerns of property owners before or during treatment is to answer their questions and to respond to their concerns clearly and directly. Be professional; view such questions as an opportunity to educate and improve communication with the public. Do not patronize property owners. They are not impressed by applicators who say that they know what they are doing, or that there is no law requiring them to tell the property owner what they are doing.

Carelessness




Many problems of pesticide application can be resolved by improving operational practices. Most operational problems are within the operator's control. They are not "unavoidable accidents." Commonly occurring violations or misuses result in significant and visual off-target impacts. These misuses include careless mixing or pesticide transfers with resulting spills, roadside disposal of leftover spray mixture at the end of the day, contamination of surface water through drift, spills or improper disposal and injury to off-target vegetation due to drift, volatility or soil lateral movement of pesticides.

Misuses relating to actual application usually are due to carelessness. It is possible to follow label instructions and still be careless. Being careless includes the following:

- Being unfamiliar with the area to be treated prior to application.
- Failing to take all possible steps to avoid drift.
- Failing to use proper pesticides or equipment for the job.
- Failing to regularly check application equipment to make sure that it is functioning properly.
- Failing to wear proper protective equipment.

If these precautions are not being followed, unnecessary risks are being taken.

Other Areas of Concern



Nearly all parts of a rights-of-way are in some form of drainage system. It's easy to recognize drainage ditches, but greenways, contour and overflow areas can be less obvious. Pesticide treatments should have minimal or no effect on these areas. Follow label directions and precautions where rights-of-way runoff water flows into sensitive areas or where the water is impounded for uses such as irrigation or livestock.

Sometimes problems are caused for a landowner without realizing it. Do not cross fields with heavy equipment when the ground is soft. Avoid crossing livestock lots without first cleaning the mud off of your equipment's tires. Communicable diseases, such as hog cholera, can be spread from one area to another by unwittingly tracking contaminated soil. If the death or injury of an animal is blamed on a pesticide application, a veterinarian should examine the animal. If investigation shows that compensation is justified, respond fairly and promptly.

Marijuana can be seen growing on utility rights-of-way in rural areas. Report it to the proper authorities. These areas should be bypassed until the marijuana has been destroyed. Use extreme caution in these areas.

Often, a landowner's questions concerning pesticide applications go

unanswered or are not answered to the owner's satisfaction. This generally results in a formal complaint and polarized view-points. Landowners think the applicator is hiding something, and the crew supervisor may view the questions as a nuisance. A simple solution to this problem is to know the answer to the landowner's question before it is asked. A quick, direct response to the public's concerns facilitates better communication and a more enjoyable working environment. Be prepared to respond to commonly asked questions, such as:

- What are herbicides, and why are they used?
- Do herbicides affect birds?
- If my garden becomes contaminated, is it safe to eat the vegetables?
- Is it safe to eat wild berries from areas that have been sprayed?
- What kind of precautions are taken to make sure that pesticides don't get into ground-water supplies?
- Do herbicides and other pesticides pose any risk to me and my family?
- What happens if herbicides wash from the treated area into my pond; how does it affect the fish?
- If my cattle graze on treated rights-of-way, is the milk and meat safe to consume?

Marijuana can be seen growing on many utility rights-of-way in rural areas. Report it . . . Use extreme caution in these areas.

Study

Questions

Pages 27–35

1. (27) Where does pesticide resistance come from?
 - a. mislabeled pesticide products
 - b. genetic diversity within the pest population
 - c. use of imported pesticides
 - d. use of “bulk package” pesticide products
2. (27) When a pest population that is resistant to one pesticide becomes resistant to another, it is called _____.
 - a. exotic
 - b. imported
 - c. cross-resistance
 - d. noxious
3. (28) Many weed species have ____ that are resistant to herbicides.
 - a. monocots
 - b. alicots
 - c. tricots
 - d. biotypes
4. (28) Resistance management attempts to ____ the development of resistance.
 - a. prevent
 - b. delay
 - c. reverse
 - d. all the above
5. (30) When a pesticide spill occurs:
 - a. attend to anyone exposed
 - b. clear the area of everyone not involved
 - c. promptly contain the spill
 - d. all the above
6. (31) When a pesticide spills on the soil:
 - a. allow it to soak out of sight
 - b. flood the area with water to aid in leaching
 - c. dig up the contaminated soil and distribute it over a large area
 - d. dig up the soil and apply it to a vegetable garden
7. (31) Consult the ____ for specific guidelines in handling spilled herbicides with inorganic components.
 - a. landowner
 - b. herbicide manufacturer
 - c. local landfill
 - d. U.S. Department of Defense (DOD)
8. (31) The risk of fire from a stored liquid pesticide is based on:
 - a. its flash point
 - b. the total amount present
 - c. the surrounding air temperature
 - d. the relative humidity in the storage area
9. (33) Much public criticism of rights-of-way pest control may be avoided if you:
 - a. are considerate of public concern
 - b. are knowledgeable and informed
 - c. use extra care in applying pesticides
 - d. all the above
10. (33) The best way to deal with concerns of property owners is:
 - a. to patronize them
 - b. bluntly inform them you know how to do it
 - c. answer all questions clearly and directly
 - d. inform them there is no law requiring your information
11. (34) Commonly occurring misuses of pesticides include
 - a. careless mixing / transfers result in spills
 - b. contamination of surface water by drift
 - c. injury to off-target vegetation by over-spray
 - d. all the above
12. (35) Formal complaints and polarized view-points often result when landowner’s
 - a. questions are answered directly
 - b. questions are not answered
 - c. concerns are recognized
 - d. are consulted before application

Absorption. The process by which a herbicide passes from the soil solution into plant root cells or from the leaf surface into the leaf cells.

Active ingredient. The chemical in a pesticide formulation primarily responsible for its activity against pests. It is identified on the ingredients statement of the product label.

Annual plant. A plant with a life cycle that is completed within one year.

Ballast. Material such as crushed rock, cinders or gravel that is placed both between and below railroad ties to make the track firm and lasting.

Berm. A shoulder along the edge of the ballast.

Biennial plant. A plant with a life cycle that is completed within two years, with seed production occurring during the second year.

Brush. Woody plants, such as brambles, shrubs and vines, that are less than 10 feet in height at maturity.

Calibration. Measurement of application equipment's delivery rate.

Cell membrane. Semi-permeable wall that surrounds the inner portion of the cell.

Chloroplast. Organelles present in large numbers within plant cells that contain protein, lipids and pigments such as carotenoids and chlorophyll.

Contact herbicide. This causes localized injury to plant tissue wherever the plant and the herbicide have contact.

Cotyledon. A specialized seed leaf, one is found in monocots and two in seeds of dicots.

Cross-resistance. Type of resistance in which a pest or pest population is resistant to closely related pesticides.

Crown. That portion of a plant between the shoot and root regions that contains the meristems (buds) from which shoots arise.

Deciduous. Those plants that lose all their leaves during a portion of the year (usually winter).

Dicot. Plants that contain two cotyledons, such as broadleaf plants.

Enzyme. Proteins, formed in plant and animal cells or made synthetically, that act as organic catalysts in initiating or speeding up specific chemical reactions.

Erosion. The movement of soil particles by water or wind.

Evergreen. Plants that are always in leaf.

Fibrous root system. Type of system formed by lateral branching of the primary root, found in monocots (grasses).

Flash point. The minimum temperature at which a liquid pesticide gives off sufficient vapor in the surrounding air to form an ignitable mixture.

Formulation. The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

Fungicide. Pesticide used for the control of fungal diseases.

Herbaceous weed. A vascular plant that does not develop woody tissue above ground.

Herbicide. Pesticide used for the control of undesirable vegetation.

Insecticide. Pesticide used for the control of insects.

Integrated management program. A system where at least two pest-control strategies are used.

Lateral movement. Movement of a substance through soil, generally in a horizontal plane, from the original site of application.

Monocot. Plants that contain one cotyledon, such as grasses.

Nonselective herbicide. A herbicide that is generally toxic to all plants. Some selective herbicides may become nonselective if used at high rates.

Nontarget organism. Plant or animal species not intentionally treated by a pesticide.

Glossary

- Nontarget site.** Area not intentionally treated with a pesticide.
- Noxious weed.** A weed specified by law as being especially undesirable, troublesome or difficult to control. Precise definition varies according to legal interpretations.
- Perennial plant.** A plant with a life cycle that lasts more than two years.
- Pesticide resistance.** The inherited ability of a pest to tolerate the toxic effects of a particular pesticide.
- Photosynthesis.** The biological production of organic substances, chiefly sugars, occurring in green plant cells in the presence of light.
- Phytotoxicity.** An effect that is injurious or lethal to plants.
- Plant growth regulator.** A substance that alters the normal growth and/or reproduction of a plant.
- Post-emergence.** Application of a herbicide after emergence of the specified weed or crop.
- Pre-emergence.** Application of a herbicide to the soil prior to emergence of the specified weed or crop.
- Residual herbicide.** A herbicide that persists in the soil and injures or kills plants for an extended period of time (several weeks to several months, depending on the herbicide).
- Respiration.** The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms.
- Rhizome.** A specialized horizontal stem that grows below ground or just at the soil surface.
- Rights-of-way.** An area involved in common transport.
- Rodenticide.** Pesticide used for the control of rodents.
- Rosette.** A circular cluster formed by basal leaves of certain broadleaf plants, particularly biennials.
- Selective herbicide.** A chemical that is more toxic to some plant species than to others.
- Spray drift.** Movement of airborne particles from the intended area of application.
- Stolon.** A specialized horizontal stem that grows above ground.
- Surfactant.** A surface-active agent that produces physical changes at the surface of liquids. Used in agricultural sprays as wetters, stickers, emulsifiers and penetrants.
- Tap root.** Type of root system, found in dicot plants, that has relatively little lateral branching.
- Translocated herbicide.** A herbicide that is absorbed and moved to other plant tissue.
- Tuber.** A short, thickened stem structure that develops below ground as a consequence of the swelling of a portion of a rhizome and subsequent accumulation of reserve materials.
- Vapor pressure.** Chemical property of a substance that describes its potential for conversion into a gaseous state.
- Vaporization.** Process by which a solid or liquid material is transformed into a gas.
- Volatility.** See vapor pressure.
- Water solubility.** Chemical property of a substance that describes its potential for dissolving in water.
- Weed.** A plant that grows out of place.
- Woody plant.** Perennials that have a thick, tough stem or a trunk covered with bark.

Answers

Pages 7–16

1. c 2. a 3. b 4. c 5. d
6. a 7. d 8. a 9. c 10. b
11. c 12. b 13. c 14. d 15. c
16. a 17. c 18. c 19. d 20. c

Pages 19–25

1. a 2. b 3. d 4. a 5. c
6. c 7. d 8. d 9. b

Pages 27–35

1. b 2. c 3. d 4. d 5. d
6. c 7. b 8. a 9. d 10. c
11. d 12. b

Donald C. Cress
Extension Pesticide Coordinator

Paul Ohlenbusch
Extension Specialist, Range and Pasture Management

Acknowledgement:

This manual is adapted from "Rights-of-way Pest Control," University of Missouri, Manual 88. Appreciation is expressed to the following for cooperation in the Pesticide Applicator Training Program:

Jeanne Fox, Certification Specialist, Pesticide Section,
Kansas Department of Agriculture

Greg Krissek, Assistant Secretary for Programs,
Kansas Department of Agriculture

Ross Manes, Pesticide Program Manager
Kansas Department of Agriculture

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned.

Publications from Kansas State University are available on the World Wide Web at: <http://www.oznet.ksu.edu>

Contents of this publication may be freely reproduced for educational purposes. All other rights reserved. In each case, credit Paul Ohlenbusch and Donald Cress, *Rights-of-Way Pest Control*, Kansas State University, April 2000.