

NATIONAL PESTICIDE APPLICATOR CERTIFICATION

CORE MANUAL



Second Edition
2014









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Published by the National Association of State Departments of Agriculture Research Foundation

This manual was supported by the U.S. Environmental Protection Agency Office of Pesticide Programs' Cooperative Agreement X8-83456201 with the National Association of State Departments of Agriculture Research Foundation. EPA officials contributed comments and suggestions intended to improve the scientific validity and technical accuracy of the document. However, the views expressed in this document are those of the authors and EPA does not endorse any products or commercial services mentioned in this publication.



Acknowledgments

The following team members generously contributed their time and expertise by writing, revising, and/or reviewing the first and second editions of this manual. EPA and NASDA Research Foundation are indebted to them for their contributions.

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Phillip Weinstein, Michigan State University
Fred Whitford, Purdue University
Harold L. Witt, Virginia Tech
Robert Wolf, Kansas State University

Appreciation is extended to Susan Terwilliger for copyediting the second edition and to the publication designers Marla Stein & Associates (first edition) and Gerald Steffen (second edition).

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Introduction

This manual is intended as a study guide for preparing to take the Pesticide Applicator Certification Core Exam administered by your state, tribe, territory, or federal department/agency. Passing the core exam is essential to becoming a certified applicator. Check with the pesticide regulatory agency to determine whether this manual prepares you for commercial or private applicator certification or recertification or registered technician status. This manual satisfies the entry-level applicator training requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). More specific pest management information, pesticide terminology, and application techniques are covered in category-specific manuals and in greater detail during recertification (continuing education).

The questions found on state, tribe, territory, or federal department/agency core exams are based on information presented in this manual. The table of contents helps you identify important topics and understand how they relate to one another through the organization of headings and subheadings. Each chapter begins with a set of learning objectives that help you focus on what you should learn from the chapter. After studying a chapter, answer the review questions located at the end and go back and make sure you can address the learning objectives. The questions on the certification exam pertain directly to these learning objectives. The review questions are not on the certification exam, but a similar concept might be addressed. The answers to the review questions are found in *Appendix A*.

Other appendices, including a glossary, provide supplemental information that help you understand the topics covered in the chapters. Terms in bold type throughout the manual are defined either within the text or in the glossary.

This certification manual benefits both you and the general public. By learning how to handle pesticides correctly, you will be able to protect yourself, others, and the environment from pesticide misuse. For further information, visit: **www.epa.gov** and select "Pesticides."



Marlin E. Rice, Iowa State University Extension.

CHAPTER 1

Pest Management



Clemson University—USDA Cooperative Extension Slide Series, Bugwood.org.

Pest: Brownbanded cockroach.

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Define "pest."
- State the four main groups of pests and give an example of each.
- Discuss the importance of pest identification in pest control.
- List six general pest management methods.
- Define "integrated pest management (IPM)."
- List five benefits of using IPM.
- Discuss how using one or more control options can improve pest control.
- Describe how selectivity and persistence affect chemical controls.
- Explain how pest population levels trigger control procedures.
- Distinguish between prevention and suppression when developing pest management goals.
- Give several reasons why pesticide applications may fail.
- Explain the importance of a pesticide's mode of action in managing pesticide resistance.
- List two tactics that will minimize the development of pesticide resistance.

PEST PROBLEMS THROUGHOUT HISTORY

Civilization has been combating insects and other pests throughout history. Perhaps the most infamous human catastrophe was the Black Plague of Europe, when millions of people in the 14th century died from a mysterious scourge. Centuries later, it was determined that the cause was a bacterial disease spread by rat fleas. When rats, the normal host animals,

were unavailable as a food source, the fleas sought other warm-blooded hosts—including humans. Although the plague is still present in parts of the world today, controlling rats, other rodents, and fleas can greatly reduce disease incidence.

The destruction of Ireland's potato crop by a fungal disease in the 19th century directly affected the population of the United States. Late blight essentially eliminated potatoes, the staple food crop of Ireland. Potatoes not destroyed in the field rotted in storage during the winter. Thousands of Irish starved in the resulting famine, and more than a million migrated to the United States. Late blight continues to be a major problem of potatoes, but today it is managed through the use of resistant cultivars, proper sanitation practices, and fungicides.

Malaria is a disease caused by the transmission of a parasitic microorganism (protozoan) by mosquitoes when they feed on humans. Historians credit malaria with altering the patterns of human history and causing the collapse of some civilizations. During World War II, 500,000 soldiers were infected in the South Pacific and African theaters, with 60,000 deaths recorded. In 2010, malaria cases numbered 219 million, with 660,000 people dying from this debilitating disease. Antimalarial drugs, insecticide applications, environmental modifications, and mosquito (bed) nets have brought great improvements to fighting this difficult-to-control disease.

Outbreaks of the native mountain pine beetle in the western United States and Canada in the early 21st century destroyed more than 4 million acres of lodgepole, ponderosa, Scots, and limber pines. Accidental introduction of the emerald ash borer from Asia during this same period has destroyed millions of ash trees in the midwestern United States. Preventive insecticidal treatments are being used to manage these two destructive beetles.

These examples illustrate the enormity and complexity of pest problems. But what is a pest? A **pest** is an undesirable organism that injures humans, desirable plants and animals, manufactured products, or natural substances. Many insects, **pathogens** (disease-causing organisms, such as viruses, bacteria, or fungi), plants (known as **weeds**), mollusks (slugs and snails), fish, birds, and a variety of mammals (from mice to deer) compete for our crops and livestock. In addition, some pests destroy clothing, furniture, and buildings; reduce the beauty and recreational value of the landscape; and invade our homes during the winter months. As the battle between humans and pests continues over time, so will innovative methods of control.

PEST CONTROL OVER THE YEARS

For many centuries, the causes of crop failures and human and animal diseases were shrouded in mystery. The first pest control measures were crude—weeds were pulled, rats were clubbed, and beetles were plucked from foliage. Other ancient nonchemical control methods included burning to control weeds, diseases, and insects (950 B.C.); Egyptians placing fishnets over beds to prevent mosquito bites (440 B.C.); and Romans using rat-proof grain storage bins (13 B.C.). The first known use of natural enemies is credited to Arabian growers (1000 A.D.). Arab farmers moved colonies of a predaceous ant species from nearby mountains to an oasis to control pest ants that were damaging their date palms.

The earliest use of chemicals as pesticides dates back to 2500 B.C, when the Sumerians used sulfur compounds to control mites and insects. The Chinese used mercury and arsenic compounds in 500 B.C. to control body lice. Early plant-derived insecticides included hellebore to control body lice, nicotine to control aphids, and pyrethrins to control a wide variety of insects. In France during the late 19th century, a farmer sprayed a mixture of lime and copper sulfate on grapevines

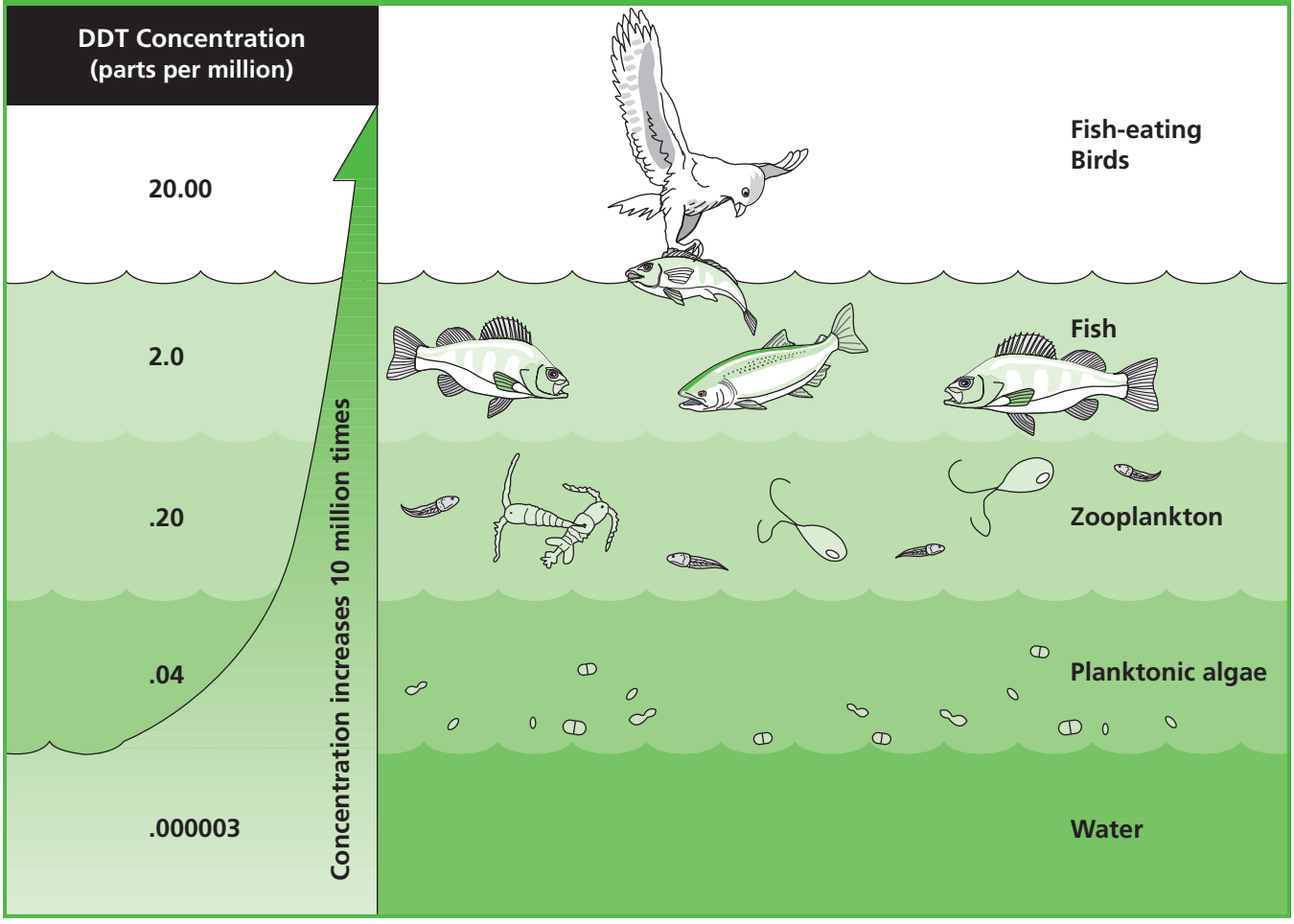
to deter passers-by from picking the grapes. The farmer found that the mixture also controlled downy mildew, a serious fungal disease of grapes. Later named Bordeaux mixture, it remains a widely used fungicide worldwide.

Until the 1940s, pest control chemicals were derived from plants and inorganic compounds. During World War II, the synthetic chemical DDT saved many Allied soldiers from insect-transmitted diseases. Synthetic pesticides launched the modern-day chemical industry and a new era in pest control. Pesticides became the primary means of solving pest problems because they were effective, relatively inexpensive, provided season-long crop protection, and could be used with fertilizers and other production practices. Modern pesticides achieved wide acceptance following their successful use in agriculture and for human health.

In recent years, however, some drawbacks of heavy dependence on pesticides have become increasingly apparent. **Pesticide resistance** to DDT was documented in 1947. Since that time, hundreds of insects have become resistant to one or more pesticides. Most notable is the Colorado potato beetle, which has developed resistance to every major group of insecticides, greatly complicating pest management efforts. Resistance also has arisen in many weeds and plant pathogens in agricultural production. (See "Pesticide Resistance" at the end of this chapter for more information.)

The impact of increasing pesticide use on the environment was graphically illustrated in 1962 by Rachel Carson. Her book, *Silent Spring*, focused on DDT and other chlorinated hydrocarbons because of their long residual activity and persistence

Figure 1.1 Biomagnification in the Food Chain



Adapted from Penn State *Pesticide Education Manual*

in the environment. Although these characteristics contributed to their effectiveness, chlorinated hydrocarbons also accumulated in the fatty tissue of some animals, especially those higher in the food chain (**bioaccumulation**). In certain situations, some organisms accumulated chemical residues in higher concentrations than those found in the food organisms they consumed (**biomagnification**). Ecologists refer to a **food chain** as the sequence of animals feeding in the natural environment, where a particular plant, animal, or microorganism is eaten by an animal that is in turn eaten by another animal. Animals at each level normally consume individuals from the previous level. Figure 1.1 depicts how biomagnification of a pesticide can occur in a food chain. Organisms with pesticides in their tissues are eaten by fish, which are in turn eaten by birds. The birds at the top of the food chain accumulate the highest concentration of pesticide residues.

Since the publication of *Silent Spring*, the United States has experienced a level of environmental awareness unequal to any other period in history. The U.S. Environmental Protection Agency (EPA) was created in 1970 by Congress to implement laws passed to protect the environment and the health of humans and other animals. In 1972, EPA banned the use of DDT in the United States. Regulatory action has since been taken against many chemicals thought to pose significant environmental and health hazards.



Weed pest: Canada thistle flowers.

Kristine Schaefer, Iowa State University Extension & Outreach

PEST RECOGNITION

There are four main groups of pest organisms: weeds, invertebrate animals, pathogens, and vertebrate animals. Never classify an organism as a pest until it is clearly determined to be one. Be certain any injury or observed damage is actually due to the identified organism and not to some other cause. Some plants, for example, can be damaged by factors in the environment. These factors include weather extremes, air pollutants, road salt, and inadequate or excessive fertilization. This damage may be mistaken for that caused by living pests.

The first step in pest management is to accurately identify the pest. Once the pest is identified, applicators can learn about its life cycle, behavior, characteristic damage, factors that favor its development, susceptible life stage(s), and known control methods. Misidentification and lack of accurate information could cause pest control failure.



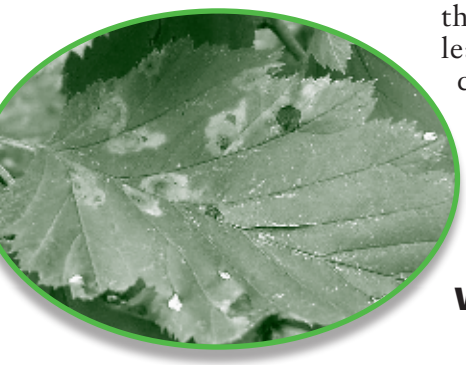
Invertebrate pest: Paper wasp.

David Cappaert, Michigan State University, Bugwood.org

Ways to Identify Pests

To identify an organism, consult reference materials: identification books, Extension bulletins, field guides, and online identification keys that contain pictures and biological information. If you cannot pinpoint a specific plant or animal, take or send the specimen to a university diagnostic lab or a local pest management specialist. Collect several specimens, if possible. Ask the specialist to recommend the best way to collect and send samples.

It may be difficult to identify small insects and most mites, nematodes, and plant pathogens. Accurate identification requires the use of a hand lens or microscope, special tests, or careful damage



Disease pathogen: Hawthorne rust.

Iowa State University Plant & Insect Disease Clinic

THE FOUR MAIN GROUPS OF PESTS

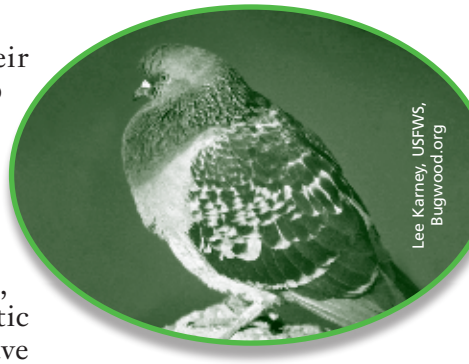
1. Weeds (undesirable plants).
2. Invertebrates (insects, mites, ticks, spiders, snails, and slugs).
3. Disease agents or pathogens (bacteria, viruses, fungi, nematodes [roundworms], mycoplasmas [parasitic microorganisms], and other microorganisms).
4. Vertebrates (birds, reptiles, amphibians, fish, and rodents and other mammals).

analysis. Often the pest's host (the animal or plant on which an organism lives) and location are important clues in making a correct identification. Information on the environmental conditions where you collect pests and the time of year of collection provide clues to the pest's identity.

Pest species have different physical forms depending on the life cycle stage or the time of year. Weed seedlings, for example, often do not resemble the mature plant. Many insect species undergo changes in appearance as they develop from eggs through immature stages to the adult form.

Characteristic Damage

Pests may leave signs of their presence or damage that will help you determine what they are. Birds and rodents often build characteristic nests. The type of feeding damage and excrement can help you identify many insects. Burrows, gnaw marks, tracks, trails in the grass, and/or feces are often characteristic of certain mammals. Weeds may have unique flowers, seeds, or fruits or unusual growth habits. Fungi and other pathogens often cause specific types of damage, deformation, or color changes in host tissues.



Vertebrate pest: Rock dove.

PEST MANAGEMENT METHODS

Once a pest problem is identified, you can begin planning how to manage the pest. Determine what management methods are available and the benefits and limitations of each. Select methods that are most effective in controlling the pest yet the least harmful to people and the environment.

Abiotic factors are natural control measures within the environment that injure or destroy plants and animals, including pests. They include climatic factors (e.g., wind, temperature, sunshine, and rain), air or water pollution, and topographic features (rivers, lakes, and mountains) that can affect pest movement. If such natural controls do not hold pests in check, humans must intervene and apply pest management tactics. Applied controls include biological, chemical, cultural, genetic, mechanical/physical, and regulatory methods.

PEST MANAGEMENT METHODS

Natural Controls

Applied Controls

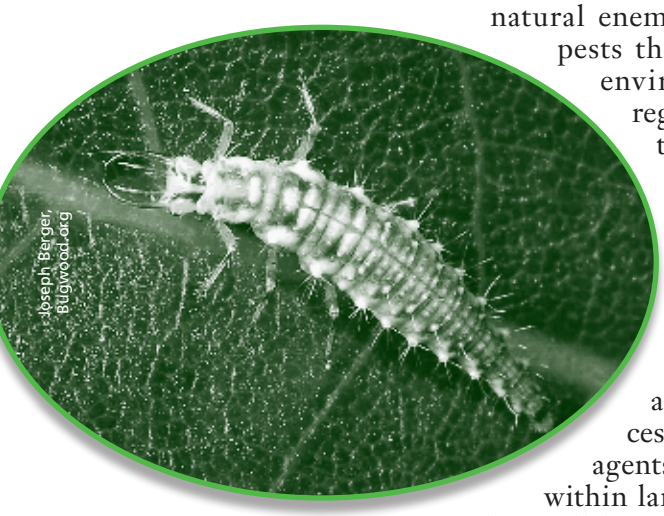
1. Biological Control
2. Chemical control
3. Cultural Control
4. Genetic control
5. Mechanical/Physical Control
6. Regulatory Control

Biological Control

In an undisturbed ecosystem, most organisms have one or more natural enemies or competitors that keep them from developing into large, damaging populations. When an organism is removed from one ecosystem to another, this natural check-and-balance is disturbed. The organism can become a pest in the new geographical area, especially when its natural enemies do not accompany it to the new location.

One pest management method involves reuniting the introduced pest with its natural enemies. **Biological control** is the use of natural enemies —predators, parasites, pathogens, and competitors—to control pests and their damage. These biological control (biocontrol) agents are being used successfully to manage certain insect, mite, fungal, fish, and weed pests.

Once suitable natural enemies from the native home of an introduced pest are located, extensive testing and evaluation are necessary to ensure that these

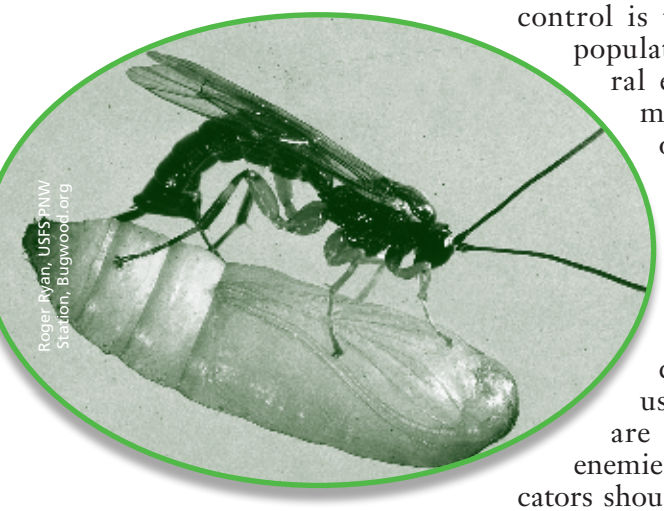


Biological control: Lacewing larva.

natural enemies will not become pests themselves in the new environment. Laws and regulations strictly control the importation of all organisms—including biological control agents—into the United States. The selected natural enemies are imported, reared, and released. If successful, these biocontrol agents become established within large areas. Over time, they will lower target pest populations for long periods with no further human intervention.

A second biological control technique is the mass release of large numbers of natural enemies into fields, orchards, greenhouses, or other locations to control specific pests. Because this method usually does not yield long-term results, the natural enemies must be released periodically. For example, predatory mites are used to control plant-feeding spider mites. Parasitic wasps are used to manage specific pests, while praying mantids, lady beetles, and lacewings are used as general predators in a garden or greenhouse. Nematodes and fungi are being studied as biological control agents for certain weeds and insects.

Another aspect of biological control is to maintain healthy populations of native natural enemies. This could mean planting crops or groundcovers to ensure a diverse plant community of pollen and nectar sources for adult insects. This method also requires careful selection and use of pesticides that are less toxic to natural enemies. Additionally, applicators should apply pesticides at lower-than-label rates (if recommended and effective) to lessen the impact on natural enemies.



Biological control: Ichneumonid wasp.

Chemical Control

Chemical control is the pest management method that involves using naturally derived and/or synthetic chemicals to manage pests. These chemicals are often called pesticides. A **pesticide** is defined as any material that is applied to plants, soil, water, harvested crops, structures, clothing and furnishings, or animals to kill, attract, repel, or regulate or interrupt the growth and mating of pests, or to regulate plant growth.



Chemical control.

Pesticides often play a key role in pest management programs and may often be the only known control method for a given pest. Major benefits associated with the use of pesticides are their effectiveness, the speed and ease of controlling pests, and their reasonable cost compared with other control options. Pesticides include a wide assortment of chemicals with specialized names and functions. They are often grouped according to the type of pest they control:

- **Avicides** control or repel pest birds.
- **Bactericides** control bacteria.
- **Chemosterilants** sterilize insects or pest vertebrates.
- **Defoliants** cause leaves (foliage) to drop from plants.
- **Desiccants** promote drying or loss of moisture from plant tissues and insects.
- **Disinfectants** (antimicrobials) control microorganisms.

- **Fungicides** control fungi.
- **Growth regulators** alter the growth or development of a plant or animal.
- **Herbicides** control weeds.
- **Insecticides** control insects and related arthropods.
- **Miticides** (acaricides) control mites.
- **Molluscicides** control snails and slugs.
- **Nematicides** control nematodes (roundworms).
- **Ovicides** destroy eggs.
- **Pheromones** attract insects.
- **Piscicides** control pest fish.
- **Predacides** control predatory vertebrates (e.g., coyotes).
- **Repellents** repel insects, mites, ticks, pest vertebrates, invertebrates, birds, and mammals.
- **Rodenticides** control rodents.

Each group of pesticides includes several classes or families. For example, the classes of insecticides include the organophosphates, organochlorines, carbamates, pyrethroids, botanicals, insecticidal soaps, and microbials, among others. The pesticides within a particular class have similar chemical structures or properties or share a common **mode of action** (how they kill the pest) or **site of action** (the specific biological system affected within the pest). The various classes of chemicals work in different ways and present different risks and problems.

Some chemicals are called **selective pesticides** because they are toxic to some pests but have little or no effect on others. For example, certain selective herbicides control broadleaf weeds but not grasses, and ovicides kill only the eggs of certain insects and mites. In contrast, fumigants are nonselective and will kill a wide variety of pests: fungi, insects, weeds, nematodes, and other organisms. Nonselective herbicides control any susceptible plant, given a sufficient dose.

Pesticides may move in various ways after they contact a host. **Systemic pesticides** are absorbed and translocated within a plant or animal. Systemic herbicides are absorbed through leaves or roots and are then transported within the treated plant. Similarly, systemic insecticides can be eaten by or injected into livestock to control insect pests. By contrast, **contact pesticides** are not absorbed by treated plants or animals. These pesticides must directly touch the pest or a site the pest frequents to be effective (see Figure 1.2).

Pesticides also vary in their **persistence**, or how long they remain active to control pests. Some **residual pesticides** control pests for weeks, months, or even years. Others provide only short-term control, sometimes lasting only a few hours.

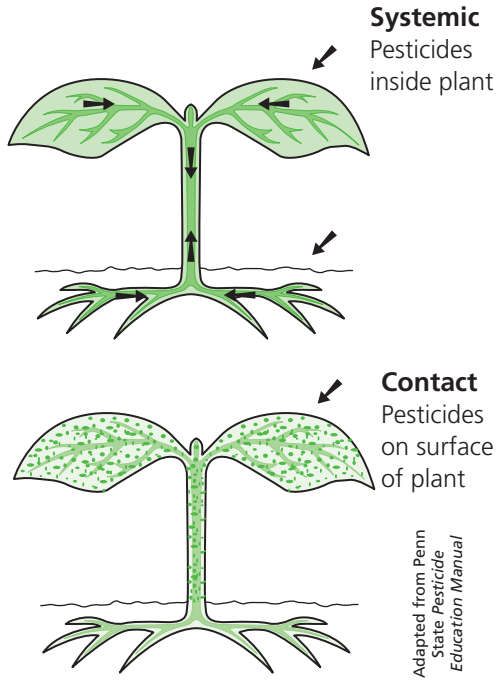
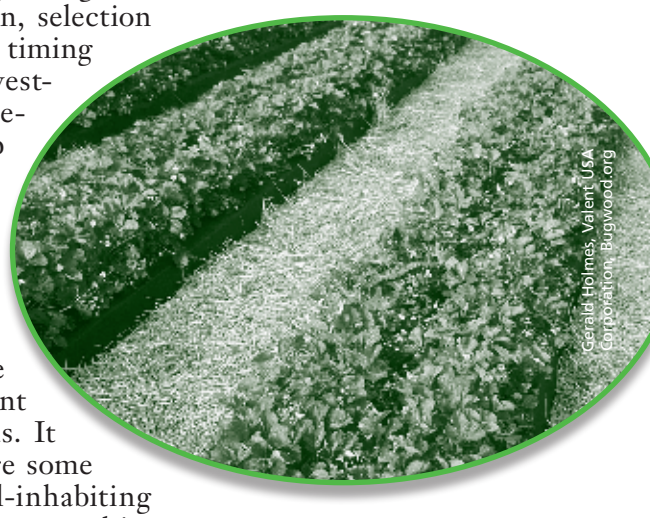


Figure 1.2
Systemic and contact pesticides on treated plants.

Cultural Control

Cultural controls are practices that reduce pest establishment, reproduction, dispersal, and survival. Cultural practices and sanitation are two examples of cultural control.

Many cultural practices affect pest survival. Mowing, irrigation, aeration, and fertilization are all important ways of producing healthy turf and preventing pest buildup and damage. In agricultural production, cultivation, selection of crop plant varieties, timing of planting and harvesting, irrigation management and timing, crop rotation, and the use of trap crops help decrease populations of weeds, microorganisms, insects, mites, and other pests. Cultivation is one of the most important ways to control weeds. It is also used to manage some insects and other soil-inhabiting pests. Plows, disks, mowers, cultivators, and bed conditioners destroy weeds or



Cultural control: Mulch.

control their growth. These tools also disrupt soil conditions suitable for the survival of some microorganisms and insects. Weeds also can be managed by mulching (with plastic, straw, shredded bark, or wood chips) and by using cover crops.

Sanitation involves eliminating the necessities important to a pest's survival, such as food, water or shelter. In crop production, sanitation includes such practices as removing weeds that harbor pest insects or rodents, eliminating weed plants before they produce seed, destroying diseased plant material or crop residues, and keeping field borders or surrounding areas free of pests and pest breeding sites. Animal manure management is an effective sanitation practice used to prevent or reduce fly problems in poultry and livestock operations. Mosquitoes can be controlled by draining standing water. Closed garbage containers and frequent garbage pickup eliminate food sources for flies, cockroaches, wasps, and rodents. Removing soil, trash, and wood debris from around and under buildings reduces termite and fungal rot damage.



Sanitation: Aquatic herbicide application.

Genetic Control

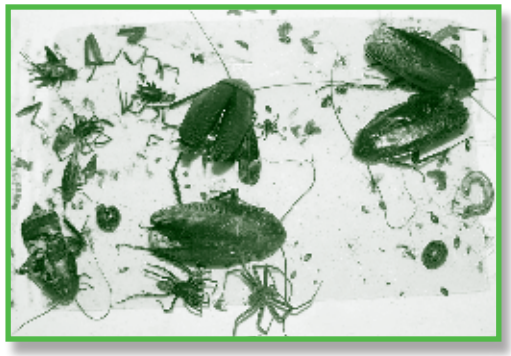
Sometimes plants and animals can be bred or selected to resist specific pest problems. For example, certain livestock breeds are selected for physical characteristics that prevent attack by some pests or provide physiological resistance to disease or parasitic organisms. Certain plant varieties are naturally resistant to insects, pathogens, or nematodes. Many plants actually repel various types of pests, and some contain toxic substances. Plant resistance to insect pests can sometimes be achieved by transferring genetic material from certain insect-destroying microorganisms to hybrid seed. Genetic control has been widely used in the past and may be an effective tool in the future, especially when combined with new gene manipulation techniques. *Bacillus thuringiensis* (Bt) corn and potatoes and herbicide-resistant corn (e.g., Roundup Ready corn and Liberty Link corn), cotton (e.g., Roundup Ready cotton), and soybean (e.g., Roundup Ready soybean) are examples of genetic control. The plant is genetically modified through molecular techniques to add a small amount of genetic material from other organisms. The incorporated genetic traits provide protection from pests (e.g., Bt crops produce a protein that kills caterpillars), tolerance to herbicides, or an improvement in quality.

Mechanical/Physical Control

Mechanical and physical controls can kill a pest directly or make its environment unsuitable. Rodent traps are examples of mechanical control. Several types of traps are commonly used. Some kill animals that come across them; others snare animals that are then relocated or destroyed. Traps can be mechanical devices or sticky surfaces, some with pheromones incorporated to increase trapping efficiency.

Physical controls include mulches for weed management, steam soil sterilization for disease control, deer fences, screens to keep insects out, and cloth mesh to exclude birds from fruit trees. Another example is sealing cracks, crevices, and other small openings in buildings to exclude insects, rodents, bats, birds, and squirrels. A band of sticky material painted around tree trunks prevents crawling insects from reaching the tree's leaves.

Pests living in enclosed areas may sometimes be suppressed by altering



Mechanical control: Sticky trap.

MH Shour, Iowa State University Extension & Outreach

physical and environmental conditions, such as water, air movement, temperature, light, and humidity. Refrigeration, for example, protects stored food products, furs, and other items from insect pests. Lowered temperatures kill the insects, cause them to stop feeding, and prevent egg hatch or development. Installing bright lights in attics sometimes discourages bats from roosting there. Lowering the humidity of stored grains and other food products reduces damage from molds and some insects. Increasing air movement in greenhouses often helps to prevent fungal diseases from developing on plants.

Regulatory Control

Some pest problems cannot be controlled successfully at a local level or by individuals. These problems are caused by pests that seriously endanger public health or are likely to cause widespread damage to agricultural crops or animals, forests, or ornamental plants. Quarantine or eradication programs directed by governmental agencies according to federal and state laws target the introduction and spread of such pests.

Quarantine is a pest control process designed to prevent entry of certain pests into pest-free areas. Some states maintain inspection stations at all major entry points to intercept pests or materials that might harbor pests. Regulatory agencies monitor airports and ocean ports. Quarantine also prevents movement of designated pests within a state. Identified items being shipped from a quarantine area must be treated to destroy pests before shipment. Nursery stock, plant cuttings, seed shipments, and budding and grafting material are also regulated to prevent the spread of pests.

Eradication is the elimination of a pest from a designated area. Often, these pests are under quarantine restrictions. When eradication is required, the geographical extent of pest infestation is determined and control measures are taken to eliminate this pest from the defined area. Procedures may include an area-wide spraying program, releasing sterile insects, and intensive monitoring for pests within and around the borders of the infested area.

Government agencies are authorized to destroy weeds and plants that cause fire hazards, harbor harmful pathogens or animals, or are noxious to people or livestock in and around agricultural areas. Similar authority applies to diseased or infected livestock or poultry and to weeds and nuisance plants in residential, commercial, and industrial areas. Mosquito abatement is an important pest control function undertaken to protect public health. Mosquito abatement laws allow state agencies to drain or treat standing water that provides breeding sites for mosquitoes.



USDA APHIS

Regulatory control: USDA inspections.

INTEGRATED PEST MANAGEMENT (IPM)

Pesticide use is a significant factor in food and fiber production, forestry, turf and landscape maintenance, and public health. In recent years, pest management has shifted from relying heavily on pesticides to using an integrated approach based on pest assessment, decision-making, and evaluation. This pest management approach has benefited pest managers and the

environment, decreased pesticide use, and reduced the occurrence of pesticide resistance in pest populations.

Integrated pest management is a balanced, tactical approach to pest control. It defines ways to anticipate pest outbreaks and prevent pest damage. IPM is a pest management strategy that uses a wide range of pest control methods (e.g., cultural, biological, mechanical, and chemical) or tactics such as sanitation and exclusion. The goal of this strategy is to prevent pests from reaching damaging levels with the least risk to the environment. Such pest management programs enable the specialist to make intelligent, site-specific decisions about control.

INTEGRATED PEST MANAGEMENT (IPM)

A pest management strategy that utilizes a wide range of pest control methods or tactics. The goal of this strategy is to prevent pests from reaching economically or aesthetically damaging levels with the least risk to the environment.

Why Practice IPM?

IPM helps preserve a balanced ecosystem—Every ecosystem, made up of living things and their nonliving environment, has a balance: the actions of one kind of organism usually affect other species. Introducing chemicals into the ecosystem can change this balance, destroying certain species and allowing other species (sometimes other pests) to dominate. Unfortunately, pesticides can kill beneficial insects that consume pests, leaving few natural pest control mechanisms.

Pesticides can be ineffective—Chemical pesticides do not always work. As mentioned earlier, many common weeds, insects, and disease-causing fungi have developed a resistance to pesticides. Furthermore, pests may survive if the chemical does not reach them, is washed off, or is applied improperly.

IPM can save money—A good IPM program can prevent crop loss and landscape or structural damage caused by pests. IPM may also avoid the cost of purchasing unnecessary pesticides. Moreover, IPM can reduce the costs of treating chronic conditions such as asthma by controlling disease triggers.

IPM promotes a healthy environment—Using IPM strategies helps reduce environmental injury. Using fewer pesticides lowers the risk that persistent chemicals may harm living creatures and contaminate groundwater. It also lessens the need to dispose of containers and unused pesticides.

IPM helps maintain a good public image—IPM is a well-known strategy that is requested in many areas of society. IPM is used to grow food, manage turf and ornamentals, protect homes and businesses, manage school grounds, and safeguard the health of humans, pets, and livestock.

WHY PRACTICE IPM?

1. IPM helps to keep a balanced ecosystem.
2. Pesticides can be ineffective.
3. IPM can save money.
4. IPM promotes a healthy environment.
5. IPM maintains a good public image.

Components of IPM

The components of an IPM approach can be grouped into the following five steps:

1. Identify the pest and understand its biology—The first step in any pest management program is to identify the pest, whether you are dealing with an insect, weed, plant disease, or vertebrate animal.

Once you have identified the pest, you can determine its significance and the need for control. Some pests have

little impact on a plant, animal, or structure and do not require control. Others warrant immediate control because they cause serious damage or present a significant threat to human health or public safety.

Key pests may cause major damage on a regular basis unless they are controlled. Many weeds, for example, are key pests because they compete with crop or ornamental plants for resources and require regular control efforts to prevent or reduce damage. Cockroaches and rodents are also examples of key pests because their waste and body coverings (shed cockroach skins; rodent hairs) can trigger asthma in some people.

Secondary pests become a problem when a key pest is controlled or absent. For example, some weed species become pests only after key weeds, which are normally more successful in competing for resources, are controlled. Certain species of fleas, ticks, and blood-feeding bugs attack people only when their natural hosts, such as pet dogs or cats, are no longer present.

Occasional pests become troublesome only once in a while because of their life cycles, environmental influences, or as a result of human activities. For instance, ants may become occasional pests when sanitation practices change, providing them with food that previously did not exist. They also may move into buildings after a rainfall or other event destroys an outdoor food source.

2. Monitor the target pest—The key to a successful IPM program is regular monitoring. This involves measuring pest populations and/or the resulting damage or losses. Monitoring procedures vary with the pest and the situation.

Carefully looking at plants or animals over time (scouting) and trapping are often used to monitor insects and their activity. Weather and temperature data are particularly helpful in following a pest's life cycle or in predicting how long it takes a certain pest to develop. Models exist for specific insects and plant diseases that predict the need for and timing of pesticide applications.

Pest Population Thresholds

Agricultural or ornamental producers must understand the concept of economic thresholds. The presence of a pest does not always cause a loss in quality or quantity of a product. To justify the cost of control, pest populations must be large enough to cause significant damage. This is called the **economic threshold** (ET). The economic threshold is the pest population density (number of pests per unit area) at which control measures are needed to prevent the pest from reaching the economic injury level. The **economic injury level** (EIL) is the pest population density that causes losses equal to the cost of control measures. To justify using a control method, it is necessary to set the ET below the EIL (see Figure 1.3). Otherwise, producers lose money—first from the damage caused by the pest, and then by the cost of the control method. Setting the ET below the EIL triggers the appropriate control method before pests reach the EIL.

For pest managers not directly involved in commodity production, the concept of an action threshold is more appropriate. An action threshold is the pest level at which some type of pest management action must be taken. This is a predetermined pest level that is deemed to be unacceptable. Often the action threshold is expressed as the number of pests per unit area. Below this level, IPM practitioners do not use any control measures, though they should continue to monitor the situation and do sanitation inspections as needed. Once a pest is at or above the action threshold, you should implement appropriate IPM strategies.

In some situations, the action threshold for a pest may be zero (i.e., no presence of the pest is tolerated). Examples include pests capable of transmitting a human pathogen (e.g., mosquitoes and the West Nile virus) or of creating a public health emergency (e.g., cockroaches or rodents). In an urban



Inspecting a plant for pests.

COMPONENTS OF IPM

1. Identify the pest and understand its biology.
2. Monitor the pest to be managed.
3. Develop the pest management goal.
4. Implement the IPM program.
5. Record and evaluate results.

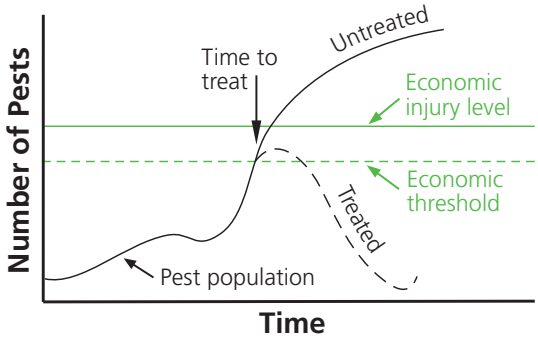


Figure 1.3
To make a control measure profitable (or at least break even), it is necessary to set the economic threshold below the economic injury level.

landscape, action thresholds consider not only the economic value of the landscape but also its ecological and aesthetic roles. A higher action threshold would be set for insect damage when no harm is done to the plant (e.g., leaf galls on a shade tree) compared to a woodborer that may destroy the tree (action threshold of zero).

Action thresholds may vary by pest (e.g., a stinging insect in a classroom vs. a foraging ant), by site (e.g., a storage room vs. a school infirmary), and by season (e.g., pests present daily vs. two weeks of a year). Establishing action thresholds for a new IPM program will require a practical approach. First, establish an arbitrary action threshold for the major pests you encounter. Then, revise the action levels up or down as you gain understanding of a specific pest management setting.

3. Develop the pest management goal—The goal of IPM programs is to keep pest damage at economically or aesthetically acceptable levels. Prevention and suppression techniques are often combined in an effective IPM program. As discussed above, eradication is sometimes (though rarely) the goal. The strategy for a sound IPM program is to coordinate the use of multiple tactics into a single integrated system. Pesticides are just one control method. Nonchemical methods may provide longer and more permanent pest control. Consider these first when developing a pest management strategy. Evaluate the costs, benefits, and liabilities of each tactic.

Prevention

There are economically and environmentally sound ways to prevent loss or damage from pests. Such techniques include planting weed- and disease-free seed and growing varieties of plants resistant to diseases or insects. Other choices are using cultural controls to prevent weedy plants from seeding and choosing planting and harvesting times that lessen pest problems. Sanitation methods often reduce pest buildup. Other preventive methods involve excluding pests from the target area or host and using practices that conserve natural enemies. Making sure that plants, poultry, or livestock receive adequate water and nutrients often reduces stress and susceptibility to diseases or pests.

Pesticides are sometimes used for pest prevention. For instance, growers treat some crops and landscapes with **preplant** or **preemergence herbicides** because they know that weed seeds are present. If plant pathogens have already infected susceptible plants, economic damage usually cannot be prevented. For this reason, fungicides are normally applied before infection occurs whenever environmental conditions favor infection. Likewise, pesticides may be applied to structural lumber before construction to protect it from wood-destroying insects and fungi.

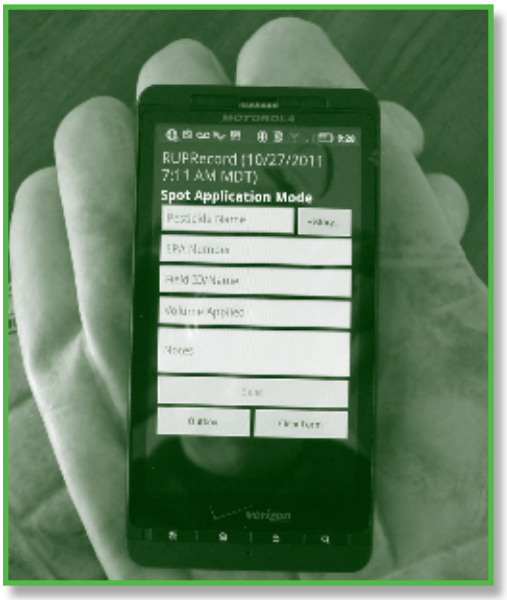
Suppression

Suppressive pest control methods aim to reduce pest population levels. These methods usually do not eliminate all pests but reduce their populations to a tolerable level or to a point below the EIL. Suppression sometimes lowers pest populations so that natural enemies can maintain control. Suppression is the goal of most pesticide applications. Other techniques, such as cultivation, mowing weeds, and releasing biological control agents, are also used to suppress pest populations.

Eradication

Eradication efforts are effective in buildings or other small, confined spaces where, once the pest is eliminated, it can be excluded. For example, eliminating cockroaches, rats, and mice from commercial food establishments requires eradication. Over larger areas, however, eradication is very expensive and often has limited success. Regulatory eradication programs are usually directed at exotic or introduced pests posing an area-wide public health or economic threat.

4. Implement the integrated pest management program—Once you have selected appropriate methods and have set predetermined thresholds, you can initiate the IPM program. IPM



programs are specific to each situation and can be adjusted as you learn more about the pest and the site. Observe all local, state, and federal regulations regarding the methods chosen.

5. Record and evaluate results—It is extremely important to record and evaluate the results of each pest management effort. Some control methods, especially nonchemical ones, are slow to yield measurable results. Other methods may be ineffective or even damage the target crop, animal, treated surface, or natural enemy. Objectively evaluate how well your strategies work so that you will be better prepared if you must control a specific pest again.

EFFECTIVENESS OF PEST MANAGEMENT PROGRAMS

As noted earlier, pesticides represent only one tool in the IPM toolbox. When combined with other control methods, they can help create an effective treatment plan to reduce pest populations. However, pesticides might not control the pests as expected. A good pest manager needs to find out why.

Why Pesticide Applications Fail

Pest identification—Sometimes a pesticide application fails because the pest was not identified correctly. Being able to accurately identify pests requires patience and practice. For example, knowing the difference between a caterpillar and a sawfly will result in success (control) or failure when using *Bacillus thuringiensis*. Bt is effective on caterpillars but not on sawflies. Even nonchemical tactics may fail if the pest and susceptible life stages are not accurately identified.

Dosage—Make sure that you have applied the correct pesticide at the correct dosage, according to label instructions.

Correct use—Some herbicides are formulated to kill grasses, others for broadleaf weeds, and still others can kill both types of weeds. Always read the pesticide label to see if the target pest is listed.

Application timing—Other applications fail because the pesticide was not applied at the correct time. The pest may not have been in the area during the application, or it may have been in a life cycle stage where it was not susceptible to the pesticide. Insects are usually more vulnerable when they are immature, and weeds are most easily controlled before they flower and go to seed. Also, remember that current pests may be part of a new infestation that developed long after the chemical was applied.

Application equipment—Concealed pests (under leaves or bark, in the soil, or within stems or fruits) are difficult to reach. This means that knowing the best type of application equipment to use is very important. For example, use an air-blast sprayer for pests hiding under apple tree leaves but a granular applicator during planting operations for soil-dwelling agronomic pests.

Environmental conditions—In general, do not apply pesticides just before a rainstorm. The pesticide may be washed off the target plants and away from the application site. Temperature extremes and windy conditions can move pesticides away from the target pests and site.

Pesticide degradation—Pesticides may degrade when stored. Under some

conditions, pesticides can change into a form that is ineffective. This might be due to the age of the product or the pesticide storage conditions. For example, granular pesticides stored in wet or very humid conditions will draw moisture. This may cause clumping and possible deactivation of the pesticide.

Pesticide Resistance

Pesticide resistance is the ability of a pest to tolerate a pesticide that once controlled it. Resistance develops when intensive pesticide use kills the susceptible individuals in a population but leaves the resistant ones to reproduce. Initially, higher labeled rates and more frequent applications are needed to control resistant pests. Eventually the pesticide will have little or no effect on the pest population as the resistant population grows (see Figure 1.4).

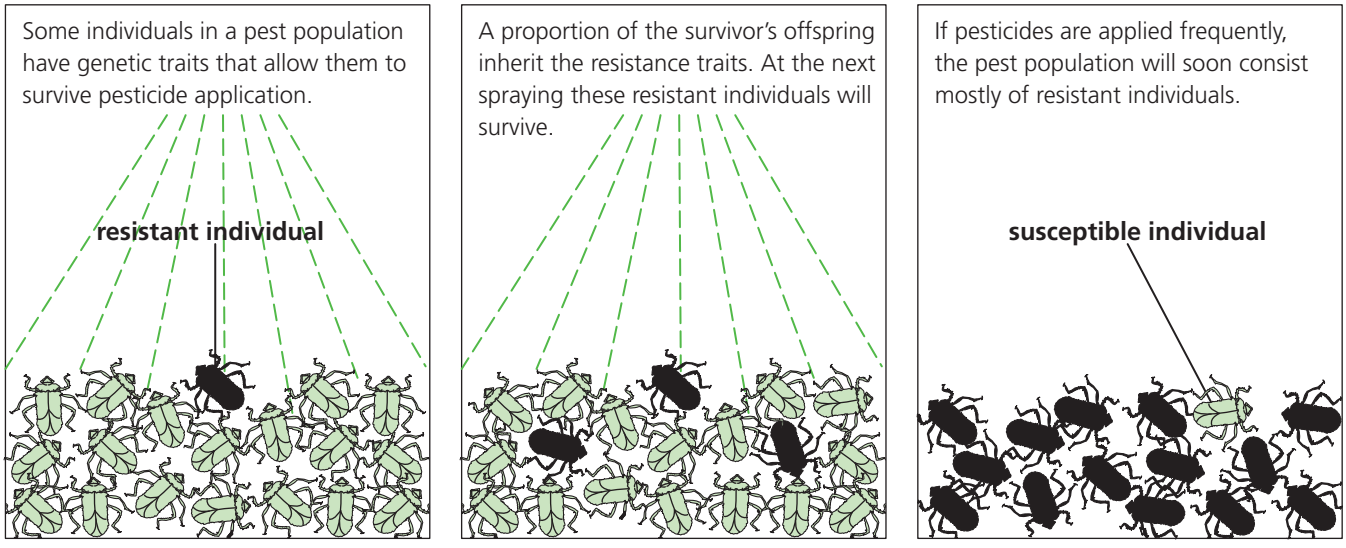
Resistance may develop to a single insecticide, fungicide, herbicide, or rodenticide. More often, however, pest populations become resistant to chemically related pesticides in a class of compounds. It is also possible for a pest to develop resistance to pesticides in two or more classes of compounds with different modes of action.

Continual use of pesticides from the same chemical class, such as all growth regulator herbicides or all pyrethroid insecticides, increases the likelihood that resistance will develop in a pest population. Frequent applications and greater persistence of the chemical further increase the chances of pesticide resistance. Finally, resistance can spread through a pest population much more rapidly in pests that have many generations per year and many offspring per generation, such as many insects, mites, fungi, and rodents.

Several pest management tactics help prevent or delay the occurrence of pesticide resistance. One approach is the use of new or altered pesticides. Using new compounds with different modes of action will lessen the likelihood of resistance developing in a population. Most pesticides have a code number at the top of the label indicating the mode of action (e.g., Group 4A Insecticides—Neonicotinoids, or Group 2 Herbicides—ALS Inhibitors). Unfortunately, new replacement products are often quite complex, difficult to synthesize, and very costly to develop. Moreover, they have very specific modes of action, which can rapidly lead to the development of resistant pest populations even after limited use in the field. No longer can we expect to respond to pesticide resistance by merely substituting one pesticide for another.

Changing pesticide use patterns is an important step in preventing resistance. When dosages are reduced, fewer pests are killed, so the pressure to develop resistant pest populations

Figure 1.4 Pesticide resistance



Adapted from U. of C. *The Safe and Effective Use of Pesticides*

is decreased. Applying pesticides over limited areas reduces the proportion of the total pest population exposed to the chemical. The result is a large pool of individuals still susceptible to the pesticide. This tactic tends to delay the development of a resistant population because pesticide-susceptible individuals continue to interbreed with resistant ones, thus diluting the resistance in the population. Also, treating alternate generations of pests with pesticides that have different modes of action decreases the selection pressure for resistance.

Managing pesticide resistance is a critical aspect of integrated pest management. Monitor pest populations carefully and treat only when necessary instead of on a schedule. Good pesticide application records are another important part of resistance management. Pesticides are more effectively managed when treatment history is known. Resistance must be detected when it is at a very low level. It should then be controlled by using all available pest management techniques to extend the useful life of our current pesticides.

SUMMARY

A successful pest management program begins with the proper identification of the pest. Choosing the appropriate pest control method depends on recognizing and understanding the pest, its life cycle, habits, and habitat. Integrated pest management programs attempt to balance the need for pest control with the desire to protect the environment from pesticide contamination.

Monitoring is critical to knowing where pests are located, when to act against growing pest populations, and what type of control measures to use. Evaluation and recording results help to determine how well the IPM program is working and whether there are any harmful human or environmental effects.

Minimizing pesticide resistance is critical for sustaining the effectiveness of pest management programs. Using a variety of tools and techniques will help prevent or delay the occurrence of pesticide resistance.

If the pest has not been properly identified, even nonchemical control tactics will fail. It is your responsibility to consider the effects of pest control actions on the entire treatment site, whether an outdoor area or inside a structure. Use good judgment—especially when pesticides are part of the control strategy—to avoid harmful effects to other living organisms and the environment.



Review Questions

CHAPTER 1: Pest Management

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Using barriers to prevent pests from getting into an area is an example of which type of pest management method?**
   - **A.** Biological.
   - **B.** Mechanical.
   - **C.** Genetic.

2. **Making use of plant varieties that are naturally resistant to insect feeding is an example of which type of pest management method?**
   - **A.** Biological.
   - **B.** Genetic.
   - **C.** Regulatory.

3. **Which statement about biological control methods is *true*?**
   - **A.** Modifying the environment to enhance natural enemies is recommended in biological control.
   - **B.** Biological control involves importing exotic pests to control natural enemies.
   - **C.** Using several cultural practices and a wide variety of pesticides works best in biological control.

4. **Sealing cracks and crevices and small openings in buildings is an example of which type of pest management method?**
   - **A.** Physical.
   - **B.** Genetic.
   - **C.** Biological.

5. **Which statement about cultural control practices is *true*?**
   - **A.** They reduce pest establishment, reproduction, and survival.
   - **B.** They use naturally derived and/or synthesized chemicals to control pests.
   - **C.** They involve the release of parasites and predators found in foreign countries.

6. **Monitoring pests at airports and ocean ports that pose a serious threat to public health or widespread damage to crops or animals is an example of which type of pest management method?**
   - **A.** Regulatory.
   - **B.** Genetic.
   - **C.** Biological.

7. **Which statement about pest management strategies in IPM is *true*?**
   - **A.** The goal is to prevent pests from reaching damaging levels.
   - **B.** Eradication is never the goal of an IPM program.
   - **C.** Nonchemical methods are short-term solutions to control pests.

8. **Which would be considered a preventive pest management strategy?**
   - **A.** Planting weed- and disease-free seed on an athletic field.
   - **B.** Releasing natural enemies to help reduce pest populations.
   - **C.** Removing a pest that is a public health concern from an area.

continued ▶

9. **Which statement about action thresholds is *true*?**

   A. The IPM technician needs to implement control measures below the action threshold level.
   B. The action threshold for a pest may be set at a zero pest population density.
   C. In an urban landscape, action thresholds are usually more related to economics than aesthetics.

10. **Which would increase the likelihood of pesticide resistance?**

   A. An insect that has one generation per year.
   B. Continual use of pesticides from the same chemical class.
   C. Applying a pesticide that has little or no residual effect.

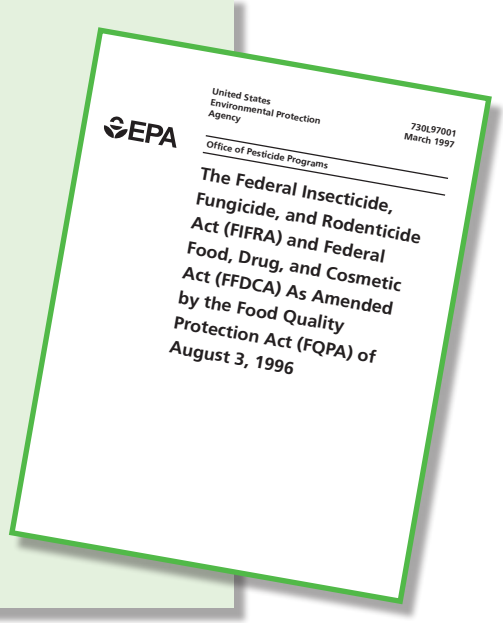
CHAPTER 2

Federal Pesticide Laws and Regulations

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Explain how and why pesticides are regulated in the United States.
- Discuss the importance of knowing and following federal laws and regulations related to pesticide use.
- State why certain pesticides are classified as restricted use.
- Distinguish between restricted-use and general-use pesticide classifications.
- Explain the importance of maintaining accurate records of pesticide applications and employee training.


United States Environmental Protection Agency
EPA
730L97001
March 1997
Office of Pesticide Programs
The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and Federal Food, Drug, and Cosmetic Act (FFDCA) As Amended by the Food Quality Protection Act (FQPA) of August 3, 1996

THE NEED FOR REGULATION

Pesticides are hazardous substances that can cause serious harm if used improperly. However, they also provide important socioeconomic benefits when used correctly. Pesticides are regulated to utilize their benefits while protecting public health and welfare and preventing harm to the environment. Federal and state pesticide laws and regulations control the labeling, sale and distribution, storage, transportation, use, and disposal of pesticides in the best public interest. Except for human and veterinary drugs, few other chemicals sold in the United States are required to undergo such extensive regulatory review and testing before being registered and marketed.

This chapter addresses the requirements of federal laws and regulations only. States, tribes, territories, and some local jurisdictions may have their own legal requirements concerning pesticides that may be more restrictive than federal law. You are responsible for learning about and complying with all such requirements before making any pesticide application. Ignorance of the law is never an excuse for noncompliance or violations.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the federal law or statute that regulates the production, transportation, sale, use, and disposal of pesticides. FIFRA is administered by the U.S. Environmental Protection Agency (EPA). Congress originally enacted FIFRA, amended it considerably in 1972, and then again in 1975, 1978, and 1988.

The Environmental Protection Agency (EPA) is the agency responsible for administering the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

FIFRA provides the overall framework for the federal pesticide regulatory program. Under FIFRA, EPA is responsible for registering or authorizing pesticide products for sale, distribution, and use in the United States. Pesticide registration decisions are based on a detailed assessment of the potential effects of a product on human health and the environment when used according to its labeling directions. This EPA-approved labeling has the force of law.

Although it is a violation of federal law to use any pesticide registered by EPA in a manner inconsistent with its labeling, FIFRA Section 2(ee) excludes several use situations and application procedures. Unless specifically prohibited by the labeling, FIFRA allows:



Restricted-use pesticides (RUPs) may be sold only to certified applicators.

- A pesticide to be applied to control a target pest not specified on the label if the pesticide is applied to a crop, animal, or site specifically listed on the labeling (e.g., interior of a home, food-handling establishments, exterior ornamental plants, corn, and tomatoes).
- Any method of application.
- A pesticide to be applied at a dosage, concentration, or frequency less than that specified on the labeling (except in the case of termiticides labeled for preconstruction treatments).
- A pesticide-fertilizer mixture.

Realize that if you exercise any of the Section 2(ee) exclusions under FIFRA, you alone are responsible for any consequences resulting from such an application.

FIFRA also gives EPA the authority to:

- Impose civil and/or criminal penalties on any person who misuses a pesticide or commits any of the other unlawful acts listed in FIFRA Section 12.
- Stop the sale or use of any pesticide.
- Issue removal orders and seize products to keep them out of the market if it determines the products pose an unreasonable risk.
- Reevaluate older pesticides to ensure that they meet more recent safety standards.
- Implement programs to require the certification of applicators of restricted-use pesticides (RUPs).
- Protect agricultural workers and pesticide handlers from occupational pesticide exposure.

All pesticides are classified according to their potential hazards under

the circumstances in which they are to be used. The two main classifications are **restricted use** and **unclassified use**. Unclassified-use pesticides are commonly referred to as **general-use pesticides**. It should be noted, however, that EPA has officially classified very few pesticides as general use. Most pesticides that might be expected to fit into the general-use category currently remain unclassified. Normally, general-use pesticides have a lower toxicity than RUPs and so are less likely to harm humans or the environment. The general public can buy general-use pesticides without special permits or restrictions.

Generally, EPA classifies a pesticide as restricted use if it exceeds one or more human health toxicity criteria or based on other regulatory standards. EPA may also classify a pesticide as restricted use if it meets certain criteria for hazards to nontarget organisms or ecosystems. Still another reason for the restricted-use classification is a determination by EPA that a product (or class of products) may cause unreasonable harm to human health and/or the environment without such restriction. The restricted-use classification designation must be prominently placed on the top of the front panel of the pesticide product labeling.

Some pesticide active ingredients may be listed in both use categories depending on the formulation, the application method, and the intended uses. For example, an emulsifiable concentrate formulation of a certain insecticide used on fruit trees might be classified as restricted use if it contains a high percentage of active ingredient (e.g., 70%). However the same chemical with a low percentage of active ingredient (e.g., 5%) in a granular formulation used to treat turf insects might be regarded as a general-use pesticide.

RUPs may be sold only to **certified applicators** or their authorized representatives. A certified applicator is an individual who has been recognized (certified) by the state, tribe, territory, or agency responsible for regulating pesticides as being competent to use or supervise the use of RUPs. There are two types of certified pesticide applicators: private and commercial. **Private applicators** are defined as certified applicators who use or supervise the use of any RUP for the purpose of producing an agricultural commodity (e.g., field and forage crops, fruit, vegetables, nursery stock, Christmas trees, greenhouse plants, and livestock) on their own property or property they rent or lease. **Commercial applicators** are individuals who use or supervise the use of any RUP for any purpose on any property except for those listed under the definition of a private applicator.

Only certified applicators or individuals under their direct supervision may mix, load, or apply RUPs. To become certified, a person must demonstrate knowledge of and competency in pesticide use and handling. Certified applicators must know how to read pesticide labeling and be able to follow directions to use these products properly and safely. Pesticide applicator certification programs and the RUP classification process provide an alternative to cancellation of these important and beneficial pesticides or more stringent controls on their use.

Only certified applicators or individuals under their direct supervision may mix, load, or apply restricted-use pesticides.

PESTICIDE REGISTRATION

Except for minimum-risk pesticides, all pesticides distributed and sold in the United States must be registered by EPA. Pesticide registration is based on scientific data showing that these products will not cause unreasonable risks to human health, workers, or the environment when used as directed on the labeling. The process of registering a pesticide begins with the pesticide company (manufacturer or registrant)'s submission of an application package to EPA. EPA's review of this application includes an assessment of the risks to human health and the environment that may be posed by the use of the pesticide. Based on this review, EPA may classify the pesticide as restricted use


ON 24(c) SPECIAL LOCAL NEED
Weed Destroyer 3.2 EC
Herbicide
FOR DISTRIBUTION AND USE ONLY WITHIN THE STATE OF MARY AND
EPA Reg. No. 2222-4444
EPA SLN No. MD-040001
Postemergence Broad-leaf Weed Control in Strawberries
DIRECTIONS FOR USE

An example of a label for a Section 24(c) special local need registration.

or general use—or the pesticide may remain unclassified.

Depending on the class of pesticide and the priority assigned to it, this review and decision process may take several years. Pesticides must be registered or exempted from registration by EPA's Office of Pesticide Programs before they may be sold or distributed in the United States. Once registered, a pesticide may not legally be used unless the use is consistent with the approved directions for use on the pesticide's labeling. FIFRA has several types of registration and exemption actions that enable pesticides to be used in the United States:

- Federal registration of pesticides under Section 3.
- Special local need registrations under Section 24(c).
- Emergency exemptions under Section 18.
- Exemption of minimum-risk pesticides from registration under Section 25(b).

These registration and exemption actions are discussed in more detail in Chapter 3, Pesticide Labeling.

EPA also plays a role in regulating devices used to control pests. A "device" is any instrument or contrivance (other than a firearm) intended to trap, destroy, repel, or mitigate any pest. A black light trap is an example of a device. Unlike pesticides, devices do not need to be registered. However, EPA does require the establishment producing the device to be registered. Devices are subject to certain labeling, packaging, recordkeeping, and import/export requirements.

TOLERANCES

Pesticides are widely used in producing food. These pesticides may remain in small amounts (called residues) in or on fruits, vegetables, grains, and animal feed. Before allowing the use of a pesticide on food crops, EPA sets a **tolerance**, or maximum residue limit. A tolerance is the amount of pesticide residue that may legally remain on or in treated crops and animals (and animal products, such as milk or eggs) to be sold for food or feed. Federal agencies monitor food and feed products for tolerance violations—such as when the residue exceeds the established tolerance. If residues are found to exceed the tolerance, the commodity will be condemned or subject to seizure by the government, and violators may be prosecuted.

Tolerance

The maximum pesticide residue limit that may legally remain on or in treated crops and animals or animal products sold for food or feed.

In setting the tolerance, EPA must make a safety finding that the pesticide can be used with "reasonable certainty of no harm." To make this finding, EPA considers:

- The toxicity of the pesticide and its breakdown products.
- How much of the pesticide is applied and how often.
- How much of the pesticide (i.e., the residue) remains in or on food by the time it is marketed and prepared.

Pesticide manufacturers must submit a wide variety of scientific studies for review before EPA sets a tolerance. These data are designed to identify possible harmful effects the chemical could have on humans (its toxicity), the amount of the chemical residue (or breakdown products) likely to remain in or on food, and other possible sources of exposure to the pesticide (e.g., through use in homes or other places).

A pesticide applicator cannot measure residues on crops or in livestock commodities because such

measurements require highly specialized equipment and techniques. But by following labeling instructions, you can be sure that products you have treated with pesticides have residues well below the tolerance level when put on the market. It is especially important to follow instructions on the correct application rate and the minimum number of days allowed between the pesticide application and harvest, slaughter, freshening, or grazing.

PESTICIDE REREGISTRATION

EPA is responsible for ensuring that each registered pesticide continues to meet safety standards to protect human health and the environment. These standards have become stricter over the years as EPA's ability to evaluate the potential harmful effects of pesticides has improved. Therefore, the agency has embarked on several programs to reevaluate pesticides as the standards evolve.

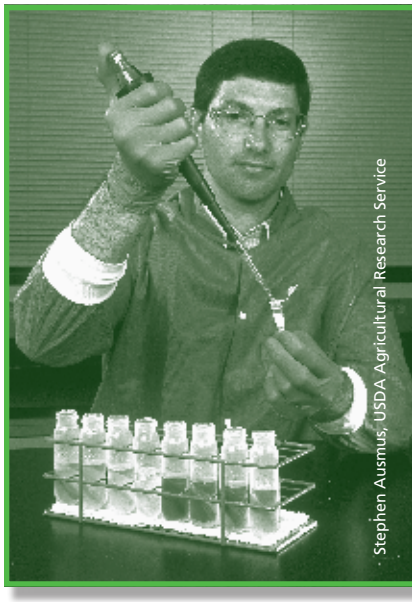
Reregistration and Tolerance Reassessment

EPA has completed a one-time program to review older pesticides (those initially registered before November 1984) to ensure that they meet current scientific and regulatory standards. This process, called **reregistration**, considered the human health, environmental, and ecological effects of pesticides. It resulted in numerous actions to reduce risks of concern identified during the review. The conclusions of those reviews are called Reregistration Eligibility Decisions (REDs).

In addition to the reregistration effort, Congress passed the 1996 Food Quality Protection Act (FQPA) amendments to FIFRA. It also passed the Federal Food, Drug, and Cosmetics Act (FFDCA), which called for reassessing existing tolerances and tolerance exemptions to ensure that they meet the legal safety standard. Implementation of REDs and tolerance reassessment decisions, including the movement of revised labeling into the marketplace, has continued beyond the completion of the reviews in 2008.

Finally, FQPA mandated a new program: **registration review**. Under this program, EPA periodically reevaluates pesticides to ensure that products in the marketplace can still be used safely as policies and practices change. As the ability to assess risk evolves, registration review allows EPA to verify that all registered pesticides continue to meet the statutory standard of no unreasonable adverse effects.

Through these assessments, EPA has identified risks of concern for some uses. In many cases, these risks could be reduced to acceptable levels by changing the product labeling. Examples include use sites, application rates and methods, timing of harvest, restricted-entry intervals, and requirements for personal protective equipment (PPE). Changes in application rates, timing of application to crop harvest, or the removal of some uses can reduce crop residues, decreasing dietary exposure and risk. Labeling requirements for PPE, closed systems, and extended restricted-entry intervals may be established to protect agricultural workers and handlers. Limitations on applications in some soil types reduce the chance of groundwater contamination. EPA expects the implementation of revised labeling in the field to be a continuing process.


Stephen Ausmus, USDA Agricultural Research Service

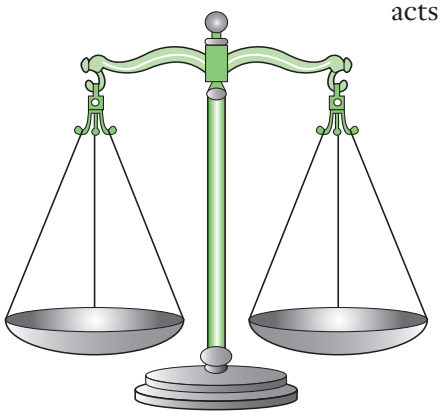
A USDA chemist prepares extracts of fruits and vegetables for analysis of pesticide residues.

How do these processes affect you, the applicator? You must review each product's labeling before application to check for recent changes and to ensure that you use the product according to the directions. Product labeling can change frequently. You can avoid misuse by making sure you are referencing the most current product labeling.


Ken Hammond, USDA

The EPA uses data from the USDA on what food people eat and how much they eat, collected through the Pesticide Data Program.

VIOLATIONS AND FEDERAL PENALITIES



Both civil and criminal penalties can be assessed for FIFRA violations.

A variety of actions by pesticide manufacturers, sellers, distributers, and users are considered unlawful acts under the provisions of FIFRA. These acts include:

- Distributing, selling, or delivering an unregistered pesticide.
- Making any advertising claim about a pesticide not included in the registration statement.
- Selling any registered pesticide if its content does not conform to labeling data.
- Selling an adulterated or misbranded pesticide.
- Detaching, altering, defacing, or destroying any part of a container or labeling.
- Refusing to keep records or permit authorized EPA inspections.
- Making a guarantee other than that specified by the labeling.
- Advertising an RUP without giving the product classification.
- Making an RUP available to a noncertified applicator (except as provided by law).
- Using a pesticide in any manner inconsistent with the labeling.

Remember...

The label is the law!

Penalties

Anyone who uses a pesticide in a manner inconsistent with its labeling directions and restrictions may be subject to civil and/or criminal penalties.

Generally, any registrant, commercial applicator, wholesaler, dealer, retailer, or other distributor in violation of FIFRA may be assessed a civil penalty. In determining civil penalties, EPA considers the size of the business, how the penalty may affect the ability of the firm to remain in business, and the gravity of the violation. Other considerations include any economic benefit realized by illegal profits or unfair gains. In cases involving only minor violations, EPA may issue a warning instead of assessing a penalty.

A knowing (intentional) violation by any registrant, applicant for registration, producer, commercial applicator of a restricted-use pesticide, or other person distributing or selling pesticides or devices is a criminal act. The penalty may include a fine and/or up to one year imprisonment. A knowing violation by a private applicator is a misdemeanor and will result in a fine and/or up to 30 days imprisonment.

Remember, you must use all pesticides exactly according to labeling directions—**the label is the law!**

FEDERAL PESTICIDE REGULATIONS UNDER FIFRA

EPA develops regulations to carry out the provisions of FIFRA. The primary federal regulations pertaining to pesticides are found in Parts 150 to 189 of Title 40 of the Code of Federal Regulations (40 CFR Parts 150-189). The most important federal pesticide regulations of concern to pesticide applicators are briefly summarized below.

Pesticide Container and Containment Regulation (40 CFR Part 165)

In 2006, EPA published regulations on pesticide containers and containment structures to ensure the safe use, refill, and disposal of containers. While most of these requirements apply to pesticide manufacturers and refillers, commercial applicators who store pesticides in containers greater than 500 gallons may need to verify that the container is surrounded by a secondary containment structure. Contact your state pesticide regulatory agency because some states are implementing state—instead of federal—containment regulations. In addition, all applicators must follow the container handling and cleaning instructions in the "Storage and Disposal" section of the pesticide labeling.

Worker Protection Standard Regulation (40 CFR Part 170)

EPA's Worker Protection Standard (WPS) is intended to reduce the incidence of occupational pesticide exposure and related illnesses and injuries among agricultural workers and pesticide handlers covered by the rule. The WPS requires employers to provide agricultural workers and pesticide handlers with certain protections. These include pesticide safety training, personal protective equipment, and decontamination supplies designed to prevent or reduce harm from occupational pesticide exposures. Owners and operators of agricultural establishments (such as farms, nurseries, and forest and greenhouse operations producing agricultural plants) and of commercial businesses hired to apply pesticides or to perform crop advising tasks on agricultural establishments must comply with the WPS. The WPS also requires employers to maintain certain records and to display specific pesticide safety information on the premises.

Certification of Pesticide Applicators Regulation (40 CFR Part 171)

As previously mentioned, EPA has the authority to classify certain products as RUPs and to require anyone applying or supervising the use of RUPs to become a certified pesticide applicator. To carry out this requirement, EPA has established standards for the certification of pesticide applicators and requirements for state, tribal, territorial, and federal agencies to establish pesticide applicator certification programs. Any such agency that wants to certify applicators to use RUPs must have an EPA-approved certification plan that describes how the certifying authority will carry out its credentialing program. This includes the requirements to become a certified applicator, recertification requirements, and the standards of competency for each category of applicator. At a minimum, all certification plans must meet federal standards and requirements.

All 50 states, as well as several tribes, territories, and federal agencies, have EPA-approved certification plans and pesticide applicator certification programs. Additionally, all 50 states have signed cooperative enforcement agreements with EPA that designate an agency within the state (i.e., the state lead agency) as the primary pesticide regulatory authority to enforce the provisions of FIFRA. In some situations, more than one state agency may be designated to enforce various parts of FIFRA. (For example, some states have structural pest control boards responsible for regulating the structural pest control industry.)

OTHER FEDERAL LAWS

Although FIFRA is the main federal law regulating pesticide use, the FFDCA is another statute that provides the EPA with regulatory authority for pesticides. Other federal laws cover certain pesticide-related activities, such as transportation, storage, disposal, protecting the safety of employees, and reporting accidents and spills. Applicators will encounter other laws and regulations that they must be aware of and obey. In some cases, the pesticide labeling will alert the applicator to these laws.

Federal Food, Drug, and Cosmetic Act

The FFDCA governs the establishment of pesticide tolerances for food and feed products. As discussed earlier, a tolerance is the maximum level of pesticide residues allowed in or on human food and animal feed. The EPA and the Food and Drug Administration are responsible for administering this act.

Food Quality Protection Act

The FQPA set a higher standard

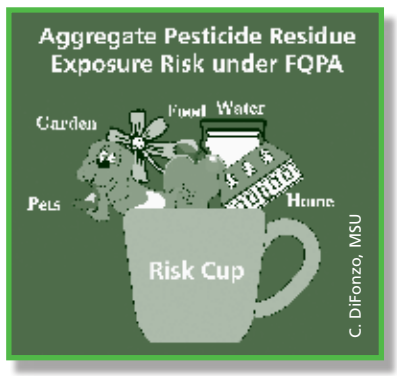


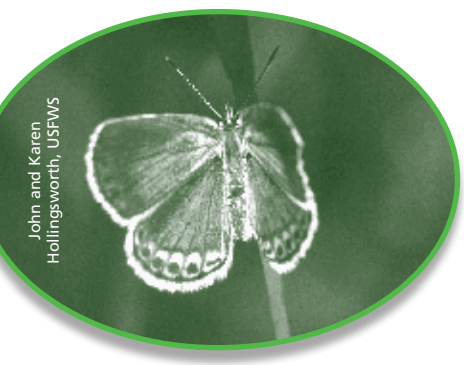
Figure 2.1
Under FQPA, the EPA must consider both dietary (food) and non-dietary (garden, home, water, pets, etc.) risks of exposure when setting tolerance levels for pesticide residues in food.



Endangered mammal: Gray wolf.



Endangered bird: Northern spotted owl.



Endangered insect: Karner blue butterfly.



Endangered plant: Painted trillium.

for pesticides used on food. It established a single, health-based standard to be used when assessing the risks of pesticide residues in food or feed. This safety standard considers the aggregate risk from dietary and other nonoccupational sources of exposure, such as drinking water and residential lawn use (see Figure 2.1). In addition, when setting new or reassessing existing tolerances, the FQPA requires EPA to focus explicitly on exposures and risks to infants and children. This act also requires EPA to assume an additional safety factor to account for any uncertainty in data.

Other FQPA mandates require EPA to:

- Establish a tolerance only if there is "a reasonable certainty" that no harm will result from all combined sources of exposure to pesticides (aggregate exposures). The combined effects of human exposure to different pesticides that may act in similar ways on the body (cumulative exposure) must also be considered.
- Review all old pesticides to make sure that the residues allowed on food meet the new safety standard.
- Test pesticides for endocrine-disruption potential. Endocrine disruptors may be linked to a variety of sexual, developmental, behavioral, and reproductive problems.
- Distribute a brochure discussing pesticides on foods to supermarkets to better inform the public.

Endangered Species Act

The Endangered Species Act (ESA) is a federal law administered by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (jointly referred to as the Services). The ESA makes it illegal to kill, harm, or collect endangered or threatened wildlife or fish, or to remove endangered or threatened plants from areas under federal jurisdiction. It also requires other federal agencies to ensure that any action they carry out or authorize is not likely to jeopardize the continued existence of any endangered or threatened species, or to destroy or harm its critical habitat. Therefore, EPA must ensure that no registered pesticide use is likely to jeopardize the survival of any endangered or threatened species.

Each state pesticide regulatory agency is responsible for implementing the federal Endangered Species Protection Program in cooperation with EPA. Under this program, a pesticide product that might harm an endangered species carries a labeling statement instructing applicators to consult a county bulletin to determine if they must take any special precautions when using the product in a specific county. EPA is developing these county bulletins and making them available through the Internet-based "Bulletins Live!" system. Precautionary measures included in the bulletins may include buffer strips, reduced application rates, or timing restrictions. An applicator might also be prohibited from using the pesticide within the identified habitat.

FEDERAL RECORDKEEPING REQUIREMENTS

Application Records

The United States Department of Agriculture (USDA) administers the program that establishes federal recordkeeping requirements for private applicators. States establish pesticide recordkeeping requirements for commercial applicators. States may also establish private applicator recordkeeping requirements that exceed USDA's. Both private and commercial applicators must be aware of the recordkeeping requirements for their industry.

Keeping appropriate application records not only meets the legal requirements but is also a wise practice because records:

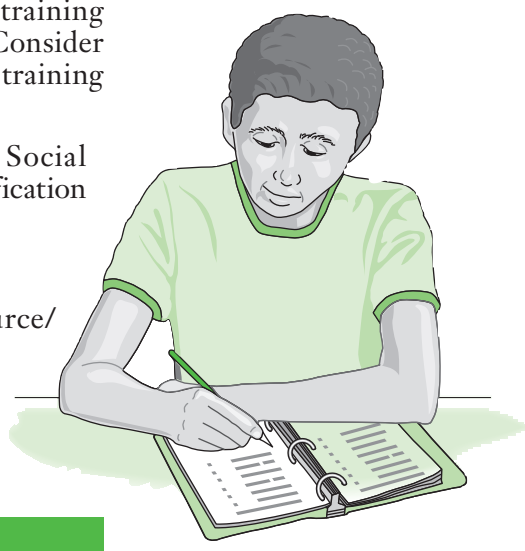
- Are invaluable documentation in the event of a complaint or lawsuit.

- Help determine which pesticide treatments work, which do not work, and why.
- Help applicators plan future purchases so that they buy only the amount needed.
- Provide information needed by medical staff.
- Document the steps taken to protect farmworkers and the environment.
- Are used for federal and state surveys.

Training Records

Owners and operators of pesticide application businesses should consider keeping documentation of employee training in pesticide use and handling. Though not currently required by federal law, such documentation may be required in the future. Therefore, make sure you are aware of applicable training requirements. Your state, tribal, territorial, or federal pesticide regulatory agency may require written proof that employees received training on proper pesticide use when they were hired. In the case of the WPS, records document that the mandatory training requirements were satisfied. Consider including the following in your training records:

- Employee's name and Social Security or work identification number.
- Date of the training.
- Materials used and source/provider of the training.
- Employee's signature and the date signed.



Both private and commercial applicators must be aware of the recordkeeping requirements for their industry.

SUMMARY

Federal pesticide laws and regulations are designed to protect the public and the environment from possible adverse effects of pesticides. It is your responsibility as an applicator to comply with these laws and regulations. FIFRA is the primary law that regulates how pesticides are produced, transported, sold, used, and disposed of. FIFRA also establishes the process for the registration and reregistration of pesticide products, and for the certification of pesticide applicators. All states, tribes, and territories must comply with FIFRA and its accompanying regulations. They may establish additional pesticide regulations more (but not less) restrictive than FIFRA.

The FFDCA regulates the tolerances (i.e., the maximum amounts of pesticide residue) that may remain in human food and animal feed. To set tolerance levels, EPA requires the review of many scientific studies to ensure the safety of food and feed products in the United States.

The FQPA has put in place even more stringent requirements to assess the risks of pesticide residues in food or feed. Under this standard, EPA must now consider the risk of aggregate (combined) pesticide exposures. These include exposure through diet, residential lawn and home uses of pesticides, and residues that may be found in drinking water. The standard also emphasizes the risk of pesticide exposure to infants and children. Under the FQPA, EPA must review all old and new pesticides to make sure the residues allowed on food and feed meet the new safety standard.

The ESA protects endangered or threatened species from harm, including pesticide injury. Pesticide products that might harm an endangered species must carry a statement instructing applicators to consult a county bulletin to determine if they must take any special measures to protect an endangered species when using the product.

All applicators must comply with recordkeeping requirements for RUP applications. Even though it is not a current federal requirement, maintaining employee training records is

a good idea. Such records, which may eventually be required by the applicator's state, tribal, territorial, or federal agency, document that the WPS safety training requirement has been met.

Review Questions

CHAPTER 2: Federal Pesticide Laws and Regulations

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Which statement about FIFRA is *false*?**
   - **A.** It provides the overall framework for the federal pesticide regulatory program.
   - **B.** It prevents states, tribes, and territories from creating pesticide use laws more stringent than federal regulations.
   - **C.** It allows applicators to deviate from the pesticide label under specific use situations.

2. **Under federal law, which statement about trained and certified applicators is *true*?**
   - **A.** They may apply and/or supervise the application of restricted-use pesticides.
   - **B.** They must receive supplemental training before mixing RUPs.
   - **C.** They are exempt from obtaining county bulletins for the protection of endangered species.

3. **What is the purpose of the pesticide registration and reregistration process?**
   - **A.** To control the flow of new pesticide products entering the marketplace.
   - **B.** To provide evidence that the pesticide will not cause unreasonable risks to human health or the environment.
   - **C.** To make sure the amount of pesticide residue remaining on food and feed crops is zero.

4. **Which statement about federal pesticide regulation is *true*?**
   - **A.** To ensure future compliance, civil penalties are typically assessed against first-time violators.
   - **B.** Like pesticides, devices used to control pests must also be registered with EPA.
   - **C.** Approved pesticide labels have the force of law.

5. **Which of the following criteria is used by EPA in establishing pesticide tolerances?**
   - **A.** Research data completely independent of the pesticide manufacturer's.
   - **B.** The anticipated volume of product to be sold in any given year.
   - **C.** The toxicity of the pesticide and its breakdown products.

6. **Under federal law, which of the following actions is unlawful and subject to civil or criminal penalties?**
   - **A.** Allowing a person under the direct supervision of a certified applicator to apply RUPs.
   - **B.** Detaching, altering, defacing, or destroying any part of a container or labeling.
   - **C.** Keeping inadequate records of employees who received training on the proper use of pesticides.

7. **Which federal regulation requires employee training in the use of pesticides?**
   - **A.** Worker Protection Standard.
   - **B.** Pesticide Container and Containment Regulation.
   - **C.** Food Quality Protection Act.

CHAPTER 3

PESTICIDE LABELING

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Distinguish between the various types of pesticide registrations.
- Explain when to read the pesticide label.
- State who may use a pesticide.
- Accurately identify the common, chemical, and brand or trade name of a pesticide.
- Determine the percentage of active ingredient(s) in a formulation.
- Interpret the meaning of label signal words, symbols, and their relative hazard levels.
- Identify the following types of statements on a pesticide label:
  - ➤ Precautionary.
  - ➤ First aid.
  - ➤ Personal protective equipment.
  - ➤ Environmental, physical, or chemical hazards.
  - ➤ Mixing, loading, storage, and disposal.
  - ➤ Restricted entry and reentry.
- Describe how to interpret other documents and online resources referenced on the label.
- Distinguish between advisory and mandatory statements on a label.
- Discuss how to use information on a Safety Data Sheet.



The **pesticide label** is the main method of communication between a pesticide manufacturer and pesticide users. The information printed on and attached to the pesticide container is the label. ***By law, pesticide users are required to comply with all instructions and use directions found on the pesticide product label.*** **Labeling** includes the label itself plus all other information about the product referenced on the label and given when you buy the product. For example, the labeling may include information that accompanies the product in the form of a comprehensive product-use manual, brochures, leaflets, and/or Safety Data Sheets (SDSs). Pesticide labeling includes instructions on how to use the product safely and correctly.

EPA APPROVAL OF PESTICIDE LABELING



No pesticide may be sold in the U.S. before it has been reviewed by EPA.

As discussed in Chapter 2 (Federal Pesticide Laws and Regulations), no pesticide may be sold in the United States until the Environmental Protection Agency (EPA) has reviewed the manufacturer's application for registration and determined that the use of the product does not present an unreasonable risk to humans, wildlife, or the environment. As part of the registration process, EPA must approve all language that the manufacturer (registrant) proposes to include in the product labeling. Exceptions to the registration requirement are covered under a specific exemption (see "Types of Pesticide Registration" later in this chapter).

Only after EPA has reviewed the labeling and registered the product can a pesticide product be sold for use. If the manufacturer wants to change the information on the labeling after the product and labeling are registered, EPA must approve the change.

THE LABEL

The label is an important tool for the safe and effective use of pesticides. Pesticide manufacturers are required by law to put certain information on the label. Failure to heed and follow label directives can result in a pesticide accident and legal action against the user. Labels are legal documents providing directions on how to mix, apply, store, and dispose of pesticide products.

Background of the Label

To appreciate the value of the information that appears on a pesticide label, one must consider the time, effort, and money spent to gather it. This research-based information takes at least six years to obtain and costs a chemical company millions of dollars. Manufacturers continually make and screen new compounds for possible pesticide use. For every new pesticide that successfully meets the standards, thousands of other compounds are screened and discarded for various reasons. Once a promising pesticide is identified, its potential use must be evaluated to determine if it is a worthwhile candidate for the label registration process. Many carefully controlled tests are conducted to determine the effectiveness and safety of each pesticide under a wide range of environmental conditions.

Toxicity and Toxicological Tests

How poisonous or dangerous is a pesticide to humans, wildlife, and other organisms? Does the chemical cause any long-term (chronic) effects? Does it cause any skin (dermal) reactions? To determine these and other health effects, researchers administer the pesticide at various dosages to test animals, usually rats and mice. Newer methods now coming into use rely on mathematical models able to predict the

same toxic endpoints without involving animal testing.

Efficacy or Performance Tests

The company must have performance data to show that the pesticide controls a particular pest or group of pests on one or more hosts or sites, including plants, animals, soil, and structures. Data must show that the pesticide, when used for its intended purpose and according to directions, is a useful product.

Information is also needed on crop varieties, soil types, application methods and rates, and a number of required applications. Tests must show that the pests are controlled, crops or animals are not injured, yield and/or quality has been improved, and the pesticide provides a measurable benefit.

Degradation, Mobility, and Residue Tests

A series of studies shows how long it takes for the compound to break down (degrade) into harmless materials under various conditions. In addition, it is important to know if the pesticide moves through the soil into groundwater or if it moves into the plant from treated soil.

Residue studies are conducted for each application method on every treated crop or animal. These tests determine how much, if any, of the pesticide residue or its breakdown products remain on or in the crop or animal at the time of harvest or slaughter. Pesticide residues on or in food or feed commodities must not exceed the residue tolerances established by EPA when the crop or animal (including meat, milk, and eggs) is ready for market or livestock feed.

Although specific tolerances are not included on product labels, **preharvest intervals** (days to harvest) and/or **preslaughter intervals** (days to slaughter) are often listed on labels of agricultural pesticides. These are the minimum number of days between the last application of a pesticide and the harvest of crops or the slaughter of livestock. Intervals are set by EPA to allow time for the pesticide to break down on crops or in livestock. Adhering to these intervals prevents unacceptable residues on food, feed, or animal products. If residues exceed the EPA tolerance or are found on commodities that do not have a specified tolerance, the commodity may be condemned and destroyed.

Effects on Wildlife and the Environment

The pesticide manufacturer must determine the effects of field applications of the pesticide on wildlife and the natural environment. Any potentially harmful effects that are recognized during these studies must be included in the environmental impact statement submitted to EPA.

TYPES OF PESTICIDE REGISTRATION

As mentioned in Chapter 2, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has several types of registrations and exemptions that enable pesticides to be used in the United States. You are responsible for applying only pesticides registered or exempted from registration by EPA and your respective state, territory, or tribe.

Section 3 registrations are the most common. Look for the official EPA registration number required on the label (except for products that EPA classifies as minimum-risk pesticides) to be sure you are buying an approved and registered product.

Special local need (SLN) registrations are categorized as Section 24(c). They allow states to expand or limit the uses of certain registered pesticides within their jurisdictions. For instance, some SLNs allow uses of pesticides for crops or sites not listed on the label. Others limit the uses of certain pesticides to address local concerns. Manufacturers must provide **supplemental labeling** for each SLN registration.



Potential adverse effects of pesticides to wildlife and the environment must be included in environmental impact statements submitted to EPA.

You must have SLN labeling in your possession to use a pesticide for that purpose. The registration numbers of special local need labeling include the SLN number and code for the state issuing the registration. These registrations are legal only in the region, state, or local area specified in the labeling. It is illegal to apply a pesticide that has an SLN registration from other states or regions.

Emergency exemptions under Section 18 address pest problems for which no pesticides are currently registered. A Section 18 exemption allows the sale and use of a registered pesticide product for a specific nonregistered purpose during a specified period. EPA can issue an emergency exemption at the request of the state, tribe, or territory regulatory agency for a public health concern or other pest crisis. There must be no other feasible pesticide alternative to the exemption.

Regulations impose strict controls and require recordkeeping for all emergency uses. The state, tribe, or territory pesticide regulatory agency prescribes application rates, safety precautions, and other vital application information. Applicators must have a copy of the Section 18 approval on hand to legally use the product.

Minimum-risk pesticides under Section 25(b) are exempt from registration provided the products satisfy certain conditions. Products identified as exempt pose a minimal risk to humans and the environment, do not require EPA label approval, and do not undergo review by EPA. Furthermore, these products have no label requirements for an EPA registration number, an EPA establishment number, any signal word, or any personal protective equipment (PPE).

To qualify for a Section 25(b) exemption from registration, each of the active ingredients in any such product must be on a list of specified minimal-risk active ingredients. Additionally, any inert ingredients in these products must also be listed as minimal-risk inert ingredients.

Minimum-risk pesticides still have certain label requirements imposed by EPA. Product labels may not claim to control microorganisms that pose a threat to human health. For example, the label may list a pest such as a mosquito or tick, but it must not claim to control any microorganisms that the pest transmits to humans.

Many states do not permit the sale of a Section 25(b) product unless it is first registered in the state.

WHEN TO READ THE PESTICIDE LABEL

It is your responsibility as the user to read and understand all labeling before buying, using, storing, or disposing of a pesticide. Read the label:

- **Before buying the pesticide**—Make sure the product is registered for your intended use. Confirm that there are no restrictions or other conditions that prohibit using this pesticide at the application site. Find out what PPE and special application equipment you will need.
- **Before mixing and applying the pesticide**—Determine what precautions to take to prevent exposure to people and nontarget organisms. Learn what first aid and medical treatments are necessary should an accident occur. Be certain the product's use is suitable for weather conditions at the time of application. Also, be sure it controls the appropriate life stage of your pest.

- **When storing pesticides**—Find out how to store the pesticide properly. Understand any special precautions to prevent fire hazards.

- **Before disposing of unused pesticides and empty containers**—From the label, learn how to prevent environmental contamination and hazards to people. Check with your state pesticide regulatory agency for any disposal restrictions and requirements. Find out whether your state has pesticide container recycling and waste disposal programs.



Tom Bowman, N.C. Dept. of Agric. & Consumer Services

Always read the label prior to purchasing and using the pesticide.

PARTS OF THE LABEL

Some labels are easy to understand; others are complicated. Each label component will be discussed in this section. See Figure 3.1 for an example of a pesticide label.

Trade, Brand, or Product Name

Every manufacturer has **trade names** for its products. Most companies register each trade name as a trademark. Various manufacturers use different trade names, even when the products contain the same active ingredient.

The **brand name** often indicates the type of formulation and the percentage of active ingredient present. For example, "Tempo 20WP" is a brand name. Tempo is the registered trade name, and the formulation is a wettable powder containing 20% active ingredient. The trade or brand name shows up plainly on the front panel of the label and is the one used in advertisements.

Ingredient Statement

Every pesticide label must list the active ingredients and the percentage of each active ingredient found in that particular product. The **active ingredient** (a.i.) is the chemical or chemicals in a pesticide product responsible for its pesticidal activity. It is the material in a pesticide formulation that actually controls a pest or performs a desired function (e.g., repellent or growth regulator). **Inert ingredients** are usually not named, but the label must show what percentage of the total contents they make up. The ingredient statement must list the official chemical names and/or common names of the active ingredients. Look at the following Tempo insecticide label excerpt as an example:

Tempo 20WP

Active Ingredient:

ß-Cyfluthrin, cyano(4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate 20%

Inert Ingredients.....80%

The **chemical name** is the complex name that identifies the chemical components and structure of the pesticide's active ingredient. This name must be listed in the ingredient statement on the label. For example, the chemical name of Tempo is:

ß-Cyfluthrin, cyano(4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate

Because chemical names or active ingredients are usually complex, many are given a shorter **common name**. Only those common names officially accepted by EPA may be used in the ingredient statement on the pesticide label. The official common name is usually followed by the chemical name in the list of active ingredients. The common name for Tempo is cyfluthrin.

By purchasing pesticides according to the common or chemical names, you are certain of getting the right active ingredient, no matter what the brand name or formulation. Remember, not all pesticides with the same a.i. are labeled for the same uses or rates.

Use Classification Statement

Currently, EPA classifies every pesticide product as either restricted use or unclassified/general use. Every product that is federally classified as a restricted-use pesticide must have the following statement at the top of the front panel of the pesticide label:

> **RESTRICTED-USE PESTICIDE**
>
> **For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification.**

Pesticides labeled for restricted use demand special attention because there is reason to believe they could harm humans, livestock, wildlife, or the environment even when used according to label directions. The restricted-use statement indicates the specific hazard of that pesticide. For example, a product may be very toxic to humans and wildlife or pose a groundwater hazard. Persons using these products must be certified applicators or have received special training and have demonstrated a certain level of competence to ensure that they can handle these pesticides properly.

Unclassified pesticides are often called general-use pesticides. Typically, they have a lower toxicity with less potential to harm humans and the environment than restricted-use pesticides. Anyone can purchase and use them without special permits or restrictions.

Type of Pesticide

The type of pesticide is usually listed on the front panel of the pesticide label. This short statement indicates in general terms what the product controls. Examples include:

- Insecticide for control of certain insects on fruits, nuts, and ornamentals.
- Herbicide for control of woody brush and broadleaf weeds.
- Insecticide for broad-spectrum control of crawling, flying, and wood-infesting insect pests on indoor and outdoor surfaces, as well as pests of trees, landscape ornamentals, and residential and commercial lawns.

Net Contents

The pesticide label must show how much product is in the container. This is expressed as pounds or ounces for dry formulations or as gallons, quarts, or pints for liquids. Liquid formulations may also list the pounds of active ingredient per gallon of product. Many labels now also include metric units (grams, kilograms, or liters) as part of the contents information.

Name and Address of Manufacturer

The law requires that the manufacturer or formulator of a pesticide product put its name and address on the label so you know who made or sold the product.

Emergency Telephone Number

Many pesticide manufacturers list an emergency telephone number on their product labels. These companies will assist anyone using their products in an emergency (e.g., poisoning, spill, or fire).

Registration Numbers

EPA registration numbers, required on all pesticide labels except Section 25(b) products, indicate that the pesticide product has been registered and the label approved by EPA. Most EPA registration numbers include just two sets of numbers, which identify the manufacturer and the specific product.

Occasionally a third set of numbers appears, which gives a distributor's identification number on labels of distributor products.

EXAMPLES OF EPA REGISTRATION NUMBERS

EPA Reg. No. 3120-280-1492

"3120" identifies the manufacturer, "280" identifies the specific product, and "1492" identifies the distributor.

EPA SLN No. PA-990005

"SLN" indicates special local need, "PA" means that the product is registered for use in Pennsylvania, "99" means it was registered in 1999, and "0005" means it was the fifth special local need product registered that year in Pennsylvania.

Establishment Number

An **EPA establishment number** (e.g., EPA Est. No. 5840-AZ-1) must be on the pesticide label to identify the facility that produced the product. This is necessary in case a problem arises or the product is found to be adulterated (contaminated) in any way. The "AZ" in the example indicates the product was manufactured in a specific facility in Arizona.

Signal Words and Symbols

Most pesticide labels must include a **signal word**. This designation indicates the relative acute toxicity of the product to humans and animals. The signal word must appear in large letters on the front panel of the pesticide label along with the statement "Keep Out of Reach of Children." The following are signal words on pesticide labels:

- **DANGER—POISON,** *skull and crossbones symbol*—These words and symbol must appear on all products that are highly toxic by any route of entry into the body. The word "poison" must appear in red. These products can cause death in very low doses. PELIGRO, the Spanish word for DANGER, must also appear on the label.
- **DANGER**—This word signals that the product is highly toxic by at least one route of entry. Products with this signal word can cause severe eye damage or skin irritation.
- **WARNING**—This word signals that the product is moderately toxic either orally, dermally, or through inhalation or causes moderate eye and skin irritation. AVISO, the Spanish word for WARNING, must also appear on the label.
- **CAUTION**—This word signals that the product is slightly toxic either orally, dermally, or through inhalation or causes slight eye and skin irritation. Although very low toxicity pesticides are not required to display a signal word, many manufacturers still include a CAUTION designation on the label of these products.



Signal words indicate the relative acute toxicity of the product to humans and animals.

A detailed discussion on signal words and toxicity appears in Chapter 5, Pesticide Hazards and First Aid.

Precautionary Statements

All pesticide labels contain statements to help you decide what precautions to take to protect yourself, other people, or animals from pesticide exposure. Sometimes these statements are listed under the heading "Hazards to Humans and Domestic Animals." Precautionary statements may be found in several sections of the label.

Routes of Entry Statements

Routes of entry statements indicate which route or routes of entry into the human body are particularly hazardous. Because many pesticide products are hazardous by more than one route, you should study these statements carefully.

PRECAUTIONARY STATEMENTS

Hazard to Humans and Domestic Animals
WARNING/AVISO

This product may cause skin sensitization reactions in certain individuals. Causes eye irritation. Do not get in eyes, on skin, or on clothing. Harmful if swallowed, inhaled, or absorbed through skin. Avoid breathing spray mist.

STATEMENT OF PRACTICAL TREATMENT

If in eyes: Flush with plenty of water. Get medical attention if irritation persists.

If on skin: Wash with plenty of soap and water. Get medical attention if irritation persists.

If swallowed: Do not induce vomiting. Promptly drink a large quantity of milk, egg whites, or gelatin solution. If these are not available, drink large quantities of water. Never give anything by mouth to an unconscious person. Call a physician or Poison Control Center immediately.

If inhaled: Move victim to fresh air.

Be familiar with first aid procedures before using the pesticide.

A **DANGER** signal word followed by "May be fatal if swallowed or inhaled" gives you a far different warning than **DANGER** followed by "Corrosive—causes eye damage and severe skin burns."

Routes of entry statements are not uniform on all labels; there are many variations. More than one precaution may appear on a label.

Typical DANGER label statements include:

- Fatal if swallowed.
- Poisonous if inhaled.
- Extremely hazardous by skin contact—rapidly absorbed through skin.
- Corrosive—causes eye damage and severe skin burns.



Follow label instructions on the use of protective clothing and equipment.

Typical WARNING label statements include:

- Harmful or fatal if swallowed.
- Harmful or fatal if absorbed through the skin.
- Harmful or fatal if inhaled.
- Causes skin and eye irritation.

Typical CAUTION label statements include:

- Harmful if swallowed.
- May be harmful if inhaled.
- May irritate eyes, nose, throat, and skin.

Specific Action Statements

Specific action statements usually follow the route of entry statements. Specific action statements give the precautions and PPE necessary to help reduce exposure to the pesticide. These statements are directly related to the toxicity of the pesticide product (signal word) and the routes of entry. DANGER labels typically contain statements such as:

- Do not breathe vapors or spray mist.
- Do not get on skin or clothing.
- Do not get in eyes.

Typical WARNING labels often combine specific action statements from DANGER and CAUTION labels.

CAUTION labels generally contain specific action statements that are less alarming than those on the DANGER label, indicating that the toxicity hazard is not as great. Examples include:

- Avoid contact with skin or clothing.
- Avoid breathing dust, vapors, or spray mists.
- Avoid getting in eyes.

Protective Clothing and Equipment Statements

Pesticide labels vary in the type of PPE information they contain. While some labels carry no such statement at all, other pesticide labels fully describe appropriate personal protective equipment. Follow all label statements on PPE or, if absent, consider the signal word, routes of entry statements, and specific action statements. Read the basic guidelines described in Chapters 5 and 6.

Other Precautionary Statements

Labels often list other precautions that should always be followed when handling the product. These commonsense, self-explanatory statements include:

- Do not contaminate food or feed.
- Remove and wash contaminated clothing before reuse.
- Wash thoroughly after handling and before eating or smoking.
- Wear clean clothes daily.
- Not for use or storage in and around a house.
- Do not allow children or domestic animals into the treated area.

First Aid Statements

First aid statements (formerly known as the Statement of Practical Treatment) list emergency treatments recommended in case of poisoning or accidental exposure. Typical statements include:

- In case of contact with skin, wash immediately with plenty of soap and clean water.
- In case of contact with eyes, flush with water for 15 minutes and get medical attention.
- In case of inhalation exposure, remove victim from contaminated area and give artificial respiration, if necessary.
- If swallowed, induce vomiting.

All DANGER labels and some WARNING and CAUTION labels contain a note to physicians describing the appropriate medical procedures and antidotes for poisoning emergencies. Always have the label readily available in case of an emergency.

Environmental Hazards

Pesticides can be harmful to the environment. Look for special warning statements on the label concerning environmental hazards.

Special Toxicity Statements

The label will say if a particular pesticide is especially hazardous to wildlife. Examples include:

- This product is highly toxic to bees.
- This product is extremely toxic to fish and aquatic invertebrates.
- This product is toxic to birds and other wildlife.

Special toxicity statements alert you to the special hazards of a product. They will help you choose the safest product for a particular job and remind you to take extra precautions.

General Environmental Statements

General environmental statements are reminders to follow certain commonsense procedures to avoid contaminating the environment. The absence of any or all of these statements does not mean that you do not need to

EXAMPLE OF AN ENVIRONMENTAL STATEMENT

Environmental Hazards

This product is toxic to aquatic invertebrates. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Under some conditions, this chemical may also have a high potential for runoff into surface water for several weeks or months after application. Do not cultivate within 10 feet of aquatic areas so as to allow growth of vegetative filter strip. Drift from applications of this pesticide is likely to result in damage to sensitive aquatic invertebrates in water bodies adjacent to treatment area.

For terrestrial uses, do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high-water mark, except under forest canopy when aerially applied to control forest pests. Do not contaminate water when disposing of equipment washwaters and rinsate. Do not apply when weather conditions favor drift or runoff from areas treated.

This pesticide demonstrates the properties and characteristics associated with chemicals detected in groundwater. The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.

EXAMPLE OF AGRICULTURAL USE REQUIREMENTS

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 12 hours. Exception: if the product is applied by drenching, the Worker Protection Standard, under certain circumstances, allows workers to enter the treated area if there will be no contact with anything that has been treated.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, includes:

- Coveralls.
- Waterproof gloves.
- Shoes plus socks.

take adequate precautions. Sometimes these statements follow a specific toxicity statement and provide practical steps to avoid harming wildlife. Examples of general environmental statements include:

- Do not apply when runoff is likely to occur.
- Do not apply when weather conditions favor drift from treated areas.
- Do not contaminate water by improperly disposing of rinse water and other pesticide wastes.
- Do not apply when bees are likely to be in the area.
- Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark.
- The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.

Physical or Chemical Hazards

The "Physical or Chemical Hazards" section of the label describes possible fire, explosion, or chemical hazards of the product. Examples include:

- **Flammable**—Do not use, pour, spill, or store near heat or open flame. Do not cut or weld container.
- **Corrosive**—Store only in a corrosion-resistant tank.

Agricultural Use Requirements

The "Agricultural Use Requirements" section is found only on the labels of agricultural products covered by the EPA Worker Protection Standard (WPS). The agricultural use statements link the pesticide product to the WPS regulations found in 40 CFR Part 170. Therefore, the user must follow the labeling as well as the WPS requirements. These requirements are intended to protect agricultural workers and handlers on farms and in forests, nurseries, and greenhouses through training, decontamination, notification, emergency assistance, personal protective equipment, and **restricted-entry intervals (REIs)**.

Restricted-Entry Intervals

Many pesticide labels covered by the WPS include a statement about a restricted-entry interval. The REI specifies how much time must pass between the pesticide application and the reentry of unprotected workers into a treated area.

The REI statement can be found under the heading "Agricultural Use Requirements." If no REI or other restricted-entry statement appears on the label, then all persons should wait at least until sprays have dried or dusts have settled before reentering a treated area. If there are multiple REIs on a label, look in the "Directions for Use" section for each crop. If two or more pesticides are mixed together, you are required to follow the most restrictive (longer) REI.

Nonagricultural Use Requirements

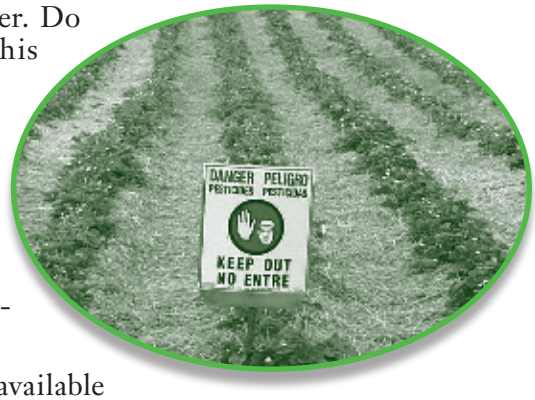
The "Nonagricultural Use Requirements" section applies to pesticide uses that are not within the scope of the WPS. Examples include the application of pesticides to lawns, golf courses, ornamental plantings, structures (except greenhouses), aquatic areas, and rights-of-way. Specific reentry times are not generally listed for these uses. However, the label often cautions people and pets not to enter treated areas until the spray has dried or the dust has settled.

Storage and Disposal

All pesticide labels contain instructions for the appropriate storage and disposal of the pesticide, its rinsate, and its container. State and local laws may vary considerably, so specific instructions usually are not included. These statements typically appear in the "Storage and Disposal" section of the label or under headings such as "Important," "Note," or "General Instructions." Examples include:

- Store herbicides away from fertilizers, insecticides, fungicides, seeds, and feed items.
- Store at temperatures above 32°F (0°C).
- Nonrefillable container. Do not reuse or refill this container.
- Do not contaminate water, food, or feed by storage or disposal.
- Triple rinse container promptly after emptying.
- Offer for recycling if available or reconditioning if appropriate or puncture and dispose of in a sanitary landfill.

If necessary, seek sound advice to determine the best storage and disposal procedures for your operation and location.



Under the federal Worker Protection Standard (WPS), workers must be notified about areas treated with pesticides so they may avoid inadvertent exposures.

Directions for Use

The "Directions for Use" section provides instructions on how to use the product (see Figure 3.1). These instructions cover:

- The pests that the manufacturer claims the product will control.
- The crop, animal, or site the product is intended to protect.
- The proper mixing instructions.
- How much to use (rate) and how often.
- How close to harvest the product can be applied.
- Phytotoxicity (damage to plants) and other possible injury.
- Where and when the material should be applied.
- Plant-back, composting, grazing, and other restrictions.
- How to minimize drift.

OTHER LABEL RESOURCES

Information Resources

Many terms used on labels describe when and how to use pesticides. Technical terms also appear in leaflets and bulletins from local Cooperative Extension offices, land-grant universities, state and federal pesticide regulatory agencies, pesticide

STATEMENT OF PRACTICAL TREATMENT

Contact a doctor (physician), clinic, or hospital immediately in cases of suspected poisoning. Explain that the victim has been exposed to galactothion and describe his/her condition. After first aid is given take victim to clinic or hospital. If breathing has stopped, start artificial respiration immediately and maintain until doctor sees victim.

If swallowed: If patient is conscious and alert, give 2 or 3 glasses of water or milk to drink, and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person. Get medical attention.

If on skin: Immediately flush the skin with plenty of water while removing contaminated clothing and shoes. See doctor immediately. *Galactothion is an organophosphate pesticide that inhibits cholinesterase.*

If inhaled: Remove to fresh air. If not breathing give artificial respiration. Get medical attention.

If in eyes: Hold eyelids open and flush with a steady stream of water for at least 15 minutes. Get medical attention.

Note to Physician

Antidote — administer atropine di-sulfate in large doses. TWO to Four mg. intravenously or intramuscularly as soon as cyanosis is overcome. Repeat at 5 to 10 minute intervals until signs of atropinization appear. 2-PAM chloride is also antidotal and may be administered in conjunction with atropine. **DO NOT GIVE MORPHINE OR TRANQUILIZERS.** Galactothion is a strong cholinesterase inhibitor affecting the central and peripheral nervous system and producing cardiac and respiratory depression. At first sign of pulmonary edema, the patient should be given supplemental oxygen and treated symptomatically. Continued absorption of the poison may occur and fatal relapses have been reported after initial improvement. VERY CLOSE SUPERVISION OF THE PATIENT IS INDICATED FOR AT LEAST 48 HOURS.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS (& DOMESTIC ANIMALS)

DANGER: Fatal if absorbed through skin, fatal if swallowed, and poisonous if inhaled. Do not breathe vapors or spray mist. Do not get on skin or clothing. May be irritating to eyes and may cause mild skin sensitization. Keep away from domestic animals. Discontinue use if allergic reaction occurs.

Signs and symptoms of overexposure

Salivation, muscle tremors, nausea, watery eyes, difficulty breathing, vomiting, pinpoint eye pupils, excessive sweating, diarrhea, blurred vision, abdominal cramps, weakness, headache.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Some materials that are chemical resistant to this product are listed below. If you want more options, follow the instructions for category G on an EPA chemical resistance category selection chart.

Applicators and Other Handlers must wear:

Coveralls over long-sleeve shirt & long pants
Chemical-resistant gloves such as barrier laminate or vitron
Chemical-resistant footwear plus socks
Protective eyewear
Chemical-resistant headgear for overhead exposures
Chemical-resistant apron when cleaning equipment, mixing, or loading
Respirator with either an organic vapor-removing cartridge with a prefilter approved for pesticides (MSHA/NIOSH approval prefix TC-23C) or a canister approved for pesticides (MSHA/NIOSH approval number TC-14G)

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

RESTRICTED USE PESTICIDE

Due to very high toxicity to humans and birds.

For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certificate.

VIP NO PEST GEL

ACTIVE INGREDIENT:

galactothion (0,0-diethyl methyl phosphorothiate)..... 20.9%
related isomers..... 1.1%

INERT INGREDIENTS: 78.00%

Total 100.00%

Net Contents: 5 Gallons

EPA Reg. No. 12345-10 EPA Est. 56787-CO-1

VIP Chemical Company
2527 VIP Drive
Biarspond, MI 22315

When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d)(4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations

Users should wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of the gloves before removing.

ENVIRONMENTAL HAZARDS

This pesticide is highly toxic to aquatic invertebrates and wildlife. Birds in treated areas may be killed. Shrimp and other aquatic organisms may be killed at recommended application rates. Do not contaminate water by cleaning of equipment or disposal of wastes.

PHYSICAL AND CHEMICAL HAZARDS

Do not use or store near heat or open flame. Not for use or storage in or around the home.

KEEP OUT OF REACH OF CHILDREN

DANGER **POISON**

PELIGRO



Si Usted no entiende la etiqueta, busque a alguien para se la explique a Usted en detalle. (If you do not understand this label, find someone to explain it to you in detail.)

STORAGE AND DISPOSAL

PROHIBITIONS: Do not contaminate water, food or feed by storage or disposal. Do not store under conditions which might adversely affect the container or its ability to function properly.

STORAGE: Do not store below temperature of 0° F.

CONTAINER DISPOSAL: Never reuse empty containers. Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedure approved by state and local authorities.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

GENERAL DIRECTIONS

Spray Preparation: To assure a uniform product, agitate or shake all containers of this product prior to use. Use 50 mesh screens or equivalent slotted strainers in spray system. To prepare for spraying, fill tank to 1/2 the needed volume of water. Add the required amount of this insecticide and mix thoroughly by mechanical or hydraulic agitation. Finish filling tank with water to desired volume and thoroughly mix. Do not store spray mixture for prolonged periods. If tank mixes are to be used, VIP Pest-No must be fully dispersed in water first, followed by addition of the intended tank-mix material. DO NOT USE MIXTURES THAT CURDLE, PRECIPITATE OR BECOME GREASY.

Note: Do not add VIP No Pest to water with pH values below 3.0 or above 8.5.

DIRECTIONS FOR AERIAL OR GROUND SPRAY APPLICATION

Application timing: Begin application when insect populations reach economic threshold levels. Consult the Extension Service, professional consultants or other qualified authorities to determine appropriate threshold levels for treatment in your area.

Application Instructions: Apply a minimum finished spray volume of 2 gallons per acre by air or 5 gallons per acre by ground unless otherwise directed under crop specific directions. For best results, it is important to obtain thorough and uniform spray coverage of the plant. Use higher dosage rates for heavy infestations, large larvae, or dense foliage. The specific length of control depends on environmental factors, plant growth, dosage rate, and degree of insect infestation

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), notification-to-workers, and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 48 hours. The REI is 72 hours in outdoor areas where the average annual rainfall is less than 25 inches a year.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

— coveralls over long-sleeved shirt & long pants
— chemical-resistant footwear plus socks
— protective eyewear
— chemical-resistant headgear

Notify workers of the application by warning them orally and by posting warning signs at entrances to treated area

Figure 3.1 Sample pesticide label (adapted from MSU Pesticide Applicator Core Training Manual).

manufacturers, and professional pest management associations. Your understanding of these terms will help you get the best results from pesticide applications. Refer to the glossary in this manual. If you do not understand the directions on a label, check with any of the sources listed above.

World Wide Web References on Pesticide Labels

A pesticide label may refer you to a website for additional use instructions or precautions. This means that all of the information necessary to use the pesticide may no longer be found on the pesticide container. This information is binding, so it is your responsibility as an applicator to seek and obtain it. If the website address has changed or is no longer available, you must contact the manufacturer and acquire the referenced material before making an application.

Digital Pesticide Specimen Labels

Many websites allow the downloading of sample or specimen pesticide labels. Such sites include EPA; state, tribe, or territory regulatory agencies; Cooperative Extension Service; registrants; publishing firms; and consulting companies, among others. While the information found on these sites can be useful and may help clarify use instructions, ***you are still bound by the labeling found on and with your pesticide container.***

Electronic or Web-Distributed Labeling

Regulatory agencies are considering significant changes to what constitutes the "official" pesticide label that an applicator must follow to comply with federal and state use laws. The agencies recognize that it may be desirable and useful to provide a legally binding label on the container and refer applicators to an "official" Internet site for the most up-to-date and customizable use directions. As a result, manufacturers are now able to develop web-distributed labeling. However, concerns about liability, unfamiliarity with a new system of labeling, and quickly evolving technology mean that changes may occur slowly. If you encounter web-distributed labeling, you must carefully follow the instructions on and with the container as well as the instructions obtained from an EPA-approved website.

Mandatory and Advisory Statements

Statements on pesticide labels may be either mandatory or advisory. Label statements that you must follow in order to legally use the pesticide are **mandatory statements**. Recommendations or best management practices that the manufacturer has determined may result in better product performance or improved safety are **advisory statements.**

Mandatory Statements

Mandatory statements direct the user to take or avoid specific actions. The directions and precautions specify where, when, and how a pesticide is to be applied. Mandatory statements are generally written in imperative or directive sentences (e.g., "Do not use…"). These statements are meant to ensure the proper use of a pesticide and prevent unreasonable harm to the environment. Examples include:

- Wear chemical-resistant gloves.
- If swallowed, call a doctor.
- Do not apply within 66 feet of wells.
- Keep away from heat, sparks, and open flame.
- Apply immediately after mixing.

Advisory Statements

Advisory statements provide information on product characteristics and how to maximize safety and efficacy. Such statements cannot conflict with mandatory statements, must not be false or misleading, or otherwise violate statutory or regulatory provisions. Advisory statements are written in descriptive or nondirective terms.

The use of words such as "should," "may," or "recommend" in advisory statements is carefully screened by EPA to clarify that such statements do not have to be followed. However, these words might also imply that a prohibited practice is still permitted. In other words, users could infer that a particular use is permitted because a statement "recommending" against such a use does not have to be followed. EPA allows the use of "should," "may," "recommend," or similar terms on a case-by-case basis as long as they are unambiguous and do not appear to cause these kinds of problems. A preferred advisory statement usually explains the purpose or benefit of doing something instead of asserting that it "should" be done without explanation.

The following are examples of hypothetical advisory statements:

- Latex gloves provide the best protection.
- Opening aluminum phosphide containers near an exhaust fan or other ventilation helps to ensure that the gas will be rapidly dispersed if the product flashes.
- If application is delayed after preparing a tank mix, agitation to re-mix the products ensures proper blending.
- Treatment along one side of interior partition walls where there are cracks in the slab or plumbing entry points prevents further infestation.
- Directing the spray mixture around the base of the cotton plants and using leaf lifters and shields on application equipment will help minimize foliage contact and plant injury.
- If an emulsifiable formulation has been used, flushing the sprayer with a detergent solution at the end of the workday will help to ensure a clean sprayer and trouble-free operation.

Understanding the Difference

Because intermingling advisory and mandatory language may cause confusion and uncertainty, EPA directs manufacturers to clearly separate advisory and mandatory label statements. Section headings must be appropriate for the information that follows. For example, if a heading includes the term "recommended," everything in that section must be purely advisory. If separation is not practical, the manufacturer must make sure it is clear that the intent of each statement is either mandatory or advisory.

Until the separation of advisory and mandatory statements is fully implemented, you will find older products with seemingly contradictory statements. When this occurs, consult with your state lead regulatory agency (or other pesticide regulatory body) for clarification.

The label provides a wealth of information. As explained above, failure to follow the instructions on a pesticide label can cause a serious pesticide accident. It may also constitute a legal violation subject to civil or criminal prosecution. Always remember that the label is a legal document. You are liable for any personal injury, crop or site damage, or pollution that occurs through the misuse of a pesticide.

SAFETY DATA SHEETS

Safety Data Sheets (formerly called Material Safety Data Sheets) provide more details about specific chemical and physical properties than do pesticide labels. Pesticide manufacturers are required to develop and provide upon request an SDS for each product. Commercial establishments are required to keep SDSs and make them available to workers or others who may contact the substance, its diluted end product, or its residues.

Unlike the FIFRA label, which is designed specifically for the pesticide end user (i.e., the applicator), the SDS is a document regulated by the Occupational Safety and Health Administration and designed for use by multiple professionals (e.g., manufacturers, transporters, medical personnel, and firefighters). Thus, the SDS contains more detailed and technical information than the label about the pesticide's chemical and physical properties, toxicological and ecological information, first aid procedures, and emergency response.

You should use the SDS in conjunction with the pesticide label to provide a better understanding of the product. NEVER use it in place of the label!

In 2012, the naming and formatting of SDSs were radically changed to adhere to international treaties. As a result, the SDS of a pesticide product may have a different signal word than the label and will include pictograms not found on the label. Section 15, the regulatory section of the SDS, specifies what is on the pesticide label.

Appendix D describes the elements of an SDS.

SAFETY DATA SHEET SECTIONS

1. Identification
2. Hazard(s) identification
3. Composition/information on ingredients
4. First aid measures
5. Firefighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information

Example of safety data sheet topics.

SUMMARY

Pesticide label language is strictly regulated by EPA in coordination with state regulatory agencies. It provides precise information on how to use pesticides correctly and safely. It is your responsibility as an applicator to read, understand, and follow label directions. Make sure the pesticide has both federal and state registration for its intended use(s).

Study all sections of a pesticide label and know where to find the specific directions and precautions for your pest control situation(s). Identify both the trade and common names of the chemical you are using, and be familiar with the product's active ingredients. Signal words and symbols help you recognize how acutely toxic (i.e., dangerous) the pesticide is to humans. Other parts of the label explain how, when, where, and on what target pest the pesticide may be applied (e.g., directions for use; mixing and loading instructions). Labels also inform you how to respond to pesticide-related emergencies and what precautions to take to avoid harming yourself, other persons, the environment, or nontarget organisms (e.g., first aid statements, environmental hazards, storage and disposal, and physical or chemical hazards). Additionally, applicators are advised to follow best management practices that may not be on the label, such as leaving a buffer zone between the treated area and sensitive sites.

Pesticide labels in combination with Safety Data Sheets provide a wealth of information on the hazards associated with each pesticide. Carefully review these documents before applying any pesticide.



Review Questions

CHAPTER 3: Pesticide Labeling

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Which group of pesticides is exempt from registration because it poses little or no risk to humans and the environment?**
   - **A.** Restricted use.
   - **B.** Minimum risk.
   - **C.** Special local need.

2. **The active ingredient in Tempo 20WP is listed as ß-Cyfluthrin, cyano(4-fluoro-3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2 dimethylcyclopropanecarboxylate. What does the term "Cyfluthrin" represent?**
   - **A.** The brand name.
   - **B.** The chemical name.
   - **C.** The common name.

3. **Which statement about pesticide label names and ingredients is *true*?**
   - **A.** Both the active ingredients and inert ingredients must be listed by chemical name.
   - **B.** Various manufacturers use different trade names, even though the products may contain the same active ingredient.
   - **C.** Common names are those officially accepted by the manufacturer.

4. **What is the purpose of the signal word?**
   - **A.** Indicates the product's relative acute toxicity to humans and animals.
   - **B.** Informs the user what type of PPE to wear.
   - **C.** Tells the user what type of first aid treatment to seek in case of exposure.

5. **The routes of entry statement, "Extremely hazardous by skin contact—rapidly absorbed through the skin," on a label would most likely carry which signal word?**
   - **A.** DANGER.
   - **B.** WARNING.
   - **C.** CAUTION.

6. **"Do not breathe vapors or spray mist" is an example of a:**
   - **A.** Specific action statement.
   - **B.** Statement of practical treatment.
   - **C.** Routes of entry statement.

7. **Directions for mixing and loading a pesticide are usually found under:**
   - **A.** Directions for use.
   - **B.** Environmental hazards.
   - **C.** Precautionary statements.

8. **"If swallowed, call a doctor" is an example of what kind of statement?**
   - **A.** Routes of entry.
   - **B.** Advisory.
   - **C.** Mandatory.

9. **Who is responsible for developing SDSs for pesticides and providing them on request?**
   - **A.** EPA.
   - **B.** OSHA.
   - **C.** The product manufacturer.

CHAPTER 4

PESTICIDE FORMULATIONS



LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Describe what a pesticide formulation is.
- Explain why pesticides are formulated for end use.
- Distinguish between active and inert ingredients.
- State the meaning of abbreviations used for common types of formulations (e.g., WP).
- List the factors to consider when choosing a formulation for a specific site or situation.
- Discuss the properties of common formulations.
- Evaluate the advantages and disadvantages of the formulations described in this chapter.
- Explain the roles of adjuvants.

A pesticide **formulation** is a combination of active and inert ingredients that forms an end-use pesticide product. Pesticides are formulated to make them safer or easier to use. This is because many pesticide **active ingredients**, in "pure" (technical grade) form, are not suitable for application. In their concentrated form, some are extremely toxic, many do not mix well with water, some are unstable, and some are difficult (or unsafe) to handle, transport, or store. To address these problems, manufacturers add **inert ingredients** to end-use pesticide products. Inert ingredients have no pesticidal activity, and some simply serve as **diluents** or **carriers**. In many cases, inert ingredients make the formulated product safer, easier to handle and apply, and/or more effective.

So, in addition to the active ingredient intended to control the target pest, a formulated product may consist of:

- A carrier or diluent, such as an organic solvent of mineral clay.
- Surface-active ingredients, such as stickers and spreaders.
- Other additives, such as stabilizers, dyes, and chemicals, which make the product safer or enhance pesticidal activity.

FORMULATIONS: AN OVERVIEW

The active ingredients in pesticide products come from many sources. Some, such as azadirachtin, pyrethrum, and rotenone, are extracted from plants. Others are derived from microbes or insects (e.g., *Bacillus thuringiensis* and insect growth regulators). Still others have a mineral origin (e.g., copper and sulfur). However, the vast majority of active ingredients used today are produced in laboratories. These synthetic active ingredients may have been designed by a chemist or discovered through screening processes by examining chemicals generated by various industries or found in nature.

Regardless of where they come from or how they are produced, pesticide active ingredients vary considerably in their physical and chemical properties. One variable is solubility. Some dissolve in water, but many do not. Some are soluble in oils or organic solvents. However, many such solvents are not available to applicators or safe to use. A few active ingredients do not dissolve readily in any **solvent**. Solubility and the intended use of the pesticide are two factors that determine how an active ingredient is formulated (i.e., made into an end-use product).

Liquid pesticide products are usually one of the following:

- A solution.
- A suspension.
- An emulsion.

A **solution** is made by dissolving a substance in a liquid. A true solution is a mixture, but it cannot be separated by filtration or other mechanical means. Once made, a true solution will not "settle out" and does not need shaking or stirring (**agitation**) to keep the mixed components in solution. Solutions are transparent: they will allow light to pass through them. (However, this may not be obvious if one or more components of the mixture are dark in color and the solution is very concentrated.) Sweetened iced tea and saltwater are examples of solutions.

A **suspension** is also a liquid mixture. However, a suspension is formed by dispersing fine (very small), solid particles in a liquid. These solid particles do not dissolve in the liquid carrier. Suspensions must be agitated to maintain uniform particle distribution. Otherwise, the undissolved parts of suspension mixtures will settle (or float to the top). Most suspensions are cloudy or opaque: they will not allow light to pass through them. Pesticide products formulated as suspensions are not water-soluble; they form more dilute suspensions when mixed with water to make a finished spray. Label directions for suspension formulations will instruct you to shake well before measuring and mixing. The label will further state to apply these products only with spray equipment that has enough agitation to keep the final mixture evenly distributed in the spray tank during application. A mixture of flour and water is an example of a suspension.

An **emulsion** is a special kind of suspension: a mixture made by suspending droplets of one liquid in another. Each ingredient retains its unique properties and identity. To make an emulsion, an active ingredient is dissolved in an oil-based solvent and then further diluted with water. Some agitation may be necessary to keep an emulsion from separating. However, most emulsion pesticide product formulations have additives (**emulsifiers** or emulsifying agents) that prevent the product from settling. As a rule, emulsions have a "milky" appearance. An emulsifiable concentrate (E or EC) is an emulsion. Homogenized milk is an example of an emulsion.

Most dry products are made by adhering the active ingredient to some solid carrier, such as talc, clay, silica (the mineral quartz), or plant residues (e.g., ground corncobs).

Some pesticide products are sold in concentrate form and must be mixed or diluted before use. **Concentrates** come in both liquid and solid form. An emul-

sifiable concentrate is an example of a liquid concentrate (LC). Wettable powders (WP), soluble powders (SP), and water-dispersible granules/dry flowables (WDG/DF) are examples of concentrated materials sold in solid form.

Other formulations are sold ready-to-use. You can apply ready-to-use products with no further dilution or mixing. Examples include liquids prepared as end-use dilutions and aerosol (A), dust (D), pellet (P), granule (G), and most bait (B) formulation products. Manufacturers package many specialized pesticides, including products intended for residential uses by non-occupational users, in ready-to-use formulations.

Concentrates are often less expensive per treatment/unit area treated than ready-to-use formulations. However, this cost savings may be offset by other considerations. For example, concentrates are usually more toxic than dilute formulations of the same active ingredient. More handling is required to mix and load them. As a result, concentrates present a higher exposure risk to the user.

Abbreviations in trade or brand names are often used to describe the formulation (e.g., WP for wettable powders), how the pesticide is used (e.g., TC for termiticide concentrate), or the characteristics of the formulation (e.g., LO for a low-odor formulation). The amount of active ingredient (a.i.) and the kind of formulation are listed on the product label. Numbers in a product's trade or brand name may also indicate the amount of active ingredient it contains. For example, 80 WDG indicates that this dry product contains 80% by weight of active ingredient and is a water-dispersible granule. In this case, a 10-pound bag of product contains 8 pounds of a.i. and 2 pounds of inert ingredient. Liquid formulations usually state the amount of a.i. in pounds per gallon. For example, 4F means 4 pounds of the a.i. per gallon in a flowable formulation. Some common formulation abbreviations are listed in Table 4.1.

A single active ingredient is often sold in several kinds of formulations. Below is a short description of common formulations, along with the pros and cons of each. If more than one formu-

Table 4.1 Abbreviations for Common Formulations

A	=	**Aerosol**
AF	=	**Aqueous flowable**
B	=	**Bait**
C	=	**Concentrate**
D	=	**Dust**
DF	=	**Dry flowables (see WDG)**
E	=	**Emulsifiable concentrate**
EC	=	**Emulsifiable concentrate**
F	=	**Flowable**
G	=	**Granules**
GL	=	**Gel**
L	=	**Liquid**
LC	=	**Liquid concentrate**
LV	=	**Low volatile**
M	=	**Microencapsulated**
P	=	**Pellets**
PS	=	**Pellets**
RTU	=	**Ready-to-use**
S	=	**Solution**
SP	=	**Soluble powder (*or* soluble packet; see WSP)**
ULV	=	**Ultra-low volume**
W	=	**Wettable powder**
WDG	=	**Water-dispersible granules (see DF)**
WP	=	**Wettable powder**
WS	=	**Water soluble**
WSB	=	**Water-soluble bag (see WSP: water-soluble packet)**
WSC	=	**Water-soluble concentrate**
WSL	=	**Water-soluble liquid**
WSP	=	**Water-soluble powder (*or* water-soluble packet; see WSB)**

lation is available for your pest control site and situation, choose the best one for the job. Base your decision on:

- Legal, labeled uses.
- The signal word.
- Applicator safety.
- Environmental safety.
- Pest biology.
- Site characteristics.
- Target (surface to be treated).
- Appropriate and available application equipment.

Ask yourself these questions:

- Is the intended use listed on the product label?
- Do I have the necessary application equipment?
- Can the formulation be applied appropriately under the conditions in the application area?
- Will the formulation reach the intended target and stay in place long enough to control the pest?
- Is the formulation likely to damage the surface?
- Could I choose a less hazardous formulation that would still be as effective?

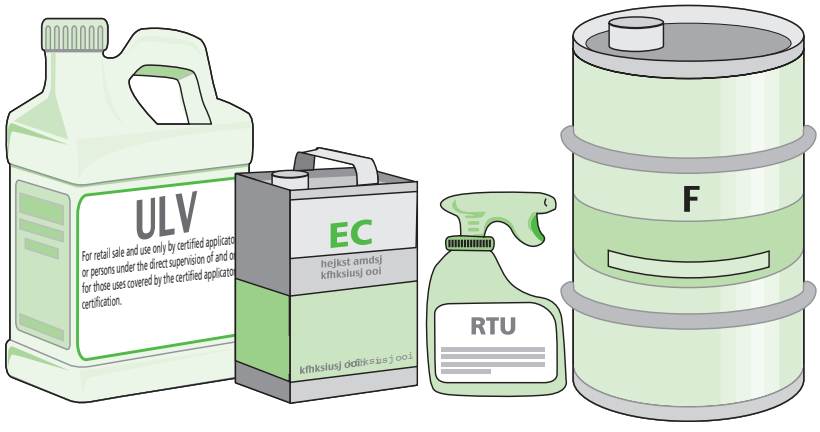
Cost is always a consideration, but pesticide and pest management concerns should come first.

LIQUID FORMULATIONS

Most liquid formulations are diluted with water to make a finished spray. However, some labels direct users to mix the product with another solvent such as crop oil or other light oil as a carrier.

Emulsifiable Concentrates (E or EC)

An emulsifiable concentrate formulation usually contains an oil-soluble liquid active ingredient, one or more petroleum-based solvents, and a mixing agent. The mixing agent allows the formulation to be mixed with water to form an emulsion. Most ECs contain between 2 and 6 pounds of active ingredient per gallon. ECs are among the most versatile formulations. They are used against pests in agricultural, ornamental and turf, forestry, structural, food processing, livestock, and public health settings. ECs are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.



Advantages:

- Relatively easy to handle, transport, and store.
- Easy to pour and measure.
- Little agitation required; will not settle out or separate when equipment is running.
- Not abrasive; does not cause excessive equipment wear.
- Will not usually plug screens or nozzles.
- Leave little visible residue on treated surfaces.

Disadvantages:

- High concentration of active ingredient(s) makes it easy to overdose or underdose through mixing or calibration errors.

- May damage treated plants or surfaces (petroleum-based solvents or overdosing may cause **phytotoxicity**).
- Easily absorbed through skin of humans or animals.
- Splashes and spills are relatively difficult to clean up and/or decontaminate.
- Many have a strong odor.
- Solvents may cause equipment "wear and tear." For example, rubber or plastic hoses, gaskets, pump parts, and other exposed surfaces may deteriorate.
- May cause pitting or discoloration of painted finishes or other treated surfaces.
- Flammable; should be used and stored away from heat or open flame.
- May be corrosive.

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based diluent. When mixed, they form a solution that does not settle out or separate. Formulations of these pesticides usually contain the active ingredient, solvent (carrier or diluent), and one or more other ingredients. Solutions are suitable for any type of sprayer, indoors or outdoors. Consequently, they are registered for many sites, including structural, institutional, public health, and household pest control; livestock and poultry pest management; space sprays in barns and warehouses; and treatment of food and fiber crops, turf, and ornamental plants.

Ready-to-Use (RTU) Low-Concentrate Solutions

Ready-to-use formulations require no further dilution before application. They consist of a small amount of active ingredient (often 1% or less per unit volume). Some ready-to-use products contain petroleum-based solvents; others are water-based. Many RTU products are produced for pest management professionals (who treat structural and institutional pests) and for nonoccupational users.

Advantages:

- Convenient; neither measuring nor mixing is required.
- Some are packaged and sold in—or with—an application device. If this is the case, no loading is required.
- Less personal exposure risk due to reduced toxicity and handling.

Disadvantages:

- Limited availability.
- High cost per unit of active ingredient.

The time saved and convenience of using RTU products may outweigh the product cost.

Concentrate Solutions (C, LC, or WSC/WSL)

Other solutions are available as concentrates that require dilution with a liquid solvent before you apply them. Often the solvent is water, but it may also be a refined oil or petroleum-based solvent. When diluted with the label-specified carrier, these formulations form true solutions.

Advantages:

- Relatively easy to handle, transport, and store; easy to pour and measure.
- No agitation necessary.
- Not abrasive; do not cause excessive equipment wear.
- Do not plug screens or nozzles.
- Do not usually leave visible residues on treated surfaces.

Disadvantages:

- Limited availability, especially water-based solutions.
- Spills and splashes may be difficult to clean up and/or decontaminate.

- Some are easily absorbed through skin of humans or animals.

The other benefits and drawbacks of concentrated solutions vary. They depend on the concentration of active ingredient, solvent or diluent used, application site, and application equipment.

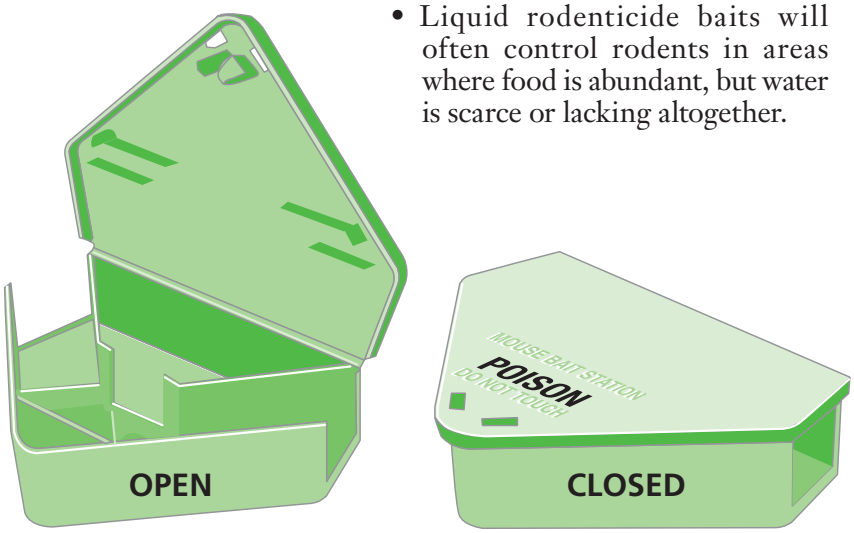
Liquid Baits

Some insecticides and rodenticides are now formulated as liquid baits. Most liquid insecticides are concentrated sugar solutions. They are packaged in ready-to-use bait stations to kill ants and cockroaches.

As a rule, liquid rodenticide baits are mixed with water and placed in specially designed bait stations. They are useful in sites where sanitation is poor because traditional food-based baits "compete" with other food sources. As is the case with solid baits, you must place bait stations in safe, strategic locations while following label directions and taking care to protect children and nontarget organisms.

Advantages:

- Liquid ant baits are very useful in controlling sugar-feeding ants.
- Ants that will feed on liquid baits carry this material to the colony.
- Liquid rodenticide baits will often control rodents in areas where food is abundant, but water is scarce or lacking altogether.



A bait station used in rodent control in the closed and open positions. Bait formulations are placed inside the tamper-resistant station.

Disadvantages:

- Not all ants, cockroaches, and rodents will feed on liquid baits.
- You must refill or replace liquid-containing bait stations frequently.

For information about solid-formulation baits, refer to "Baits" in the "Dry or Solid Formulations" section.

Ultra-Low Volume

Ultra-low-volume concentrates have almost 100% active ingredient. They are designed to be used "as is" or diluted with only small quantities of specified solvents. These special-purpose formulations are most suitable for outdoor applications, such as in agricultural, forestry, ornamental, and mosquito control programs. ULV products are applied as very fine droplets at very low rates per unit area (or volume).

Advantages:

- Relatively easy to handle, transport, and store.
- Little or no agitation required.
- Not abrasive to equipment.
- Do not plug screens and nozzles.
- Leave little visible residue on treated surfaces.

Disadvantages:

- High drift hazard due to small droplet size.
- Specialized equipment required.
- Easily absorbed through skin of humans or animals; high dermal and inhalation exposure risk (concentrated product applied as fine droplets).
- Products and/or solvents may cause rubber or plastic hoses, gaskets, and pump parts and other surfaces to deteriorate.
- Calibration and application must be performed with special care because ULV products are applied in concentrated form.

Invert Emulsions

Invert emulsions contain a water-soluble pesticide dispersed in an oil carrier. These products require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil. Invert emulsions are less susceptible to drift because oil evaporates more slowly than water. When applied on a hot, dry day, a water-based droplet will become smaller as the water portion of the droplet evaporates. Invert emulsion droplets do not "shrink" as rapidly when applied in the same weather conditions. This means less drift and more pesticide on target. Invert emulsions are thick mixtures, with the consistency of mayonnaise. In addition, invert emulsions are applied as very large droplets, which reduce drift.

The oil phase of this kind of formulation also serves as a sticker-spreader. This quality improves rainfast properties and surface coverage. It also increases **absorption** and/or penetration. This, in turn, reduces loss due to runoff. Invert emulsions are relatively uncommon. They are most often used in weed control on rights-of-way to reduce the chance of drift to susceptible nontarget plants or sensitive areas.

Advantages:

- Low drift.
- Increased rate of penetration and/or absorption.
- Increased rainfastness and reduced runoff.

Disadvantages:

- Difficult to treat the underside of foliage or other targets because droplets are large and heavy.
- Limited availability.

Flowables (F or AF)

Some active ingredients are insoluble solids: substances that will not dissolve in either water or oil. These may be formulated as flowables. (Most manufacturers use the letter "F" by the trade name to designate that the formulation is a flowable. However, some use the letter "L," meaning that an insoluble material is presented in "liquid" form.) Most flowables are prepared by first impregnating them onto a dry carrier, such as clay. Then, the active ingredient plus carrier (or the active ingredient alone) are ground into a fine powder. Next, the fine powder is suspended in a very small amount of liquid (and perhaps other inert ingredients). The resulting product is a thick liquid suspension.

Flowables combine many of the characteristics of liquid emulsifiable concentrates and dry wettable powders. They appear in the "Liquid Formulations" section because the end-use product is a thick liquid. Flowables are often used for the same types of pest control operations as ECs.

Advantages:

- Easy to handle and apply; low exposure risk.
- Generally not phytotoxic.
- Seldom clog nozzles.
- Splashes are less likely than with other liquid formulations.

Disdvantages:

- May settle; need shaking before measuring and mixing.
- Difficult to remove all of product from the container. Containers may be difficult to rinse.
- Require moderate agitation.
- May be **abrasive**; contribute to "wear and tear" of spray application equipment.
- Spills may be harder to clean up.
- May leave a visible residue on treated surfaces.

Aerosols (A)

Aerosol formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. There are two types of aerosol formulations:



- The ready-to-use type (often sold in pressurized sealed containers that serve as application devices).
- Those made for use in electric or gasoline-powered aerosol generators that release the formulated product as a smoke or fog.

Ready-to-Use Aerosols

Ready-to-use aerosol formulations are usually small, self-contained units that release pesticide when the nozzle valve is triggered. An inert pressurized gas pushes the pesticide through a fine opening when the gas is released, creating fine droplets. These products are effective in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold 5 to 10 pounds of pesticide, are usually refillable.

Advantages:

- Easy to use; convenient.
- Portable.
- Easily stored.
- Convenient way to buy and apply a small amount of pesticide.
- Retain potency for some time.

Disadvantages:

- Practical for only a few limited or specialized uses.
- Risk of inhalation exposure.
- Hazardous if punctured, overheated, or used near an open flame.
- May be difficult to direct material released to a single target site or pest.

Formulations for Smoke or Fog Generators

Formulations for smoke or fog generators are not packaged and sold under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol). Using a rapidly whirling disk or heated surface, the machines produce and distribute very fine droplets. These formulations are used mainly for insect control in structures such as greenhouses, barns, and warehouses and for outdoor mosquito and biting fly control.

Advantages:

- Easy way to fill an entire space with pesticide.

Disadvantages:

- Highly specialized use sites and equipment.
- Difficult to confine to target site or pest.
- Spills and splashes may be difficult to clean up and/or decontaminate.
- May require respiratory protection to prevent inhalation exposure.

DRY OR SOLID FORMULATIONS



There are two general types of dry formulations. Some are ready-to-use. Others are concentrates, which must be mixed with water and applied as a spray.

Dusts (D)

Most dust formulations are ready-to-use and contain a low percentage of active ingredient (usually 10% or less by weight). A few dust formulations, however, are concentrates and contain

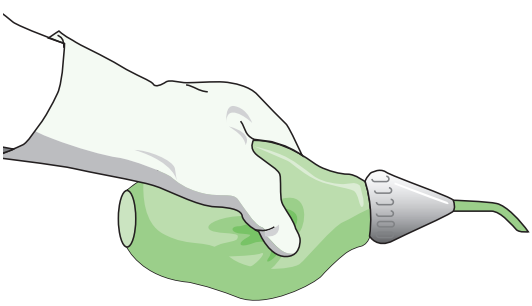
a much higher percentage of active ingredient. These concentrates must be mixed with dry inert carriers before application.

Dusts have one or more active ingredients plus a very fine, dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles varies, but all are quite small. Due to their small size, dusts need careful handling to prevent nontarget exposure, including drift. They are not water-soluble. Therefore, do not mix them with a liquid solvent.

Dusts are always used dry. They are often used as seed treatments and in some other agricultural operations. Some ornamental and garden pest management products aimed at homeowners are dust formulations. In structures, dust formulations are useful to treat cracks and crevices and for spot treatments to control insect pests. Dusts are also a good tool to control lice, fleas, and other external parasites on pets and livestock.

Special dusts known as tracking powders are effective for insect and rodent monitoring and control. These products are finely ground dusts with an adsorbed stomach poison. Insects and rodents walk through the dust, pick it up on their legs and bodies or feet and fur, and ingest the poisonous dust when grooming. Tracking powders are effective in sites and situations where bait acceptance is poor (for example, where food is abundant).

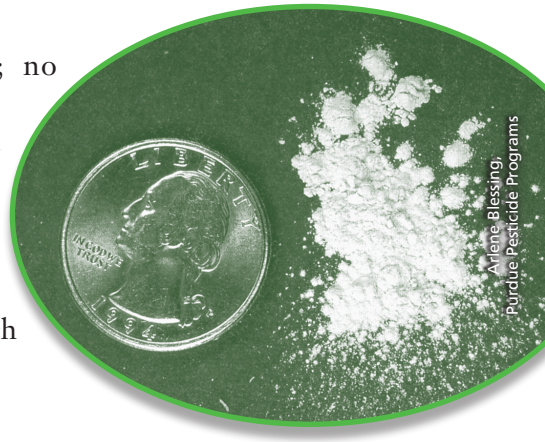
NOTE: *Another option is to use a nontoxic powder, such as talc or flour, to monitor and track rodent activity in buildings.*



A bulb duster used for applying dust formulations to cracks, crevices, and voids in buildings.

Advantages:

- Usually ready-to-use; no mixing.
- A good alternative where moisture from a spray might cause damage.
- Applied with simple application equipment.
- Effective in hard-to-reach indoor areas.



Dust formulations are always used dry.

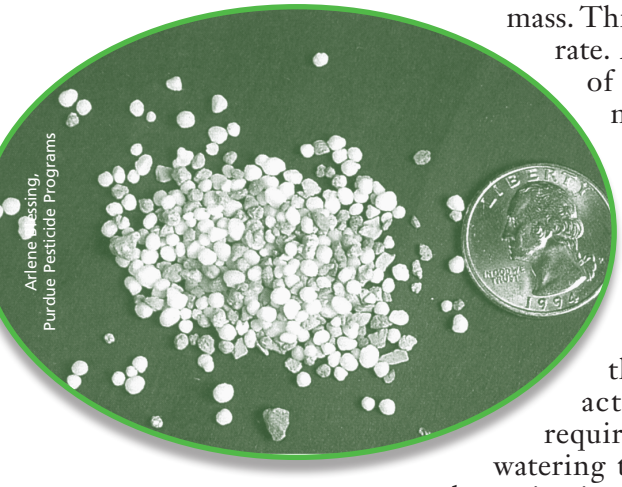
Disadvantages:

- Easily drift off target during application.
- Residues do not adhere to treated surfaces, including foliage, as well as liquids do; may easily wash off or blow away.
- May irritate eyes, nose, throat, and skin; pose a relatively high inhalation exposure risk to handlers.
- Dampness may cause product to clump and equipment to clog; difficult to apply in damp or humid environments.
- Some kinds of application equipment and devices are hard to calibrate.
- Difficult to get an even distribution of particles.

Granules (G)

Granular formulations are similar to dust formulations; however, granular particles are larger and heavier. Like dusts, they are not water-soluble. They are ready-to-use–not intended to be mixed with water and applied as a liquid suspension. The coarse particles that serve as carriers for granular formulations are adsorptive substances like clay or absorptive plant material such as ground corncobs or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1% to 15%.

Because many granular formulations use carriers that absorb moisture, humidity will affect particle size and



Granular formulations are larger and heavier than dust formulations.

mass. This, in turn, will affect flow rate. Also, different "batches" of the same formulation may differ slightly in size or shape and density. For these reasons, you must calibrate granular application devices often.

Once applied, granules slowly release the adsorbed or absorbed active ingredient. Some require soil moisture, rain, or watering to initiate the release of the active ingredient. Other granules do so as they decompose.

Granular pesticides are mostly used to apply chemicals to the soil, where they control weeds, nematodes, and insects or are absorbed by plant roots. Most granular formulations are used to deliver systemic pesticides. Granules are a common choice in many sites and situations.

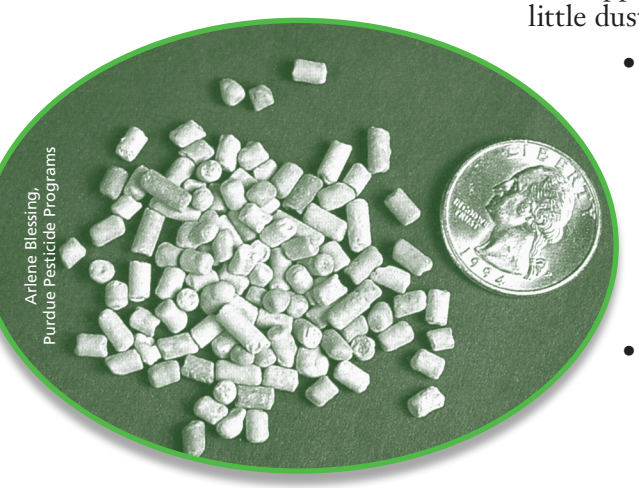
Aerial applicators sometimes use granular formulations to reduce drift or penetrate dense vegetation. Granular formulations are also useful in aquatic situations to control mosquito larvae and aquatic weeds.

Advantages:

- Ready-to-use; no mixing.
- Drift hazard is low, and particles settle quickly.
- Low applicator hazard: no spray; little dust.
- Weight carries the formulation through foliage to soil or water target.
- Applied with simple application equipment, such as seeders or fertilizer spreaders.
- May break down more slowly than WPs or ECs because of a slow-release coating.

Disadvantages:

- Application equipment needs frequent calibration.
- Application equipment is not as convenient to calibrate as spray equipment. Released particles are measured by weight instead of by volume.
- Uniform application may be difficult with some devices (e.g., rotary spreaders).
- Granules do not stick to foliage or other uneven surfaces. For this reason, contact products are rarely formulated this way.
- May need to be incorporated into soil or planting medium.
- May need moisture to release the active ingredient; may not be effective in drought conditions.
- May be hazardous to nontarget species, especially waterfowl and other birds. This is because birds may feed on grain- or seed-like granules or mistake them for "grit" they need to grind up their food.
- Bulky; low percentage of active ingredient per unit volume.



In pellet formulations, all particles are the same weight and shape.

Pellets (P or PS)

Most pellet formulations are very similar to granular formulations in their uses, advantages, and disadvantages. However, in pellet formulations, all the particles are more or less the same weight and shape. They are produced by combining the active ingredient with inert materials to form a "slurry"—a thick liquid mixture. This mixture is then extruded under pressure. As a result, pellets are round in cross section and cut to a specific length. Because pellet particles are more uniform, you can apply them with precision. However, in many cases, pellets are applied as spot treatments. A few fumigants are formulated as pellets and are clearly labeled as such to avoid confusing them with nonfumigant pellets.

Wettable Powders (WP or W)

Wettable powders are dry, finely ground solid materials. Most include wetting and/or dispersing agents. Usually, they must be mixed with water

and applied as a spray. A few products, however, may be applied dry or as a liquid suspension.

Wettable powders contain 5% to 95% active ingredient—usually 50% or more. Wettable powder particles do not dissolve in water. When mixed with water, they form a suspension. They will settle out quickly without constant agitation to keep them suspended.

To prepare a spray suspension, you must form a slurry. Mix a WP with a small amount of water, and then dilute this slurry mixture further.

Wettable powders are effective for most pest problems and in most types of spray equipment where agitation is possible. They have excellent residual activity and do not usually harm treated surfaces. When you apply a WP spray suspension to a target, most of the pesticide remains on the surface. This is true even for porous materials, such as concrete, plaster, and untreated wood. In such cases, only the water carrier penetrates the porous material. Wettable powder particles remain on the treated surface.

Advantages:

- Easy to store, transport, and handle.
- Less likely than ECs and other petroleum-based formulations to harm treated plants, animals, and surfaces.
- As a rule, not phytotoxic.
- Less risk of skin and eye absorption than ECs and other liquid formulations.

Disadvantages:

- Not easy to measure; must be weighed.
- Not easy to mix.
- Inhalation hazard to applicator while measuring and mixing the concentrated powder.
- Suspended particles require good and constant agitation (usually mechanical) in the spray tank and quickly settle out if agitation ceases.
- Abrasive to pumps and nozzles; cause equipment wear.
- Difficult to mix in very hard or very alkaline water.
- If not mixed properly, may clog nozzles and screens.
- Residues may be visible on treated surfaces.



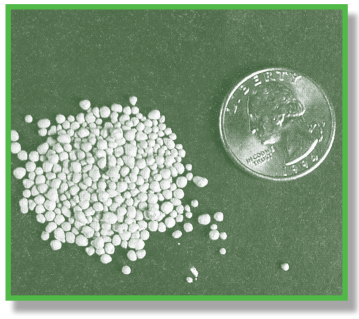
Arlene Blessing, Purdue Pesticide Programs

Wettable powders are dry, finely ground formulations that look like dusts.

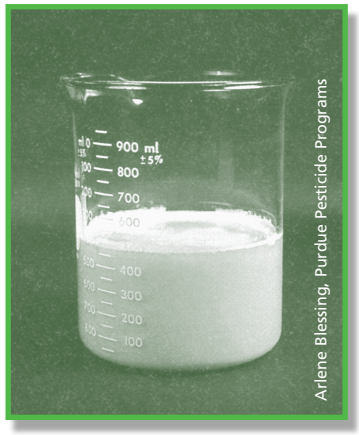
Water-Dispersible Granules (WDG) or Dry Flowables (DF)

Water-dispersible granular formulations are wettable powder formulations compressed into dust-free, granule-sized particles. Most come with a product-specific measuring device, with dry ounce (or pound) increment marks based on product density (weight per unit volume). Because of this and the fact that they readily flow or pour out of their containers, they are easier to measure and cleaner to handle than WPs. Like wettable powders, water-dispersible granules are mixed with water and applied as a spray suspension. Once in water, the granules break apart into fine powder. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of wettable powders. However, WDGs have one added benefit: reduced handler exposure risk. This is because WDGs/DFs are:

- Made of larger, less "dusty" particles.
- Easier to remove from their container and measure.


Arlene Blessing, Purdue Pesticide Programs

Water-dispersible granule before mixing.



Arlene Blessing, Purdue Pesticide Programs

Water-dispersible granule after mixing.

Soluble Powders (SP or WSP)

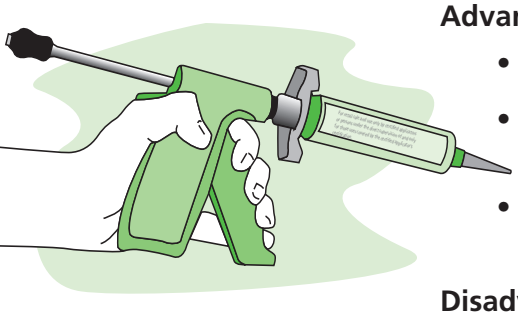
Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily in water and form a true solution. After a thorough mixing, no additional agitation is necessary. The amount of active ingredient in soluble

powders ranges from 15% to 95%; it usually is more than 50%. Soluble powders have all the advantages of WPs but only one of the disadvantages: inhalation hazard during mixing. Not many pesticides are available in this formulation because very few active ingredients dissolve in water.

Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Many baits are solid (blocks, granules, or pellets), but some are liquids, pastes, or gels. The amount of active ingredient in most bait formulations is quite low, usually less than 5%.

Baits are used inside buildings to control ants, cockroaches, flies, and other insects. Outdoors, they can control vertebrate pests, such as rodents, other mammals, and birds as well as snails, slugs, and some insects. Applicators must place bait stations in safe, strategic locations while following label directions to protect children and nontarget organisms.



A bait gun used by the pest control industry to treat small cracks and crevices.

Advantages:

- Ready-to-use.
- Entire area need not be covered because pest goes to bait.
- Control pests that move in and out of an area.

Disadvantages:

- May be attractive to children and pets.
- May kill domestic animals and nontarget wildlife.
- Require careful placement and inspection.
- Pest may prefer the crop or other food to the bait.
- Dead vertebrate pests may cause odor problems.
- If baits are not removed after the pesticide stops working, they may serve as a food supply for the target pest or other pests.
- May not work in situations where pests have many other food or water sources.

For information about liquid baits, see "Liquid Formulations" above.

Pastes, Gels, and Other Injectable Baits

Pastes and gel baits are mainly used in the pest control industry for ants and cockroaches. In fact, insecticides formulated as pastes and gels are now the primary formulations used in cockroach control. They are designed to be injected or placed as either a bead or dot inside small cracks and crevices of building elements where insects tend to hide or travel. Two basic types of tools are used to apply pastes and gels: syringes and bait guns. The bait is forced out of the tip of the device by applying pressure to a plunger or trigger.

Advantages:

- Odorless; no vapors.
- Low human toxicity.
- Last for long periods.
- Low applicator exposure risk.
- Hidden placements minimize human and pet exposure.
- Very accurate in their placement and dosage.
- Easily placed where insects shelter for maximum effectiveness.

Disadvantages:

- Can become contaminated from exposure to other pesticides and cleaning products.
- When exposed to high temperatures, gels can run and drip.
- May stain porous surfaces.
- Repeated applications can cause an unsightly buildup.

OTHER FORMULATIONS

This section describes other formulations that:

- Are not easily classified as liquid or dry/solid.
- Are formulated and/or applied as gases.
- Have some special packaging or delivery method.

Fumigants

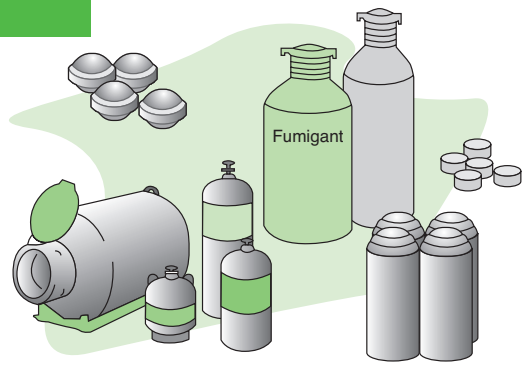
Fumigants are pesticides that deliver the active ingredient to the target site in the form of a gas. Some active ingredients are liquids when packaged under high pressure but become gases when released. Other active ingredients are **volatile** liquids. They may be enclosed in an ordinary container and not packaged under pressure. Still others are solids that release gases after application in humid conditions or in the presence of water or water vapor. Fumigants are used for structural pest control, in food- and grain-storage facilities, and in regulatory pest control at ports of entry and state and national borders. In agricultural pest control, fumigants are effective in soil, greenhouses, and commodity storage areas (such as grain bins).

Advantages:

- Toxic to a wide range of pests.
- Can penetrate cracks, crevices, wood, and tightly packed areas (such as soil or grains).
- A single treatment will usually kill most pests in the treated space.

Disadvantages:

- The target site must be enclosed or covered to prevent the gas from escaping.
- Nonspecific and highly toxic to humans and all other organisms.
- High inhalation exposure risk.
- Most require the use of specialized personal protective equipment.
- May require the use of specialized application equipment.
- Some have specific temperature requirements.



Fumigants are packaged in liquid and solid forms. Both turn into poisonous gases when applied.

Microencapsulated Pesticides (M)

Microencapsulated pesticides are dry particles or liquid droplets surrounded by a coating. Coatings may be plastic, starch, or some other material. Microencapsulated pesticides are mixed with water and applied as a spray. Once applied, the pesticide is released from the capsule. In some situations, the encapsulation process can provide "timed" slow release of the active ingredient. Depending on the physical properties of the coating, release of the pesticide active ingredient may be weather-dependent. If the release is slower than normal (for example, due to dry or cool weather), residues may remain on treated plants or surfaces longer than expected. As a result, some microencapsulated products have relatively long restricted-entry or preharvest intervals.

Some microencapsulated pesticide products contain highly toxic materials with a coating to increase handler safety. Others are microencapsulated for different reasons; for example, to reduce staining or odor or to protect the active ingredient from photodegradation. Highly toxic microencapsulated pesticides may be very hazardous to bees if the particles do not break down quickly and are the same size as pollen grains. Foraging bees may collect them and carry them back to the hive. Later, when the coatings break down and release the pesticide, the colony may be poisoned. Some microencapsulated soil-applied products may be more prone to leaching.

Advantages:

- Coatings help protect the applicator.

- Easy to mix, handle, and apply.
- Timed release of active ingredient prolongs effectiveness (i.e., may result in fewer applications; application timing may be less critical).
- Reduced volatility.
- Reduced odor.
- Less likely to stain or otherwise damage treated surfaces.
- Reduced phytotoxicity.

Disdvantages:

- Constant agitation may be necessary in spray tank (depending on the properties of the coating).
- Risk of injuring or killing bees (if the microencapsulated product is toxic to them).
- Long restricted-entry or preharvest intervals for highly toxic products.

Water-Soluble Packaging (WSB or WSP)

More and more pesticide products are available in water-soluble bags (WSBs). A special film packages a precise amount of wettable powder, soluble powder, or gel containing the pesticide active ingredient(s). When added to water in a spray tank, the bag dissolves and releases the contents, which then are suspended or dissolved. This packaging method reduces handler exposure risk. It also simplifies measuring. However, water-soluble packaging is just that—as a rule, it will not dissolve in organic solvents or undiluted ECs. As a result, mixers and loaders must follow label instructions when preparing a spray mixture. Store water-soluble products in a dry place, and do not handle them with damp or wet gloves.


M.J. Weaver, Virginia Tech Pesticide Programs

Adding water-soluble packet to a spray tank.

Advantages:

- Accurate premeasured unit doses.
- Increased handler safety; greatly reduced exposure risk.
- Lower risk of spills.

Disadvantages:

- Package size may not match volume of prepared solution needed and/or spray tank volume.
- May not be suitable for products applied in pounds or gallons of active ingredient per acre, due to the size or number of packets required.
- Must be kept dry—away from water or high humidity—until ready to use.

Impregnates

Some pesticide products consist of a pesticide active ingredient incorporated into a solid material, usually some kind of plastic. The pesticide evaporates or is released over time, and the vapors control nearby pests. Common examples include:

- Livestock ear tags.
- Plastic pest strips and adhesive tapes.
- Pet collars.

Fertilizers may also be impregnated with pesticides.

Animal Systemics

Animal systemics are absorbed by, enter the tissues of, and move within the treated animal. Usually, these pesticides are applied externally or orally. They can control fleas and other external blood-feeding insects as well as worms and other internal parasites. External application methods include pour-on liquids, sprays, and dusts. Oral applications include food additives and premeasured capsules, pastes, or liquids.

Pesticide-Fertilizer Combinations

Many pesticide products—usually granule and pellet formulations—are

combinations of fertilizers and pesticides. Such products are convenient because they allow the applicator to control pests and apply nutrients at the same time. Some are prepackaged: homeowners commonly use these for their lawns. Dealers or growers may custom mix pesticides with fertilizers to meet specific crop requirements.

PESTICIDE MIXTURES

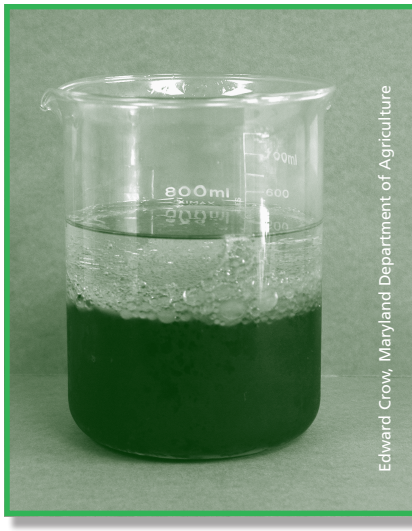
Sometimes, product manufacturers combine pesticides with other pesticides or fertilizers for sale as premixes (see "Pesticide-Fertilizer Combinations" above). However, when premixes are not available (or are not offered in the desired combination), you may combine products at the time of application. **Tank mixing**—combining two or more crop-production products (pesticides and/or fertilizers) and applying them at the same time—is convenient and cost-effective. This practice can save the time, labor, fuel, and equipment wear involved in multiple applications. Tank mixing also reduces soil compaction and the risk of mechanical damage to crops or treated areas. Situations appropriate for tank mixing include combining fungicides and insecticides to treat fruit trees or field crops. Another common example is combining herbicides to increase the number of weed species controlled (control spectrum). However, products must be compatible in order to be tank-mixed.

Federal law allows applicators to combine pesticides unless the labeling of one or more components of the intended tank mix specifically prohibits it. If no prohibitions exist, applicators may mix:

- Pesticide with fertilizer.
- Two or more pesticides.

When pesticides are tank-mixed, all of the dosages must be at or below the label rate for each separate component of the mixture.

For more information about the causes and effects of incompatibility, how to do a compatibility test, and how to prepare a tank mix, see Chapter 10, Planning the Pesticide Application.



Incompatibility is a condition that prevents pesticides from mixing together properly to form a uniform solution or suspension.

ADJUVANTS

An **adjuvant** is a chemical that can affect how a pesticide works. Adjuvants:

- Improve the action of a pesticide.
- Change the characteristics of a pesticide formulation or a spray mixture (suspension or solution).

Most end-use pesticide products, especially those that are applied to foliage, contain adjuvants. However, in some situations, applicators may add them to a tank mix when making a finished spray mixture. Many adjuvants increase effectiveness and/or safety. Although they enhance the action of a pesticide or modify the properties of a spray solution, adjuvants alone have no pesticidal activity. Use them to customize the product or formulation for specific needs or to compensate for local conditions.

Because adjuvants lack pesticidal properties, the U.S. Environmental Protection Agency does not register them. As a result, there are no standards for composition, quality, or performance. If you have questions about an adjuvant, contact the manufacturer. Companies that produce these products can provide labels, technical data sheets, Safety Data Sheets (SDSs), supplemental labeling, and promotional literature.

Before using any adjuvant, consult the pesticide product label. Some products have very specific adjuvant recommendations or prohibitions. If a label instructs you to use an adjuvant, use the type called for at the directed

rate. As noted, many products already contain those adjuvants deemed necessary or useful by the manufacturer or formulator. Adding others may actually decrease efficacy or result in unintended —and possibly undesirable—effects.

Types of Adjuvants

There are many types of adjuvants. Here are some that are commonly used:

- Antifoaming (defoaming) agents —reduce foaming of spray mixtures that may result from using some surfactants and/or from vigorous agitation.
- Buffers or pH modifiers—allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity. Most pesticide solutions or suspensions are stable between pH 5.5 and 7.0 (slightly acidic to neutral). Water outside this range may cause pesticides to degrade—very rapidly, in some cases. If you use a buffer, add it to the spray tank water first and mix well. The water must be pH neutral or slightly acidic to start, before adding pesticides or other adjuvants.
- Compatibility agents—help combine pesticides (or pesticides and fertilizers) effectively; reduce or eliminate incompatibility.
- Drift control additives (deposition aids)—reduce drift; increase average droplet size and/or lower the number of "fines" (very small droplets) produced.
- Emulsifiers—allow petroleum-based pesticides (ECs) to mix with water.
- Extenders—keep pesticides active on a target for an extended period. Some adjuvant manufacturers use this name for stickers. (See "Stickers" below.)
- Invert emulsifiers—allow water-based pesticides to mix with petroleum carrier.
- Plant penetrants—allow the pesticide to pass through (penetrate) the outer surface to the inside of treated foliage. Certain plant penetrants may increase penetration on some—but not all—plant species.
- Safeners—reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.
- Spreader—allow pesticide to form a uniform coating layer over the treated surface.
- Stickers—allow pesticide to stay on a treated surface. Some types of stickers increase adhesion of solid particles to a treated surface. This reduces the amount of pesticide that washes off due to rain or irrigation. Others reduce evaporation and/or slow photodegradation. (See "Extenders" above.)
- Surfactant—see "Surfactants" below.
- Thickeners—increase viscosity (thickness) of spray mixtures. Thickeners may reduce drift and/or slow evaporation. (Slowing evaporation is useful when applying systemic pesticides. It increases the time during which the active ingredient can be absorbed by or penetrate plant foliage.)
- Wetting agents—allow wettable powders to mix with water.

TYPES OF ADJUVANTS

- **Surfactants**
  - Wetting agents and spreaders
- **Stickers**
- **Extenders**
- **Plant penetrants**
- **Compatibility agents**
- **Buffers or pH modifiers**
- **Drift retardants**
- **Defoaming agents**
- **Thickeners**

Surfactants

Some of the most common adjuvants are **surfactants** (***sur***face ***act***ive ingredie***nts***), which alter the dispersing, spreading, and wetting properties of spray droplets. Examples of surfactants are wetting agents and spreaders. These products physically change the surface tension of a spray droplet. In order to perform well, some pesticide sprays must be able to wet treated foliage thoroughly and evenly. Surfactants that reduce surface tension enable droplets to spread out instead of bead up. This results in better coverage and increases the odds that the pest will contact the

pesticide. Surfactants are particularly helpful when treating plants with waxy or hairy leaves (see Figure 4.1).

Surfactants are classified by how they split apart into charged atoms or molecules, called ions.

- Anionic surfactants have a negative charge. They are most often used with contact pesticides, which control the pest by direct contact instead of being absorbed systemically.
- Cationic surfactants have a positive charge. Do not use them as "stand-alone" surfactants—often, they are phytotoxic.
- Nonionic surfactants have no electrical charge. They are often used with systemic products and help sprays penetrate plant cuticles. They are compatible with most pesticide products.

A pesticide can behave very differently in the presence of an anionic, cationic, or nonionic surfactant. For this reason, you must follow label directions when choosing one of these additives. Selecting the wrong surfactant can reduce efficacy and damage treated plants or surfaces.

The terms used when talking about pesticide additives can be confusing. People sometimes use the words "adjuvant" and "surfactant" interchangeably. However, an adjuvant is ANY substance added to modify properties of a pesticide formulation or finished spray. A surfactant is a specific kind of adjuvant—one that affects the interaction of a spray droplet and a treated surface. All surfactants are adjuvants, but not all adjuvants are surfactants. For example, drift control additives and safeners are not surfactants.

Choosing the Right Adjuvant

Here are some factors to consider when deciding whether to use an adjuvant and how to choose the right one for a particular site and situation.

- Read and follow the label. Is an adjuvant recommended? If so, what type? Do not make substitutions. Note that some product labels may recommend an adjuvant for one type of use or site but prohibit any kind of adjuvant for another labeled use or site. Many end-use formulated products already have adjuvants, and adding adjuvants "on the fly" can decrease efficacy. Suppose, for example, that a certain product is formulated with a wetting agent. If you add another wetting agent when you mix and load a foliar-applied spray, the product may not give better spreading and coverage. Instead, the extra adjuvant may increase runoff, reduce deposition, and even damage the target plant.
- Use only those adjuvants manufactured for agricultural or horticultural uses. Do not use industrial products or household detergents in pesticide spray mixes.
- Remember that no adjuvant is a substitute for good application practices.
- Take adjuvant performance claims "with a grain of salt." Be skeptical of claims such as "improves root uptake" or "keeps spray equipment clean" unless a reliable source can provide research-based evidence to support them. Only use adjuvant products that have been tested and found effective for your intended use.
- Test spray mixes with adjuvants on a small area before proceeding with full-scale use.

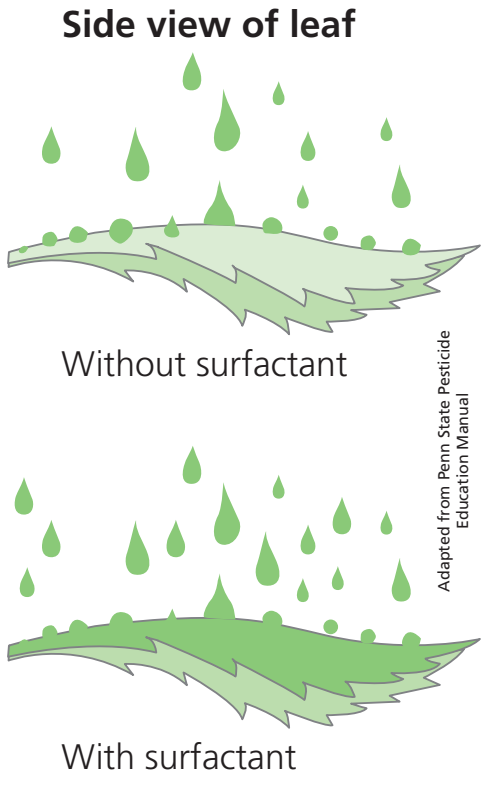


Figure 4.1
Surfactants increase the ability of the pesticide to spread evenly over the surface of a leaf or fruit.

SUMMARY

The ingredients of a formulated pesticide include both active and inert components. The active ingredient controls the pest. Inert ingredients include carriers or diluents and adjuvants. The type of formulation may be provided in the identifying information on the front panel of the label. (The SDS for a product will describe the formulation and also provide information about hazardous inert ingredients.)

Learn what formulations are available for the pesticide active ingredients you will use. To decide which formulation is best for a specific site and situation, you must know the properties—and be able to evaluate the pros and cons—of various formulation types. You must be familiar with formulation types and active ingredient properties in order to understand the characteristics of the products you use and apply them properly.

Most end-use pesticide products contain adjuvants. Although adjuvants themselves lack any direct pesticidal activity, they are added to pesticide formulations to improve product performance. You should know when and how to use an adjuvant.

In summary, you must consider several factors when choosing a pesticide formulation. These include the risks and benefits associated with the options available, the practicality of using a specific formulation in a particular site to control the target pest, and whether the formulated product will provide effective control. Understanding the properties of common formulations before choosing a pesticide will help you avoid problems and apply your product in an effective and efficient manner.

Review Questions

CHAPTER 4: Pesticide Formulations

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **The name "X-Pest 5G" on a pesticide label indicates a:**
   - **A.** Granular pesticide with 5% active ingredient.
   - **B.** Granular pesticide with 5% inert ingredients.
   - **C.** Gel pesticide with 5% active ingredient.

2. **Which is the pesticide formulation process by which solid particles are dispersed in a liquid?**
   - **A.** Emulsion.
   - **B.** Solution.
   - **C.** Suspension.

3. **Which liquid pesticide formulation consists of a small amount of active ingredient (often 1% or less per unit volume)?**
   - **A.** Microencapsulated (M).
   - **B.** Ready-to-use (low-concentrate) solution (RTU).
   - **C.** Ultra-low volume (ULV).

4. **Which liquid pesticide formulation may approach 100% active ingredient?**
   - **A.** Aerosol (A).
   - **B.** Emulsifiable concentrate (EC).
   - **C.** Ultra-low volume (ULV).

5. **Which is a disadvantage of both EC and ULV formulations?**
   - **A.** Difficult to handle, transport, and store.
   - **B.** Require constant agitation to keep in suspension.
   - **C.** Solvents may cause rubber or plastic hoses, gaskets, pump parts, and other surfaces to deteriorate.

6. **Which dry/solid formulation is mixed in water and reduces the risk of inhalation exposure during mixing and loading?**
   - **A.** Soluble powder (SP).
   - **B.** Water-dispersible granule (WDG) or dry flowable (DF).
   - **C.** Wettable powder (WP).

7. **Which type of dry/solid pesticide formulation consists of particles that are the same weight and shape?**
   - **A.** Bait.
   - **B.** Granule.
   - **C.** Pellet.

8. **Which is an advantage of microencapsulated materials?**
   - **A.** Delayed or slow release of the active ingredient prolongs their effectiveness.
   - **B.** Their pesticidal activity is independent of weather conditions.
   - **C.** They usually require only short restricted-entry intervals.

9. **Which type of adjuvant functions as a wetting agent and spreader (i.e., physically altering the surface tension of spray droplets)?**
   - **A.** Buffer.
   - **B.** Extender.
   - **C.** Surfactant.

10. **Which type of adjuvant increases the viscosity of spray mixtures?**
    - **A.** Sticker.
    - **B.** Extender.
    - **C.** Thickener.

CHAPTER 5

PESTICIDE HAZARDS AND FIRST AID

LEARNING OBJECTIVES



After studying this chapter, you should be able to:

- Differentiate between types of harmful effects (allergic, acute, chronic, and delayed) associated with pesticide application.
- Identify common exposure routes for various pesticides and application methods.
- Explain the hazard level classification system for pesticides, including the corresponding signal words.
- Describe typical symptoms of pesticide exposure in humans.
- Discuss the appropriate first aid response to oral, ocular, dermal, and inhalation exposures to pesticides.
- List other health risks (such as heat stress) that may occur during pesticide application.

Pesticides are designed to be toxic to living organisms so they can control pests (e.g., plants, insects, rodents, fungi, and bacteria). At the same time, pesticides must be used with special care to avoid harming nontarget organisms, including pesticide applicators, handlers, and anyone else exposed to the product. Though many pesticides are toxic to humans, they vary significantly in the type and level of hazards they present. In many cases, something that is toxic to one species may also be toxic to other species of organisms. This is especially true if the organisms are closely related. For example, insects, rodents, and humans are all animals and have similarities in their nervous, circulatory, and respiratory systems. Because of these similarities, pesticides can affect people as well as the target pest.

Pesticides can have both short-term and long-term effects on humans. The signal word on the product label and the information contained in the "Hazards to Humans and Domestic Animals" section of the label indicate the human toxicity concerns and the precautions you should take to minimize your own risk. Pesticides can pose additional physical and chemical risks by being explosive and/or combustible. If the product presents either a physical or a chemical hazard, this information is included in the "Precautionary Statements" section. Refer also to the Safety Data Sheet (SDS) for more information on toxicity and precautions.

TOXICITY, EXPOSURE, AND HAZARD

Toxicity refers to the ability of a pesticide to cause short-term (**acute**) or long-term (**chronic**) injury. "Toxicity," a measure of the pesticide's capacity to cause injury or illness, is a combination of its chemical properties and concentration.

Exposure occurs when pesticides get onto or into the body through the skin (dermal), the lungs (inhalation), the mouth (oral), or by eye contact (ocular). Product formulations differ greatly in their exposure risk. Some routine pesticide-handling procedures present an especially high likelihood of exposure. Examples include handling opened containers; mixing and loading concentrates; working around contaminated application equipment; making spray, mist, or dust applications; cleaning up spills; and reentering a recently treated area before the spray has dried or the dust has settled.

Hazard, or risk, is the true concern for the applicator or handler. It is the potential or probability for harm (injury, illness, or allergy) to occur because of the combination of the product's innate toxicity and the level of human exposure. "Hazard" reflects both the pesticide's toxicity and the likelihood that you will be exposed to the product in a particular situation. As an applicator, you can reduce your risk by choosing a less-toxic product, by reducing exposure, or both. In situations when a different product cannot be used, you can still reduce the hazard (risk) by taking steps to reduce exposure. As a result, pesticide users need to be concerned with the hazards associated with exposure to the chemical and not exclusively with the toxicity of the pesticide. A good equation to remember is:

Hazard = Toxicity x Exposure

The following two examples illustrate that risk takes into account both toxicity and exposure:

- Gasoline is extremely toxic to humans, especially if swallowed or inhaled. Yet every day, millions of people fill their gas tanks without incident. The toxicity is high, but gas pumps are designed to virtually eliminate human exposure. Therefore, the risk associated with filling a car's gas tank is very low. If someone siphons gas, the risk is much greater because exposure is much more likely.

- Aspirin has a low toxicity to humans. However, if someone takes too many aspirin at one time, he or she can become very ill. In this case, toxicity is low but the potential for exposure is high, increasing the overall hazard or risk.

Engineering controls, such as gas pumps and childproof caps, are often designed to reduce exposure. Engineering controls that reduce handler exposure are also available for pesticide mixing and loading (see Chapter 11, Pesticide Application Procedures, for more information). Examples are lock-and-load devices and water-soluble bags containing formulated product.

Often, the greatest hazard to the applicator occurs while mixing and loading the pesticide concentrate. There is a significant risk of exposure to a chemical in its most concentrated, toxic form unless engineering controls are used. Hazards associated with the actual application are frequently much lower when diluted pesticides are handled or applied. The hazards may still be substantial, however, in the case of a single high exposure (such as when an accident occurs) or when many smaller exposures occur over an extended period.

The best way to avoid or reduce the risks of pesticide use is to understand what you are using and how to use it safely in a way that minimizes

your exposure. This means reading the label carefully and following instructions. The user's attitude is of utmost importance. If you assume that you know exactly how to use a pesticide without reading the product label or do not bother to take the precautions indicated on the label, you are more likely to experience excess exposure. Your risk may increase significantly.

Pesticide users have a legal and moral obligation to protect their own health and that of others when handling pesticides. Besides protecting yourself, you must be aware of other people, wildlife, or pets that may be in or near the treatment area and could be exposed to the pesticide during or after application. Taking adequate precautions and following good safety practices will reduce the chance of exposure from pesticide application.

In Chapter 2 (Federal Pesticide Laws and Regulations), you learned that the pesticide registration process requires manufacturers to do risk-assessment studies. These studies gauge the risk to applicators during and unprotected people after application. Using the data from these studies, the manufacturer develops product labels that provide instructions on minimizing exposure, personal protective equipment (PPE), engineering controls, symptoms of overexposure, first aid, and postapplication restricted-entry intervals (REIs). ***Be sure to read and follow all label directions.***

POTENTIAL HARMFUL EFFECTS OF PESTICIDES

Effects from chemicals, including pesticides, may be classified into two broad types: local and systemic. **Local** effects are those that occur to the area of contact with skin, eyes, or respiratory tract. Local effects are often referred to as **contact** symptoms or effects. **Systemic** effects may occur once the substance is absorbed and distributed throughout the body. They may be acute or chronic.

Local effects (or contact symptoms) are localized to the area that the pesticide actually touches. Examples are:

- Skin irritation (dermatitis) or injury:
  - ➢ Itching, redness, rashes, blisters, burns, and discoloration.
  - ➢ Many herbicides and fungicides cause dermatitis. Fumigants can cause severe blisters.
- Eye irritation or injury:
  - ➢ Swelling, stinging, and burning.
  - ➢ Herbicides, fungicides, insecticides, and fumigants may cause eye irritation or injury through contact, sometimes resulting in irreversible damage.
- Nose, mouth, or throat irritation or injury:
  - ➢ Swelling, stinging, and burning.
  - ➢ Permanent respiratory damage occurs less often.



LOCAL EFFECTS

Injury at the point of contact, including skin discoloration and irritation (dermatitis) such as itching, redness, rashes, blisters, and burns. Also, swelling, stinging, and burning of the eyes, nose, mouth, or throat are contact effects.

Systemic effects may occur once a pesticide has been absorbed and distributed throughout the body. These effects depend on the toxicological profile of the chemical itself, the amount absorbed, and the individual's ability to detoxify and eliminate the chemical. Examples are:

- Cholinesterase inhibition or neuropathies (damage to nerves).
- Impairment of the blood's clotting ability.
- Some cancers.
- Reproductive problems.
- Impaired metabolism (the body's ability to use energy).
- Hormonal effects.
- Damage to various organ systems, such as the kidneys or liver.



SYSTEMIC EFFECTS

Poisoning effects that occur at sites other than the entry point into the body.

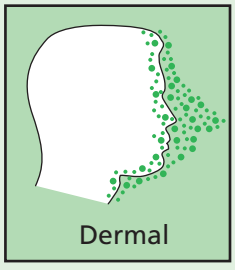
ALLERGIC EFFECTS/ ALLERGY

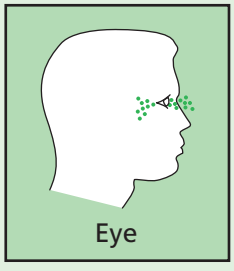
A hypersensitivity to a specific substance, often called the allergen.
An allergy may cause dermatitis, blisters, hives, and itching of the eyes.
It could also cause illness, asthma-like symptoms or life-threatening shock.
Often the entire body is affected.

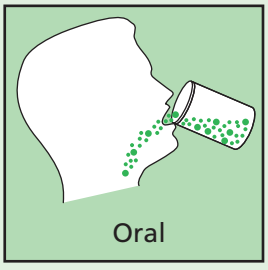
The U.S. Environmental Protection Agency (EPA) considers local and systemic effects when deciding whether to register a chemical. They are also used to set label restrictions, such as limiting the method, timing, or rate of application; to determine appropriate levels of PPE; or to establish REIs (in combination with exposure factors).

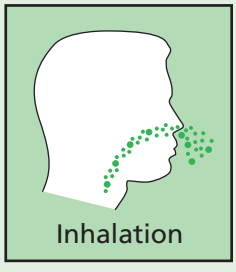
Allergic effects are harmful effects that occur in some people in reaction to certain substances. An allergy to a chemical contained in a product formulation may cause dermatitis, blisters, hives, or more serious problems, such as asthma or even life-threatening shock. Pesticide allergy symptoms are similar to other allergy symptoms: red and/or itchy eyes, respiratory discomfort, and asthma-like effects. Unfortunately, there is no way to predict which people will develop allergies to a particular product. Having an allergic reaction does not predict whether someone would also be more sensitive to other effects of the pesticide, such as chronic or delayed effects (see below). These types of effects depend on different chemical reactions within the body.

Common ways in which pesticide handlers and other workers are exposed to pesticides









Dermal exposure

- **Not wearing gloves or other protective clothing.**
- **Not washing hands after handling pesticides, product containers, or application equipment.**
- **Not washing hands before using the toilet.**
- **Splashing or spilling pesticide on skin.**
- **Being exposed to spray or dust drift.**
- **Applying pesticides in windy weather or above your head.**
- **Touching treated plants, soil, or livestock.**

Eye exposure

- **Rubbing eyes with contaminated gloves or hands.**
- **Splashing pesticide in eyes.**
- **Handling dry formulations when not wearing eye protection.**
- **Applying pesticides in windy weather.**

Oral exposure

- **Not washing hands before eating, smoking, chewing, or drinking.**
- **Splashing pesticide in mouth.**

Inhalation exposure

- **Handling pesticides in confined or poorly ventilated areas.**
- **Handling dusts or powders.**
- **Using an inadequate or poorly fitting respirator.**
- **Being exposed to spray or dust drift.**

EXPOSURE—HOW PESTICIDES ENTER THE BODY

Pesticide exposure occurs when pesticides get onto or into the body. The four primary routes of exposure are: skin (dermal), eyes (ocular), lungs (inhalation), and mouth (oral).

Skin or Dermal Route

In most cases, the skin is the main route of pesticide entry onto or into the body. Some studies show that up to 97% of all body exposure to pesticides during a spraying operation is by skin contact. Dermal absorption or contact injury may occur from airborne dust, splashes, spills, or spray mist when mixing, loading, applying, or disposing of pesticides. Skin exposure may also result from contact with pesticide residues on treated surfaces or contaminated equipment during cleaning, adjustment, or repair.

Once a pesticide contacts the body, absorption, penetration, and distribution throughout the body depend on many factors. These include the chemical properties of the pesticide product, the area of contact and its rate of absorption, and the body's own detoxification and elimination capabilities. Some products that cause systemic injury are just as toxic when absorbed through the skin as when they are swallowed.

Parts of the body differ in their ability to absorb pesticides. Warm, moist areas, such as the groin, armpits, head, neck, backs of the hands, and tops of the feet, tend to absorb more than the palms and forearms (Figure 5.1). However, palms and forearms must still be protected because they get the most exposure. Cuts, abrasions, and skin rashes can increase absorption. Remember, the rate of absorption (i.e., how quickly the pesticide can get into the body) differs depending on the area contacted, but the rate is also a function of time. The longer a pesticide (or any other chemical) remains in contact, the more will be absorbed. So, protecting your skin is still important even if the area of the body most likely to contact a pesticide has a low absorption rate.

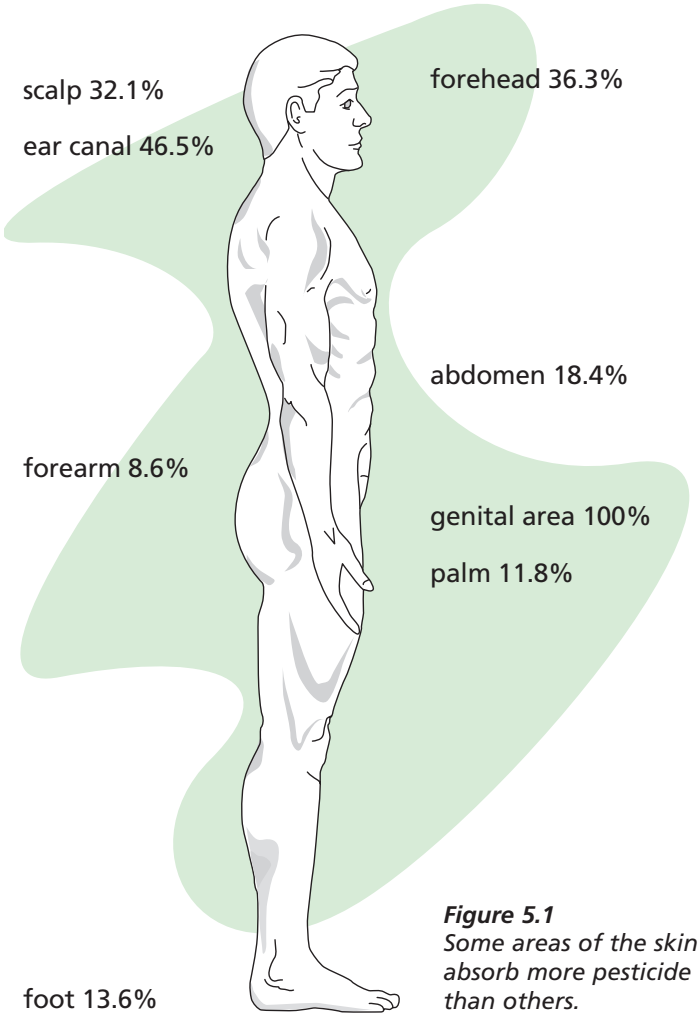


Figure 5.1
Some areas of the skin absorb more pesticide than others.

Pesticide formulations vary in how well they penetrate skin. In general, water-soluble liquids or powders, wettable powders, dusts, and granular pesticides do not easily penetrate skin. However, oil-based liquid formulations, such as emulsifiable concentrates, are readily absorbed.

Application techniques may also affect exposure levels for applicators. Making overhead applications, using blower application equipment for mists and dusts, using animal pour-ons, and dipping livestock and pets are all application methods that often have high dermal exposure levels. Additionally, contaminated hands or gloves can transfer pesticides to other body parts. Be sure to wash your hands and gloves after each pesticide-handling activity.

Eyes or Ocular Route

Eye tissues are extremely absorbent. Blood vessels are very close to the surface of the eye, so pesticides can be quickly and easily absorbed into the bloodstream. Under certain conditions when using certain pesticides, absorption through the eyes can be particularly hazardous. Eyes are very sensitive to many pesticides. For their size, they are able to absorb surprisingly large amounts of chemical. In addition to systemic concerns, some products are corrosive and can cause severe eye damage or even blindness. Significant eye exposure may result from airborne dusts or particles, splashes or spills, broken hoses, spray mists, or from rubbing the eyes with contaminated hands or clothing.

Breathing or Inhalation Route

Protecting the lungs is especially important when mixing, loading, or applying pesticides, particularly in confined areas. If inhaled in sufficient amounts, pesticides can cause contact damage to nose, throat, and lung tissue. Once breathed into the lungs, pesticides can enter the bloodstream very rapidly, eventually damaging other body organs (systemic illness). Another major concern is the aspiration (suction) of petroleum solvents (ingredients in emulsifiable concentrate formulations) and other substances into the lungs while vomiting. As the person vomits, some of the material is aspirated into the lungs, where it can cause severe damage.

Swallowing or Oral Route

When people work around pesticides, oral exposure can occur when liquid concentrates splash into the mouth during mixing and loading of pesticides or while cleaning equipment. Never use your mouth to clear a spray line or to begin siphoning a pesticide. Eating, drinking, or smoking without first washing your hands may transfer product to your mouth.

Other people are most likely to accidentally swallow pesticides when chemicals are improperly stored in the home or when transferred into an unlabeled bottle or container normally used for food or beverages. Rodent baits may also pose an accidental exposure hazard if they are not properly placed. Unfortunately, children are the most common victims of these mishaps.

Mark all pesticide measuring cups and containers. Store them in a separate area away from measuring devices used for food and beverages so they are not used for water, drink, or food. Never store pesticides in beverage or other food containers. Practice good personal hygiene and wear proper protective equipment. Preventing exposure is key to the safe use of pesticides.

PRODUCT TOXICITY AND HEALTH CONCERNS

ACUTE TOXICITY

Injury or illness produced from a single exposure. LD_{50} and LC_{50} are common measures of the degree of acute toxicity.

CHRONIC TOXICITY

The ability of small amounts of pesticide from repeated, prolonged exposure to cause injury or illness.

Historically, the toxicity of pesticides and other substances has been determined by subjecting test animals (usually rats, mice, rabbits, or dogs) to various dosages of the active ingredient and to each of its formulated products. Toxicity, measured for both short-term (acute) and long-term (chronic) exposure, is evaluated at a range of doses: those that cause no immediate effects, those that cause some immediate effects, those that cause delayed or long-term effects, and those that cause death. For some of the tests, the doses are administered only once to assess what effect(s) the pesticide may have from a single exposure. Other tests involve dosing the animals over several years to simulate exposure to small amounts throughout a lifetime. These tests can detect many different types of toxic effects ranging from subtle changes, such as weight loss or gain (which could indicate underlying problems), to specific illnesses, to death.

Today, agencies that regulate pesticides, prescription medications, over-the-counter drugs, and many other toxic substances are developing

tests that can identify and predict the same toxic endpoints as the earlier tests required. The newer methods use mathematical models and techniques without animal testing.

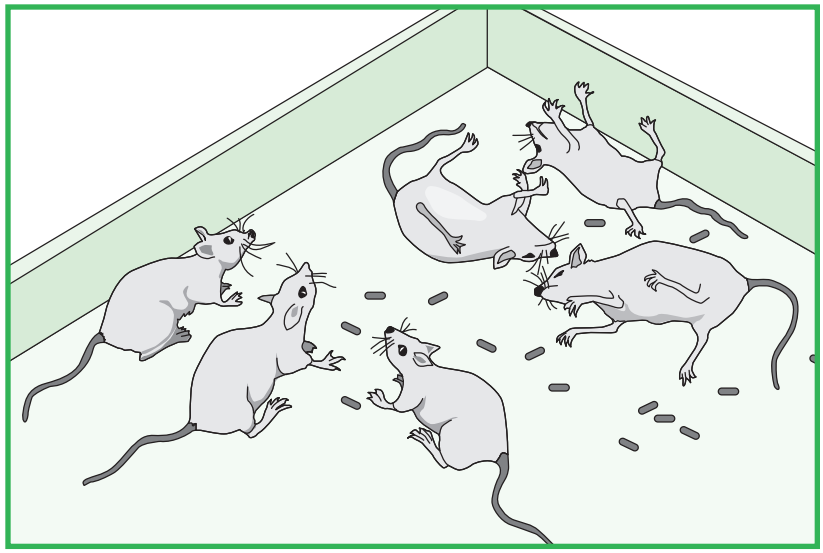
Acute Toxicity

Acute toxicity is the measure of harm (systemic or contact) caused by a single, one-time exposure event. Acute effects are determined after test animals have been exposed to a chemical through contact with their skin and eyes, through inhalation, or through ingestion. The harmful effects may be systemic or contact in nature (or a combination of both), depending on the product, formulation, dose, and route of exposure. Acute effects occur shortly after exposure, usually within 24 hours.

The following example of acute toxicity illustrates the damaging effects that can occur when people are exposed to a harmful dose of alcohol:

> *Alcohol consumption is fairly common. Each year, relatively few people die from lethal alcohol toxicity due to a single episode. Many people, however, experience varying levels of harmful effects after drinking too much, including headaches, digestive disorders, and disorientation. Symptoms from drinking alcohol depend on the dose, the exposure period, body chemistry, weight, diet and exercise, and other factors.*

Acute systemic toxicity is the measure of illness or death resulting from a change in critical body function in a test animal. The common method used for comparing acute toxicity is the **LD_{50}**, or lethal dose 50%. The LD_{50} is the dose of a toxicant required to kill 50% of the population of test animals under a standard set of conditions. For comparison purposes, LD_{50} values of pesticides are recorded in milligrams of toxicant per kilogram of body weight of the test animal (mg/kg). When the animal is exposed to material by feeding, the result is referred to as the **oral LD_{50}**. When the material is tested by skin exposure, the result is called the **dermal LD_{50}**.



LD_{50} is the amount of pesticide that kills half of the test animals.

Another commonly used measure of acute toxicity is the **LC_{50}**, or lethal concentration 50%. This is the concentration of a substance in air or water required to kill 50% of the test population. The LC_{50} is generally expressed as a ratio of the proportional amount of pesticide to a total volume of air or water. This is usually expressed in parts per million or milligrams per liter (mg/l). The LC_{50} is a common measure of lethal effects of chemicals on fish and other aquatic organisms. The LC_{50} values most directly applicable to human health are those expressing lethal concentration of chemicals in air.

The LD_{50} and LC_{50} values are useful in comparing the systemic toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD_{50} value of a pesticide, the less it takes to kill 50% of the population of test animals and the greater the toxicity of the chemical. Table 5.1 summarizes the range of LD_{50} and LC_{50} values and their relationship to the different toxicity levels.

The lower the LD_{50} value of a pesticide, the less it takes to kill 50% of the population of test animals. Therefore, the greater the toxicity of the chemical.

LD_{50} and LC_{50} values have limitations because they measure only one toxic effect—death. They do not indicate what dose may lead to other, less serious acute systemic effects or to other, possibly equally serious contact or delayed systemic effects. Also, they do not translate directly to humans because our body systems are slightly different from those of test animals. Lastly, the LD_{50} and LC_{50} are measures

Adapted from University of Illinois *General Standards* manual

Table 5.1 Toxicity Categories

Signal Word & Symbol	Toxicity Level & Class	LD_{50} Oral (mg/kg)	LD_{50} Dermal (mg/kg)	LC_{50} Inhalation (mg/l)	Contact Injury Concern	Toxicity Concern
DANGER—POISON/PELIGRO Skull & Crossbones	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2	Signal word based on oral, dermal, or inhalation toxicity.	Very low dose could kill a person (a few drops to 1 teaspoon).
DANGER/PELIGRO	Highly toxic, Hazard Class I				Corrosive—permanent or severe skin, eye, or respiratory damage.	Based on the corrosive or irritant properties of the product.
WARNING/AVISO	Moderately toxic, Hazard Class II	50 to 500	200 to 2,000	0.2 to 2	Moderate skin, eye, or respiratory damage.	Small to medium dose could cause death, illness, or skin, eye, or respiratory damage (1 teaspoon to 1 ounce).
CAUTION	Slightly toxic, Hazard Class III	500 to 5,000	2,000 to 20,000	2 to 20	Mild skin, eye, or respiratory irritation.	Medium to large dose could cause death, illness, or skin, eye, or respiratory damage (1 ounce to 1 pint or 1 pound).
CAUTION or no signal word	Hazard Class IV	Greater than 5,000	Greater than 20,000	Greater than 20	Slight concern for skin, eye, or respiratory injury.	Slight to none (over 1 pint or 1 pound).

of a single exposure, not the potential sequence of effects resulting from multiple exposures.

Some pesticides produce acute toxic effects because of their corrosive or irritant properties. These can result in respiratory, skin, or eye irritation or damage. Some can cause severe burns or permanent blindness. Chemicals with these irritant or corrosive properties require extra care and special PPE. Fungicides, herbicides, and some insecticides may cause contact injuries. Manufacturers list nonlethal systemic and contact effects in addition to the signal word. Systemic and contact acute toxicity concerns are indicated by the signal word. They are further explained in the "Precautionary Statements" portion of the product label under the "Hazards to Humans and Domestic Animals" section.

EPA and the manufacturer take into account both systemic and contact toxicity measures in assigning the signal word and toxicity category to a product. These are assigned on the basis of the greatest concern—be it oral, dermal, or inhalation systemic effects or skin, eye, or respiratory tract contact effects.

Signal Words and Skull and Crossbones Symbol

The Globally Harmonized System (GHS) for classification and labeling of chemicals is an international system for hazard communication. The goal of GHS is to help ensure more consistency in the classification and labeling of all chemicals, thereby improving and simplifying hazard communication. This improved communication system will alert the user to the presence of a hazard and the need to minimize exposure and risk. The result should be safer transportation, handling, and use of chemicals.

Under GHS, many substances—including paint, oven cleaner, dish soap, antifreeze, window cleaner, and others

—could eventually bear common signal words and pictograms. Signal words and pictograms will identify more types of hazards than the current signal words on pesticide labels. For instance, separate pictograms and/or signal words will provide information about chronic toxicity as well as acute toxicity. For the current status and implementation of GHS, go to http://www.epa.gov/oppfead1/international/globalharmon.htm.

There are four distinct signal words found on pesticide labels: DANGER—POISON, DANGER, WARNING, and CAUTION. Signal words are based on the acute toxicity of the product. Depending on their acute toxicity, pesticide products are categorized into several hazard classes. Some very low toxicity products (Hazard Class IV) are not required to have a signal word.

Danger—Poison

Pesticides classified as highly toxic (Hazard Class I) with acute oral LD_{50} values from a trace to 50 mg/kg must have the signal words DANGER and POISON (in red letters) and a skull and crossbones symbol prominently displayed on the package label. The lethal toxicity may be based on oral, dermal, or inhalation exposure, depending on which exposure route presents the greatest risk for that particular product.

PELIGRO, the Spanish word for DANGER, must also appear on the labels of highly toxic chemicals. As little as a few drops of a DANGER—POISON material taken orally could be fatal to a 150-pound person. Note that the human oral LD_{50} of paraquat, a herbicide active ingredient, is 3 to 5 mg/kg, whereas the rat oral LD_{50} is 150 mg/kg. Consult the precautionary statements that follow the signal word and symbol on the label to learn more about the product's hazard to humans. Most fumigants, some insecticides and rodenticides, and a few herbicides are assigned the DANGER—POISON signal word.



Larry Schulze, University of Nebraska

Hazard Class 1 pesticides that are highly toxic due to acute oral, dermal, or inhalation toxicity must have the signal words DANGER and POISON and the Spanish word for danger, PELIGRO, in red letters, and the skull and crossbones symbol prominently displayed on the package label.

DANGER-POISON
PELIGRO



Fatal if swallowed. May cause blindness if swallowed. May be fatal if inhaled or absorbed through eyes. Causes irreversible eye damage. Do not get in eyes, on skin, or on clothing. Do not breathe vapors or spray mist.



Larry Schulze, University of Nebraska

Hazard Class 1 pesticides that are highly toxic due to acute contact toxicity must have the word DANGER but not the word POISON or the skull and crossbones symbol.

Danger

Some highly toxic (Hazard Class I) pesticide products carry the signal word DANGER (without the word "poison" or the skull and crossbones symbol) because of their potential to cause acute contact injury. DANGER indicates the potential for permanent or severe damage to skin, eyes, or lungs. For products with this signal word, it has been determined that these contact effects are more dangerous than the acute systemic toxicity (LD_{50}) of the product. Several carry warnings of concern about the products' ability to cause irreversible eye damage at low exposures. Consult the precautionary statements that follow the signal word on the label to learn more about the products' hazard for humans. Some herbicides, insecticides, and antimicrobials carry the DANGER signal word.



Larry Schulze, University of Nebraska

Hazard Class II pesticides must have the signal word WARNING (AVISO in Spanish) on the label.

Warning

A pesticide product considered moderately toxic (Hazard Class II) must have the signal words WARNING and AVISO (Spanish) on its label. If the concern is due to systemic toxicity, the acute oral LD_{50} values range from 50 to 500 mg/kg; 1 teaspoonful to 1 ounce (2 tablespoons) of this material could be fatal to a 150-pound person. The concern could also be due to contact injury to skin, eyes, or respiratory tract. The WARNING signal word alone does not indicate whether the concern is systemic, contact, or both. Consult the precautionary statements that follow the signal word on the label to learn about the product's specific contact or systemic hazard for humans.



Larry Schulze, University of Nebraska

Hazard Class III pesticides are required to have the signal word CAUTION on the label.

Caution

Pesticide products classified as slightly toxic (Hazard Class III) are required to have the signal word CAUTION on the pesticide label. Acute toxicity may be systemic or contact in nature. If systemic, the acute oral LD_{50} values are between 500 and 5,000 mg/kg. Contact effects are generally irritation of eyes, skin, or respiratory tract. Consult the precautionary statements that follow the signal word on the label to learn about the product's contact or systemic hazard to humans.

Chronic Toxicity

The **chronic toxicity** of a pesticide is determined by subjecting test animals to long-term exposure to an active ingredient. The length of exposure is typically two years, which represents a lifetime for these test animals. The harmful effects that occur from small, repeated doses over time are termed chronic effects.

The following is an example of chronic toxicity:

> *In addition to acute toxicity of alcohol, chronic effects may also occur from alcohol exposure over long periods. Cirrhosis and other liver diseases, miscarriages, cardiovascular disease, neurological effects, and various cancers have been shown to be associated with long-term use of alcohol. As with acute effects, the illnesses and symptoms expressed in different people depend on the dose, the frequency of exposure, body chemistry, weight, diet and exercise, and other factors.*

The general range of suspected chronic effects from pesticide exposure includes genetic changes, noncancerous or cancerous tumors, reproductive effects, infertility, fetal toxicity, miscarriages, birth defects, blood disorders, nerve disorders, and hormonal or endocrine-mediated diseases. Each pesticide has its own characteristic pattern of diseases and adverse effects that it might cause. However, no single pesticide is likely to be able to cause the entire range of harmful effects listed here. Remember that the tests used to characterize each pesticide's potential for harm are conducted at different doses. This helps regulators determine levels and conditions under which each pesticide could safely be used. ***Minimizing the likelihood of chronic effects is one of the important reasons to follow all label directions and be cautious in handling and applying pesticides.***

If a product causes chronic effects in laboratory animals, the manufacturer is required to include chronic toxicity warning statements on the product label. This information is also listed on the SDS. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than the acute toxicity and cannot be expressed by a single measure. Thus, there is no chronic toxicity measure equivalent to the acute toxicity LD_{50}.

Delayed Effects

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. They may be delayed for weeks, months, or even years. Whether you experience delayed effects depends on the pesticide, the extent and route of exposure(s), and how often you were exposed. Under "Precautionary Statements," the label states any delayed effects that the pesticide might cause and how to avoid exposures leading to them. Delayed effects may be caused by either an acute or a chronic exposure to a pesticide.

FACTORS AFFECTING RESPONSE

Like all living organisms, humans have built-in mechanisms to reduce the risks of toxic substances—including pesticides—and to eliminate them from the body. The liver is the primary organ that transforms toxic substances to nontoxic or less-toxic forms.

The chemical breakdown process performed by the liver also helps make most of these substances more water-soluble. They can then be eliminated from the body in urine. The kidneys are the most important organs in filtering water-soluble pesticides and other unwanted chemicals out of the blood and into the urine. Unwanted substances that cannot be made water-soluble eventually are stored in our bodies, primarily in fatty deposits throughout the body and in breast milk. Most of the pesticides in use today are more water-soluble than those of the past (before 1970). Most are eliminated relatively quickly (hours to days instead of months to years) in urine.

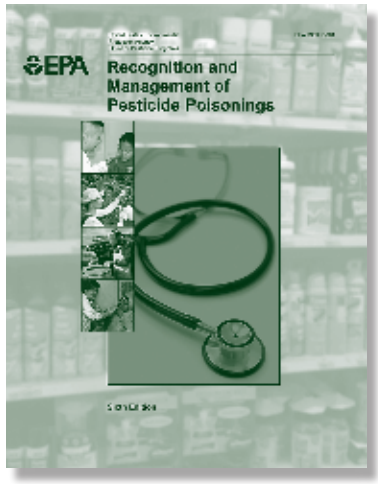
Some pesticides can cause changes, called mutations, to our DNA. DNA is the carrier of genetic information in our bodies. This information is stored as codes for all of the chemicals our bodies make to help them function properly. Some DNA mutations do not cause any effects. Others cause serious malfunctions and may lead to various types of illnesses or other problems, such as birth defects. Although our bodies constantly monitor and repair DNA mutations, over time our ability to repair the DNA decreases.

Our bodies continually manufacture the enzymes we need to help detoxify pesticides and other toxic substances. However, continual or very frequent exposures may overwhelm the body's capacity for chemical breakdown and elimination. Keeping your exposure low and having periods of nonexposure between applications of the same class of pesticide can reduce the chance that your body will be overwhelmed.

SYMPTOM RECOGNITION

Symptoms can be correlated with certain groups of pesticides. For example, borates (insecticides) tend to irritate the skin, nose, and respiratory system. Some fungicides are irritants to the skin, eyes, and mucous membranes of the respiratory system. Anticoagulant-type rodenticides affect the blood's ability to clot and may cause bloody noses and bleeding gums. Organophosphate and carbamate insecticides are cholinesterase inhibitors. They may cause certain systemic symptoms (*see sidebar*) that could lead to respiratory failure and death. Symptoms associated with synthetic pyrethroid insecticides include nausea, dizziness, weakness, nervousness, and eye and skin irritation. Chlorophenoxy herbicides, such as 2,4-D and some related products (dicamba, MCPA, and MCPP), are irritating to the skin and mucous membranes. They may also cause vomiting, headaches, diarrhea, and confusion.

Because symptoms of pesticide poisoning or exposure can vary widely, medical professionals need training



Reference material for toxicological symptoms.

to recognize this variability and treat appropriately. A manual entitled *Recognition and Management of Pesticide Poisonings* provides treatment guidelines for medical professionals. It may be obtained through the EPA Office of Pesticide Programs or from the EPA website, http://www.epa.gov/.

Cholinesterase Inhibition

Cholinesterase is an enzyme necessary for proper nerve impulse transmission and nervous system function. If the amount of this enzyme is reduced below a critical level, nerve impulses throughout the body can no longer be controlled. This may cause serious health problems, affecting the ability of certain muscles, including the heart and breathing muscles, to function properly. Without medical attention, death may result.

Two classes of insecticides, organophosphates and carbamates, act as cholinesterase inhibitors. That is, they reduce the amount of cholinesterase available for the body's use. Cholinesterase inhibition can cause acute or delayed effects. Large exposures to organophosphate or carbamate insecticides can cause immediate illness. Although smaller exposures may not cause outward symptoms, small, repeated exposures over several days or weeks may continually reduce the body's cholinesterase level. This may ultimately trigger mild, moderate, or severe symptoms of overexposure.

In the case of cholinesterase inhibition, it is not always obvious whether a worker is showing symptoms from an acute exposure or experiencing delayed effects from repeated exposures. For example, an applicator who is exposed to a single, large amount of an organophosphate may suffer acute effects. However, if over time the applicator is exposed to several small amounts, cholinesterase levels are slightly reduced at each exposure. Eventually, a small additional exposure may cause illness. In this case, the illness sets in soon after an exposure—but only following previous repeated exposures.

Common symptoms associated with organophospate and carbamate insecticide poisoning

Mild poisoning

- Fatigue
- Headache
- Dizziness
- Blurred vision
- Excessive sweating/salivation
- Nausea and vomiting
- Stomach cramps and diarrhea

Moderate poisoning

- Inability to walk
- Weakness
- Chest discomfort
- Constriction of pupils
- Mild symptoms more severe

Severe poisoning

- Unconsciousness
- Severe constriction of pupils
- Muscle twitching
- Running nose and drooling
- Breathing difficulty
- Coma and death

Cholinesterase Monitoring

Each person has a certain baseline level of cholinesterase enzyme that is considered normal for him or her. The blood cholinesterase test measures the effect of exposure to organophosphate and carbamate insecticides. A baseline must be established for each person before he or she begins working with cholinesterase inhibitors, or during the off-season. Always conduct baseline testing during the time of year when insecticides are not being used or at least 30 days from the most recent exposure. Establishing an accurate baseline value often requires that two tests be performed at least 72 hours (but not more than 14 days) apart.

If you regularly use organophosphate or carbamate insecticides, cholinesterase tests should be taken periodically and results compared with your baseline level. Also, anytime you feel ill or have mild or moderate poisoning symptoms, your medical professional should conduct a blood test to evaluate your cholinesterase level and compare it with the baseline level. The purpose of routine or emergency cholinesterase monitoring is to enable a medical professional to recognize the occurrence of excessive exposure to organophosphate and carbamate insecticides. A significant reduction in your body's cholinesterase level indicates poisoning. A medical professional normally suggests that the affected pesticide handler avoid further exposure until his or her cholinesterase level returns to normal. A drop in cholinesterase may require you to have no exposure to these chemicals for a certain period—usually three to five weeks—to allow your body time

to build new cholinesterase. Medical professionals can help to establish the frequency of this testing program, which will depend on how often you use cholinesterase-inhibiting pesticides. Occupational and environmental medicine specialists are most familiar with this type of testing program. Also, because different laboratories may use slightly different methods, the same laboratory should be used to collect and test all samples from any one individual.

FIRST AID FOR PESTICIDE POISONING

Get medical advice immediately if you or any of your fellow workers have unusual or unexplained symptoms that develop within 24 hours of a pesticide exposure. Be alert for the early symptoms of pesticide poisoning and contact (local) effects in yourself and others. Do not wait until you or someone else gets dangerously ill before calling a physician or going to a hospital. It is better to be too cautious than to act too late. To help the medical professional treat you appropriately and quickly, take the pesticide label with you. Bring either a duplicate copy or the one attached to the container (or, at a minimum, the EPA registration number of the product). To avoid contamination and exposure, do not carry pesticides in the passenger space of the vehicle.

The label is important because the medical professional needs to know the pesticide ingredients to determine the proper course of treatment. It is a good idea to print off extra copies of the label from the Internet. Place one copy in your service vehicle and one in your office in case of a medical emergency.

Keep in mind that even symptoms commonly associated with certain pesticides are not always the result of pesticide exposure. Common illnesses (e.g., the flu, heat exhaustion or heatstroke, pneumonia, asthma, respiratory or intestinal infections, and even a hangover) can cause symptoms similar to those of many frequently used pesticides. Contact with certain plants, such as poison oak or poison ivy, may also produce skin effects like those resulting from pesticide exposure. However, it is best to take every precaution. When symptoms appear after contact with pesticides, always seek medical attention immediately.

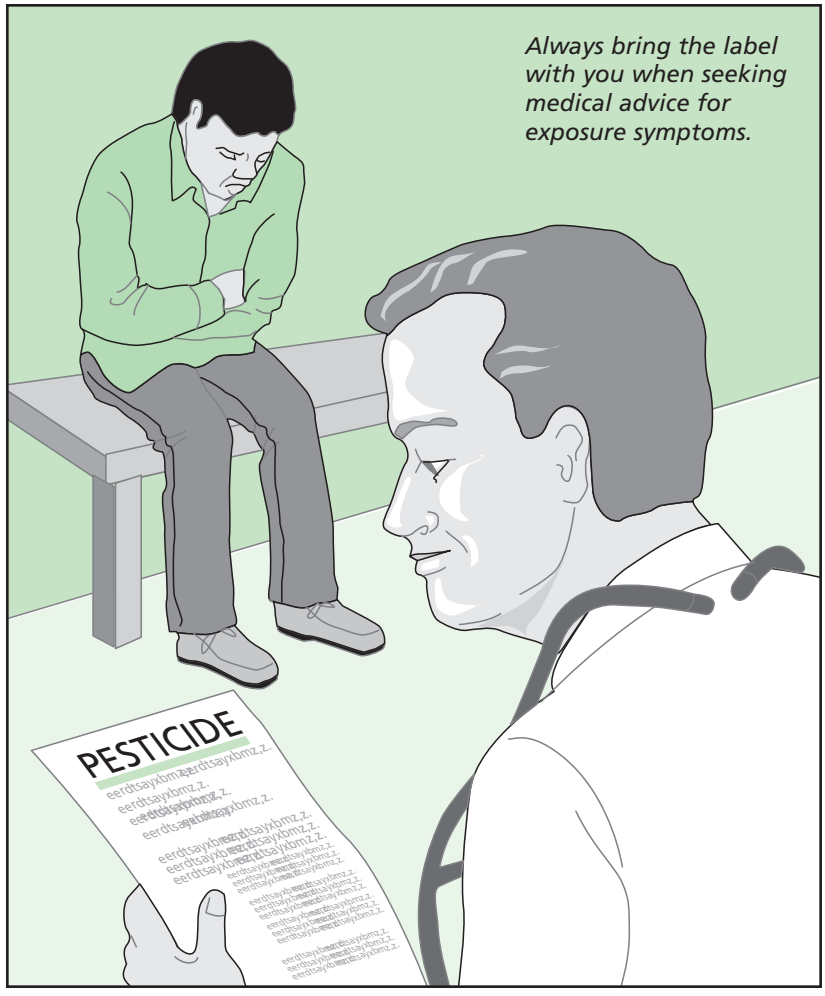
General First Aid

First aid is the initial effort to assist a victim while medical help is on the way. If you are alone with the victim, make sure he or she is breathing and is no longer being exposed to the pesticide before you call for help. Protect yourself from pesticide exposure before and while giving assistance. Make sure you wear the appropriate PPE, including a respirator if indicated, before assisting someone in an enclosed area. Administer artificial respiration if the victim is not breathing and is not vomiting.

American Association of Poison Control Centers
1-800-222-1222
(Staffed 24 hours)

Animal Poison Control Center (APCC)
1-888-426-4435

National Pesticide Information Center (NPIC)
1-800-858-7378



Always bring the label with you when seeking medical advice for exposure symptoms.

Immediate action can indeed be a life-or-death matter in a pesticide poisoning. The product label is the primary source of information. Follow the label's specific first aid instructions carefully. Beyond the label, call the American Association of Poison Control Centers (AAPCC) or a physician for additional advice. The AAPCC's poison help line (**800-222-1222**) is available 24 hours each day. First aid is only the first response and is not a substitute for professional medical help. It is very important to get the victim to a hospital, or contact 911 for emergency response, without delay. The following are a few key points to remember when administering first aid during a pesticide emergency:

- If oral or dermal exposure has occurred, the first objective is usually to rinse the exposed area with water to dilute the pesticide and prevent absorption.
- Always have a source of clean water available. In an extreme emergency, use water from a farm pond, irrigation system, or watering trough to rinse exposed areas and dilute the pesticide.
- Never try to give anything by mouth to an unconscious person.
- Do not induce vomiting unless the label tells you to.
- If inhalation exposure has occurred, get the victim to fresh air immediately.
- Become familiar with the proper techniques of artificial respiration. It may be necessary if a person's breathing has stopped or becomes impaired.
- If first responders are likely to be directly exposed to a pesticide, be sure they wear appropriate PPE.

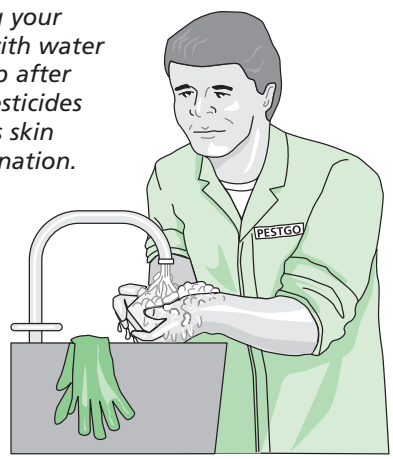
In addition to the AAPCC, you can call the National Pesticide Information Center (NPIC). NPIC provides a variety of information about pesticides to anyone in the United States by phone (800-858-7378 or online (search for "National Pesticide Information Center"). Post all emergency numbers near telephones and in service vehicles used by pesticide handlers.

Pets, horses, and other livestock may also be poisoned by exposure to pesticides. For emergency information on treating pets or livestock harmed by pesticide contamination or poisoning, call the Animal Poison Control Center (888-426-4435).

Pesticide on the Skin

Proper hygiene helps protect the skin from pesticide exposure. Keep an adequate water supply with you whenever skin exposure is possible. Other key points:

- Remove all contaminated clothing immediately.
- Wash the affected area, including the hair, with water and soap. Rinse well. Showering is better than bathing to avoid prolonged contact with pesticide residues. Avoid harsh scrubbing, which could damage the skin and enhance pesticide absorption.
- Gently dry the affected area and wrap it in loose cloth or a blanket, if necessary.
- If the skin has chemical burns, cover the area loosely with a clean, soft cloth. Do not use ointments, greases, powders, and other medications unless instructed to do so by a medical authority.



Washing your hands with water and soap after using pesticides prevents skin contamination.

Wash and store contaminated clothing separately from the family laundry. If clothing is contaminated with a pesticide concentrate or if there is concern about getting contaminated clothing clean, it is often best to dispose of it. Place the clothing in a plastic bag, seal the bag, and write the name of the pesticide on it. Take it to a household hazardous waste collection.

Pesticide in the Eyes

Because eyes readily absorb material, fast action is required. Other key points:

- Hold the eyelid open and immediately begin gently washing the eye with drips of clean water. Do not use chemicals or drugs in the wash water unless instructed to do so by a medical professional or a poison control center.
- Drip the water across—not directly into—the eye, or use an eyewash dispenser.
- Continuously rinse the eye for 15 minutes. If only one eye is affected, be careful not to contaminate the other eye.
- Flush under the eyelid with water to remove debris.
- Cover the eye with a clean piece of cloth and seek medical attention immediately.

Inhaled Pesticide

The basic first aid procedure for someone who has inhaled a pesticide is to get him or her to fresh air. Other key points:

- Immediately carry the victim to fresh air (do not allow him or her to walk).
- Do not attempt to rescue someone who is in an enclosed, contaminated area unless you are wearing appropriate PPE.
- If other people are in the area, warn them of the danger.
- Have the victim lie down and loosen his or her clothing.
- Keep the victim warm and quiet. Do not allow him or her to become chilled or overheated.
- If the victim is convulsing, protect his or her head, turn the head to the side, and watch that breathing continues. Do not attempt to insert anything into the person's mouth during a seizure.
- Keep the person's chin up to ensure that air passages are open for breathing.
- If breathing stops or is irregular, give artificial respiration.

Pesticide in the Mouth or Swallowed

If pesticide is in someone's mouth but has not been swallowed, rinse the mouth with plenty of water. Then give the victim large amounts (up to 1 quart) of milk or water to drink. If the pesticide is swallowed, one of the most critical first aid decisions is whether to induce vomiting. Induce vomiting only if the label instructs you to do so. Several pesticides cause more harm when vomited than if they remain in the stomach. To provide first aid for a swallowed pesticide, you must know the appropriate treatment. The decision to induce vomiting must be made quickly and accurately—the victim's life may depend on it.

Never induce vomiting if the victim:

- Is unconscious or having convulsions.
- Has swallowed a corrosive poison, such as a strong alkali or acid. The material burns the throat and mouth as severely coming up as it did going down. Also, it can be aspirated into the lungs and cause more damage.
- Has swallowed an emulsifiable concentrate or oil solution product, which is dissolved in petroleum solvents. Emulsifiable concentrates and oil solutions may be fatal if aspirated into the lungs during vomiting.

Note: Ipecac syrup, used as an emetic for almost 50 years, is **no longer recommended for routine use in most poisonings.** Clinical studies have demonstrated no benefit from its use. Ipecac works too slowly (about 20 minutes) in inducing vomiting and results in only about one-third of stomach contents being voided.

How to Induce Vomiting (if appropriate)

Induce vomiting only as a first aid measure until you can get the victim to a hospital. Do not waste a lot of time trying to induce vomiting. Follow these steps:

- Make sure the victim is kneeling forward or lying on his or her side to prevent vomit from entering the lungs and causing additional damage.
- Give the victim at least two glasses of water to dilute the product. Do not use carbonated beverages.
- Put your finger or the blunt end of a spoon at the back of the throat. Do not use anything sharp or pointed. Do not give the victim saltwater.
- Collect some of the vomitus for the doctor, who may need it for chemical analysis.

Activated charcoal is another first aid treatment that can be administered when a pesticide has been swallowed. It acts as a magnet to adsorb many chemicals. Pharmaceutical-grade activated charcoal is available from most drugstores. Activated charcoal prepared for cleaning up pesticide spills may be substituted in an emergency. Seek the advice of a medical professional or poison control center before administering activated charcoal. Take the victim to a physician or hospital.

Only general first aid practices have been discussed here. Contact a poison control center for more help in administering first aid. If necessary, get the victim to a medical professional or hospital. Take the pesticide label with you.

Antidotes

Antidotes are available for only a few classes of pesticides: anticoagulant-type rodenticides and organophosphate or carbamate insecticides. Because antidotes can be extremely dangerous if misused, they should be prescribed and administered only by a qualified medical professional. Antidotes should ***never*** be used to prevent poisoning.

HEAT STRESS



Avoid heat stress by taking breaks and drinking water throughout the workday.

Heat stress occurs when the body cannot cope with a certain level of heat. Heat stress may affect both pesticide handlers and other workers. A person suffering from heat stress exhibits symptoms that closely resemble poisoning symptoms of some pesticides. PPE worn during handling or early-entry activities may increase the risk of heat stress. The protective qualities of the PPE may restrict the evaporation of sweat, thus impeding the body's natural cooling system. If you are under a physician's care, consult him or her before working in hot or humid conditions. Vests and headbands with special pockets for ice packs or other heat stress prevention devices may be worn with or beneath PPE. These will help maintain a cool body temperature.

Symptoms of Heat Stress

Mild forms of heat stress make people feel ill and impair their ability to do a good job. You may feel weak and get tired sooner than usual. You may also be less alert and less able to use good judgment. Severe heat stress, also known as heatstroke, is life-threatening. The normal human body temperature ranges from about 97°F to 99°F, with an average of 98.6°F. With heatstroke, body temperature may exceed 105°F. Staggering, loss of consciousness, or convulsions may result. Lack of sweating is a common symptom of heatstroke. Brain damage or even death

may occur if the heatstroke victim is not cooled down very quickly. More than 10% of severe heat stress victims die—including young, healthy adults. Sometimes victims remain highly sensitive to heat for months and cannot return to the same type of work.

Heat stress symptoms include:

- Fatigue, exhaustion, or muscle weakness.
- Dizziness and fainting.
- Clammy or hot, dry skin.
- Altered behavior: confusion, slurred speech, quarrelsome or irrational conduct.
- Headache, nausea, and chills.
- Severe thirst and dry mouth.
- Heavy sweating: eventually, this can progress to a complete lack of sweating as the body loses the ability to control its temperature.

Act immediately to cool down if you suspect that you may be suffering from even mild heat stress. Drink plenty of water and take breaks in the shade throughout the workday. In hot conditions, watch for symptoms of heat stress in other workers as well.

SUMMARY

Pesticide risk can be summarized by the equation **hazard (risk) = toxicity x exposure.** "Toxicity" is the capacity of the pesticide to cause either short-term (acute) or long-term (chronic) injury or illness; "exposure" is the means by which the pesticide gets into or onto the body. These two factors determine the likelihood that harm (i.e., hazard) will come to a person who handles pesticides.

Harmful effects of pesticides may occur at the area of local contact or after uptake into the body (i.e., systemic effects). Pesticides can enter the body by any of four routes: through the skin (dermal), eyes (ocular), lungs (respiratory), or mouth (oral). Some adverse effects may occur within 24 hours after a single (usually large) exposure (acute effects). Others may occur many years after exposure (delayed effects), typically from small exposures over a long period (chronic effects). Pesticide handlers can minimize exposure—and reduce risk—by following label directions, using the proper application and handling procedures, and wearing appropriate personal protective equipment.

The toxicity of a pesticide product is measured in test animals by the LD_{50} and LC_{50} values. These values determine the signal word that occurs on the pesticide label. Signal words—DANGER–POISON, DANGER, WARNING, and CAUTION—help the user recognize how acutely toxic the pesticide is and what precautions to take. Remember, however, that the signal word only provides information about the acute toxicity of the product. Chronic and delayed effects are often the result of different mechanisms and are not related to the substance's level of acute toxicity.

People who use pesticides routinely should have regular medical checkups to determine if they are experiencing any ill effects from pesticide use. Regular monitoring of blood cholinesterase levels can determine if certain insecticides are affecting an individual before symptoms appear.

Early recognition of pesticide poisoning symptoms is the key to preventing further injury. The label often provides important information on first aid procedures for the particular pesticide product. Make sure a copy of the label is readily available whenever you are using pesticides. Take the label to a medical professional if a poisoning incident occurs.



Review Questions

CHAPTER 5: Pesticide Hazards and First Aid

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **The capacity of a pesticide to cause short-term (acute) or long-term (chronic) injury is referred to as its:**
   - **A.** Toxicity.
   - **B.** Exposure.
   - **C.** Hazard.

2. **Which statement about harmful effects of pesticides is *false*?**
   - **A.** The most common form of pesticide injury is by inhalation.
   - **B.** Asthma-like symptoms may be caused by allergies to pesticides.
   - **C.** Many herbicides and fungicides cause dermatitis (skin reactions).

3. **Which signal word is associated with very low oral LD_{50} values?**
   - **A.** DANGER-POISON.
   - **B.** WARNING.
   - **C.** CAUTION.

4. **Which statement about pesticide toxicity is *true*?**
   - **A.** A pesticide with an oral LD_{50} of 5 mg/kg is more toxic than a pesticide with an LD_{50} of 250 mg/kg.
   - **B.** Manufacturers are not required to include chronic toxicity warning statements on product labels.
   - **C.** The signal word on the product label indicates how likely the product is to cause both acute and chronic toxic effects.

5. **For which class(es) of pesticides might cholinesterase monitoring be appropriate?**
   - **A.** Organophosphate and carbamate insecticides.
   - **B.** Pyrethroids.
   - **C.** Phenoxy herbicides, such as 2,4-D.

6. **Which statement about what happens to pesticides inside the body is *true*?**
   - **A.** Most pesticides used today are stored in our body fat.
   - **B.** The kidneys filter pesticides from the blood into the urine.
   - **C.** Most chemical breakdown of toxic substances takes place wherever the pesticide is first absorbed.

7. **Which statement about pesticide exposure routes is *true*?**
   - **A.** Studies show that about 97% of all body exposure to pesticides during a spraying operation is by inhalation.
   - **B.** Eating, drinking, or smoking without first washing your hands after handling pesticides is likely to transfer the product to your mouth.
   - **C.** The palms and forearms absorb pesticides more quickly than the scalp, ear canal, and forehead.

8. **Which statement about first aid response for pesticide exposure to the eye is *false*?**
   - **A.** You should hold the eye open and immediately begin gently washing it.
   - **B.** You should drip water directly into the eye.
   - **C.** You should flush under the eyelid with water to remove debris.

continued ▶

9. **What is the first thing you should do to help a victim of inhalation exposure?**

   A. Get the victim to fresh air.
   B. Administer artificial respiration.
   C. Have the victim lie down and loosen clothing.

10. **Which statement about heat stress is *true*?**

   A. Wearing extra PPE prevents heat stress.
   B. Constricted pupils is a symptom of heatstroke.
   C. Lack of sweat is a symptom of heatstroke.



CHAPTER 6

PERSONAL PROTECTIVE EQUIPMENT

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Identify where on the label to find the minimum clothing and personal protective equipment (PPE) required to handle a given pesticide product.
- State the criteria to properly select skin, eye, and respiratory protection required by the pesticide label based upon your expected use and exposure.
- List three work practices each for correct use of gloves, footwear, and eyewear that minimize pesticide exposure and contamination.
- List the signs of wear and tear, damage, or other PPE failures that may expose you to pesticides.
- Explain the importance of wearing respiratory protection devices approved by the National Institute for Occupational Safety and Health.
- Tell when to replace particulate filters and chemical cartridges or canisters on your respirator.
- Distinguish between a fit test and a seal check for tight-fitting respirators.
- Describe how to clean and maintain pesticide-contaminated work clothes and PPE.
- Describe how to dispose of PPE when necessary.



PERSONAL PROTECTIVE EQUIPMENT

The pesticide label prescribes handling precautions, personal protective equipment (PPE), and other safety measures to minimize your exposure while handling pesticides. PPE comprises the clothing and devices you wear to protect your body from contact with pesticides. Wearing PPE can reduce exposure (dermal, inhalation, ocular, or oral) and thereby lower the chances of pesticide injury, illness, or poisoning. Basic protective work clothing consists of a

long-sleeved shirt, long pants, closed-toed shoes, and socks. PPE, as defined by the U.S. Environmental Protection Agency (EPA), includes coveralls, apron, gloves, footwear, headgear, eyewear, and respirators.

It is important that all pesticide applicators and handlers understand the protections and limitations of PPE. Although PPE may reduce your exposure to pesticides, it does not necessarily eliminate it. Proper PPE selection, use, and care are essential. The following are some good work practices that you should always follow when using pesticides.

GOOD WORK PRACTICES

It is important to take basic steps to reduce exposure when you handle pesticides or work in pesticide-treated areas. Remember to use common sense—no guidelines cover all situations.

Prevent oral exposure

- Never eat, drink, chew gum, use tobacco products, or handle cellphones while working with pesticides. Contaminated hands are a source of oral exposure to pesticides.

Prevent dermal exposure

- Wash your hands before using the toilet—the groin area readily absorbs pesticide.
- Wear a minimum of a long-sleeved shirt, long pants, and closed-toed shoes.
- Do not wipe contaminated gloves on your clothing—the pesticide may seep through.

Prevent ocular exposure

- Wear protective eyewear to protect from splashes, sprays, mists, fogs and aerosols.

Prevent inhalation exposure

- Avoid breathing in dusts, spray droplets, or vapors.
- Wear a respirator when needed, even if the label does not require it.

Decontaminate yourself and your PPE

- Wash your gloves with soap and water before you take them off. Remove them and wash your hands and face.
- Immediately wash off any pesticide that gets directly on you. Remove and replace damaged or contaminated clothing or PPE. Have spare clothing available. At the end of the day, wash or replace contaminated PPE.
- Shower at the end of the workday. Wash your hair and scalp and under your fingernails. Put on a complete change of clothing after you shower.
- Launder your work clothes separately from non-work and other clothes at the end of each workday.

PROTECT YOURSELF FROM PESTICIDES

A pesticide label lists the minimum PPE that an applicator, handler, and early-entry worker must wear. Wearing anything less is illegal and dangerous. All pesticide handlers (e.g., applicators, mixers and loaders, and flaggers) are responsible for following the pesticide label, including wearing PPE.

PPE requirements are typically listed under the "Precautionary Statements" section of the pesticide label. If you work in or on a farm, forest, nursery, or greenhouse, look for additional PPE requirements listed in the "Agricultural Use Requirements" box on the label. Also, always check to see

if state regulations are more restrictive than label requirements. For example, a label may allow you to wear less PPE when engineering controls (e.g., enclosed cab) are used, but the state, tribal, or territorial pesticide regulatory agency may prohibit this practice. Additionally, some states have more restrictive occupational health and safety regulations specific to pesticide applicators or to protect commercial sector workers, such as landscapers or pest management professionals. When a state, tribal, or local regulation is more restrictive than federal pesticide laws, it ***must*** be followed.

Under EPA's Worker Protection Standard (WPS; 40 CFR Part 170), agricultural employers are legally required to provide PPE that is in good working order. They also must train pesticide handlers on the use proper use and maintenance of label-required PPE.

PPE label requirements vary, depending upon the toxicity, formulation, dilution, and route of exposure of the pesticide product and activity. For example, a single label may have one set of PPE requirements for applicators and a different set for agricultural early-entry workers going into areas during the restricted-entry interval. Even very low hazard pesticides require a long-sleeved shirt, long pants, shoes, and socks.



Posted field during the restricted-entry interval.

Consider all work situations where using PPE may be hazardous. Be careful around moving equipment parts (such as a power takeoff unit) that can catch apron strings. Protective clothing can restrict evaporation of sweat, thus impeding the body's natural cooling system and causing heat-related illnesses, including heat stress (see Chapter 5, Pesticide Hazards and First Aid, for more information).

EXAMPLE PPE STATEMENTS ON A LABEL

Personal Protective Equipment

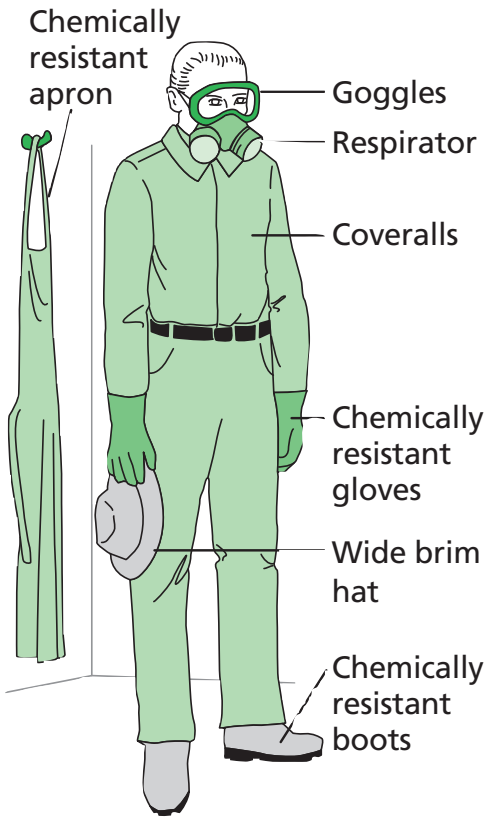
All mixers, loaders, applicators, and other handlers must wear:

- Long-sleeved shirt and long pants.
- Shoes and socks.
- Nitrile rubber, butyl rubber, barrier laminate, or Viton® gloves.
- Protective eyewear (goggles or face shield).
- Chemical-resistant apron when mixing or loading, cleaning up spills or equipment, or otherwise exposed to the concentrate.

Agricultural Use Requirements

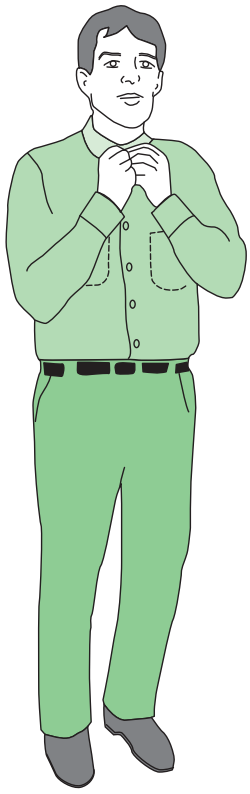
PPE required for early entry to treated areas as permitted under the Worker Protection Standard and that involves contact with anything that has been treated (such as plants, soil, or water) includes:

- Coveralls over short-sleeved shirt and short pants.
- Nitrile rubber, butyl rubber, barrier laminate, or Viton® gloves.
- Shoes plus socks.
- Protective eyewear.



Wearing appropriate types of personal protective equipment (PPE) can greatly reduce the risk of pesticide exposure.

PROTECT YOUR BODY



At a minimum wear a long-sleeved shirt, long pants, shoes, and socks when working around pesticides.

Different types of clothing, aprons, hats, boots, and gloves are not equally protective against all pesticides and under all conditions. For PPE to be protective, it must:

- Shield your skin (head, face, neck, trunk, arms, legs, and feet) from exposure throughout the pesticide-handling activity.
- Be durable and resist punctures and tears during normal use.
- Be comfortable enough without restricting your movement so you will wear it.

To protect your skin, your normal work clothing must cover most of your body. Depending on the product's toxicity and use, other PPE (such as coveralls, apron, hat, boots, and gloves) may also be required. Protective clothing, gloves, and boots must provide a barrier for the duration of the task when you are exposed to a pesticide. Labels may require waterproof gloves or boots. Additionally, chemical-resistant gloves, aprons, hats, boots, or suits are required on some labels. EPA defines "chemical resistant" as preventing any measurable amount of material from moving through (breaking through) the fabric or material. Things that can affect the extent of **breakthrough** are contact time, concentration, temperature, and the product itself. When selected correctly, protective clothing reduces the risk of dermal exposure but does not eliminate it.



Jack Kelly Clark, University of California Statewide IPM Program

A well-designed coverall makes it hard for pesticides to get through to your inner clothing or skin.

Work Clothing

Your work clothes provide a basic barrier to minimize pesticide contact with your skin. Always wear—at a minimum—a long-sleeved shirt, long pants, closed-toed shoes, and socks whenever you handle pesticides or work around pesticide residues. Select work clothes made of tightly woven fabrics to reduce pesticide penetration. Make sure they are free of holes and tears. Fasten the shirt collar completely to protect the lower part of your neck.

Do not use these work clothes for anything other than handling pesticides. Store and launder fabric work clothing separately from all other clothing after each day's use. See "Maintaining Clothing and Personal Protective Equipment" at the end of this chapter for details on cleaning and disposing of pesticide-soiled work clothes.

Good work practices—basic work clothes

- Always wear at a minimum a long-sleeved shirt and long pants.
- Make sure work clothes are sufficiently durable.
- Wash work clothes at the end of the day, separate from other clothing.

Coveralls

Some pesticide labels require coveralls (a second layer of clothing) over work clothes. According to regulations, coveralls must be loose-fitting, one- or two-piece garments that cover the entire body except head, hands, and feet. A coverall can be made of woven (like cotton or twill) or nonwoven fabrics. It should be either easy to clean and sturdy enough for laundering and repeated use or disposable. Wearing a disposable coverall reduces decontamination time and lowers the risk of contaminating yourself, your application equipment, and your vehicle. Disposable coveralls differ in their level of protection. Most importantly, wearing coveralls lessens the chance that you will take pesticides home. Handle disposable coveralls carefully so as to not contaminate other people.

Very few pesticides require a chemical-resistant coverall. If one is required, work with your PPE supplier to find a coverall that provides the necessary level of protection based on the tasks

you perform, the product formulation, and exposure.

Good work practices—coveralls

- Make sure coverall is durable and does not rip, tear, or puncture easily.
- Wash before reuse; do not wash with other laundry.
- Protect from excess heat (conditioning, hydration, and cooling) when wearing additional layers of clothing.

Apron for Mixing

Some pesticide labels require you to wear a chemical-resistant apron when mixing or loading a pesticide, or when cleaning application equipment. Select aprons that cover the front of your body from the middle of the chest to the knees.

Good work practices—apron for mixing

- Select aprons that cover the front of your body from the middle of the chest to the knees.



Jack Kelly Clark, University of California Statewide IPM Program

Choose a chemical-resistant apron that extends from your neck to at least your knees.

Headgear for Overhead Applications

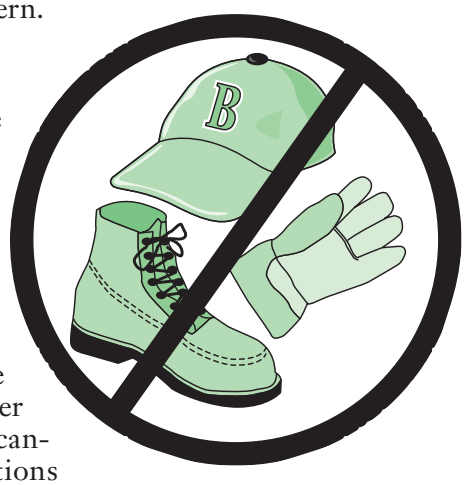
If an overhead application may result in exposure, a pesticide label may require chemical-resistant headgear. This headgear must protect against sprays so that no liquid breaks through the hat or hood. You may use either a chemical-resistant hat with a wide brim or a hood. Hoods attached to jackets or suits protect your neck and back from pesticide sprays that might otherwise run down your back. Wash headgear at the end of the day. When making overhead applications, do not use headgear made of absorbent material, such as cotton, leather, or straw.

Good work practices—headgear for overhead exposures

- Cotton ball caps absorb pesticides. Do not wear them if overhead exposure is a concern.

Footwear

Many pesticide labels require you to wear shoes and socks. Make sure the shoes have closed toes. However, some product labels require you to wear chemical-resistant footwear. A heavy-duty pair of unlined rubber boots or shoe covers provides protection from pesticides. Wash them inside and out at the end of the day. Leather and canvas absorb pesticides and cannot be decontaminated. Regulations allow you to substitute leather for chemical-resistant boots only when the chemical-resistant footwear required by the pesticide label is not durable enough for use in rough terrain. Do not use these boots for other purposes.



Clothes made of cotton, leather, or canvas are not chemically resistant, even to dry formulations.

Good work practices—footwear

- Never wear open-toed shoes or sandals when applying pesticides.
- Wear heavy-duty rubber boots that extend past your ankle and at least halfway up to your knee if you will enter or walk through treated areas before spray has dried.
- Put your pant legs outside your boots to prevent pesticides from running down your legs and becoming trapped in your footwear.
- Do not use footwear used for applying pesticides for anything else.
- Do not wear work footwear home.

FOLLOW THE LABEL CAREFULLY

Know which particular gloves are required. For most products, a waterproof glove is sufficient. However, if the label requires a specific glove type and you wear the wrong one, the glove may degrade quickly from the solvents in the formulated product.

Gloves

Pesticide handlers get by far the most exposure from pesticides on their hands and forearms. Research has shown that workers mixing pesticides received 85% of the total exposure on their hands and 13% on their forearms (see Figure 6.1). The same study showed that wearing protective gloves reduced exposure by 99%. Protective gloves are essential to dermal protection.

Pesticide labels often require waterproof gloves or one of the following glove types: nitrile rubber, butyl rubber, neoprene rubber, barrier laminate, and Viton®. Each glove type varies significantly in how well it protects from the different solvents in formulated products. For this reason, it is important to read each label to determine which glove type is appropriate. The glove type varies from product to product, even those with similar active ingredients.

The solvent in a pesticide formulation determines the protective glove type. Pesticide labels require either waterproof gloves (for solid or water-based formulations) or chemical-resistant gloves for the various solvents (e.g., alcohols, ketones, and petroleum distillates) used in different formulations. For liquid products with a solvent other than water, EPA requires the label to specify particular glove materials that provide protection. Note that labels that have not been recently updated may still refer to a solvent category (A through H) in the EPA Chemical Resistance Category Selection Chart for Gloves.

Read the label carefully to make sure you have the correct protective glove material. Explain to your supplier which glove types you need.

Some pesticide labels specify both the glove material and its thickness. As a general rule, the thicker the glove (of the same material under identical conditions), the longer the breakthrough time. A pesticide label's specification of glove type is generally based upon a thickness of 14 mils, except for polyethylene and barrier laminate gloves. Use the 14 mils thickness as a rule of thumb when selecting glove materials that appear on the pesticide label.

Glove durability is another important consideration. Select a glove that is protective, does not tear or puncture easily, and protects you for the duration

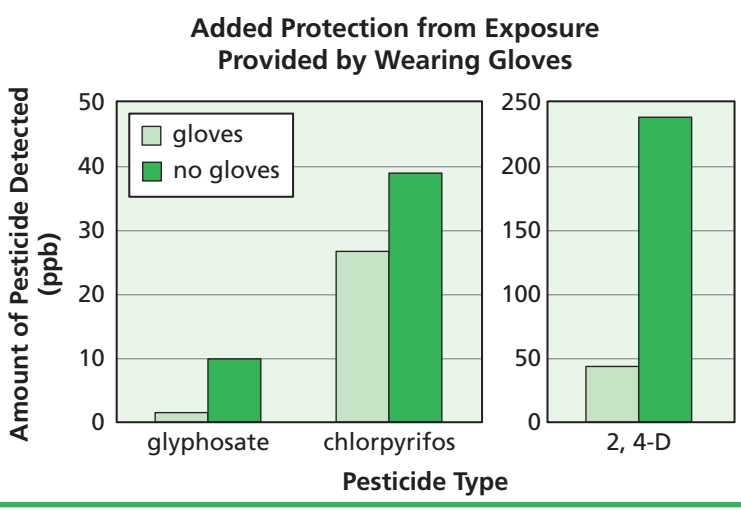


Figure 6.1
*Farmers who wore gloves while applying pesticides reduced their risk of exposure (*The Farm Family Exposure Study, *John Acquavella).*

REFERENCE CHART FOR GLOVES*

Category A	Any waterproof material
Category B	ONLY butyl rubber or barrier laminate
Category C	Butyl rubber, nitrile, neoprene, polyvinyl chloride, barrier laminate, or Viton®
Category D	ONLY butyl rubber or barrier laminate
Category E	Nitrile, neoprene, barrier laminate, or Viton®
Category F	Butyl rubber, nitrile, barrier laminate, or Viton®
Category G	ONLY barrier laminate or Viton®
Category H	ONLY barrier laminate or Viton®

**Two or more hours contact*



Nitrile and butyl rubber gloves.
Edward Crow, Maryland Department of Agriculture

of the task. Discard the gloves if there is any sign of wear or if the gloves leak.

Do not use gloves made of any kind of absorbent material, lining, or flocking, including leather or cloth (exception: cloth gloves are used with fumigants). These types of gloves absorb pesticide and trap it closely against your bare skin, greatly increasing skin absorption.

Choose a glove size that fits you comfortably. Gloves that fit well provide increased dexterity for equipment maintenance or calibration. Gloves that are too tight stretch the material, allowing pesticides to break through. Gloves that are too large can get caught in equipment. And gloves that are too loose may allow pesticides to run down the inside and be directly absorbed by your skin.

Select gloves designed to give you extra protection when needed for the job, such as elbow-length gloves when mixing and loading. Wear gloves according to how you are applying the pesticide. Do not use a glove beyond the breakthrough time.

When using reusable gloves, rinse them at each break and wash them thoroughly at the end of the workday. Absorbed pesticides will continue to permeate the material if not cleaned. Make sure your gloves are in top condition. Throw out any gloves showing wear. Check glove integrity before each use. Rinse disposable gloves before discarding them.

Good work practices—gloves

- Wear waterproof or chemical-resistant gloves when applying pesticides. Although pesticide labels do not always specifically require gloves, wearing them reduces your exposure (exception: when handling fumigants).
- Check gloves closely for holes by filling the gloves with clean water and gently squeezing. Discard them if you find any leakage.
- Wear gloves whenever you might get pesticides or residue on your hands, such as when cleaning sprayer nozzles or working around contaminated equipment or surfaces.
- Wear gloves according to the type of arm movements you make when handling pesticides (see Figure 6.2).
- Wash your gloves before taking them off between tasks.
- If pesticide is spilled, splashed, or gets inside your gloves, take them off immediately. Wash your hands and put on a clean pair of gloves.
- Replace your gloves immediately if they get cut, torn, or damaged.
- If making several applications during the day, change out gloves between jobs to avoid contaminating yourself and your vehicle.
- Rinse and slash used gloves before discarding.

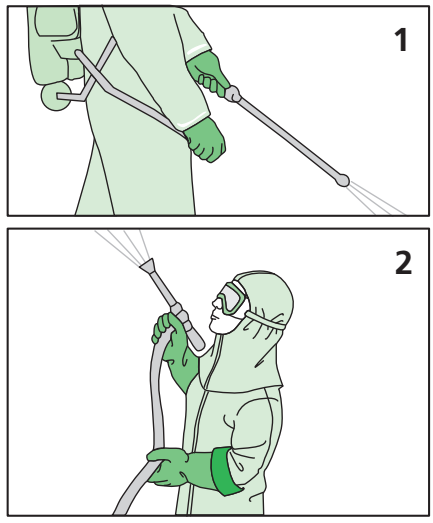
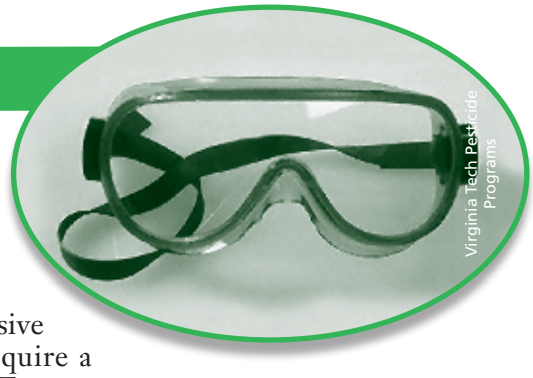


Figure 6.2
Wear gloves according to how you are applying the pesticide: (1) sleeves over gloves for jobs where your hands are mostly lowered, (2) gloves outside your sleeves with cuff folded up 1 or 2 inches when spraying above your head.

PROTECT YOUR EYES

Eyes readily absorb pesticides. When a label says to wear protective eyewear, you may use goggles; a face shield; safety glasses with shields at the front, brow, and temple; or a full-face respirator. Use common sense and select eyewear that protects you for the task at hand. Eyewear made of impact-resistant material, such as polycarbonate, can protect you from flying objects, such as granular pesticides. However, safety glasses will not protect your eyes from pesticide splashes.

Products that are corrosive to the eyes (e.g., Danger) require a particular type of eyewear. For example, goggles may be required when your eyes may be exposed to liquids or par-



Tight-fitting goggles help protect your eyes from pesticide exposure.

ticulates during a certain application or use. Wear tightly fitting goggles when you are in high-exposure situations, such as an open cab during an air-blast application; applying mists, fogs, or aerosols indoors; or in any other location where you will be enveloped in a spray, mist, or dust. Make sure goggles are splash- and spray-proof and have an air baffle system for airflow and no side vents. If fogging is a problem, use anti-fog lens treatments or purchase low-fog goggles.

If your eyewear has a headband that is made of pesticide-absorbent material, change it often or use a rubber strap. If possible, wear the strap under your hat or hood to protect it from becoming contaminated.

Protective eyewear can be worn with a half-face respirator. If you wear eyeglasses, you can buy an eyeglass insert for your full-face respirator that is fitted with your prescription. People who wear contact lenses should consult an eye doctor or their medical professional before using pesticides or wearing respirators.

Good work practices—eyewear

- Minimum eyewear is safety glasses with shields at the front, brow, and temple.
- If goggles are required, have an eyewash dispenser immediately available.
- Consult an eye doctor if you wear contact lenses.

PROTECT YOUR RESPIRATORY SYSTEM

When you use pesticides, you may be exposed to toxic gases, vapors, particulates (solids or liquids), or all of these. A respirator is a safety device that protects you from inhaling contaminated air. The pesticide label states whether you must use a respirator and if so, which type. The respirator type is based on the pesticide formulation, application method, and environment where the application is made.

The National Institute for Occupational Safety and Health (NIOSH) certifies that respirators have been tested according to certain standards. The NIOSH approval of a respirator indicates that it protects the wearer against specified contaminants. All respirator manufacturers issue approval certificates with a chart of all of the components considered part of the approved assembly. Respirator approvals are manufacturer-specific: do not interchange parts, cartridges, or filters between different manufacturers' units. These certificates are typically package inserts with new respirators, cartridges, and filters.

Find out if there are federal, state, tribal, or territorial health and safety regulations that stipulate proper respirator selection, care, and use.

TYPES OF RESPIRATORS

Atmosphere-supplying respirators

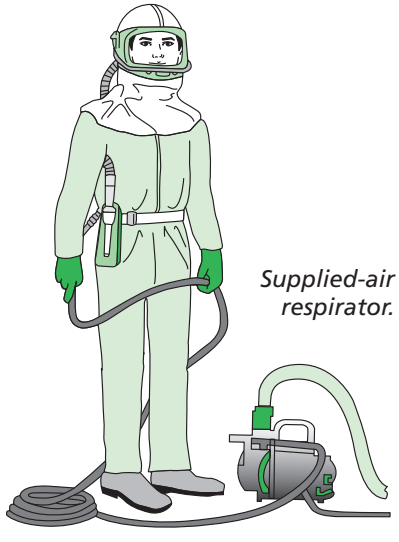
- Supplied-air respirator
- Self-contained breathing apparatus (SCBA)

Air-purifying respirators

- Non-powered particulate respirators
- Powered air-purifying respirators (PAPR)
- Chemical cartridge respirators (half facemask and full facemask)
- Gas masks with canisters



Self-contained breathing apparatus (SCBA).



Supplied-air respirator.

There are other respirators on the market that are not NIOSH-approved, such as nuisance dust masks and some surgical masks. When a respirator is required for working with pesticides, wear a NIOSH-approved device that is listed on the label.

SAMPLE PESTICIDE LABEL LANGUAGE

Wear a NIOSH-approved respirator with an organic vapor (OV) cartridge with any combination N, R, or P filter with NIOSH approval number prefix TC–84A; or a NIOSH-approved powered air-purifying respirator with OV cartridge and combination HE filter with NIOSH approval number prefix TC–23C; or a NIOSH-approved gas mask with an OV canister with NIOSH approval number prefix TC–14G.

Types of Respirators

The two classes of respirators most often required for protection from pesticide exposure are atmosphere-supplying and air-purifying respirators.

Atmosphere-supplying respirators provide clean, breathable air from an uncontaminated source. Examples are airline respirators and self-contained breathing apparatus. In very specific uses, such as using phosphide fumigants in enclosed areas, the environment may be immediately dangerous to life and health. In these cases, the only kind of atmosphere-supplying respirators that may be used are either a pressure-demand self-contained breathing apparatus (SCBA) with a full facepiece or a pressure-demand full facepiece air-line respirator with an SCBA escape bottle for emergencies.

Air-purifying respirators (APRs) remove contaminants from the air that you breathe. These respirators do not supply oxygen and should never be used in an environment that has limited oxygen or is immediately dangerous to life or health.

Air-purifying respirators may be either powered or nonpowered.

- Powered air-purifying respirators (PAPRs) use a blower to pass contaminated air through purifying elements. PAPRs are available with a tight-fitting facepiece or a loose-fitting hood.
- Nonpowered air-purifying respirators have tight-fitting facepieces that seal directly to your face. There are single-use particulate-filtering facepiece respirators and half-masks and full facepiece masks with replaceable purifying elements. Gas masks, which use canisters instead of cartridges, are one type of APR.

Purifying Elements for Air-Purifying Respirators

When selected and used appropriately, purifying elements for air-purifying respirators remove specific contaminants from the air passing through them. The pesticide label specifies which type of purifying element is required. Elements that remove particulates (e.g., dusts or sprays) are called **filters**, while vapor- and gas-removing elements are called either **chemical cartridges** or **chemical canisters**.

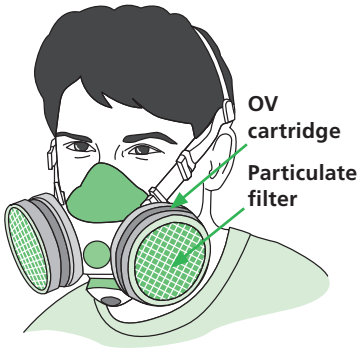
Particulate Filters

Particulate filters remove dusts, aerosols, or sprays suspended in the air that you breathe. Particulate filters DO NOT remove gases or vapors. The type of filter required on the pesticide label depends on whether the respirator is powered or nonpowered.

- **PAPR particulate filters** are rated "High Efficiency." When a PAPR with a particulate filter is required, the pesticide label will specify this by the acronym "HE."
- **Nonpowered APR particulate filters** are NIOSH-rated for three levels of oil degradation resistance (N, R, and P) and three levels of filter efficiency (95, 99, and 100). A higher efficiency rating means lower filter leakage.



Powered air-purifying respirator (PAPR) with particulate filter (TC-21C).



Half face mask chemical cartridge and particulate filter (TC-84A).



Gas mask with canister (TC-14G).

Adapted from University of Illinois *Private Applicator* manual

- N-series filters are not oil-resistant.
- R-series filters are oil-resistant for up to eight hours.
- P-series filters are oil-proof.

For a nonpowered APR, the pesticide label specifies an N, R, or P filter to be used with your respirator. N-series filters must not be used with pesticide mixes that contain oil because the filter's efficiency may become degraded with use and fail to protect you. If you add an adjuvant to a tank mix, do not use an N-series filter as the adjuvant may either contain oil or act like an oil.

The pesticide label may also specify the filter efficiency (95, 99, or 100) needed. For example, if the pesticide label specified a filter efficiency of 100 for all three oil degradation ratings, you could select an N100, R100, or P100 filter. The class of the filter (such as N95) will be clearly marked on the filter, filter package, or respirator box.

Always change particulate filters (HE, N, R, and P) for PAPR or nonpowered APR respirators whenever they are damaged, torn, soiled, or it becomes too difficult to breathe. As you use a particulate filter, pesticides load on its surface. Use caution when handling soiled filters. Once a particulate filter becomes dirty, it cannot be cleaned. To avoid spreading pesticide contamination to you or your respirator, discard particulate filters when they become soiled.

EPA regulations require that you replace particulate filters according to respirator manufacturer recommendations or pesticide labeling (whichever is more frequent). If there are no other use directions, dispose of particulate filters at the end of eight hours of cumulative use.

Chemical Cartridges or Canisters

Chemical cartridges or canisters use sorbents to remove contaminant-specific gases and vapors. They do not remove particulates! The most typical chemical cartridge or canister specified by the label for pesticide applications is an organic vapor removing (OV) cartridge or canister.

Always use the type of chemical cartridge or canister purifying element required by the pesticide label! Keep purifying elements sealed until ready to use. Although it is not a requirement, some respirator manufacturers stamp the expiration date of purifying elements on the outside of the product package. Do not use a purifying element after the expiration date, even if it was never opened. The service life of a chemical cartridge or canister depends on the type and concentration of pesticide, the user's breathing rate, and humidity.

Chemical cartridge respirators, when selected appropriately, are essentially 100% efficient until the gas or vapor breaks through. Any taste, smell, or irritation indicates that breakthrough of the pesticide has occurred. Cartridges should be changed immediately whenever you detect breakthrough in the mask. And once used, an organic vapor cartridge must be disposed of at the end of the day. The pesticide trapped by the sorbent in the cartridge may desorb very easily overnight. If you were to use the cartridge the next day, you could breathe in the desorbed pesticide vapors. Always dispose of chemical cartridges at the end of a workday unless the manufacturer directs otherwise.

GOOD WORKING PRACTICE

Make sure that the respirator protects you for the duration of use. Replace cartridges if necessary. Always dispose of chemical cartridges at the end of the workday unless the manufacturer directs otherwise and as allowed by state, tribe, or territory regulations.

Combination Chemical Cartridge and Particulate Filters

The pesticide label may direct you to use both a chemical cartridge or canister and a particulate filter. You have two options:

- A chemical cartridge or canister with a disposable N, R, or P filter using a retaining ring.

NIOSH DESIGNATIONS FOR RESPIRATORS	
TC-84A:	Filtering facepiece respirators (N, R, or P) APR with particulate filters (N, R, or P) APR with combination chemical cartridge and particulate filter (N, R, or P)
TC-21C:	Powered air-purifying respirator with particulate filter (HE)
TC-23C:	APR with chemical cartridges PAPR with chemical cartridges PAPR with combination chemical cartridge and particulate filter (HE)
TC-14G:	Gas mask with or without particulate filter (N, R, or P) Tight-fitting PAPR with gas canister with or without particulate filter (HE)
TC-13F:	Self-contained breathing apparatus Supplied-air respirator with a self-contained escape bottle
TC-19C:	Supplied-air respirator

- A single combination cartridge or canister.

The combination chemical cartridge or canister for nonpowered air-purifying respirators will include N-, R-, or P-rated filters. The combination chemical cartridges for powered air-purifying respirators will include an HE filter.

Follow the same change-out practices listed individually for particulate filters and chemical cartridges. For example, if you were using a combo chemical cartridge with a P100 filter and detected breakthrough in your mask, you would change out your cartridges immediately even though the filter was still useable.

Identifying the Respirator Type from the Pesticide Label

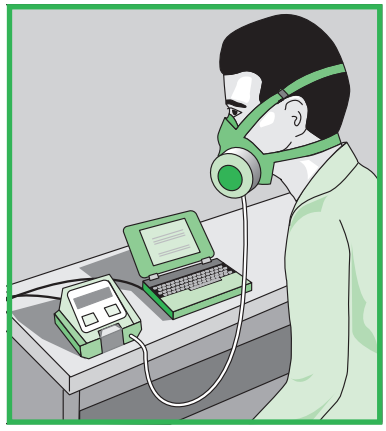
The respiratory protection required by the pesticide label is product- and task-specific. The pesticide label will typically cite respiratory protection required using a NIOSH "TC" (Testing and Certification) designation. The NIOSH designations correspond to the types of respirators that may be specified by the pesticide label and include: TC-84A, TC-21C, TC-23C, TC-14G, TC-13F, and TC-19C.

Use Tight-Fitting Respirators Properly

Before selecting and using any respirator, get a medical evaluation to make sure wearing a respirator does not endanger your health. Next, read and understand the manufacturer's instructions and NIOSH approval certificate that accompany the respirator and its components.

For full protection, conduct a fit test before wearing a tight-fitting particulate-filtering facepiece, half mask, or full-face mask. When wearing a tight-fitting respirator, nothing must interfere with the seal between the surface of the mask and your face, including beards and stubble.

- **Fit Tests**—Fit testing is a method to select the right size and type of tight-fitting respirator for your face. Perform a qualitative or quantitative fit test of a given mask type on a user's face to select the best-fitting respirator. It is important to get a fit test annually and whenever you use a different respirator facepiece. Get fit tested again whenever something physically changes that could affect the fit of



In a quantitative fit test, a particle-counting instrument is used to measure respirator fit.



Positive pressure seal check



Negative pressure seal check

Adapted from University of Illinois *Private Applicator* manual

Be sure to perform a seal check each time you use your respirator.

your respirator (e.g., facial scarring, dental work, cosmetic surgery, or a significant change in body weight). A respirator cannot protect you from pesticide exposure if it does not fit your face.

- **Qualitative fit test**—A method that uses a test agent outside the mask to check for leakage at the seal to the face. Kits for qualitative testing are available and easy to use.
- **Quantitative fit test**—A method that uses instrumentation to numerically measure leakage into the respirator.

- **User Seal Checks for Tight-Fitting Respirators**—Perform either positive or negative user seal check—preferably both—every time you put on your mask to make sure that it is properly seated on your face. This also ensures that all inhalation and exhalation valves are functioning properly.
  - **Positive-pressure user seal check**—Cover the exhalation port with the palm of your hand and lightly exhale into the mask. You will feel air escaping through any gaps in your seal. Readjust the mask until there is no leakage.
  - **Negative-pressure user seal check**—Cover or seal off the surface or hose where air is inhaled and suck in. If your mask is properly sealed, it should collapse on your face with no signs of leakage in the facepiece or hoses. If you cannot get a seal, readjust the mask until there is no leakage.

If you cannot get a proper fit with a tight-fitting respirator, you can use a PAPR with a loose-fitting helmet or hoodlike head covering that does not have to form a seal on your face. PAPRs do not need a fit test, and people with facial hair can use them.

Always consult the pesticide label for the appropriate respirator and purifying elements. If you have any questions about your respirator, consult the manufacturer or use online resources. Be sure to review the manufacturer approved labels for use limitations of the respirator. Contact your Cooperative Extension pesticide safety education program or your state, tribal, territorial, or federal safety and health agency for help in selecting the correct respirator and any of its component parts.



Jack Kelly Clark, University of California Statewide IPM Program

Wash pesticide-contaminated items separately from other laundry.

MAINTAINING CLOTHING AND PERSONAL PROTECTIVE EQUIPMENT

At the end of each workday, wash all work clothes and PPE. Some items, such as clothes and coveralls, can be washed using a washer and dryer. Other items, such as gloves, protective suits, goggles, aprons, boots, and eyewear, require hand washing. Wear protective gloves when handling contaminated items. Rinse and discard disposable items. Dispose of any nonreusable or contaminated item carefully to prevent cross-contamination or contamination of others who might handle the discarded item. Dispose of heavily contaminated items as household hazardous waste.

Woven Work Clothes and Coveralls

Launder fabric coveralls and work clothing after each day's use. Some commonsense guidelines for cleaning pesticide-soiled clothing include:

1. Outdoors, shake any dry material from cuffs and pockets and then hang garments to air them out.
2. Wash work clothes and coveralls worn when handling pesticides separately from other laundry.
3. Load only a few items into the washing machine so there is

plenty of agitation and water for dilution.

4. Use hot water and the highest water level.
5. Prerinse items by using the prewash cycle.
6. Use heavy-duty liquid detergent.
7. Run the washer on the longest wash cycle. Use two entire machine cycles for lightly or moderately contaminated items.
8. Properly handle and discard heavily contaminated clothing.
9. Line dry laundered items outdoors if possible.
10. Run one additional empty cycle without clothing, using detergent and hot water, before using the washer for your household laundry.

If using a laundry service, notify them the clothing may be contaminated with pesticides.

Never wash any garments made of absorbent materials that have been splashed or soaked with undiluted pesticide or large quantities of diluted pesticide. Remember to remove them immediately and dispose of them carefully.



Discard contaminated PPE in the appropriate container.

Nonwoven Clothing

Coveralls may be either a one-day disposable item or a reusable garment. For reusables, make sure to check the PPE manufacturer's use limitations and laundering instructions. Replace these garments regularly and at any sign of wear. If any PPE cannot be cleaned properly, dispose of it according to applicable federal, state, tribal, and local regulations. Follow manufacturers' instructions, if any, for the service life of reusable nonwoven garments. Pay close attention when reusing these items, and be ready to change them whenever you think that the inside surface may be contaminated.

If using disposable garments, render them unusable and discard. If they are heavily contaminated with high-risk pesticides, handle them appropriately and take them to a household hazardous waste facility.

Boots and Gloves

Be sure to clean boots and gloves, even if they are worn only briefly. Before taking your gloves off, wash them thoroughly. Wash both the inside and outside of boots and gloves once removed. Inspect these items and discard if there is any sign of wear or if they leak. Hang or leave to dry. Gloves are not designed to be reused over and over again. Replace them often to ensure protection of your hands. Properly cared for, boots should last multiple seasons. Sun will degrade rubber materials quickly, so store gloves and boots out of the sun.

Eyewear and Respirators

Most eyewear, respirator bodies, facepieces, and helmets are designed to be cleaned and reused. These items can last many years if they are good quality and are maintained according to the manufacturer's directions.

Respirators require more maintenance than most PPE. When you have finished using your respirator, remove and properly dispose of any expendable components, such as filters, cartridges, or canisters. Wash the facepiece according to the respirator



Jack Kelly Clark, University of California Statewide IPM Program

Clean goggles, face shields, and respirator bodies and facepieces in detergent and hot water.

manufacturer's directions. Take care to clean under and around gaskets and valves. Allow to air dry. Store cleaned respirators, as well as replacement purifying elements, in a clean, dry place that is not exposed to sunlight or extreme temperatures. Make sure that the rubber facepiece is not distorted when stored so that it maintains its shape.

Do not store any protective equipment—including respirators—with or near pesticides or other chemicals.

SUMMARY

Wearing PPE can reduce the potential for dermal, inhalation, ocular, and oral exposure, thereby lowering the chances of pesticide injury, illness, or poisoning.

Consult the pesticide label for the minimum PPE required by law. In order to appropriately select and wear PPE, you must understand both its protections and its limitations. Then determine what protective equipment you need for the pesticide task at hand. Personal protective equipment reduces your exposure to pesticides but does not necessarily eliminate it. Maximize your safety by following certain good work practices when using pesticides.

Personal hygiene is critical. Wash your hands every time you remove your gloves. Shower at the end of the day.

Contact your Cooperative Extension pesticide safety education program for assistance in the selection, use, and maintenance of PPE for handling pesticides. Check the "Agricultural Use Requirements" box on the label and the WPS requirements for any other statements about PPE use in farms, forests, nurseries, or greenhouses.



Review Questions

CHAPTER 6: Personal Protective Equipment

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Which statement about PPE requirements listed on the pesticide label is *true*?**
   - **A.** A label may have different PPE requirements for pesticide handlers and early-entry workers.
   - **B.** You are not required to wear all the PPE listed on the label.
   - **C.** Wearing the PPE listed on the label eliminates your exposure to pesticides.

2. **Which part of the product formulation determines what glove type is needed?**
   - **A.** Active ingredient.
   - **B.** Surfactants.
   - **C.** Solvents.

3. **If there are no manufacturer use recommendations, a pesticide applicator should replace the chemical cartridges of his or her respirator:**
   - **A.** At the end of each season.
   - **B.** After one week of use.
   - **C.** At the end of each workday.

4. **When oil may be present, which particulate filter must be used?**
   - **A.** N-series.
   - **B.** P-series.
   - **C.** Dust mask.

5. **Air-purifying respirators protect applicators from pesticide exposure by:**
   - **A.** Filtering and/or absorbing the pesticide.
   - **B.** Breaking down the pesticide.
   - **C.** Neutralizing the pesticide.

6. **You should do a qualitative fit test of your respirator:**
   - **A.** Every five years.
   - **B.** Semiannually.
   - **C.** If you have a significant change in weight.

7. **Every time you wear any tight-fitting respirator to apply pesticides, you should *first*:**
   - **A.** Perform seal check(s).
   - **B.** Do a qualitative fit test.
   - **C.** Put Vaseline® on the edges of the respirator to enhance the seal.

8. **Which statement about washing work clothes soaked with a pesticide concentrate is *true*?**
   - **A.** Use cold water and one wash cycle.
   - **B.** Wash separately from other laundry items.
   - **C.** Do not attempt to wash it—dispose of it immediately.

9. **Work clothes worn to apply pesticides should be laundered with a suitable detergent:**
   - **A.** After each day's use.
   - **B.** After they get wet with spray.
   - **C.** When they have a strong odor like the pesticide.

CHAPTER 7

PESTICIDES IN THE ENVIRONMENT



LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Describe how pesticide applications can affect the environment.
- Explain how to prevent pesticide drift, runoff, and movement to nontarget areas.
- Identify sensitive areas that could be harmed by pesticides.
- Discuss how to prevent pesticide residue accumulation associated with mixing, loading, and equipment washing.
- State when to adjust or delay an application to minimize environmental impact and maximize effectiveness.

Applicators and the public share concerns about how pesticides may harm the environment. Initially, hazards to humans were the primary reason the U.S. Environmental Protection Agency (EPA) decided to classify a pesticide as a restricted-use product. Now, more and more pesticide labels list environmental effects (such as contamination of groundwater or toxicity to birds or aquatic organisms) as reasons for restriction. To register new pesticides, EPA requires manufacturers to submit extensive environmental tests. The agency also reviews environmental effects when reevaluating existing pesticide registrations.

THE ENVIRONMENT

The environment comprises everything that is around us. It includes not only the natural elements that the word "environment" usually brings to mind but also people, the manufactured parts of our world, and the indoor areas in which we live and work.

The environment is air, soil, water, plants, animals, houses, restaurants, office buildings, factories, and all that they contain. Anyone who uses a pesticide—indoors or outdoors, in a city or on a farm—must consider how that pesticide affects the environment. Applicators must ask three questions:

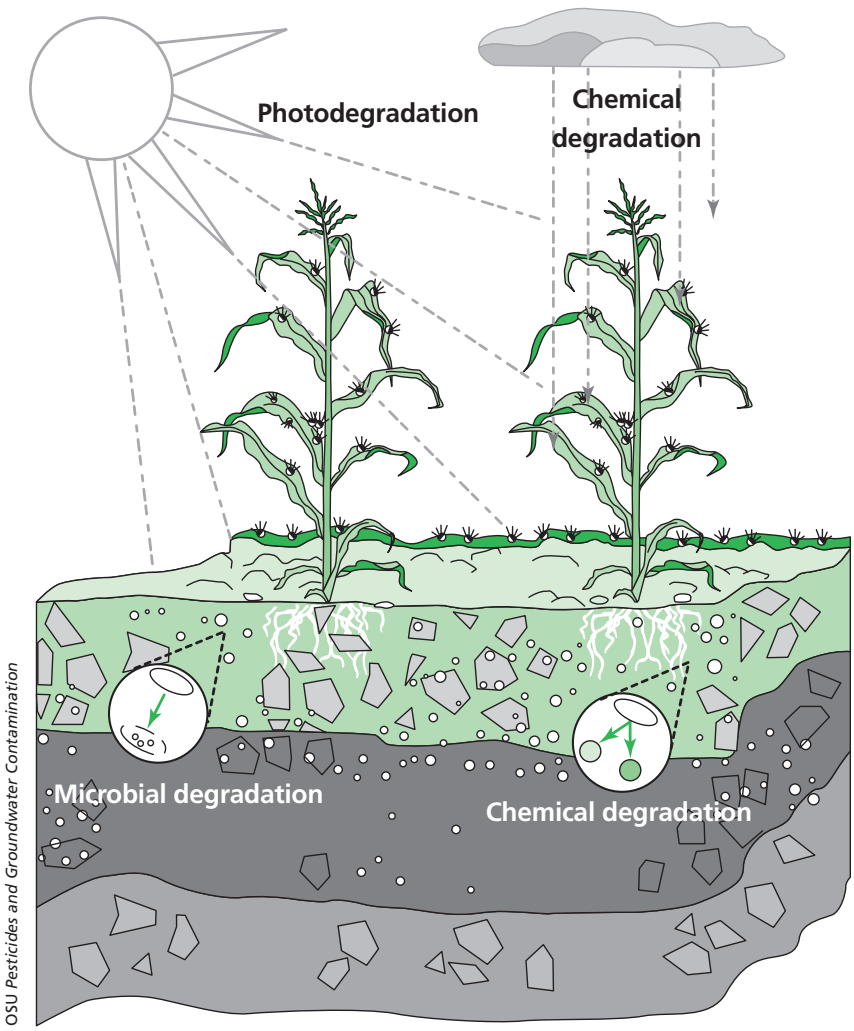
- Where will the pesticide go after it leaves its container or application equipment?
- What effects could this pesticide have on those nontarget sites it may reach?
- What can I do to minimize harmful effects?

PESTICIDE CHARACTERISTICS

To understand how pesticides move in the environment, you must first understand certain physical and chemical characteristics of pesticides and how they determine a pesticide's interaction with the environment. These characteristics are solubility, adsorption, persistence, and volatility.

Solubility

Solubility is a measure of the ability of a pesticide to dissolve in a solvent, usually water. Pesticides that are highly soluble in water dissolve easily. These products are more likely than less-soluble pesticides to move with water in surface runoff or through the soil.



OSU Pesticides and Groundwater Contamination

Figure 7.1
Breakdown of pesticides in the environment.

Adsorption

Adsorption is the process whereby a pesticide binds to soil particles. Adsorption occurs because of an attraction between the chemical and soil particles. Typically, oil-soluble pesticides are more attracted than water-soluble pesticides to clay particles and organic matter in soil. Also, pesticide molecules with a positive charge are tightly adsorbed to negatively charged soil particles. A pesticide that adsorbs to soil particles is less likely than one that does not adsorb tightly to soil to move from the spray site.

Persistence

Persistence is the ability of a pesticide to remain present and active in its original form for an extended period before breaking down. A chemical's persistence is described in terms of its "half-life": a comparative measure of the time needed for the chemical to break down (degrade). The longer the half-life, the more persistent the pesticide. The pesticide that remains in the environment after an application or spill is called **residue**. Sometimes residue is desirable because it provides long-term pest control and reduces the need for repeated applications. However, some persistent pesticides can harm sensitive plants or animals, including humans. Therefore, it is especially important to prevent persistent pesticides from moving offsite through improper handling, application, drift, leaching, or runoff.

Besides presenting a hazard to persons and nontarget animals entering a treated area, the application of persistent pesticides may produce illegal residues on rotational food or feed crops. To protect consumers, there are legal limits on how much residue may remain on products sold for food or feed. Check the label for statements about the persistence of the pesticide and for replanting restrictions. The rate of pesticide breakdown relates to the persistence of the pesticide.

Pesticide Breakdown

Several processes break down pesticide compounds into simpler and often less toxic chemicals. Some pesticides break down very rapidly—in a matter of days or even hours. Others linger in the environment for a year or more.

Pesticides are broken down or degraded by the following processes (Figure 7.1):

- **Chemical degradation**—the breakdown of chemicals that do not involve living organisms, usually by a chemical reaction with water.
- **Microbial action**—the breakdown of chemicals by soil microorganisms, such as fungi or bacteria.
- **Photodegradation**—the breakdown of chemicals in reaction to sunlight.

Water and temperature both affect the breakdown of pesticides. Warm, wet conditions can increase the speed of pesticide breakdown; cool, dry conditions slow down the degradation process.

Volatility

Volatility is the tendency of a pesticide to turn into a gas or vapor. Some pesticides are more volatile than others. The chance of volatilization increases as temperatures and wind increase. Volatility is also more likely under conditions of low relative humidity because evaporation increases in drier conditions.

HOW PESTICIDES MOVE IN THE ENVIRONMENT

Pesticides may move from the targeted application site in several ways: in air, in water, attached to soil particles, and on or in objects (see Figure 7.2).

Movement in Air

Pesticide movement away from the application site by wind or air currents is called **drift**. People who mix, load, and apply pesticides outdoors are usually aware of how easily pesticides may drift offsite. Those who handle pesticides indoors may not realize how readily some pesticides move offsite in the air currents created by ventilation systems and by forced-air heating and cooling systems. Pesticides may travel offsite as spray droplets, vapors, dusts or solid particles, and even on blowing soil particles.

Movement in Water

Most pesticide movement in water is either by surface movement off the treated site (**runoff**) or by downward movement through the soil (**leaching**). Runoff and leaching may occur when:

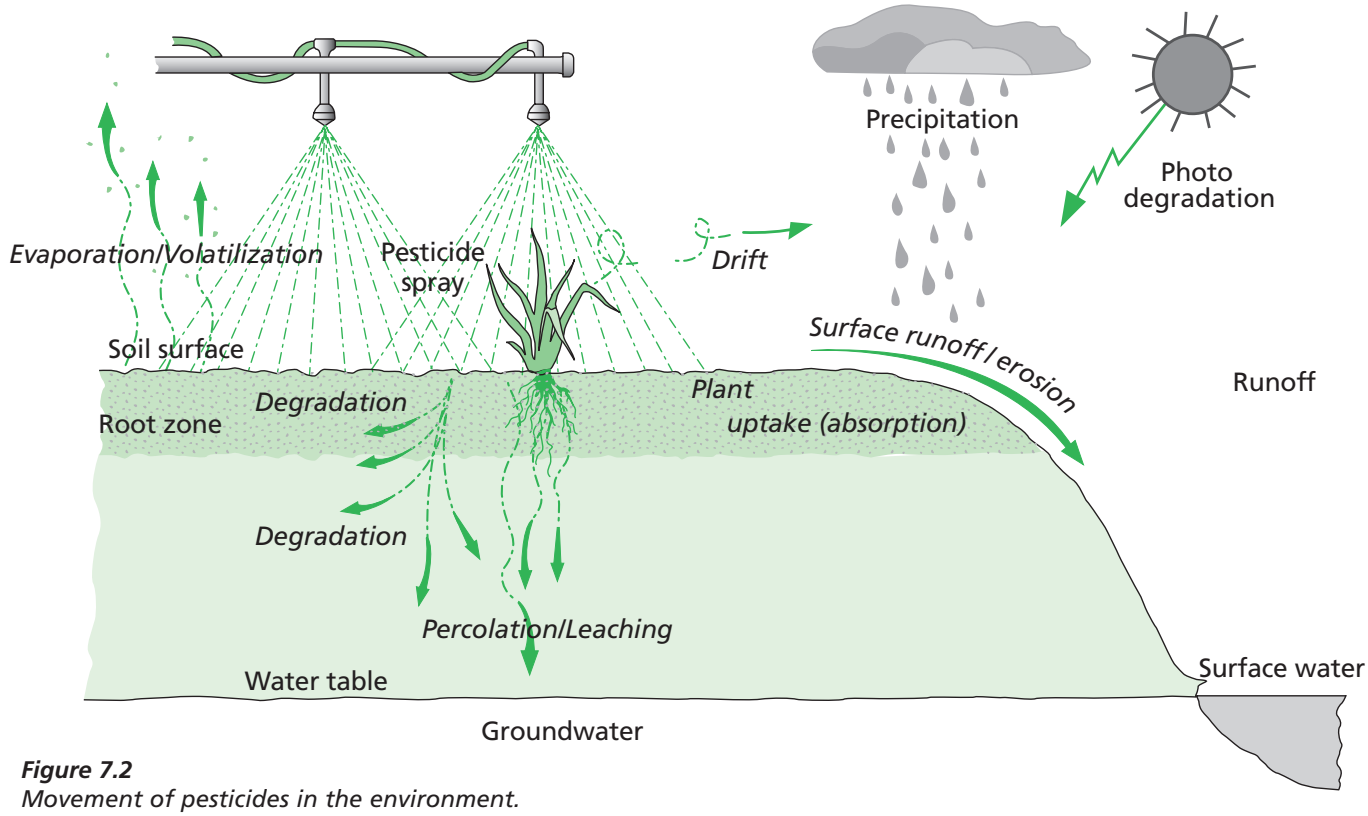
- Too much pesticide is applied or spilled onto a surface.
- Too much rainwater or irrigation water moves pesticide through the soil offsite or into groundwater.
- Highly water-soluble or persistent pesticides are used.

Runoff water in an outdoor environment may move into drainage systems, streams, ponds, or other surface water, where the pesticides can travel great distances. Pesticides that leach downward through the soil may reach groundwater.

In an indoor environment, water containing pesticides can flow into floor drains and contaminate water systems. A careless act, such as dumping a pesticide or rinsate down a sink or toilet, may contaminate an entire sewage or water-treatment facility.

Some pesticides can leach indoors. In a greenhouse, for example, pesticides may leach through the soil or other planting medium and contaminate other greenhouse surfaces.

Look for special instructions on the label that warn of pesticide hazards caused by the movement of pesticides in water. Sometimes labels require buffers or setbacks from water and wells.



Adapted from University of Illinois *General Standards* manual

Figure 7.2
Movement of pesticides in the environment.

Movement on or in Objects, Plants, or Animals

Pesticides can also move away from the application site when they are on or in objects or organisms that move (or are moved) offsite. When pesticide handlers bring or wear home contaminated personal protective equipment, work clothing, or other items, pesticide residues may rub off on carpeting, furniture, and laundry items and onto pets and people.

PREVENTING PESTICIDE DRIFT

Studies have shown that a sizable percentage of pesticides may never reach the intended target site because of drift. Significant drift can damage or contaminate sensitive crops, poison bees, pose health risks to humans and animals, and contaminate soil and water in adjacent areas. It is impossible to eliminate drift, but it is possible to reduce it to a tolerable level.

Spray Drift

Spray drift refers to the off-target movement of a pesticide during a liquid application. This is the result of small spray droplets traveling offsite on air currents. Spray drift occurs more frequently than vapor drift or particle (dust) drift.

You can avoid most spray drift problems by paying close attention to *spray droplet size*, *wind direction*, and *wind speed*. Large spray droplets are less likely to drift than smaller ones. Selecting the proper nozzle and pressure is important to reduce drift. High pressure and nozzles with smaller orifices (openings) produce small droplets likely to drift. Conversely, large nozzle orifices and low pressures produce larger droplets.

Classification of Droplet Size

Nozzles produce a range of droplet sizes, known as the droplet size spectrum. Regardless of the type of nozzle used, a percentage of droplets created by a nozzle will be small enough to drift. Modern nozzle designs are

excellent options because they reduce the amount of droplets prone to drift during an application.

A droplet size classification system can help describe the droplet sizes produced by a nozzle. This standard (S-572.1—Spray Nozzle Classification by Droplet Size), established by the American Society of Agricultural and Biological Engineers, classifies nozzles into eight categories (see Table 7.1). Using these categories, you can select a nozzle, orifice size, and operating pressure that produce a label-recommended droplet size spectrum. Consult the label for the droplet size specifications that may be in place for a particular application.

Other Factors

The thickness of the liquid also affects droplet size. As the thickness increases, so does droplet size, thus reducing the chance of off-target movement. Fine spray droplets may begin to evaporate before reaching their target. These droplets become very small and light and may move offsite. Modern drift control additives will decrease drift potential without dramatically shifting the droplets to a larger size. Remember, however, to always follow the label directions about using a spray adjuvant intended to minimize drift. Some drift control additives may actually increase the drift potential of an applied tank mix. Also be aware that large spray droplets may reduce coverage, resulting in less pest control.

Wind speed and direction are the most important environmental factors influencing spray drift. Labels may indicate maximum and minimum wind speeds for application. Except in the case of temperature inversions (see below), the early morning and evening are often the best times to apply pesticides. This is because windy conditions are more likely to occur around midday, when the temperature near the ground increases. This causes hot air to rise quickly and mix rapidly with the cooler

Table 7.1
Spray Droplet Spectrum Categories.

ASABE STANDARD S-572.1[a] SPRAY DROPLET SPECTRUM CATEGORIES		
Category[b]	Symbol	Color Code[c]
Extra Fine	(XF)	Purple
Very Fine	(VF)	Red
Fine	(F)	Orange
Medium	(M)	Yellow
Coarse	(C)	Blue
Very Coarse	(VC)	Green
Extra Course	(XC)	White
Ultra Coarse	(UC)	Black

[a] Revised 2009. This standard defines droplet spectrum categories for the classification of spray nozzles relative to the specified reference fan nozzle. The purpose of classification is to provide the nozzle user with droplet size information primarily to indicate off-site spray drift potential and secondarily for application efficacy.

[b] Please refer to product label for specific guidelines on a droplet spectrum category required for a given application scenario.

[c] Nozzle manufacturers will provide information necessary to place their nozzle types into a droplet spectrum category based at least on orifice size and pressure. The color code is also standard.

air above it, favoring drift. The best time to spray is when spray droplets move slowly upward in the absence of windy or inversion conditions.

Low relative humidity and/or high temperatures also can increase the potential for spray drift. Under these conditions, the evaporation rate of water increases, resulting in smaller spray droplets that drift more easily. Avoid spraying during these times.

The height at which the pesticide is released above the ground or target may also affect drift. Applications that use large droplets close to the ground often produce little drift. Aerial spraying and tall tree spraying, on the other hand, are more likely to produce spray drift because they intersect large distances of air far from the ground. Drift from boom sprayers can be reduced by lowering the boom height to within 20 to 24 inches of the target crop.

Decrease outdoor drift by:

- Spraying when the wind speed is between 3 and 10 miles per hour.
- Spraying downwind from sensitive areas, such as residential properties, schools, crops, waterways, or beehives.
- Using proper nozzles and pressures.
- Using drift control additives (if appropriate).
- Lowering boom height.
- Leaving an untreated border or buffer area in the downwind target area.

To reduce drift indoors, pest control operators must consider the air circulation patterns inside buildings. Turn fans and air conditioners off and close vents where necessary to prevent pesticides from drifting to other parts of the building. Use low-volatile or nonvolatile pesticides and low-pressure treatments to reduce indoor pesticide drift.

Temperature Inversions

Applications made under low-wind conditions can sometimes produce more extensive drift than under high winds. Drift that occurs over long distances (more than a mile) is most often the result of applications made during a **temperature inversion** (under stable atmospheric conditions).

A temperature inversion exists when the air at ground level is cooler than the air above it. Under these conditions, the air is considered stable because there is little or no vertical air movement. Almost all air movement during an inversion is sideways (lateral). This causes a high concentration of small spray droplets to be suspended in this layer of cool air near the ground. These droplets can then be carried long distances, especially if wind speeds increase. When the spray droplets settle out, they may still be concentrated enough to cause damage or harm.

Inversions may occur at any time of the day and at any height above the ground. However, they most often develop during the early evening hours as the ground temperature begins to cool and the warm air has already risen.

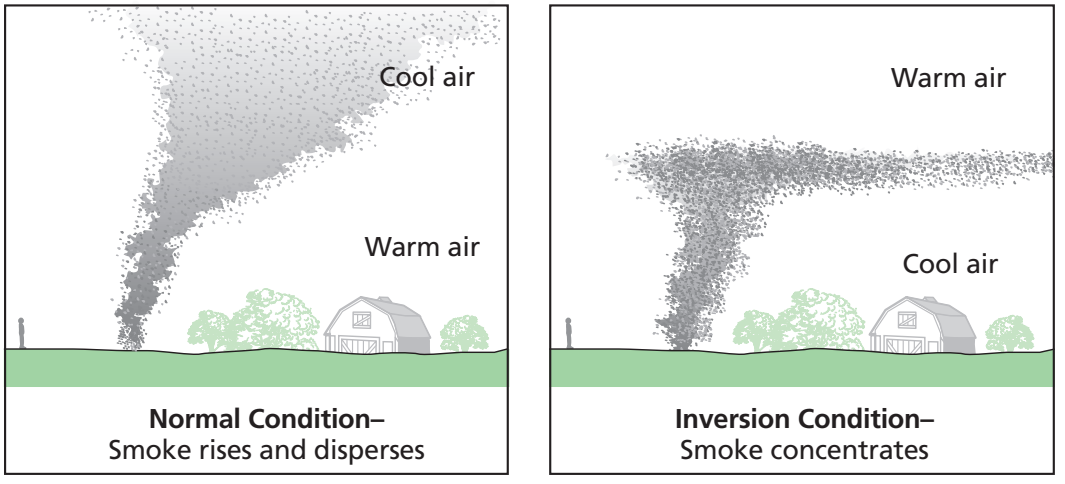


Figure 7.3 *Dispersion of smoke particles under normal and inversion conditions.*

Inversion conditions intensify during the night and may persist until mid-morning, when the ground has warmed enough to start the vertical mixing of air (i.e., the wind starts to blow). This causes a dilution and separation of suspended spray droplets. Consequently, applications made during early evening, night, or morning hours under seemingly ideal conditions may result in highly damaging drift that can move long distances. This is especially true if the humidity is high. Such movement could occur up to one to three hours after the application.

You can recognize these stable air conditions (inversions) by observing the movement of dust or smoke. If dust or smoke rises little from its source and tends to hang in the air, an inversion may be present or developing (see Figure 7.3). Another way to detecting inversions is to place one thermometer at ground level and a second thermometer high above the ground. Then compare the difference in temperature. If the temperature at ground level is below that found at the elevated thermometer, a temperature inversion exists. Do not apply pesticides under such conditions.

Vapor Drift

Vapor drift refers to the movement of pesticides as gaseous vapors from the target area. Some pesticides are volatile: they change readily from a solid or liquid form into a gas under the right conditions. This usually occurs in hot weather. Pesticides that have volatilized into a vapor or gas may drift farther and for a longer time than they would have as spray droplets. Only those pesticides that are able to volatilize are susceptible to vapor drift. As air temperatures increase, the likelihood that these pesticides will volatilize and drift also increases.

Whenever possible, choose a pesticide formulated as a low-volatility product. Do not apply volatile pesticides on hot days. Some products may even volatilize several hours after application, so beware if high temperatures are predicted for later in the day (Figure 7.4). Many product labels advise against applying these products when temperatures are at or above 85°F. Remember to check label precautions for product-specific concerns about vapor drift.

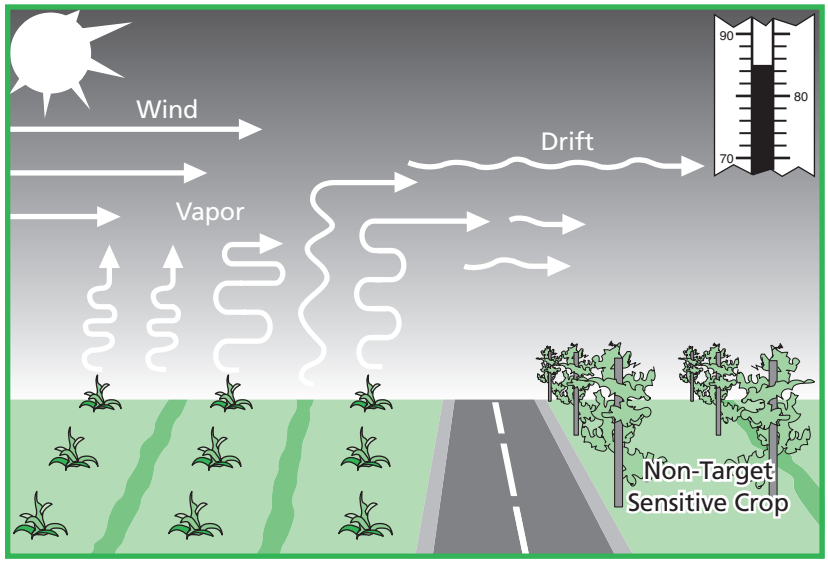


Figure 7.4
Vapor drift of pesticides is more likely as heat and wind increase and the relative humidity decreases.

Particle Drift (Dust Drift)

Particle drift refers to the movement of solid particles from the target area in the air during or just after an application. These solid particles may include pesticides formulated as dust or soil particles to which pesticides are attached. Some pesticides can remain active on soil particles long after they are applied. If particles are blown off the target site, sensitive areas may be contaminated or damaged. To prevent particle drift from outdoor pesticide applications from entering nearby buildings, be sure to close all windows and vents. Turn off all circulating fans, forced-air heating systems, and air-conditioning units.

For indoor pesticide applications, reduce particle drift by turning off fans, forced-air heating systems, and other air-circulating equipment. Check pesticide labels for statements related to these concerns.

Applicator Responsibility

As an applicator, you are legally responsible for any damages resulting from the off-target movement of pesticides. Assess the vulnerability of neighboring properties and those areas downwind of the application site. Evaluate weather conditions for tem-

perature inversions, wind direction, and wind speed before making the all-important decision about whether to spray. You may have to adjust your application equipment to reduce spray drift. Consider using low-volatile formulations or adding a drift control agent or thickener to help minimize drift. (For further discussion on equipment designed to minimize drift, see Chapter 11, Pesticide Application Procedures.) A good drift management program includes a combination of all drift reducing techniques available for a particular application.

If you apply pesticides indoors, you are also responsible for preventing drift. Ensure that:

- Pesticides do not move beyond the target site.
- All people and animals are kept out of the treatment area according to label instructions.



University of California Statewide IPM Porgram

Particle drift in a field.

SOURCES OF WATER CONTAMINATION

Surface water or groundwater contamination results from either **point-source** or **nonpoint-source** pollution (see Figure 7.5). Nonpoint-source pollution from pesticide applications is usually blamed for pesticide contamination of the outdoor environment. However, studies show that water contamination may also result from point-source pollution.

Point-source pollution comes from a specific, identifiable location, such as:

- A pesticide spill entering a storm sewer.
- Back-siphoning of pesticides into water supplies.
- Contaminated surface water entering sinkholes.
- Repeated spilling of pesticides at mixing and loading sites.
- Careless spilling of wash water at equipment cleanup sites.
- Improper handling of spills and leaks at storage sites.
- Improper disposal of containers, rinsate from containers, and excess pesticides.

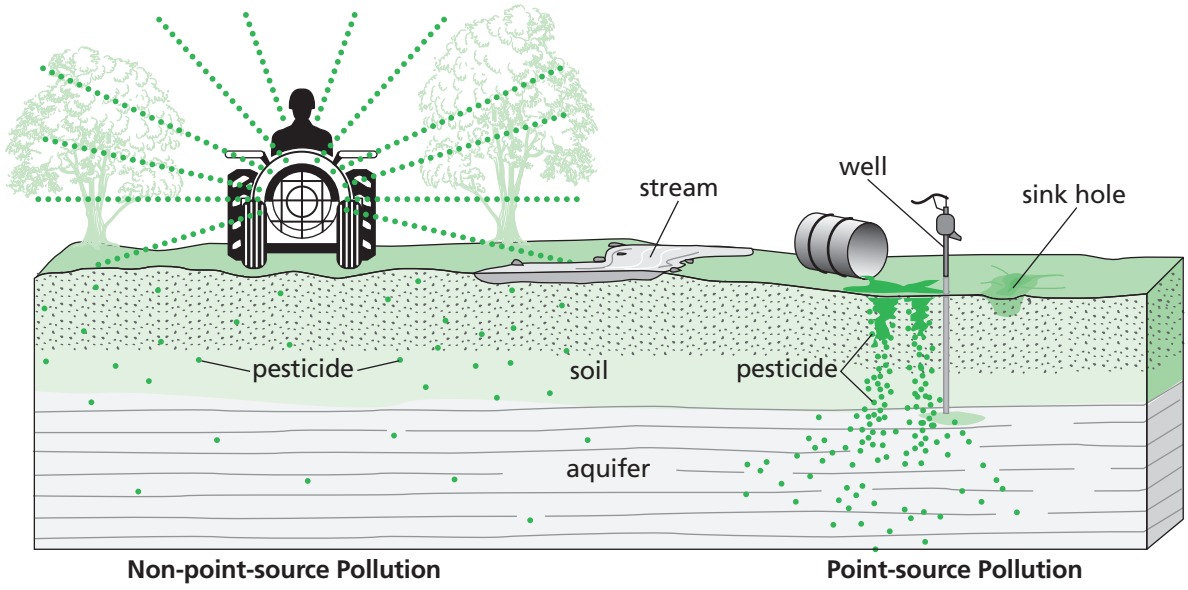
Nonpoint-source pollution comes from a widespread area. An example is the movement of pesticides into streams or groundwater after broadcast applications to large agricultural fields, rights-of-way, or turf areas.

Pesticide Contamination of Surface Water

Surface water is often a source of drinking water. Therefore, pesticide contamination of surface water (such as ditches, streams, rivers, ponds, and lakes) is a health concern. Pesticides that move in runoff water or with eroded sediment may contaminate plants and animals located downslope and reach sources of surface water.

Factors affecting runoff and erosion rates include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. These factors influence how much water runs off and how much moves into the soil (infiltration). In urban areas, runoff may occur on hard surfaces when granules are left on sidewalks and streets.

Runoff is a potential problem for most outdoor application sites. In areas



Adapted from U. of C. *The Safe and Effective Use of Pesticides*

Figure 7.5
Non-point-source pollution comes from a widespread area, while point-source pollution comes from a specific, identifiable location.

treated with any type of pesticide, it is critical that runoff does not carry the pesticide into water sources or other vulnerable areas.

Generally, runoff risk is greatest when heavy rains immediately follow pesticide applications or when the ground is saturated or frozen. Although surface waters are most likely to be contaminated by runoff, groundwater may also be affected when surface streams connect with shallow groundwater.

Pesticide Contamination of Groundwater

Groundwater provides 70% of the water used for public and private water supplies, irrigation, and industry. Like surface water, groundwater must be protected from contamination. Once groundwater is contaminated, correcting the problem is difficult or even impossible. Groundwater is found underground in cracks in the bedrock and in the spaces between soil particles, gravel, and rocks. It is the source of water for wells and springs.

The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water is the **saturated zone**. The boundary between the saturated zone and the overlying unsaturated rock and soil is known as the **water table**. The overall geologic formation from which groundwater can be drawn is called an **aquifer** (see Figure 7.6).

Leaching

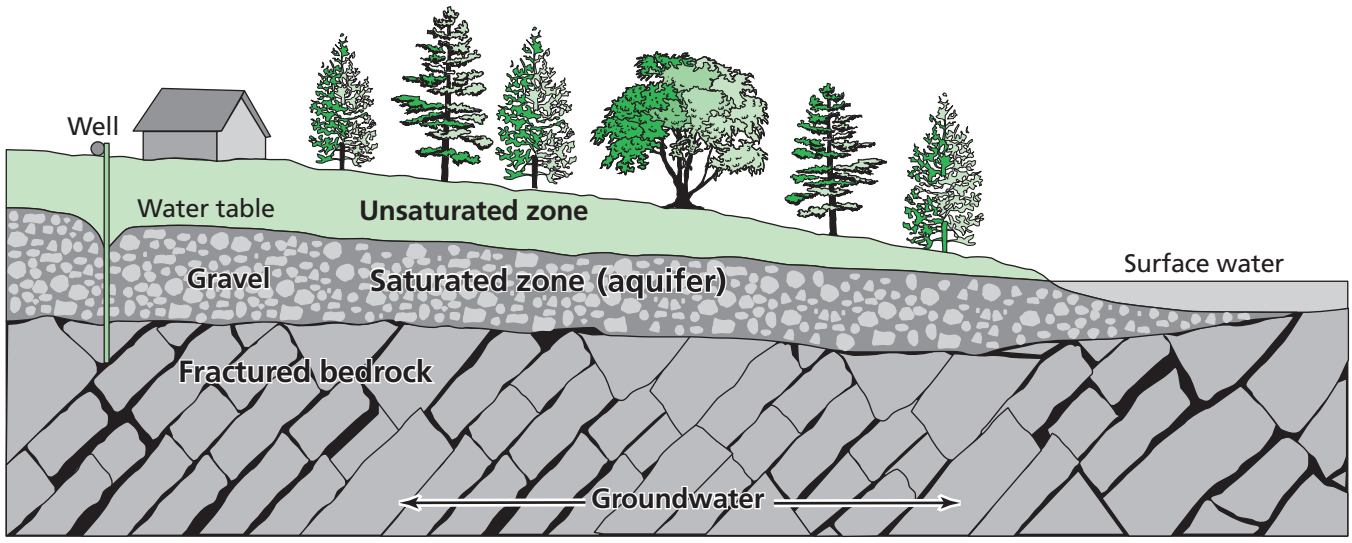
Some pesticides reach groundwater by moving through the soil in a process called leaching. A pesticide that leaches into groundwater must move down through the soil in water and resist binding to soil particles and breaking down into nontoxic compounds. Pesticides that have high solubility, low adsorption, and/or are persistent are more likely to leach. They typically have a label statement describing these concerns. A pesticide that adsorbs or binds itself strongly to soil particles will not leach as easily. Besides the characteristics of the pesticide, soil properties and environmental conditions also affect whether and to what extent a pesticide will leach.

Soil Properties

Four soil properties affect a pesticide's potential for leaching: texture and structure, organic matter, depth to groundwater, and geology.

Texture and Structure

Soil texture is the relative proportions of sand, silt, and clay-sized particles. Percolating water moves faster in sandy soils. Sand also has fewer binding sites available for the adsorption of dissolved chemicals than do clay or silt soils. Though sandy soils are more prone to pesticide movement, leaching may also occur in clay or silt soils.



Adapted from Penn State *Pesticide Education Manual*

Figure 7.6
Where groundwater occurs.

Soil structure is the shape or arrangement of soil particles. It plays a big role in determining the size and shape of the pores through which water moves. Small amounts of pesticides may also move through soil cracks, worm holes, and root channels. These features are called macropores.

Organic Matter

Organic matter consists of decaying plant material. The higher the soil organic matter content, the greater the ability of the soil to hold both water and adsorbed pesticides. Pesticides held in the root zone are less likely to leach into groundwater and may be taken up by plants.

Depth to Groundwater

Areas with a shallow water table have a greater chance for groundwater contamination because less soil is available to act as a filter. There are fewer opportunities for pesticide degradation or adsorption. When using pesticides in areas where the groundwater is close to the surface, choose a product with a low leaching potential.

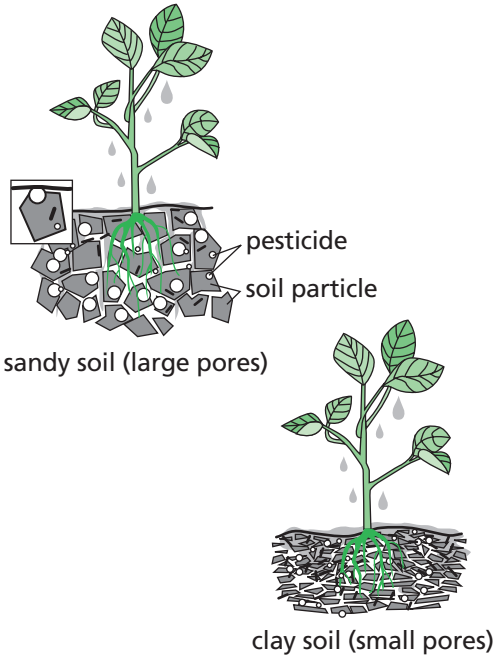


Table 7.2 Soil Properties

TEXTURE (affects movement of water particles)	ORGANIC CONTENT (measures volume of water and soil's ability to adsorb pesticides)	PERMEABILITY (measures speed of water's downward movement)
coarse (sand)	**low organic content=** faster water flow and little adsorption of pesticides	↓ **high permeability** (fast flow)
smooth (clay, silt)	**high organic content=** higher water retention and greater adsorption of pesticides	↓ **low permeability** (slow flow)

OSU *Pesticides and Groundwater Contamination*

Take extra precautions during mixing, application, and cleanup.

Geology

The **permeability** of the geologic layers lying between the surface of the soil and the groundwater is also an important factor. Highly permeable materials (such as gravel deposits) allow water and dissolved pesticides to move freely downward to groundwater. Layers of clay, which are much less permeable, can inhibit and slow the downward movement of water.

PREVENTING SURFACE WATER AND GROUNDWATER CONTAMINATION

To help prevent surface water and groundwater contamination, EPA requires all pesticide products labeled for outdoor uses to include the following environmental hazard statement on the label:

"Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water supplies when cleaning equipment or disposing of equipment wash waters."

Pesticides that could contaminate groundwater must bear groundwater warning statements on their labels. When such statements appear on product labels, choose pesticides appropriate for use in sandy soils or where extra precautions are needed to reduce the risk of water contamination.

You can minimize the risk of point- or nonpoint-source contamination by following best management practices (BMPs). BMPs are effective, commonsense procedures that emphasize proper mixing, loading, application, and disposal of pesticides. Following BMPs reduces the chance that pesticides will harm the environment.

Use Integrated Pest Management Principles

Apply pesticides only when and where necessary, and only in amounts adequate to control pests. Use nonchemical control methods whenever possible. When using pesticides:

- Determine the type of pest, the density of the pest population, and the proper control method.
- If a pesticide is necessary, choose the least toxic product that will do the job.
- Calibrate pesticide application equipment regularly.
- Use spot treatments or band applications, if possible, to reduce pesticide use.

Identify Vulnerable Areas

The presence of sandy soil, sinkholes, wells, streams, ponds, and shallow groundwater increases the chance of groundwater contamination. Never dispose of empty pesticide containers in sinkholes, or dump or rinse sprayers into or near sinkholes (see Chapter 10, Planning the Pesticide Application). Also take care to avoid contaminating drainage ditches and other potential sources of runoff to streams and waterways. ***Never*** clean tanks or intentionally discharge water from a tank of any vehicle into a street, along a road, or into a storm drain.

Do Not Mix and Load Near Water

Mix and load as far as possible (at least 50 feet) from wells, lakes, streams, rivers, and storm drains. When possible, do so at the application site. Consider using a sealed permanent or portable mixing and loading pad to prevent seepage into soil.

Keep Pesticides Away from Wells

Do not store or mix pesticides around wells. Poorly constructed or improperly capped or abandoned wells

may allow surface water containing pesticides and other contaminants direct entry into groundwater. Note that wells are sometimes located in or near treated fields and other application sites.

Avoid Back-siphoning

Back-siphoning is the reverse flow of liquids into a fill hose. It sucks tank contents (including pesticides) back into the water supply. Back-siphoning starts with a reduction in water pressure and can draw very large quantities of pesticide directly into the water source. This happens when the end of the water hose is allowed to extend below the surface of the spray mixture when filling a spray tank. The simplest way to prevent backflow is to maintain an air gap between the discharge end of the water supply line and the pesticide solution in the spray tank. An air gap prevents contamination of the hose and keeps pesticides from back-siphoning into the water source if a drop or loss of water pressure occurs. Keep the air gap at least twice the diameter of the discharge pipe. Another method to prevent back-siphoning is to use a backflow prevention device or check valve (see Chapter 10).



M.J. Weaver, Virginia Tech Pesticide Programs

Maintain an air gap between the discharge end of the water supply line and the spray tank to prevent backflow of pesticides.



Ed Crow, Maryland Department of Agriculture

Use an anti-backflow device (check valve) to prevent back-siphoning.

Improve Land Use and Application Methods

Terraces and conservation tillage practices can reduce water runoff and soil erosion. Ideally, growers should leave as much plant residue as possible on the soil surface to lessen erosion. Where conservation tillage is not possible, decrease runoff potential by incorporating a low concentration of the pesticide into the soil. In ornamental plantings, consider using mulches to reduce water runoff and soil erosion.

Grass buffer strips are very effective in reducing pesticide runoff because they trap sediment containing pesticides and slow runoff water. This allows more runoff water to infiltrate the soil. Leaving untreated grass strips next to streams, ponds, and other sensitive areas can trap much of the pesticide running off of treated areas.

Time Pesticide Applications According to the Weather Forecast

Pesticides are most susceptible to runoff from heavy rains or irrigation during the first several hours after application. Do not apply to saturated or frozen ground. To avoid overspraying an area and causing drift, check the pesticide label for application precautions or restrictions during windy conditions. Wind speed, temperature, and humidity all affect the off-target movement of pesticides.

Select Products Wisely

Whenever possible, use pesticides that are less likely to leach. Read labels for such warnings.

Handle Pesticides Safely

Follow these guidelines to prevent surface water or groundwater contamination:

- Immediately contain and control pesticide spills.
- Check application equipment regularly for leaks or damage.
- Mix and load pesticides away from water sources.
- After the pesticide application is complete, follow label directions for proper equipment cleanup and container disposal.
- After applying granular pesticides, sweep or blow any granules from sidewalks, driveways, or patios onto the treatment area.

Whenever possible, clean sprayers at the application site at a safe distance from wells, ponds, streams, and storm drains. Spray the rinsate on the treated area or on another site listed on the pesticide label, or use in the next tank mix. Be sure not to exceed label rates.

PREVENTING HARMFUL EFFECTS ON SENSITIVE AREAS AND NONTARGET ORGANISMS

To avoid harming the environment, you must be aware of sensitive areas, nontarget plants and animals (especially endangered species), and damaging effects on habitat.

Sensitive Areas

In addition to water sources, sensitive areas include sites where living things could easily be injured by a pesticide. Outdoor sensitive areas include:

- School grounds, playgrounds, and recreational areas.
- Habitats of endangered species.
- Apiaries (honey bee sites), wildlife refuges, and parks.
- Areas where domestic animals and livestock are kept.
- Ornamental plantings, public gardens, and sensitive food or feed crops.

Indoor sensitive areas include places where:

- People live, work, shop, or are cared for (such as hospitals and daycare centers).
- Food or feed is processed, prepared, stored, or served.
- Domestic or confined animals live, eat, or are otherwise cared for.
- Ornamental or other sensitive plants are grown or maintained (such as in malls and buildings).

Sometimes pesticides must be deliberately applied to a sensitive area to control a regulated pest (such as mosquito abatement or gypsy moth forest treatments). Only well-trained applicators should perform these applications.

At other times, the sensitive area may be part of a larger target site. Whenever possible, take special precautions to avoid treating the sensitive area. Leaving an untreated buffer zone around a sensitive area is a practical way to avoid contaminating it.

In still other instances, the sensitive area may be near a site used for mixing and loading, storage, disposal, or equipment washing. Be very careful to avoid contaminating the sensitive area. Check the label for statements that alert you to special restrictions around sensitive areas.



Sensitive area—apiary.



Sensitive area—wildlife habitat.

Pesticide Effects on Nontarget Organisms

Pesticides may affect nontarget organisms directly, causing immediate injury. Or they may produce long-term consequences through environmental pollution. Pesticides may build up in the bodies of animals or in the soil. For example, if you use the same mixing and loading site or equipment cleaning site over a long period, pesticides are likely to accumulate in the soil. When this occurs, plants and animals that come into contact with the soil may be harmed. The following sections discuss the effects of pesticides on nontarget plants; bees and other beneficial insects; and fish, wildlife, and livestock.



Sensitive area—playground.

Nontarget Plants

Nearly all pesticides can cause plant injury (phytotoxicity) due to chemical exposure, particularly if applied at too high a rate, at the wrong time, or under unfavorable environmental conditions. Phytotoxicity can occur on any part of a plant—roots, stems, leaves, flowers, or fruits. Most phytotoxic injury is due to herbicides. Although damage to crops or other nearby plants is primarily caused by drift, it may sometimes be a consequence of surface runoff and root uptake.



Avoid pesticide effects on non-target plants.



Bee hazard icon on labels indicate use restrictions.

Bees and Other Beneficial Insects

Besides making honey and beeswax, bees pollinate many fruit, nut, seed, vegetable, and field crops. You must be aware of bee activity when planning pesticide applications. There has been increasing concern about the decline of bee colonies and the role pesticides may play. Preventing bee loss is the joint responsibility of the applicator, the grower, and the beekeeper. Bees may travel as far as 3 miles from their hive to find blooming flowers. Before applying pesticides labeled as toxic to bees, notify beekeepers in the area so they can protect or move their bee colonies. Some states have laws requiring notification and registries for beekeepers.

Bees and other insect pollinators may be exposed to pesticides through different routes, including:

1. Direct contact during foliar applications.
2. Contact with residues on plant surfaces after applications.
3. Drift from the application into the hive entrance.
4. Ingestion of residues in nectar, pollen, or guttation water (dew) when the pesticide is applied as a seed treatment, soil or tree injection, or foliar application.



Avoid spraying when bees are actively foraging.

Insecticides are generally toxic to bees, but some are more hazardous than others. Herbicides are unlikely to harm bees directly. Fungicides do not appear to affect adult bees but may affect larval development. Tank mixing insecticides and fungicides may create a mixture that is more toxic to bees than either product used alone.

Minimize bee kills from insecticide poisoning by following a few basic principles:

- Pay careful attention to pesticide labels. For each application site, look for the bee hazard icon in the "Directions for Use" section for specific use restrictions and instructions to protect bees and other pollinators.
- Do not apply insecticides to crops in bloom.
- Apply insecticides in the evening or at night when bees are not foraging. (Early morning application may protect honey bees, but wild bees forage at or before dawn.)
- Do not apply insecticides when weeds or other plants around the treatment site are in bloom.
- Do not allow the pesticide to drift onto attractive habitat, natural areas, or beehives.
- Choose the least hazardous insecticide, formulation, and application method.

Pesticides can harm other beneficial insects in addition to bees. These beneficials may be valuable allies in keeping pest populations below damaging levels. A pesticide application often harms the beneficial insect population as much as the target pest. So do not spray when beneficial insects are in the target area unless it is unavoidable. Alternatively, choose a product that does not harm beneficials.

Fish, Wildlife, and Livestock

Pesticides can harm all kinds of animals. Most injuries occur from the direct effects of acute poisoning. Fish kills often result from water pollution by a pesticide. Insecticides are the most likely cause, especially when small ponds or streams are under conditions of low water flow or volume.

Bird kills resulting from pesticide exposure may happen in a number of ways. Birds may: ingest pesticide granules, baits, or treated seeds; be exposed directly to sprays; consume treated crops or drink contaminated water; or feed on pesticide-contaminated insects and other prey. Granular or pelleted formulations are a particular concern because birds and other animals often mistake them for food. Liquid formulations may be safer when birds and other wildlife are in or near the treated area. Remove pet dishes from spray areas. Place baits properly so

they are inaccessible to pets, birds, and other wildlife.

Animals may also be harmed when they eat plants or animals carrying pesticide residues. Predatory birds or mammals feeding on animals killed by pesticides are a special concern. Pesticide residues remaining on or in the bodies of the dead animal may harm predators. This is called secondary poisoning. Check the pesticide label for statements about **secondary poisoning**.

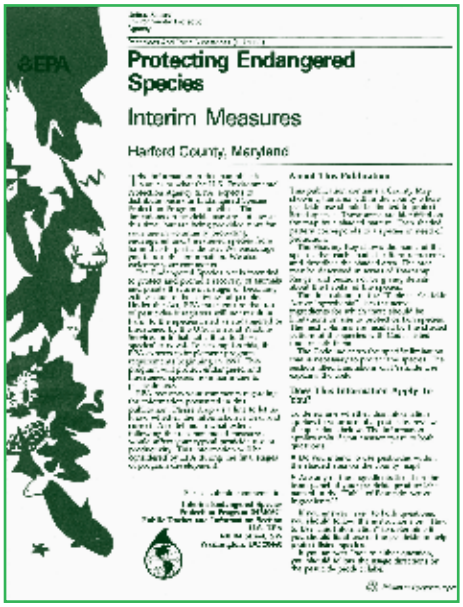
The less obvious effects resulting from long-term exposure to pesticides are a major concern. For example, certain pesticides have been banned because of fish and bird kills and the reproductive failures of several bird species.

The most important source of livestock pesticide poisoning has been through contaminated feed, forage, and drinking water. Contamination often occurs as a result of improper or careless transportation, storage, handling, application, or disposal of pesticides.

PROTECTING ENDANGERED SPECIES

Certain plants and animals have been identified as endangered or threatened species. Be very careful not to harm these populations. Because all living things are part of a complex, delicately balanced network, removing a single species may set off a chain reaction that affects many other species. The full significance of extinction is not always readily apparent, and the long-term effects are often difficult to predict.

An **endangered species** is one on the brink of extinction throughout all or a significant part of its range. A **threatened species** is one likely to become endangered. The reasons for a species' decline are usually complex, and thus recovery is difficult. A major problem for most wildlife is the destruction of habitat, usually the result of industrial, agricultural, residential, or recreational development.


EPA

Protecting Endangered Species

Interim Measures

Harford County, Maryland

Consulting a county bulletin is necessary for pesticides that might adversely affect endangered species.

Each state is responsible for implementing the federal Endangered Species Protection Program in cooperation with EPA to protect endangered and threatened species from the harmful effects of pesticides. Under this program, pesticide products that might harm an endangered species carry a label statement instructing applicators to consult a county bulletin to determine if they must take any special precautionary measures when using the product. EPA develops these bulletins, which identify precautionary measures required in each county where one or more pesticides could affect an endangered or threatened species. Precautionary measures may include buffer strips, reduced application rates, and timing restrictions. Or an applicator might be prohibited from using the pesticide within the identified habitat altogether. Check with your state, tribe, or territory department of agriculture; local Extension Service; or the EPA website (www.epa.gov) to find out the status of available county bulletins.


Craig Koppie, USFWS

Pesticides can be harmful to all kinds of animals.

SUMMARY

An important part of using pesticides legally and responsibly is considering where the pesticide may end up once it leaves the container and whether it might harm or damage nontarget sites, plants, or animals. By applying pesticides at the right time, in the right place, and with the proper application technique, you can greatly reduce—or even prevent—drift, runoff, and leaching.

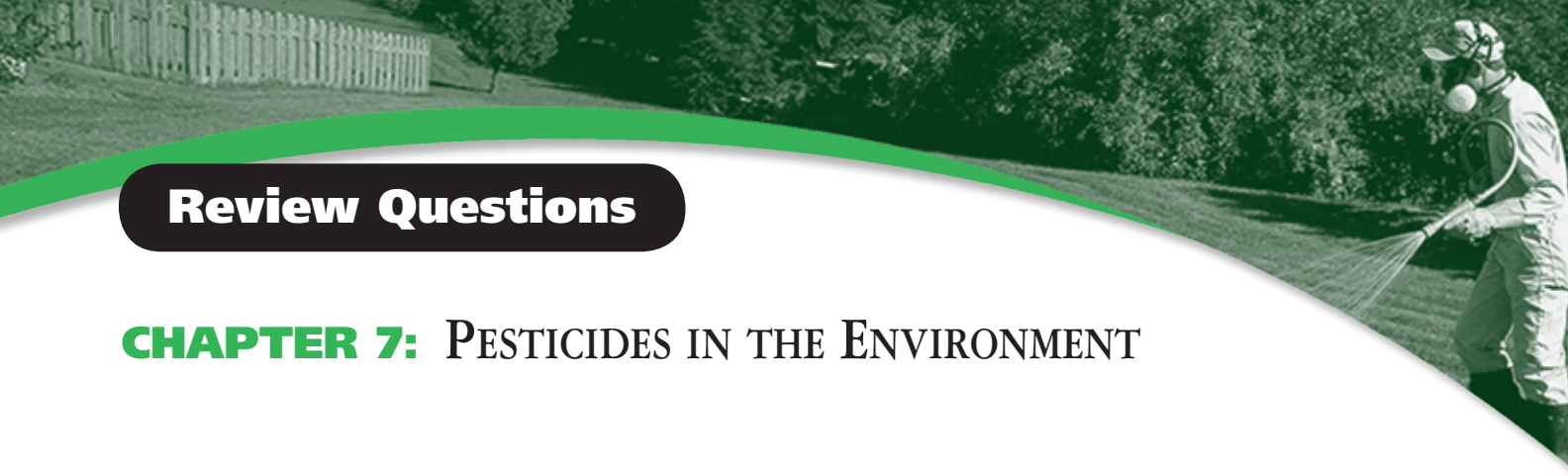


Endangered species need to be protected from pesticides.

Pesticides that enter groundwater and surface water are hazardous to aquatic organisms, plants, and wildlife. Therefore, you should implement best management practices to prevent runoff and leaching of pesticides.

Sensitive areas include places such as schools, playgrounds, endangered species' habitats, and ornamental plantings. Nontarget organisms include plants, bees and other beneficial insects, fish, wildlife, and livestock. Because of the greater risk of injury to people, plants, and animals, you must know when and how to properly apply pesticides in or near such areas.

Always check the label for statements on endangered and threatened species. You may need to consult a county bulletin that details the procedures for protecting them. It is your responsibility not only to follow label directions but also to use the best management practices that present the least risk to the environment while achieving effective pest control.



Review Questions

CHAPTER 7: Pesticides in the Environment

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Which property of a pesticide would make it more likely to move in surface water runoff?**
   - **A.** High solubility.
   - **B.** High adsorption.
   - **C.** High volatility.

2. **Which statement about movement of pesticides from the application site is *true*?**
   - **A.** Drift is seldom an issue with indoor applications.
   - **B.** Runoff and erosion are sources of surface water contamination by pesticides.
   - **C.** Leaching is the main way that pesticides move great distances.

3. **Which is an example of nonpoint-source contamination of groundwater?**
   - **A.** Back-siphoning of pesticide spills at a wellhead.
   - **B.** Leaching from a pesticide mixing area.
   - **C.** Pesticides that dissolve and leach through soil after it rains.

4. **Under which conditions are pesticides more likely to leach through soil?**
   - **A.** Heavy clay soil, high in organic matter.
   - **B.** Sandy soil, high in organic matter.
   - **C.** Sandy soil, low in organic matter.

5. **Which best management practice will help prevent contamination of surface water and groundwater by pesticides?**
   - **A.** Using pesticides that are highly water-soluble.
   - **B.** Following IPM principles.
   - **C.** Selecting persistent pesticides.

6. **Which two factors are most important in avoiding vapor drift?**
   - **A.** Droplet size and wind speed.
   - **B.** Air stability and temperature.
   - **C.** Temperature and pesticide volatility.

7. **Which statement about sensitive areas is *true*?**
   - **A.** Do not spray a larger target site if it contains a sensitive area.
   - **B.** Pesticide labels may list special precautions around sensitive areas.
   - **C.** Endangered species' habitats are not considered sensitive areas.

8. **Which statement about protecting bees from pesticide injury is *true*?**
   - **A.** Use foliar applications when possible.
   - **B.** Spray crops when they are in bloom.
   - **C.** Apply insecticides in the evening or at night.

CHAPTER 8

TRANSPORTATION, STORAGE, AND SECURITY

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- State what precautions to take before transporting pesticides.
- Summarize what the label says about legally disposing of unwanted pesticides.
- List the steps to take to restrict access to pesticides.
- Explain how to create a safe and secure storage area.
- Describe how to properly store pesticides.
- Discuss how to reduce the amounts stored by controlling inventory.
- Explain how to maintain the integrity of pesticide containers.

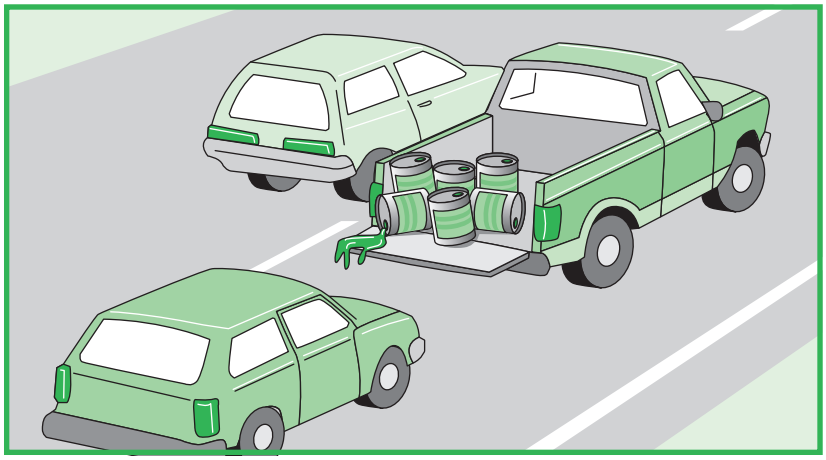


This chapter discusses safety and security issues that may arise when pesticides are moved or stored. Serious accidents involving pesticides are more likely to occur while they are in transit. Securing pesticides in a vehicle or in storage is a critical step to prevent vandalism or theft of product. You can reduce pesticide transport and storage problems by being aware of conditions that lead to increased security risks.

TRANSPORTATION

Every pesticide applicator should understand the hazards of transporting pesticides and the procedures for minimizing those risks.

Pesticides are moved by manufacturers to distributors, from retailers to end users, and from storage sites to job sites. Transportation-related accidents can happen at any point in the distribution chain from the manufacturer to the job site. Your first line of defense is recognizing how to prevent these transportation mishaps. When accidents occur, the timing of your response could determine the size of the spill.



Secure pesticides while transporting them even for short distances.

Transport Vehicle

Transport vehicles should be in good mechanical condition. Make sure brakes, tires, and steering are in proper working order. Repair all fluid leaks before putting a truck on the road or leaving the job site. Regularly inspect application equipment to be transported and used. Inspect hoses under pressure for wear and cracks and hose clamps for rust. Always carry supplies and replacement parts to make emergency repairs if a leak should develop while going to and from the job site.

Never carry liquid pesticides in the passenger area because spilled chemicals may cause harmful fumes that can be inhaled. A pesticide spilled in the cab is difficult to remove and may lead to long-term inhalation exposure.

It is best to keep pesticide containers in the original shipping box. Depending on the material, many of these boxes meet the U.S. Department of Transportation (DOT) packaging standards to give added protection to the contents. Try to carry a minimum amount of pesticide products on a vehicle at any one time.

Secure and protect pesticide containers against punctures and impacts from items packed closely together. Enclosed cargo boxes provide extra security from curious children, thieves, or vandals. Never stack pesticide containers higher than the sides of the vehicle. Make sure flatbed trucks have tie-down rings or racks to simplify the job of securing the load.



Edward Crow, Maryland Department of Agriculture

Never carry pesticides in the passenger compartment of a vehicle.



Jack Kelly Clark, Univ. of California Statewide IPM Program

Cargo boxes allow for secure transport of pesticides and help prevent theft and vandalism.

Vehicle Operator

The person driving the vehicle and/or the owner of the company is accountable for injuries to people and any pesticide release into the environment. The vehicle operator (driver) is the first person who can contain the spill and prevent it from spreading. By the time first responders arrive on the scene, the spill may already be contained. Therefore, it is important that the driver know basic emergency response procedures to contain the spill, company guidelines, and who will notify local, state, and federal authorities. Chapter 9, Emergency or Incident Response, explains in detail how to respond to a fire, spill, or leak involving pesticides.

It should be noted that some drivers transporting pesticides regulated as hazardous materials will be required to follow DOT regulations regarding commercial driver licenses, placarding, shipping papers, and annual inspections.

Other Safety Precautions

Always carry product labels and Safety Data Sheets (SDSs) when transporting pesticides on highways. The SDS contains critical information for the driver and emergency responders after a pesticide spill. It lists steps to safely deal with the spill, including the personal protective equipment (PPE) to use, whether the spill carries an inhalation or explosion risk, decontamination procedures, and emergency telephone numbers. Have the labels and SDSs well organized and alphabetically arranged by product name to allow quick access in the event of a spill.

Always carry a spill kit with the items you will need to handle a spill during transport. (The contents of a spill kit are discussed in Chapter 9.) Inspect containers to ensure they have legible and attached labels, tight closures, and pesticide-free outside surfaces. Secure application equipment (such as hand sprayers, backpack sprayers, and spreaders) during transport.

Protect pesticides from extreme temperature and moisture during transit. Depending on the pesticide, either extremely low or extremely high temperatures can alter the stability of certain pesticide formulations.



NC Dept. of Agriculture & Consumer Services

Pesticides stored incorrectly with feed, seed, and fertilizers increase the risk of contaminating non-pesticide products.

Vehicle Placards

DOT requires diamond-shaped signs called **placards** to be placed on vehicles that transport certain types and quantities of hazardous materials. Most distributors will give you any required placards to place on your transportation vehicle. Hazardous materials include some pesticides; fertilizers such as anhydrous ammonia or ammonium nitrate; and fuels such as gasoline, diesel, and propane. Placards provide emergency responders with the information necessary to quickly assess an accident situation.



Adapted from University of Illinois *Private Applicator* manual

Always secure the load and carry in the truck a spill kit that includes a broom and shovel.

If you ship or transport materials in quantities that require placards, you must develop and implement a **transportation security plan**. Vehicles must be placarded when transporting pesticides:

- Bearing a DOT poison label.



Examples of placards placed on vehicles that transport certain types of hazardous materials.

- In containers larger than 119 gallons.
- In quantities greater than 1,000 pounds.

The security plan must include measures to prevent unauthorized access, a security check of employees who pick up and transport placarded hazardous materials, and the intended route of travel. For further details on the transportation security plan, contact the Hazardous Materials Information Center.

STORAGE OF PESTICIDES IN BUILDINGS

Although existing buildings are often used for pesticide storage, it is best to have a separate storage facility for pesticides, fertilizers and other similar products. Storing pesticides separately gives emergency response crews more options in dealing with fires and spills. Keeping equipment, employees, and records away from pesticides is always recommended where possible.

A well-designed pesticide storage site:

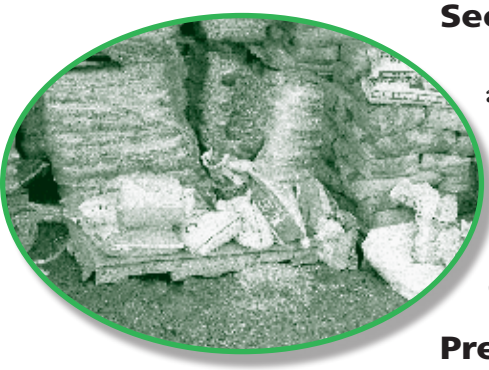
- Limits access.
- Permits better inventory control.
- Protects people from exposure.
- Reduces the chance of environmental contamination.
- Prevents damage to pesticides from temperature extremes and excess moisture.
- Safeguards pesticides from theft, vandalism, and unauthorized use.
- Allows fire departments to know the location of products.



Maintain a well designed, secure pesticide storage facility with highly visible warning signs. Keep it well ventilated and located where water damage is not likely to occur.

Secure the Site

Whether the designated storage area is a cabinet, an entire room, or a separate building, keep it locked when not in use. Post warning signs on doors and windows to alert others that pesticides are stored inside. Pesticide security is covered in detail later in this chapter.



Do not store pesticides in locations that can become damp or wet.

Prevent Water Damage

Pesticide storage facilities should not be located in a flood zone. Carefully consider soil and land surface characteristics when selecting a storage site to prevent contamination of surface water or groundwater. Do not locate the storage facility near a stream likely to flood or where runoff water flows toward the facility. If flooding is likely, consider building dikes around the storage facility. Work with local zoning and building code professionals to determine how best to protect the environment if high water were to enter the storage facility.

Consider storing pesticides on a raised pallet or on shelves to prevent high water from damaging pesticide containers or flowing water from moving them offsite.

Water or excess moisture may damage pesticide containers and their contents and cause:

- Metal containers to rust.
- Paper and cardboard containers to split or crumble.
- Pesticide labeling to peel, smear, or otherwise become unreadable.
- Dry pesticides to clump, degrade, or dissolve.
- Slow-release products to release their active ingredients.

Control the Temperature

Choose a well-ventilated room where temperatures are controlled. Exhaust fans directed to the outside of the building reduce the buildup of noxious vapors from many of the solvents used in pesticide formulations. Ventilating the pesticide storage room into an adjoining room does little to solve the problem. Pesticide labeling often gives temperature limits for storing a product.

Consider installing an exhaust fan on a timer to automatically turn on at a certain temperature. If the exhaust fan is not on a timer, turn on the fan switch before entering the storage room. Wait a few minutes to allow any vapors to clear.

Provide Adequate Lighting

Be sure the pesticide storage facility is well-lighted. Pesticide handlers entering the building must be able to read the product labels and determine whether containers are leaking.

Use Nonporous Materials

Use cement or other impervious materials for flooring to retain the spilled material on the surface. Such surfaces are easy to clean and decontaminate in the event of a release. A floor that slopes into a sump helps collect and contain the spill. Consider using shelving and pallets made of nonabsorbent materials, such as plastic or metal, for the same reasons as impervious floors.



USDA

Be sure the floor of the pesticide containment site is made of non-porous materials such as sealed cement. A recessed floor helps control spills or leaking pesticides.

Maintain the Storage Site

Store *only* pesticide containers, pesticide equipment, and a spill cleanup kit at the storage site. Keep food, drink, tobacco, feed, medication, medical or veterinary supplies, seed (treated and untreated), clothing, and PPE (other than that necessary for emergency response) out of the storage location.

Keep Labels Legible

Store pesticide containers with the labels in plain sight. Costly errors may result if the wrong pesticide is chosen. Be sure labels are always legible. If the label is destroyed or damaged, immediately mark the container with some basic labeling information, such as the trade name, the U.S. Environmental Protection Agency (EPA) registration number, signal word, and use classification. Go online to find a product replacement label or get a new label from the manufacturer.

Store Pesticide Containers Safely

Store pesticides in their original containers or, if allowed by state law, in a properly labeled service container. Never use any other container to store a product. Besides being illegal, serious injury may result when using food containers, such as milk jugs or soft drink bottles. Children will associate the shape, size, and color of the container with its usual contents. Never use a pesticide product from an unmarked or unlabeled container unless you are certain what it is. Guessing wrong can cause serious damage at the application site.



D. Brown-Rytlewski, MSU

Do not store pesticides in food containers.

Keep pesticide containers securely closed when not in use. Just like bagged fertilizer, dry pesticide formulations can clump together under high humidity. Consider placing partially used bags of wettable and soluble powders, dry flowables, dusts, and granules in a plastic trash bag or tub with a cover to reduce clumping.

Place drums and bags on plastic pallets. Store other pesticides on metal shelving, placing the heaviest containers on lower shelves. Do not allow containers to extend beyond the edge of the shelving—they could be knocked off or torn open.



Store pesticides on metal shelving, with the heaviest containers and liquids stored on the lower shelves. Never extend beyond the edge of the shelving.

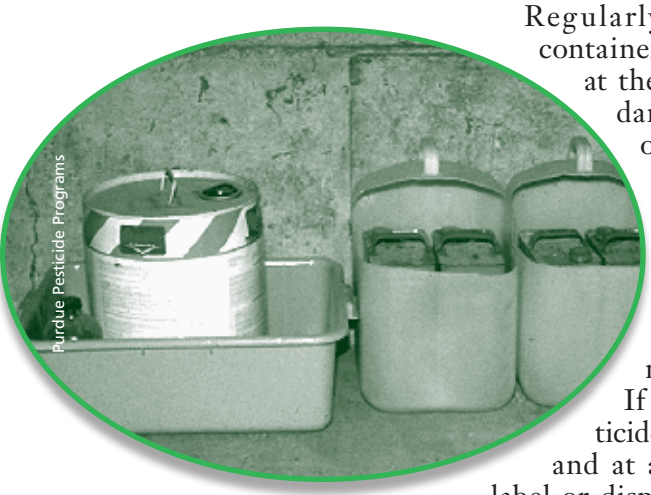
Place bulk and mini-bulk tanks on a reinforced concrete pad. Diking around bulk tanks keeps leaking pesticides inside a contained area. Make the area inside a dike large enough to contain the volume of the liquid in the tank plus at least an addi-

tional 10%. Keep valves and pumps as well as transfer hoses within the diked area when not in use.

Contact your state, tribe, or territory pesticide regulatory agency for guidance on what constitutes bulk pesticides and to learn specific rules for building containment structures.

Look for Damage

Regularly inspect pesticide containers to detect problems at the outset. If you find a damaged container, put on appropriate PPE and place it into a larger container, such as a 5-gallon bucket. Clean up spilled pesticide and place any contaminated materials in the bucket. If possible, use the pesticide immediately on a site and at a rate allowed by the label or dispose of it according to label directions.



Place damaged pesticide containers in secondary containment.

Note Shelf Life of Pesticides

Keep an inventory of all pesticides in storage, marking each container or box with the year it was purchased. In this way, you can use the oldest product first. Remember to use it as it was meant to be used: a replacement product may have different label directions and uses. If you have questions about the shelf life of a product, contact the dealer or manufacturer.

Avoid storing large quantities of pesticides for long periods. Buy only as much as you need for the season.

Mark each container with its purchase date.



Purdue Pesticide Programs

Follow These Safety Tips

For best results:

- Have duplicate copies of pesticide labels and SDSs available in case of an emergency.
- Wear appropriate protective clothing when handling pesticide containers.
- Label items such as measuring utensils and protective equipment to prevent their use for other purposes.
- Have absorbent materials readily available to soak up leaks in the storage room. Keep a shovel, broom, and heavy-duty plastic bags on hand to remove the contaminated absorbent material.
- Check the SDS for materials that will deactivate a contaminated surface. When in doubt, contact the pesticide manufacturer for a recommendation.

Have readily accessible clean water for decontamination, an eyewash station, personal protective equipment, a fire extinguisher rated for chemical fires, first aid equipment, and emergency telephone numbers. Additionally, keep plenty of soap, water, and paper towels available near the storage facility.

Isolate Unwanted or Waste Products

Do not accumulate outdated or unwanted pesticide products. Not only will you lose money by not using the product, but you may have to pay a disposal service. If you use the product up according to the label, you will avoid both problems.

Sometimes EPA will cancel a product registration. When this occurs, EPA usually either allows the continued use of the product until it has cleared the distribution chain or issues a federal notice prohibiting use after a specific date. If you keep such products after that date, you may have to dispose of them as hazardous waste. Be sure to follow label directions for disposal of any excess or leftover product.

If you are holding pesticides or emptied pesticide containers for disposal or recycling, keep them in a special section of the storage area. See Chapter 10 (Planning the Pesticide Application) for information on pesticide container rinsing procedures.

Some states sponsor pesticide disposal programs that collect unwanted pesticides from growers and applicators free or at reduced cost. Contact your state, tribe, or territory pesticide regulatory agency to see if a program is available in your area.



Have a designated area for properly rinsed containers.

PESTICIDE SITE SECURITY

Minimizing risks for the safety of employees, customers, and communities should always be a top priority when it comes to storing pesticides. Every pesticide storage facility should examine its security efforts and plan for worst-case scenarios.

Routinely review your security measures to determine whether all risks have been accounted for in the plan. Without effective security procedures, you may be vulnerable to both internal (employee theft) and external (terrorism, theft, and vandalism) threats. This puts both employees and the community at risk.

Benefits of Security Efforts

By developing a strong and workable security plan, managers, employees, and emergency responders can reduce the likelihood of theft or other mishaps. In addition, effective security avoids costly losses. An incident of any magnitude can seriously disrupt operations and result in lawsuits, costly remediation actions, employee fear and uncertainty, and damage to the company's reputation.

A well-planned security program can:

- Safeguard employees and the community.
- Maintain the integrity of operations.
- Reduce insurance costs.
- Prevent theft.
- Reduce vandalism and sabotage.
- Protect confidential business information.
- Improve relationships with local authorities and community leaders.

Risk Assessment

The first step in developing a security program is to conduct a risk assessment of your business or farm's vulnerabilities. Make a list of assets that need protecting, possible threats, and steps that can be taken to protect them.

Any place that stores or transports pesticides shares similar assets, which are broadly defined as people, information, and property. "People" includes employees, visitors, customers, contractors, and neighbors. "Information" includes business, proprietary, and employee material deemed confidential. "Property" may include:

- Pesticide storage facilities.
- Vehicles.
- Application equipment.



Be sure to guard against unauthorized entry.

- Bulk storage tanks.
- Mixing and loading sites.
- All utilities, such as telephone, water, gas, and electric.

Employee Training and Security Awareness

Train employees to be vigilant in detecting security threats. Employees are familiar with what occurs in and around a pesticide storage facility or at the job site. They can provide an early warning when something seems out of place or someone is acting suspiciously. At a minimum, instruct all employees on pesticide inventory control, security of storage facilities and application equipment, and emergency preparedness and response.



Outside lights on a pesticide storage building help prevent theft and vandalism.

Evaluating Pesticide Security

Fundamental security tasks include:

Secure buildings, manufacturing facilities, storage areas, and surrounding property— Prevent the unauthorized entry of persons into areas used to manufacture or store pesticides. Elements of an effective security plan may range from log sheets, identification badges, fencing, lighting, and locks to detection systems, cameras, and trained guards.



Lock backpack sprayers securely onto the transport vehicle.

Secure pesticide application equipment and vehicles— Keep unauthorized people away from equipment used for storing, mixing, loading, transferring, transporting, and applying pesticides. Secure and disable equipment in the field to prevent misuse. For example, do not leave keys in the ignition, and lock doors and cabinets. Reclaim keys from employees when they terminate employment.

Protect confidential information— As safety and security systems become more reliant on computers and other technology, it is important to secure them from hackers and intruders. Such efforts include contingency planning for power disruptions, adherence to password and backup procedures, and other measures to ensure that only authorized personnel have access.

Develop procedures and policies that support security needs— Recommended practices include effective hiring and labor policies, inventory management, and planning for emergencies. Hiring and labor policies should include employee training, background checks, and workplace violence prevention. Inventory management is necessary to keep track of pesticides stored at the facility. Planning for emergency response is critical. It helps to ensure that managers and employees know how to respond in the unlikely event of pesticide release, bomb threat, or terrorist activity.

Coordinate with authorities in a timely manner— If you believe a security breach or suspicious activity has occurred, contact local authorities immediately. In addition to alerting the police department, call the local emergency planning commission, fire departments, and other emergency response agencies. The Federal Bureau of Investigation (FBI) cautions that any suspicious activity related to the use, training, or acquisition of pesticides should be immediately reported to management and local authorities.

Steps to Prevent Security Problems

To minimize risks:

- Adopt security measures to deter tampering with chemicals, equipment, or the facility itself.
- Include local authorities (e.g., police and firefighters) in developing the security plan.
- Keep an accurate inventory of all chemicals.

- Keep chemical storage areas locked when not in use.
- Update your emergency response plan and practice the procedures.
- Post telephone numbers of law enforcement and emergency response agencies in a prominent location.
- Be cautious of unknown persons who want to pay cash for large quantities of pesticides.
- Ask employees to report any unusual incidents or requests.
- Restrict access of nonemployees to your pesticide storage facilities.

SUMMARY

It is essential to establish safety and security practices for moving pesticides on the highways and at storage and job sites. Because spills and accidents are more likely to occur while transporting or applying pesticides, drivers and pesticide applicators must be trained to respond quickly to a spill. Pesticide labels and SDSs for the pesticide carried in the vehicle can provide important information in the event of a spill.

Attention to pesticide site security and managing pesticides should be a top priority. Develop security and emergency management plans for every pesticide-handling and storage facility to safeguard employees and the community. Design security plans to reduce the risk of theft, vandalism, and deliberate misuse of pesticides by those wanting to harm others. Train employees in security and emergency response procedures and to coordinate efforts with local police, emergency response personnel, and the FBI.



Review Questions

CHAPTER 8: TRANSPORTATION, STORAGE, AND SECURITY

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. Which statement about transporting pesticides is *true*?

- **A.** Carry pesticides in the passenger compartment to prevent unauthorized access.
- **B.** Enclosed and lockable cargo boxes offer the greatest protection.
- **C.** The operator (driver) is not held responsible if a pesticide spill or accident occurs.

2. Which statement about pesticide storage facilities is *true*?

- **A.** A ventilation system may reduce noxious vapors by venting air into an adjoining area.
- **B.** Carefully consider the terrain when selecting a storage site.
- **C.** The floor should remain as bare soil to absorb any spilled material.

3. What is the first thing to do if a pesticide container is leaking?

- **A.** Put on personal protective equipment.
- **B.** Transfer contents into another container.
- **C.** Clean up any spilled material.

4. Which recommended practice will minimize pesticide storage problems?

- **A.** Purchase quantities based on previous usage.
- **B.** Purchase more than you need to ensure availability of the product.
- **C.** Store metal pesticide containers on the higher shelves to prevent rusting.

5. What is the first step a business should take to develop an effective pesticide security program?

- **A.** Coordinate planned actions with authorities.
- **B.** Conduct a risk assessment of business vulnerabilities.
- **C.** Train employees on security measures.

6. Which of the following is considered a good security practice?

- **A.** Instruct employees on pesticide inventory control.
- **B.** Allow employees access to inventory.
- **C.** Back up confidential data daily and keep it at the facility.

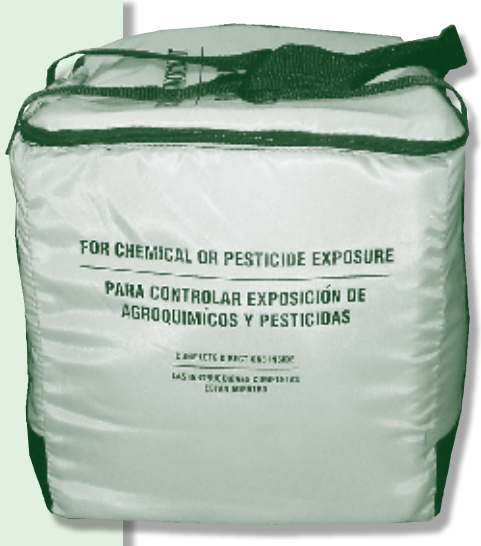
CHAPTER 9

EMERGENCY OR INCIDENT RESPONSE

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Discuss how pesticide releases from spills and fires can endanger humans and the environment.
- Explain how to execute an emergency response plan.
- State how to dispose of contaminated materials resulting from a spill cleanup.
- Discuss how to implement cleanup procedures to lessen the environmental impact from a spill.
- List the items to include for emergency response equipment (e.g., spill cleanup kit, first aid kit, and personal protective equipment).



Although pesticide accidents and emergencies are rare, they do occur. Pesticides spilled on the ground or burning in a fire can contaminate water, soil, and air; damage plants; injure livestock, wildlife, or pets; and endanger the health of the applicator and emergency responders. Pesticide spills and fires may lead to financial loss due to cleanup, liability claims, and fines assessed by government agencies. Do all that you can to prevent accidents, but be prepared in case of emergency.

EMERGENCY RESPONSE PLANNING

Like a pesticide site security plan, a carefully thought-out emergency response plan (i.e., a contingency plan) can help to prevent an emergency situation from becoming a catastrophe. An emergency response plan helps protect employees and the community, minimizes environmental damage, and reduces liability if an accident happens.

Emergencies can take many forms: tornado or high winds, flood, fire, or a highway accident. How you and emergency personnel respond determines whether the problem is quickly and safely resolved.

Follow these guidelines when developing an emergency response plan:

Do you know what to do in a pesticide emergency?



Be prepared for emergency situations.

- Designate an emergency coordinator as the "go-to" person. This person must have authority to make important decisions during an emergency, including coordinating with local first responders, such as fire, police, and paramedics. The emergency coordinator is the person who will make the necessary calls and fill out reports to government agencies.
- Post in the office, shop, and truck a list of names and telephone numbers of response agencies that may require notification.
- Prepare a/an:
  - ➢ Fill-in form or an outline of critical information to convey to emergency personnel. Keep it with your calling list. Be sure to include the following:

Emergency Response Agency Contacts

- Persons/agencies required to be notified by local, state, and federal requirements.
- Local emergency planning committees.
- Police and fire units.
- Paramedics and area hospitals.
- Appropriate chemical manufacturers and dealers.
- Containment and hazardous waste cleanup contractors.
- Your attorney, to protect your rights and the rights of others.

    - ○ Name of the person reporting the incident.
    - ○ Precise location of the incident.
    - ○ General description of what happened.
    - ○ The exact name, quantity, and classification of pesticides involved.
    - ○ The extent of injuries.
    - ○ Whether pesticides have entered surface water.
  - ➢ Facility map that shows a layout of all chemical storage buildings and bulk storage tanks; access roads; main shutoffs for electricity, water, and gas; perimeter fencing or gates; fuel storage tanks; the location of fire alarms, fire extinguishers and other firefighting equipment, and protective clothing; and drainage ditches, wells, and surface flow of water.
  - ➢ Area map that shows your facility in relation to the surrounding area. Provide emergency response agencies with an updated copy of the facility map and area map whenever changes are made (see Figure 9. 1).
- Keep:
  - ➢ A product inventory of chemicals stored at the facility. Let your emergency response plan reflect peak seasonal storage of pesticides, fertilizers, and fuel.
  - ➢ Copies of pesticide labels and Safety Data Sheets (SDSs) away from the storage area.
- Maintain in good working order the emergency equipment and supplies needed to respond to fires and spills.
- Train all employees how to execute the response plan each year.

Do you know where your emergency equipment is?

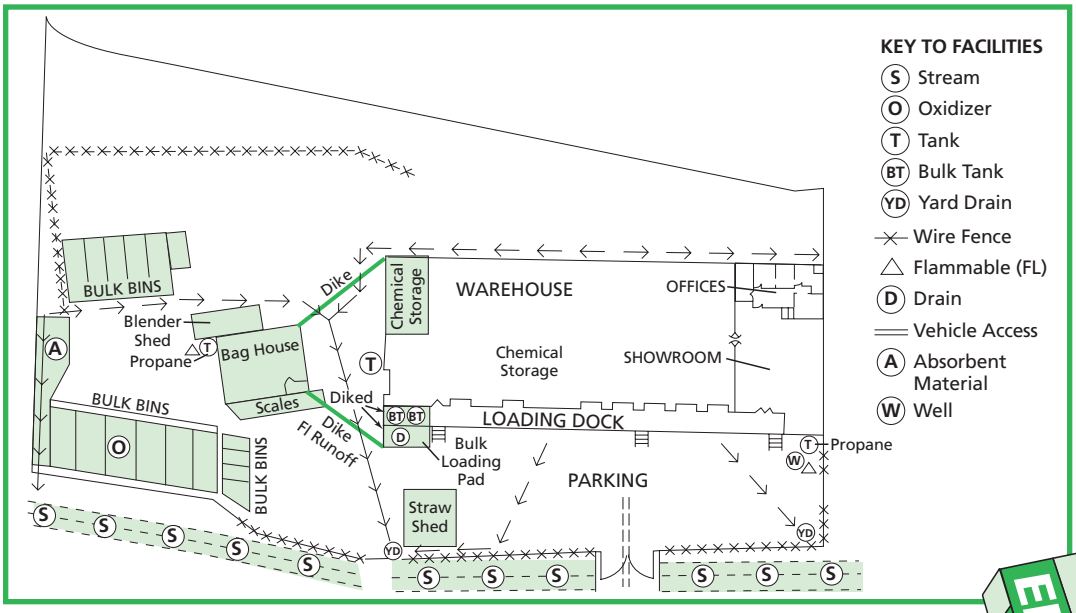
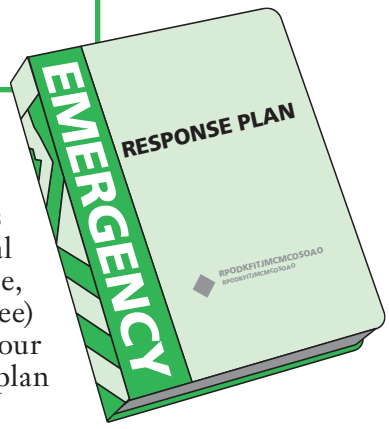


Figure 9.1
Include a facility map as part of the emergency response plan.

The backbone of any emergency response plan is a description of the sequence of actions to take in a crisis. Prepare step-by-step procedures on how to respond to various emergencies: fires, spills, ammonia leaks, tornadoes, hurricanes, and transportation accidents, among others. Specify in writing every activity from sounding the alarm to interacting with local emergency response agencies. Once internal emergency procedures have been established, ask your local response agencies (e.g, fire, police, and emergency planning committee) if they have anything to add to your plan. Offer them a copy of your plan for their files.



Develop a written emergency response plan.

FIRES

Pesticide products vary significantly in their flammability. However, any pesticide product involved in a fire is dangerous to responders working at the scene because of smoke and fumes. Even after the fire has been extinguished, pesticide residue in the debris, soil, and runoff may be dangerous.



Paul Love, Michigan State University

Install fire detection systems such as this sprinkler system with a sensor.

Precautions to Reduce Fire Hazards

Chapter 8 (Transportation, Storage, and Security) discussed where to locate a pesticide storage facility and the proper design and components of a secure facility. Follow these guidelines to help you prepare for—and respond to—a fire in the storage area:

- Store combustible pesticides away from heating sources.
- Install a fire-detection system.
- Train employees to use a fire extinguisher.

Prompt action is essential when a fire occurs. Coordinate all details on managing a fire with local emergency response officials. Take the following actions:



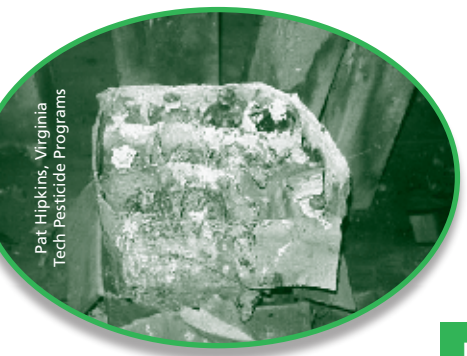
Edward Crow, Maryland Department of Agriculture

Post signs that indicate pesticides are stored in the facility.



J. Ples Spradley, University of Arkansas

A National Fire Protection Association (NFPA) warning on a storage box for fumigants. The strikeover on the letter W in the white diamond alerts firefighters not to use water to put out a fire.


Pat Hipkins, Virginia Tech Pesticide Programs

Cleanup and salvage operations after a fire must be done under expert supervision after everything has cooled.


Tom Bowman, Virginia Tech Pesticide Programs

Clean up all spills immediately.

- Make sure employees evacuating the premises go to a designated rendezvous point where everyone can be accounted for.
- Notify the fire department.
- Provide emergency response teams with SDSs, labels, the emergency plan, and a site map.
- Follow the instructions given by the onsite incident commander.
- Establish a security perimeter to discourage onlookers.
- Contain contaminated runoff water and leaking pesticide onsite by building berms.
- Consult with emergency responders to decide whether to allow the fire to burn out.
- Call your insurance agent.
- Make all regulatory phone calls required by state and federal agencies.



Paul Love, Michigan State University

Have a fire extinguisher approved for chemical fires readily available.

PESTICIDE SPILLS

A spill is an accidental release of any amount of pesticide, small or large. Spills on public highways, such as when a tank on a truck overturns, usually have major consequences. Failure to respond quickly and appropriately to such mishaps could seriously endanger public health and environmental quality.

In the event of any pesticide spill, remember the three C's: CONTROL the spill, CONTAIN it, and CLEAN it up.

The Three Cs

Control
Contain
Clean up the spill

Control the Spill

Act immediately to control the spilled product. Always put on the appropriate personal protective equipment (PPE) before responding to a spill. Place small, leaking containers into larger ones. If a larger container (such as a drum) is leaking, try to plug the leak. Then, transfer the contents to another container. To stop leaks from



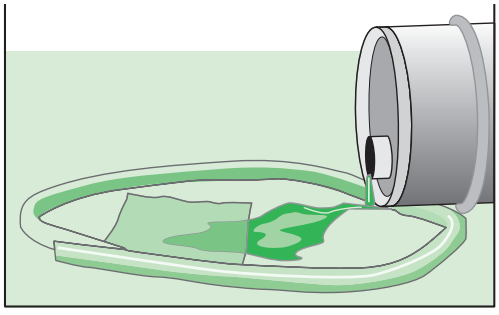
Adapted from OSU *Applying Pesticides Correctly*

Wear appropriate PPE when cleaning up a spill.

pressurized systems (such as sprayers), turn off the pump. Never leave the site unattended.

Contain the Spill

Do all you can to keep the spill from spreading or getting worse. Prevent the material from entering surface water. Using a shovel, you can quickly berm off an area to keep the spilled pesticide out of drains and waterways. A spill that is contained on the surface is much easier to clean than one that has entered a body of water.



Take action to prevent spills from spreading. In this case, an absorbent spill tube is used to contain the spill.

If the spilled pesticide does contaminate a stream, pond, or other waterway, immediately contact the state, tribe, or territory regulatory agencies responsible for streams and fisheries and for pesticides. Do not delay notifying the authorities. They need time to alert downstream users who draw surface water for drinking, prevent accidental poisoning of livestock, evacuate people using the water for recreational purposes (such as swimming and fishing), and avoid contamination of irrigated crops. Call the manufacturer's emergency number on the SDS to find out what steps you or the emergency response coordinator should take to lessen the dangers of water contamination.

Call 911 to report the spill and be ready to respond to the authorities arriving at the scene. Be sure to have the product label and SDS available for emergency responders. After the spill has been contained, follow your emergency plan. In some cases, the applicator will call the emergency responder, who will then call the proper authorities.

Clean up the Spill

The last step at the spill site is to clean up the spilled product. Sweep up any absorbent materials and other contaminated items and place them in a drum. If the spill occurred on concrete or asphalt, you will have to neutralize the surface. Follow the instructions on the SDS or contact the manufacturer, whose number is listed on the data sheet.

The state, tribe, or territory regulatory agency involved with pesticide spills will tell you what to do when the spill occurs on soil. For example, they may require that the top 2 to 3 inches of

For emergency response information call:

CHEMTREC

1-800-424-9300

National Fire Protection Association

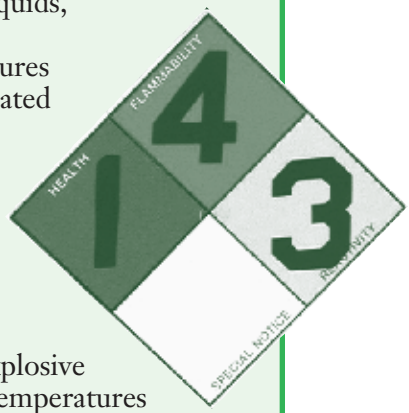
A hazardous rating system used to assist emergency response personnel is the NFPA Hazard Identification System. This system uses a diamond-shaped warning symbol. The top, left and right boxes refer to flammability, health, and instability hazards, respectively, and each contains a number from 0 to 4. The bottom box is used for special hazards; the most common of these is a warning against the use of water. See the diagram below.

Health Hazard - Blue Section

4 Severe hazard
3 Serious hazard
2 Moderate hazard
1 Slight hazard
0 Minimal hazard

Flammability Hazard - Red Section

4 Flammable gases, volatile liquids, pyrophoric materials
3 Ignites at ambient temperatures
2 Ignites when moderately heated
1 Must be preheated to burn
0 Will not burn



Special Hazard - White Section

OX Oxidizer
~~W~~ Avoid use of water

Instability - Red Section

4 Capable of detonation or explosive decomposition at ambient temperatures
3 Capable of detonation or explosive decomposition with strong initiating source
2 Violent chemical change possible at elevated temperature and pressure
1 Normally stable, but becomes unstable if heated
0 Normally stable



Adapted from OSU *Applying Pesticides Correctly*

Use an absorbent material to help clean up a spill.

soil be excavated, removed, and replaced with clean soil.

Keep records of your activities and conversations with regulatory authorities, emergency responders, news media, and the public when dealing with a pesticide spill. Photographs help document any related damage as well as steps you have taken to clean up the spilled product.



Purdue Pesticide Programs

Keep emergency supplies and a shovel on hand.

Prevent Spills

A key to reducing the likelihood of any spill is to properly maintain your application equipment and transport vehicles. Leaks and drips from cracked hoses or loose hose clamps clearly indicate problems. Defensive driving techniques and refraining from cell-phone use while driving are two important habits that can prevent vehicle accidents that might result in a spill.

Keep a spill cleanup kit in each pesticide transport vehicle and at the site where pesticides are mixed, loaded, and stored. Store your spill kit items in a plastic container and keep them clean and in working order.

Include the following items in a spill response kit:

- Telephone numbers for emergency assistance.
- PPE designed for use with pesticides.
- Absorbent materials, such as spill pillows, absorbent clay, and cat litter.
- A shovel, broom, and dustpan.
- Heavy-duty detergent.

SUMMARY

Prepare for a pesticide emergency. Make sure the plan includes designating an emergency response coordinator, maintaining a list of emergency response agencies, preparing a map of the facility, and keeping a product inventory. Be sure all employees at the facility are familiar with the emergency response plan and know what to do in a crisis. Take precautions to reduce the chance of pesticide fires. The best way to manage pesticide spills is to prevent them from happening. It is your responsibility as a pesticide applicator to do everything possible to avoid spills and adhere to a few basic guidelines when handling spills and leaks. Accidents happen. Be prepared so that they will not become catastrophes.

Review Questions

CHAPTER 9: Emergency or Incident Response

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Which statement about emergency response planning is *true*?**
   - **A.** The main reason to have an emergency response plan is to reduce economic losses.
   - **B.** The first person to contact in an emergency is an attorney.
   - **C.** It is important to make a detailed report of what took place before, during, and after the incident.

2. **What is the backbone of any emergency response plan?**
   - **A.** Outlining the sequence of actions to take in a crisis.
   - **B.** Knowing where labels and SDSs are kept.
   - **C.** Having a designated emergency responder.

3. **In addition to an emergency response plan, which of the following will further reduce the risk of a pesticide fire?**
   - **A.** Store pesticides close to a heat source to prevent freezing.
   - **B.** Keep a fire-detection system in the storage area.
   - **C.** Post the storage area with a warning sign.

4. **Which is a recommended action to take in the event of a pesticide fire?**
   - **A.** Construct berms to contain contaminated runoff water.
   - **B.** Enter the storage facility and remove as much pesticide as possible.
   - **C.** Try to extinguish the fire before calling 911.

5. **Which is an appropriate action to take in the event of a pesticide spill?**
   - **A.** Take a "time out" to read your emergency response plan.
   - **B.** Call 911 only if the spill has a chance of entering surface water.
   - **C.** Put on the appropriate PPE before responding to the spill.

CHAPTER 10

PLANNING THE PESTICIDE APPLICATION

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Explain how to select appropriate pesticides and additives (if needed).
- Follow all label instructions and other legal restrictions pertaining to a pesticide application.
- Determine whether two or more pesticides may be tank-mixed.
- Follow the label for safe mixing and loading.
- Describe how to prevent pesticide contamination of water sources during mixing, loading, and cleaning.
- List what personal protective equipment to wear during mixing, loading, and cleaning.
- Explain how to open pesticide containers and transfer the contents safely.
- Measure pesticides accurately using proper utensils and devices.
- Discuss how to rinse and dispose of pesticide containers properly.
- State some basic procedures that ensure the correct application of pesticides.
- Describe how to clean and properly store application equipment after use.
- Explain the basics of professionalism for pesticide applicators.



Planning is essential before beginning a pesticide application. To help plan, you should know how to:

- Select the right pesticide for the job.
- Review the label.
- Test for pesticide compatibility before mixing.
- Choose what personal protective equipment to wear.
- Transfer pesticides safely.
- Clean up after an application.

Careful planning and consideration of all details is the hallmark of professionalism.

SELECTING THE PESTICIDE



Always read the label before applying the pesticide.

Choosing the right pesticide for your particular situation is critical to determine whether the pesticide can be used safely under the application conditions. You also need to determine how much product is required for the area you are treating.

Before purchasing or applying the pesticide, read the label to determine:

- The safety measures to follow.
- Where you can legally use it (i.e., target sites).
- When to apply it (considering factors such as the life cycle of the pest, weather conditions, preharvest and/or grazing interval, and the rotational or replanting interval).
- How to apply it (e.g., selecting and setting up equipment; following label directions).
- If there are any special use restrictions (e.g., restricted-entry intervals or prohibitions against certain types of application methods or equipment).
- Whether there are other restrictions (e.g., environmental conditions, setbacks or buffers, and drift warnings).

Some labels require you to add an adjuvant (or additive) to the spray mixture to improve mixing or application, or to enhance pesticidal performance. See Chapter 4 (Pesticide Formulations) for a more detailed discussion of spray adjuvants.

REVIEWING THE PESTICIDE LABEL

As you learned in Chapter 3 (Pesticide Labeling), it is important to review the label carefully and to apply the pesticide as directed on the product label. The "Directions for Use" section lists the various crops, animals, or sites on which you may legally use the pesticide. Under this subheading, the label lists the target pests, application rates, spray quality (droplet size) specifications, and general application methods. You should also consult the label on sprayer cleanout as well as proper storage and disposal of the pesticide and empty containers.

DETERMINING PESTICIDE COMPATIBILITY

As discussed in Chapter 4, tank mixing two or more pesticides saves time and labor. In some cases, however, it can impair the effectiveness of one or more of the products. For this reason, you should determine the compatibility of your products before mixing them.

Pesticides are **compatible** when they can be mixed and applied in combination without reducing the effectiveness or changing the physical and chemical properties of the mixture. When problems develop from mixing two or more products together, the chemicals are **incompatible**. There are two main types of incompatibility: physical and chemical.

Physical incompatibility is the failure of pesticide products to stay uniformly mixed in the spray tank. Physical incompatibility may result in a putty or paste formation, a separation into layers, or a mixture that looks like cottage cheese (precipitates). This mixture may clog screens and nozzles and will not control target pests.

Physical incompatibility may be caused by:

- Improper mixing procedures.

- Inadequate agitation.
- Lack of stable emulsifiers in some emulsifiable concentrates.
- Mixing with liquid fertilizers.
- Mixing pesticides with hard water (a pH greater than 7).



Physical incompatibility results in an unsprayable mixture, in this case, excessive foaming.

Chemical incompatibility occurs when mixing certain pesticides in the spray tank alters the activity of one or more of them. In other words, a chemical reaction takes place and produces new substances. Clues indicating chemical incompatibility may include heat, a color change, the formation of a gas or a precipitate, the appearance of surface scum or foam, or the formation of gel or "sludge." The resulting mixture is different from the products applied separately. There are two types of chemical incompatibility. In the first type, the pesticidal activity of at least one of the components is reduced when two or more products are mixed. In the second type, the activity of two or more products applied together may be greater than if each pesticide were applied separately. This added effectiveness may weaken the selective nature of the individual products and damage target plants.

Some pesticide product labels list pesticides (and other chemicals) known to be compatible with that formulation. Many have very helpful tank-mixing instructions. If you cannot find information about tank mixing on one or more products you wish to combine, do a "jar test" (see below) with a small amount of the mixture before you mix a large quantity.

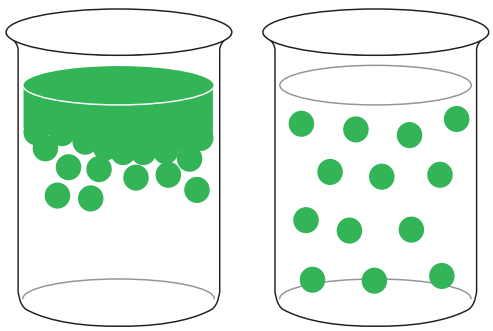
Remember, it is illegal to mix pesticides with other products (e.g., other pesticides, adjuvants, or carriers) when such mixtures are expressly prohibited on the label. Also, if a tank mix contains a pesticide that has a higher toxicity level (e.g., DANGER) than the other pesticides (e.g., WARNING or CAUTION), treat the entire mixture according to the more restrictive signal word (e.g., as a DANGER pesticide). You must use the required safety equipment and follow all other label requirements found on the label with the greatest restrictions.



In this case of chemical incompatibility, mixing pesticides reduced their effectiveness, allowing weeds to grow along with the corn.

Conducting a Compatibility Test

To conduct a jar (compatibility) test, use a small glass or plastic container. Mix proportionate amounts of all the carrier and products you intend to combine in the spray tank. Start by filling the jar one-fifth to one-half full with the carrier (water or liquid fertilizer). Then add proportionate amounts of each product, one at a time, in the order suggested under "Making Tank Mixes" (below). Shake the jar thoroughly after each product is added. Allow the mixture to stand for 10 to 15 minutes. If flakes, sludge, gel, precipitates, or other solids form; the products



A jar test indicates whether two or more pesticides can be safely mixed.

Adapted from *The Safe and Effective Use of Pesticides*, University of California

separate into layers; or heat is given off, the products cannot be safely tank-mixed. Adding compatibility agents may improve the mixing of the ingredients. Certain kits can help you test for compatibility. There are also online sources as well as smartphone apps to help you determine the proper mixing order for various tank mix components.

Making Tank Mixes

To minimize compatibility problems with tank mixes, follow correct mixing procedures (see inset). Add and thoroughly mix the products, one at a time, beginning with those hardest to mix.

To ensure thorough mixing of dry formulations before adding them to the mixture, make a preslurry—mix the products with a little water to form a paste before adding them to the tank mix. To be certain you have a uniform spray mixture at all times, keep the mixture agitated during the entire application until the tank is empty.

Tank Mixing Order

1. Fill tank one-fifth to one-half full with carrier (e.g., water or liquid fertilizer). Start agitation.
2. Add compatibility agent (if needed).
3. Add suspension products: first, dry formulations—wettable powders (WP), dry flowables (DF), water-dispersible granules (WDG) (as a preslurry, if necessary), then liquids—flowables (F), liquids (L), microencapsulated (ME).
4. Add solution products—solutions (S), soluble powders (SP).
5. Add surfactants or other adjuvants (if needed).
6. Last, add emulsion products—emulsifiable concentrates (EC).

FOLLOWING SAFE MIXING AND LOADING PRACTICES

People who mix and load concentrated pesticides have an especially high risk of accidental exposure and poisoning. Observe the following precautions to reduce the risks involved with this part of the job.



Observe all precautions when mixing and loading pesticides.



Locate the pesticide mixing and loading site outdoors or in a well ventilated area.

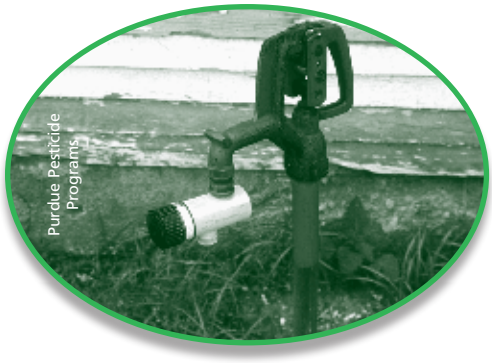
Select an Appropriate Mixing and Loading Area

Locate the pesticide mixing and loading area in a well-ventilated (if indoors), well-lighted place away from people, animals, food, and other items that might be contaminated.

Protect Water Sources

Ensure that no tank mixture can back-siphon into a water source. When filling a mix tank using a water pipe or hose, place the pipe or hose end well above the surface of the pesticide mixture, leaving a distinct air gap between the two. If water is pumped directly from the source into a mix tank, use a check valve, anti-siphoning device, or backflow preventer to prevent back-siphoning if the pump fails. The backflow preventer has a mechanism that automatically closes if a drop or loss of water pressure occurs. Check valves are crucial for **chemigation** and similar systems where pesticides are injected into irrigation water.

Mix pesticides in areas where any spills, leaks, and overflows cannot flow toward a drain or into water sources. If using a permanent mixing and loading site, use a containment pad (see Chapter 11, Pesticide Application Procedures). When possible, mix and load the pesticides at the application site. Be careful not to use the same site repeatedly, and do not contaminate any water sources.



Use a backflow device when water is pumped directly from the source.



Leave a distinct air gap between the hose and the surface of the pesticide mixture to prevent back-siphoning.

Use Personal Protective Equipment

Be sure to wear appropriate personal protective equipment (PPE) when handling pesticide containers, even before opening them. Pesticide handlers must wear all of the PPE that the pesticide labeling requires. This may include:

- **Body protection**—Wear a bib-top apron made of butyl, nitrile, or foil-laminate material in case you get splashed while mixing and loading or come in direct contact with contaminated equipment. The style that includes built-in gloves and sleeves is especially protective.
- **Face protection**—Wear a face shield to keep splashes and dusts off your face, nose, and mouth while pouring liquid pesticides or adding dry pesticides to a liquid.
- **Respiratory protection**—Wear the appropriate respirator when handling pesticides. Choose one with the National Institute for Occupational Safety and Health (NIOSH) code given on the pesticide product label.
- **Eye protection**—Wear shielded safety glasses, goggles, or a face shield to protect your eyes.

Open Containers Carefully

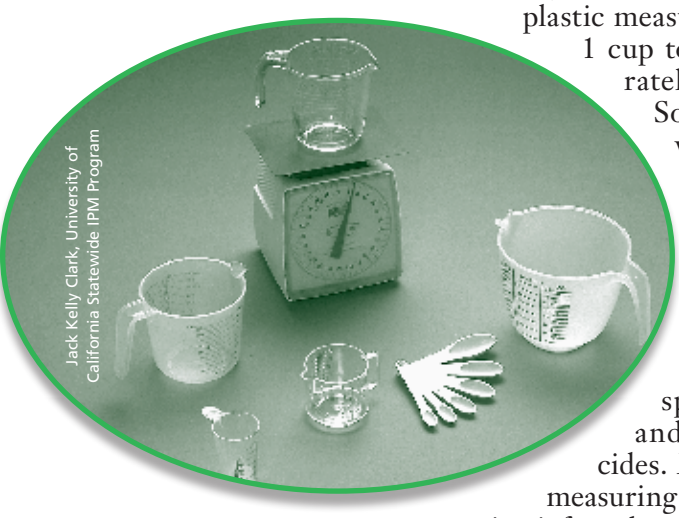
Do not tear open paper or cardboard containers. Use a sharp knife or scissors. This reduces the danger of spilling and makes bags easier to close after use. Clean the knife or scissors afterward, and do not use them for other purposes. To prevent spills, close containers after each use even if you plan to mix more of the same pesticide.



Use a sharp knife to open pesticide bags and wear appropriate PPE.

Measure Accurately

Liquids and some granular pesticides are measured by volume; dusts, powders, and most dry formulations are measured by weight. Pesticide labels use the English system of measurement (i.e., fluid ounces, pints, quarts, and gallons for liquids; pounds and ounces for dry materials). Use an assortment of glass or plastic measuring utensils, from 1 cup to 1 gallon, to accurately measure liquids. Some pesticides react with metal—especially aluminum and iron—so avoid using metal measuring utensils. Use an accurate scale and a set of measuring cups and spoons to measure and weigh dry pesticides. Mark each pesticide measuring item clearly to avoid using it for other purposes. To prevent accidental poisonings, paint handles with brightly colored waterproof paint or attach waterproof warning labels. After each use, clean and wash utensils before storing them to prevent contaminating future mixtures. When you are not using them, keep all measuring and weighing equipment and utensils locked in the pesticide storage area.


Jack Kelly Clark, University of California Statewide IPM Program

Accurately measure pesticides.


Virginia Tech Pesticide Programs

When transferring wettable powders, dusts, or other dry formulations, avoid inhalation of dusts.

Transfer Pesticides Carefully

After measuring or weighing the correct amount of pesticide, carefully add it to the partially filled spray tank. When pouring, keep the container and pesticide below face level. If there is a breeze outdoors or strong air current indoors, stand so the pesticide cannot blow back on you. Rinse the measuring container thoroughly and pour the rinsate into the spray tank. Use caution while rinsing to prevent splashing. Never leave the spray tank unattended while it is being filled.

When transferring wettable powders, dusts, or other dry formulations, avoid spillage and inhalation of dusts.

CLEANING AND DISPOSING OF PESTICIDE CONTAINERS



Adapted from Penn State *Pesticide Education Manual*

Triple-rinse containers.

Follow the container-handling instructions on the pesticide label. The instructions will tell you how to clean and dispose of an empty container. Not all containers must be **triple-rinsed** or **pressure-rinsed**. If rinsing is required, follow the directions on the label and rinse immediately after emptying the container. Otherwise, residues may become difficult to remove if allowed to dry. If possible, add the rinsate to the next application.

Do not leave pesticide containers unattended at a mixing, loading, or application site—return them to a secured storage area until they can be recycled or disposed of properly. Clearly mark and safely store them. Follow the label directions on what to do with an empty container.

If a pesticide label says it is a "refillable" container, it will have instructions to return the container to the pesticide dealer or manufacturer for refilling. Never tamper with a container designed to be returned and refilled. If it is a "nonrefillable" container, the label will tell you whether you can recycle, recondition, or dispose of the container and the manner of disposal. Never reuse pesticide containers. If recycling is an

option, check with your state, tribe, or territory pesticide regulatory agency or the Ag Container Recycling Council (www.acrecycle.org or 877-952-2272) to locate a pesticide container recycling program.

Container Rinsing Procedures

For small containers 5 gallons or less, triple rinse as follows: Empty the remaining contents into application equipment or a mix tank (drain for 10 seconds after the flow begins to drip). Fill the container one quarter full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

For containers too large to shake (i.e., with capacities more than 5 gallons or 50 pounds), triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container one-quarter full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, making at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times.

For bags or liners: Completely empty bag or liner by shaking and tapping sides and bottom to loosen clinging particles. Empty residue into application equipment or a mix tank or store for later use or disposal.

To pressure rinse containers: Empty the remaining contents into application equipment or a mix tank (drain for 10 seconds after the flow begins to drip). Hold container upside down over application equipment or a mix tank or collect rinsate for later use or disposal. Insert pressure-rinsing nozzle in the side of the container and rinse at about 40 pounds per square inch for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.


Larry Schulze, University of Nebraska

A pesticide container recycling center.


Purdue Pesticide Programs

Pressure rinsing directs high-pressure water into the container.

APPLYING PESTICIDES CORRECTLY

Applicators have many important responsibilities when applying pesticides: protecting themselves, others, and the environment and making sure the pesticide is applied correctly. This means using proper PPE and following correct application procedures.

Personal Protective Equipment

By law, applicators must wear the PPE and other clothing the pesticide labeling requires. Consider using additional protection for some types of pesticide application tasks.

Hand-Carried and Backpack Applications

Exposure is quite likely when applying pesticides using hand-held equipment or dust shakers. Dripping or partially clogged nozzles, leaky hoses, and loose equipment connections are other potential sources of exposure.

Many applications performed on foot cause the applicator to walk


M.J. Weaver, Virginia Tech Pesticide Programs

Wear appropriate protective PPE whenever you must walk into the path of a pesticide application.

into the path of the pesticide being applied. Whenever possible, apply pesticides so you are backing out of the treated area. If you must walk into the path of the pesticide, consider wearing shin-high or knee-high rubber boots (or other protective footwear) with spray-resistant or waterproof pants. Wear appropriate protective clothing and equipment when entering treated areas to fix clogged nozzles or other malfunctioning equipment parts.

High-Exposure Applications

Certain types of pesticide applications are especially risky because they may expose the applicator to large amounts of pesticide. These include:

- Mist blower or air-blast sprayers.
- Aerosol and fog generators.
- High-pressure sprayers and power dusters.
- Equipment that directs applications overhead, such as to tree canopies or roof eaves.


Tom Bowman, Virginia Tech Pesticide Programs

In high-pressure spray applications, consider wearing more PPE than the label has listed.

Pesticide exposure is likely whenever you are working in these situations. For high-exposure applications, use appropriate gloves, protective coveralls with a hood, footwear with sealed cuffs, and a full-face respirator or half-face respirator with sealed goggles.

Pesticides are sometimes applied in enclosed spaces, such as warehouses, factories, restaurants, and homes; railcars; ship and truck cargo areas; silos, elevators, and other grain storage areas; and greenhouses. This increases the risk of inhalation and dermal exposure. Wear an approved respirator and additional protective clothing, even if you would not need them for the same application outdoors.

Application Procedures

To ensure that pesticides are being applied properly, follow these basic procedures:

1. Before applying a pesticide, clear all people and pets from the area. Remove toys and pet dishes from the application area and cover garden furniture, swimming pools, and birdbaths. Even for narrowly directed pesticide applications (such as crack-and-crevice treatments), keep people and animals out of the immediate area during the application. Check the pesticide label to find out when it is safe to return to the application area. If the label does not include specific restricted-entry statements, keep people and nontarget animals out of the treated area until the spray has dried or the dust has settled.

2. Ensure that the pesticide is reaching the target surface or area. Be sure to remove granules from sidewalks and other nontarget areas.

3. Apply the pesticide evenly and in the correct amounts. Do not allow liquid pesticides to form puddles or dry pesticides to pile up in the application area. Be especially careful in places where you turn or pause your equipment. You may have to shut off your equipment in these areas. After applying the

pesticide to the first part of the target site, check to be sure the right amount of pesticide has been used.

4. Ensure that the pesticide maintains a uniform mix or appearance during the application. Several pesticide formulations mixed with liquid require agitation to remain in suspension. Granules and dusts should appear dry and not form clumps on the target site.

5. Check hoses, valves, nozzles, hoppers, and other equipment parts often during the application.

6. Turn spray equipment off when you pause for any reason. Agitation must be maintained if the spray mix is a suspension of particles (such as wettable powders, flowables, or dry flowable formulations). Whenever you stop an application, depressurize spray tanks. Turn off the main pressure valve on the tank and release the pressure remaining at the nozzles.

7. Check the label for any postapplication requirements, such as incorporating the pesticide into the soil.

CLEANING UP AFTER MIXING, LOADING, AND APPLICATION

After mixing, loading, or applying a pesticide, clean the pesticide equipment and yourself thoroughly. While the facts are still fresh in your mind, record all information about the application to comply with pesticide recordkeeping laws.

Do not leave equipment containing pesticides at the mixing and loading or application sites. Avoid washing equipment repeatedly in the same location unless you use a containment pad or tray.

Instruct everyone who cleans pesticide-contaminated equipment on proper safety procedures. Equipment cleaning presents as great a risk of pesticide exposure as do many other pesticide-handling tasks. When cleaning pesticide-contaminated equipment, wear the same PPE that the labeling requires for making applications, plus a chemical-resistant apron or other appropriate protective equipment. Consider wearing eye protection even if not required by the label.

Cleaning Procedures

After the equipment is empty, clean both inside and outside thoroughly, including nozzles or hopper openings. Certain pesticides (e.g., petroleum-based products) use a carrier that may require special cleaning agents or high water pressure to get the equipment clean.

Rinsates

Rinsates from equipment that has been cleaned contain pesticides and can harm people and the environment. Do not allow rinsates to flow into water systems, including sink or floor drains, storm sewers, wells, streams, lakes, or rivers. If possible, rinse your equipment at the application site. Also, collect and apply rinsates to labeled sites at or below label rates.

Equipment rinsate may also be used as a diluent for future pesticide mixtures provided the:

- Pesticide in the rinsate is labeled for use on the target site where the new mixture will be applied.
- Amount of pesticide in the rinsate plus the amount of pesticide product in the new mixture does not exceed the label rate for the target site.
- Rinsate is used to dilute a mixture containing the same or a compatible pesticide.

Collect rinsate and apply to a labeled site at or below labeled rates.

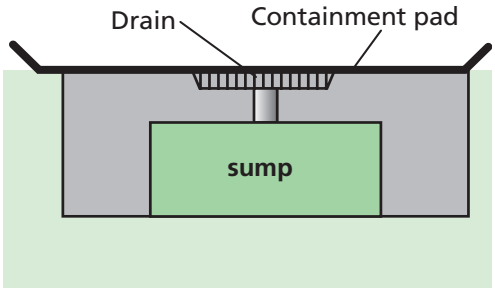


Be sure to wear appropriate PPE when cleaning application equipment.

Rinsate may not be added to a pesticide mixture if it:

- Contains strong cleaning agents (such as bleach or ammonia) that might harm the plant, animal, or surface to which the pesticide will be applied.
- Would alter the pesticide mixture and make it unusable; for example, if the pesticides are physically or chemically incompatible.

If rinsates cannot be used, dispose of them according to the label as you would waste pesticides.



A mixing and washing pad may require a sump that can be pumped out to collect rinsate after each use.

Equipment Cleanup

Clean your equipment thoroughly after each use or when changing chemicals. Pesticide residues can corrode metal, plug hoses, or damage pumps and valves unless removed immediately after use. Sometimes residues react with pesticides used later, reducing the effectiveness of the pesticides. Special tank-cleaning nozzles are available to clean the interior walls of spray tanks.

For all application scenarios, make sure the entire spray system is cleaned, not just the tank. This is especially true for commercial row-crop boom sprayers. Besides the spray tank, problem spots for pesticide contamination include the **eductor** (sometimes called an inductor); plumbing, which includes valves and hoses; filters and screens; boom segments; nozzle bodies; and nozzles and screens. When possible, thoroughly rinse equipment with a strong water-detergent solution (8 to 16 ounces of detergent in 30 to 40 gallons of water). Allow the water-detergent solution to circulate through the system for several minutes. Remove the nozzles and screens, then flush the sprayer system twice with clean water. Some pesticide labels may require triple rinsing to rid the spray system of any possible pesticide contamination. Regardless of how the spray system is cleaned, make sure all visible deposits are removed.

Sloppy cleanup practices are one of the main causes of equipment failure or malfunction. Pesticides allowed to dry in the application equipment tend to clump and stick and cannot be easily removed. These deposits may eventually dissolve into the spray solution. Thus, improper cleanout may lead to contamination of tank mixes and damage to susceptible crops.

Several commercial compounds will aid in tank cleaning. These can neutralize and remove pesticide residues, remove mineral deposits and rust, and leave a protective film on tank walls to help prevent corrosion.

When preparing to store your sprayer, add 1 to 5 gallons of lightweight oil (depending on the size of the tank) before the final flushing. As water is pumped from the sprayer, the oil leaves a protective coating on the inside of the tank, pump, and plumbing. To prevent corrosion, remove nozzle tips and screens and store them in a can of light oil, such as diesel fuel or kerosene. In addition, add a small amount of oil and rotate the pump four or five revolutions by hand to coat interior surfaces completely.

It may be necessary to winterize the spray system to prevent damage from freezing temperatures. Be sure to either drain all water from the spray system or replace the water in the pump and other critical parts with an antifreeze material (RV antifreeze is commonly used).

After thoroughly cleaning and draining the equipment, store it in a dry, clean building. Replace worn-out, deteriorated, or broken parts. If you store the sprayer outside, remove the hoses, wipe them clean of oil, and store

them inside where they will not become damaged. When using trailer sprayers, you may want to put blocks under the frame or axle to reduce tire pressure during storage.

As with any pesticide-related procedure, remove contaminated clothes and take a shower immediately after cleaning equipment. Waiting until the end of the day to clean up may allow additional absorption of the pesticide through the skin. See Chapter 6 (Personal Protective Equipment) for detailed information on how to clean pesticide-contaminated clothing.



Take a shower immediately after using pesticides.

PROFESSIONALISM

As a pesticide applicator, you do important work and provide valuable services. These services include:

- Producing a safe and plentiful food and fiber supply.
- Protecting public health from vector-borne diseases.
- Creating value for property owners through their landscapes and structures.
- Protecting land and water ecosystems from invasive species.
- Enhancing the public's quality of life through parks and other recreation venues.
- Creating safe roadways and other rights-of-way.

So far, this manual has provided you with information on how to safely, properly, and effectively manage pests and use application equipment. Another consideration is your professionalism as a pesticide applicator.

What you do and how well you handle yourself while on the job will leave an impression on others. These expectations of conduct and your actions in specific situations create your professional image, best summed up as "professionalism."

What Is Professionalism?

Merriam-Webster defines professionalism as "*the skill, good judgment, and polite behavior that is expected from a person who is trained to do a job well.*" The heart of professionalism for a pesticide applicator is exercising good judgment when there are no clear-cut right or wrong options. Professionalism includes fair treatment of customers, respect for others, and being an asset to your community.

While regulatory compliance is necessary, you as an applicator or a supervisor will need the expertise and good judgment to make decisions on issues affecting security, safety, health, or the environment not addressed by regulations or the pesticide label. You should:

- Study this manual to help you acquire the basic knowledge needed to educate your customers and others who are concerned about pesticides.
- Educate others about the work you do.
- Know how to minimize risks to yourself, coworkers, the public, and the environment.
- Learn how to communicate the benefits and risks of pesticide use with your customers, coworkers, and the public.

The impression you make on others depends on your ability to answer questions from customers, neighbors, and others about the work you do.

Demonstrate Professional Ethical Standards

A professional demonstrates ethical behavior in all aspects of his or her work. This means not taking shortcuts that may harm your customers, the public, or the environment. Offer honest and knowledgeable advice, keeping in mind the best interests of

others. Integrated pest management is also part of your professional training because it helps you make sound pest management decisions, apply pesticides only when needed, and protect sensitive sites from harm.

Communicate with Customers, Neighbors, and the Public

Being a professional involves knowing the correct terminology when discussing your work and communicating with others. When speaking with the public, it is better to use simple, direct language than to use technical jargon. Be proactive and reach out to neighbors, customers, and others who may have concerns about a nearby sensitive site where you are applying pesticides. Inform others that you are a professionally certified and trained pesticide applicator. Explain what that means because many people will not know. Be familiar with your company or organization policy for talking to customers, neighbors, or the media.

Keep accurate records of all your pesticide applications. Good records provide the facts of what you did and demonstrate your care in the work you do. If there is a complaint or legal action following an application, having good records may be your most valuable defense. Having no or insufficient records makes you vulnerable to baseless accusations and additional scrutiny.

In a nutshell, being an effective pesticide applicator is more than just the skills and knowledge needed to conduct an application. It also requires good judgment, polite behavior, and a professional demeanor.

SUMMARY

Applying pesticides correctly requires careful planning, especially when making tank mixes. Pesticide labels do not always specify whether products can be tank-mixed. Therefore, applicators must know how to conduct a compatibility test to determine which products can be safely mixed.

Safe mixing and loading practices include selecting an appropriate mixing and loading area, protecting water sources, and using appropriate PPE. Rinsable containers must be triple- or pressure-rinsed, properly disposed of, or recycled. Empty nonrinsable containers as completely as possible before disposing of, recycling, or refilling them.

When applying pesticides, protect yourself and the environment by wearing appropriate PPE and removing all people and pets (nontarget organisms) from the area to be treated.

After mixing, loading, and applying pesticides, be sure to clean equipment and yourself properly. If possible, reuse application equipment rinsates as a diluent in a spray mixture containing the same or a compatible pesticide. Apply the rinsates to a labeled site at or below the label rate.

Review Questions

CHAPTER 10: Planning the Pesticide Application

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Determining *when* to apply a pesticide includes considering the:**
   - **A.** Life cycle of the pest and weather conditions.
   - **B.** Percent active ingredient.
   - **C.** Need for additives or adjuvants.

2. **The "Directions for Use" section of a pesticide label indicates the:**
   - **A.** Various crops or areas on which the pesticide may be legally used.
   - **B.** Disposal of pesticide waste.
   - **C.** Environmental, physical, and chemical hazards.

3. **When two or more pesticides mixed together form a putty or paste, separate into layers, or look like cottage cheese, it is an example of:**
   - **A.** Limited agitation.
   - **B.** Chemical incompatibility.
   - **C.** Physical incompatibility.

4. **After filling a tank one-fifth to one-half full with carrier, what is the usual order for tank mixing the remaining products?**
   - **A.** Add suspension products, add emulsion products, add solution products, add surfactants (if needed), add compatibility agent (if needed).
   - **B.** Add compatibility agent (if needed), add suspension products, add solution products, add surfactants (if needed), add emulsion products.
   - **C.** Add surfactants (if needed), add suspension products, add emulsion products, add solution products, add compatibility agent (if needed).

5. **Which statement about the proper technique for opening pesticide containers is *true*?**
   - **A.** Put on the appropriate PPE after the containers have been opened.
   - **B.** Use a sharp knife or scissors to open paper or cardboard containers.
   - **C.** Leave the container open until you have finished mixing pesticides for the day.

6. **Which statement about measuring and/or transferring pesticides is *true*?**
   - **A.** Metal measuring utensils are recommended over plastic.
   - **B.** Most dusts, powders, and dry formulations are measured by volume.
   - **C.** After adding the pesticide to the partially filled spray tank, rinse the measuring container and pour the rinse solution into the tank.

7. **Which statement about cleaning and disposing of pesticide containers is *true*?**
   - **A.** Do not puncture rinsed pesticide containers.
   - **B.** Pesticide containers that cannot be recycled or returned to the manufacturer should be reused.
   - **C.** Containers must be disposed of in accordance with label directions and current regulations.

continued ▶

8. **Which statement about triple-rinsing and pressure-rinsing pesticide containers is *true*?**

   A. Triple rinsing is a more effective method than pressure rinsing.
   B. All containers must be either triple-rinsed or pressure-rinsed.
   C. Rinsate from triple rinsing or pressure rinsing may be stored for later use.

9. **Which statement about pesticide rinsates is *true*?**

   A. Rinsates may be applied to labeled target sites at or below labeled rates.
   B. Rinsates containing strong cleaning agents may be reused in pesticide mixtures.
   C. The amount of pesticide in the rinsate plus the amount of pesticide product in the new mixture may exceed the label rate for the target site.

10. **Which statement about pesticide equipment cleanup is *false*?**

    A. Sprayers should be thoroughly rinsed with a water-detergent solution for several minutes.
    B. When getting ready to store your sprayer, add some lightweight oil to the tank before the final flushing.
    C. Leftover pesticide residue in the spray tank is permitted when changing products.

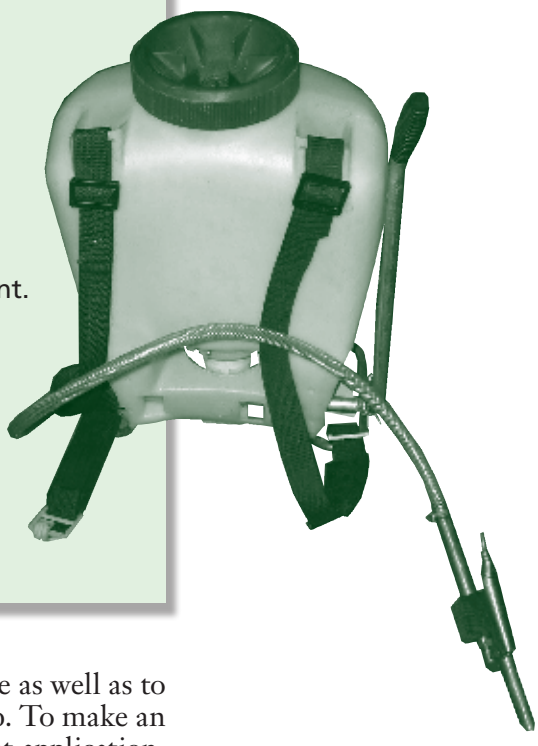
CHAPTER 11

PESTICIDE APPLICATION PROCEDURES

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

- Name several different application procedures and types of equipment.
- Discuss appropriate safety systems (e.g., closed mixing and loading, enclosed cab, and pesticide containment).
- Identify the factors (e.g., nozzles, volumes, pressures, and speeds) that affect calibration.
- Explain the importance of calibrating application equipment.
- Show how to calculate the size of the application area.
- Indicate how to determine the pesticide application rate.
- Demonstrate how to determine the amount of pesticide concentrate and diluent to use.
- Explain how to choose appropriate drift reduction practices.



Today's pest management practices require modern equipment to apply a variety of pesticides. Pesticides may be applied as sprays, dusts, granules, gases (vapors), fogs, baits, rubs, or dips. The vast array of application equipment must be matched to the pesticide as well as to the size and type of the job. To make an effective, safe, and efficient application, ***read the label first***. In addition, you must properly select, operate, calibrate, and maintain your equipment.

APPLICATION METHODS

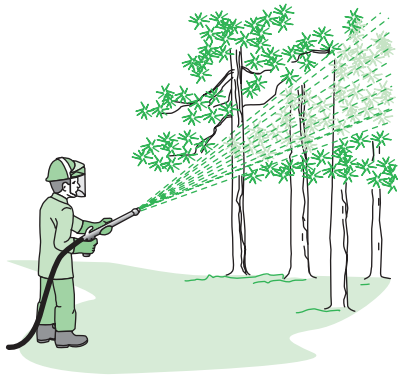
The pesticide application method you choose depends on the nature and habits of the target pest, characteristics of the target site, properties of the pesticide, suitability of the application equipment, and cost and efficiency of alternative methods. Your choice is often predetermined by one or more of these factors. The following are some common application methods:



Broadcast application



Crack and crevice application



Foliar application

- **Band application**—applying a pesticide in parallel strips or bands, such as between or over rows of crops.
- **Basal application**—directing herbicides to the lower portions of brush or small trees.
- **Broadcast application**—uniformly applying a pesticide to an entire area or field.
- **Crack-and-crevice application**—placing small amounts of pesticide into cracks and crevices in buildings, such as along baseboards and in cabinets.
- **Directed-spray application**—specifically targeting pests to minimize pesticide contact with nontarget plants and animals.
- **Foliar application**—directing pesticide to the leafy portions of a plant.
- **Rope-wick or wiper treatments**—releasing pesticides onto a device that is wiped onto weeds taller than the crop, or wiped selectively onto individual weeds in an ornamental planting bed.
- **Soil application**—placing pesticide directly on or in the soil instead of on a growing plant.
- **Soil incorporation**—using tillage, rainfall, or irrigation equipment to move pesticide into the soil.
- **Soil injection**—applying a pesticide under pressure beneath the soil surface.
- **Space treatment**—applying a pesticide in an enclosed area.
- **Spot treatment**—applying a pesticide to small, distinct areas.
- **Tree injection**—applying pesticides under the bark of trees.

SAFETY SYSTEMS

Closed mixing and loading systems, enclosed application systems (e.g., enclosed cabs), and pesticide containment systems are excellent investments if you use large quantities of pesticides or the kind that is very hazardous to humans or to the environment.

Closed Mixing and Loading Systems

Closed mixing and loading systems are designed to prevent pesticides from contacting handlers or other persons during mixing and loading. Sometimes the label of pesticides with a high risk of causing human health effects may require the use of a closed mixing and loading system.

There are two primary types of closed mixing and loading systems. One type uses mechanical devices to deliver the pesticide from the container to the equipment. The other type uses water-soluble packaging.

Closed systems...

- Increase handler safety.
- Reduce the need for some personal protective equipment.
- Decrease the occurrence of spills.
- Provide a more accurate measurement of pesticide concentrate, which reduces overdosing or underdosing.



Jack Kelly Clark, Univ. of California Statewide IPM Program

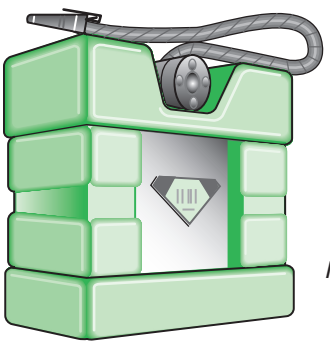
A closed loading system.

Mechanical Systems

Mechanical systems often consist of a series of interconnected equipment parts that allow for the safe removal of a pesticide concentrate from its original container, either by gravity or by suction. These systems minimize exposure when rinsing the empty container and transferring the pesticide and rinsate to the application equipment.

Mechanical systems are often custom-made with components from several commercial sources. These systems are available for containers as small as 2.5 gallons. Because pesticide container openings vary in shape and size, no single closed system can be used with all containers.

A mechanical loading system is often used with **minibulk containers**. These containers range in volume from 40 to 330 gallons and are adapted to closed systems. Typically, pump-and-drive units deliver the product. A meter allows accurate measuring from the minibulk tank to the sprayer. Minibulks usually must be returned to the dealer for refilling. This process eliminates the need to triple rinse or pressure rinse multiple small containers and reduces the volume of used plastic containers.



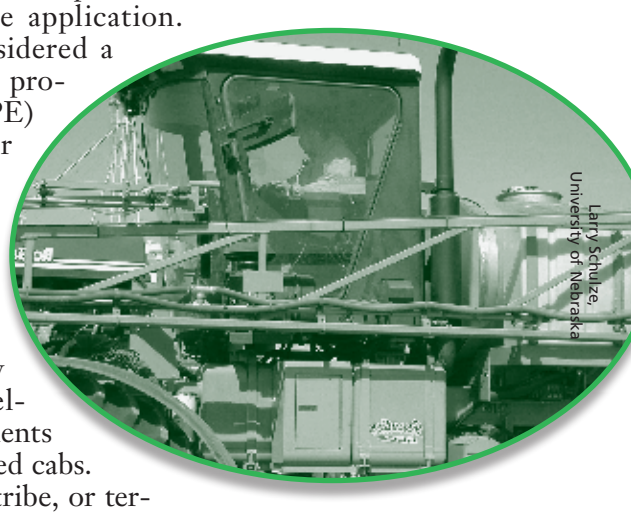
Mini-bulk tank.

Water-Soluble Packaging

Water-soluble bags are a simple type of closed mixing and loading system. The premeasured pesticide is contained inside a water-soluble bag or packet. The pesticide bag is placed unopened into the water or fertilizer in the mixing tank. Few manufacturers, however, provide water-soluble bags for small-volume applications. There must be ample time during mixing to allow for the bags to dissolve.

Enclosed Cabs

An **enclosed cab** (such as a tractor cab, cockpit, or truck/vehicle cab) surrounds the occupant(s) and may prevent pesticide exposure as long as the doors, hatches, and windows are kept closed at all times during the application. Enclosed cabs are considered a supplement to personal protective equipment (PPE)—not a replacement for it. So, you must wear all PPE specified on the label while working inside the enclosed cab. However, the labeling of some agricultural use pesticides may allow exceptions to the label-specified PPE requirements for applicators in enclosed cabs. Check with your state, tribe, or territory pesticide regulatory agency for any other requirements regarding PPE and enclosed cabs. Remember, outside surfaces of the application equipment and cab are contaminated. Be sure to wear appropriate PPE when getting in and out of the cab or performing routine equipment maintenance.

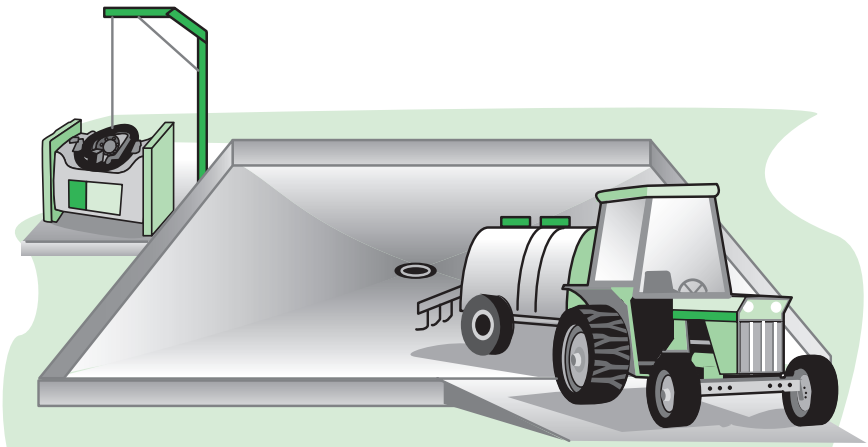


Larry Schulze, University of Nebraska

Enclosed cabs are considered a supplement to PPE, not a replacement for it.

Pesticide Containment Systems

If you often use the same location to mix and load pesticides or clean equipment, you may have to install a **pesticide containment pad**. Check U.S. Environmental Protection Agency and state, tribe, or territory regulations to determine when a containment pad is required. Keep spray tanks containing pesticides on a pad. These pads are



A mixing and loading pad.

designed to contain spills, leaks, overflows, and wastewater for reuse by the applicator or disposal by a commercial waste management contractor. They make it easier to clean up spills and help prevent environmental contamination.

Use a permanently installed containment pad to mix, load, and clean equipment and in areas where large quantities of pesticides are handled or stored. Generally, the containment pad must be made of impermeable material. It should be concave or have curbs, berms, or walls high enough to hold the largest amount of spill, leak, or equipment wash water likely to occur at the site. It also must be equipped with a system to remove and recover spilled, leaked, or released material by either an automatic sump system or a manually operated pump. Smaller, portable pads and lightweight trays made of heavy-duty plastic may be used when mixing and loading at the application site. Again, check regulations for containment pad design requirements.

APPLICATION EQUIPMENT

The application equipment or device must be able to apply the pesticide to the intended target at the proper rate. The label specifies the legal application rate and may suggest the appropriate equipment for use with the product. Application equipment may range from an aerosol can to hand equipment to power equipment, including aircraft. The equipment may be carried, towed, or self-propelled.

Sprayers

The most common type of pesticide application equipment is the sprayer: nearly 90% of all pesticides are formulated for spraying. A **hydraulic** (liquid) **sprayer** uses water or other liquid carrier for the pesticide. However, in the case of ultra-low-volume spraying, the pesticide is either applied directly as formulated or with dramatically reduced carrier volumes. Hydraulic sprayers range from large agricultural sprayers with multiple-nozzle **booms** and power sprayers to small manual backpack and hand-held compressed-air sprayers. In all cases, pressure from either a pump or compressed gas or air is used to atomize the spray mix at the nozzle.



Larry Schulze, University of Nebraska

A hydraulic sprayer with a spray boom.



Larry Schulze, University of Nebraska

A backpack sprayer is a type of hydraulic sprayer.

Manual sprayers are designed for spot treatments and for areas unsuitable

for larger units. They are relatively inexpensive, simple to operate, maneuverable, and easy to clean and store. Adjustable spray guns are often used with these units, but some models have the option for a spray boom.

The **air-blast** (or mist) **sprayer** uses both water and air as carriers. Spray droplets are formed by the nozzles and delivered to the target by an airstream. Air-blast sprayers are typically used for disease and insect control on fruit trees, vineyards, vegetables, and Christmas trees.



M.J. Weaver, Virginia Tech Pesticide Programs

An air blast sprayer uses both water and air as carriers.

Sprayer Components

Because sprayers use water or other liquids to dilute and carry a pesticide, a tank is necessary to contain the spray mix. Choose a tank made of or coated with a material that does not corrode and can be easily cleaned. Corrosion and dirt clog screens and nozzles and increase wear on the equipment. Large tanks require an opening in the bottom to aid in cleaning and draining. A large top opening is useful for filling, cleaning, and inspecting the tank. The opening must have a watertight cover to prevent spillage. A tank agitation system/device is useful for most sprayable formulations, especially for wettable powders or dry flowables. Constant mixing of a pesticide and liquid carrier produces a uniform spray mixture (suspension or solution), resulting in an even application of the chemical.

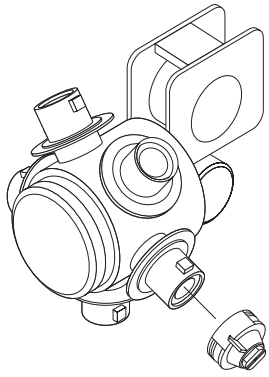
Sprayers use a pump to produce the flow of spray material to the nozzles and for agitation. The pump parts must resist corrosion and be abrasion-resistant, especially when wettable powders or other abrasive formulations are used. Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. You may damage the pump if it is operated dry or with a restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and to prevent overheating.

Nozzles control the amount of material applied, droplet formation and size (coverage and drift), and the distribution and pattern of the droplets. A nozzle's spray pattern is made up of a wide variety of spray droplet sizes. Nozzles are classified based on the spray pattern they produce (see Figure 11.1). The size of the nozzle opening



AGCO

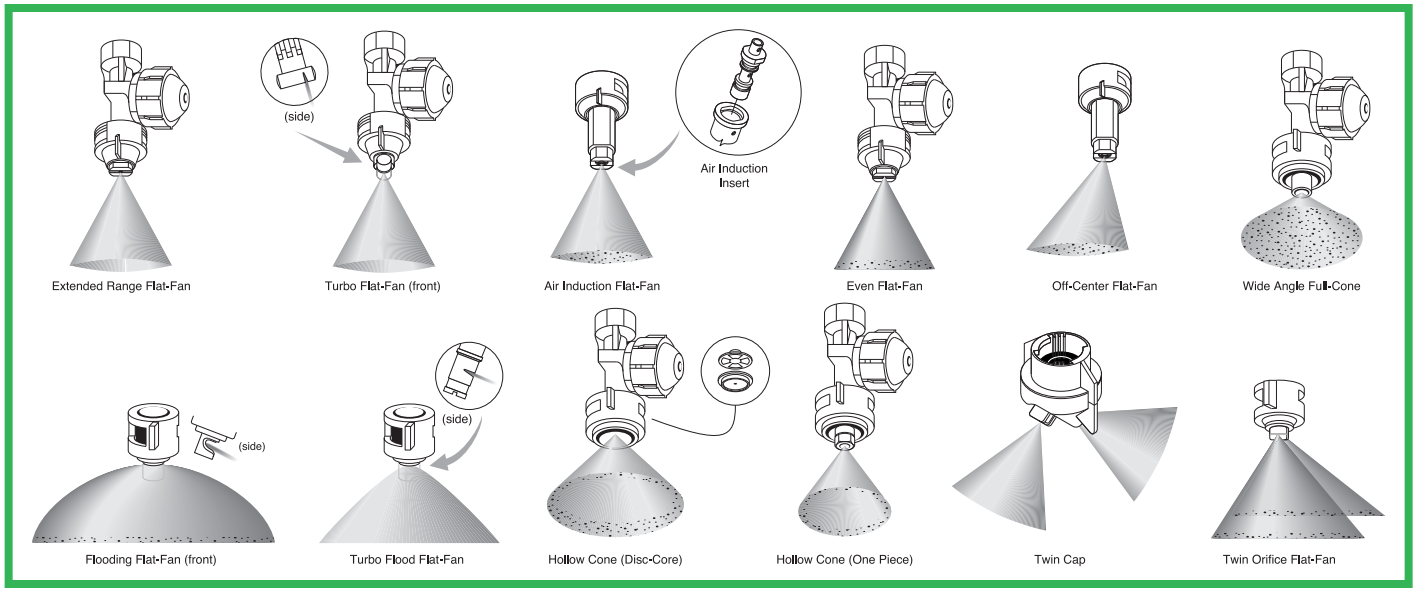
Ground sprayer.



Illinois PSEP program.

Rotating turret nozzle body with five nozzle positions. The position pointing down is the active nozzle.

Figure 11.1
Nozzle Spray Patterns



Illinois PSEP program.



Figure 11.2
A device to measure nozzle flow.

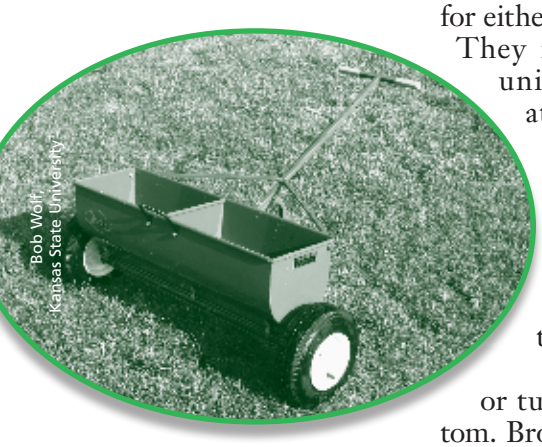
(**orifice**) affects the droplet size and flow rate. A nozzle that primarily produces larger droplets is most likely to minimize off-target drift. A nozzle that mainly produces smaller droplets will maximize surface coverage of the target. See Chapter 7 (Pesticides in the Environment) for a more detailed discussion of droplet size classification. Choose nozzles based on the target pest, type of application, coverage desired, and drift potential.

Nozzles are available in various materials: brass, aluminum, plastic, stainless steel, hardened stainless steel, and ceramic. Select the nozzle material best suited for the pesticide formulation. Never use brass or aluminum tips to apply abrasive materials (such as wettable powders and dry flowables) because they wear too fast. Since wear destroys the proper working of a nozzle, replace worn nozzles. To reduce wear, use nozzle tips made of a hard, wear-resistant material, such as plastic, hardened stainless steel, or ceramic. Also, be sure you have the correct nozzle screen size for each nozzle.

Flow meters and other devices measure nozzle flow rate and the uniformity of flow from nozzles along a boom. Figure 11.2 is a device that measures flow over time. It can be used to check nozzles for output and is also useful during calibration, particularly when sprayers are set up with multiple nozzles.



A rotary spreader.



A drop spreader.

Granular Applicators

Granular applicators are available for either band or broadcast application. They may be operated as separate units. However, they are often attached to other equipment (such as planters or cultivating equipment) to combine two or more operations. Granular applicators usually operate by gravity feed and have an adjustable opening to regulate the flow.

Band applicators use hoses or tubes with deflectors on the bottom. Broadcast applicators use a system of tubes and deflectors or a spinner to spread the granules. The application rate is affected by ground speed; granule size, shape, and density; field terrain; and even relative humidity and air temperature. When multiple band applicators are used, each individual unit must be calibrated with the specific material to be applied to ensure accurate application.

Rotary and **drop spreaders** are two common types of granular applicators. Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disk or fan. In a drop spreader, an adjustable sliding gate opens holes in the bottom of the hopper. Granules flow out by gravity feed. Drop spreaders are superior to rotary spreaders when more precise placement of the pesticide is desired.

Other Application Equipment

Additional types of application equipment include:

- Rubs, walk-through sprayers, and dipping vats to control pests on animals.
- Bait dispensers to control rodents, insects, and predators.
- Foggers for indoor pest control and for some outdoor insect control.
- Chemigation systems for greenhouses and field crops.
- Dusters for small-scale disease and insect control.



Jack Kelly Clark, University of California Statewide IPM Program

Rubs are used for applying pesticides to livestock.

EQUIPMENT CALIBRATION

Calibration is the process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area. The purpose of calibration is to ensure that your equipment is applying the correct amount of material uniformly over a given area.

Equipment is made to be adjustable. Charts or tables assist the operator in adjusting the settings. These recommended settings, however, are only approximate and may not be appropriate for all situations. Therefore, your equipment must be calibrated periodically. How often depends on the type of equipment and the frequency of use. The application rate of a sprayer is affected by travel speed, nozzle size, and sprayer pressure. Even with the widespread use of electronics to monitor and control the pesticide application, a thorough sprayer calibration procedure is essential to avoid misapplication.

Equipment can be calibrated by making a trial run on some premeasured area and measuring the output. For example, using a hand-held sprayer, spray a premeasured test area with water using the same pressure and techniques (i.e., travel speed and equipment) you would use when applying the pesticide. After spraying the test area, determine how much water was used. This volume can then be used to calculate the amount of water and pesticide needed to cover the intended application area.

When calibrating a boom sprayer, there are three variables that affect the amount of spray material applied per area of measurement (i.e., gallons per acre or gallons per 1,000 square feet):

1. Nozzle flow rate.
2. Ground speed of the sprayer.
3. Width sprayed per nozzle.

To calibrate and operate a sprayer properly, it is important to understand how each of these variables affects sprayer output. The nozzle flow rate varies according to the size of the orifice, the nozzle pressure, and the density of the spray liquid. The spray application rate varies inversely with the ground speed. Doubling the ground speed of the sprayer reduces the gallons of spray applied per acre by one-half. Likewise, doubling the effective width sprayed per nozzle decreases the applied amount by one-half.

The time invested in calibrating your equipment is time well-spent. Accurate calibration to determine the application volume under your operating conditions is important for cost, efficiency, and safety. Without properly calibrating the sprayer to deliver the correct application volume, you will not be able to apply the pesticide at the proper rate to control the pest.

Your category-specific manual will explain in detail how to calibrate your application equipment.



M.J. Weaver, Virginia Tech Pesticide Programs

Calibrating a backpack sprayer.

Why Calibrate?

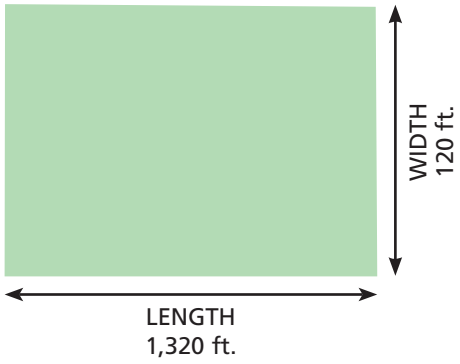
The purpose of calibration is to ensure that your equipment is applying the correct amount of pesticide material uniformly over a given area. Too little pesticide may fail to control the target pest. Too much pesticide is illegal and can result in damage to the treated plant, animal, or surface; can produce illegal residues on treated crops and animals; and can cause adverse effects to the environment and non-target organisms.

CALCULATING AREA

For precise application, you need to know the size of the area to be treated. The following examples show how to determine the size of rectangular, triangular, and circular areas.

Rectangular Areas

You want to apply a pesticide to an area that measures 1,320 feet by 120 feet. What is the area in square feet and in acres?



Area = length x width

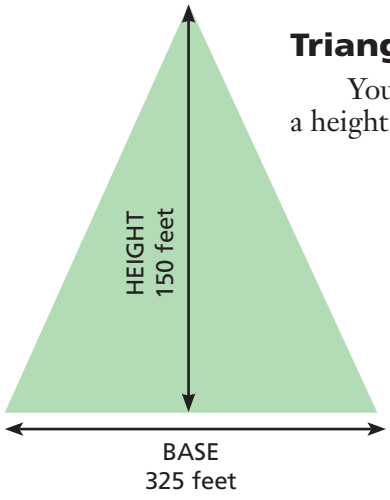
Area in square feet (sq. ft.)
1,320 ft. x 120 ft. = 158,400 sq. ft.

$$\text{Area in acres (A)} = \frac{158{,}400 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 3.6 \text{ A}$$

Note: 1 acre (A) = 43,560 sq. ft.

Triangular Areas

You are applying a pesticide to a triangular area that has a base of 325 feet and a height of 150 feet. What is the area?



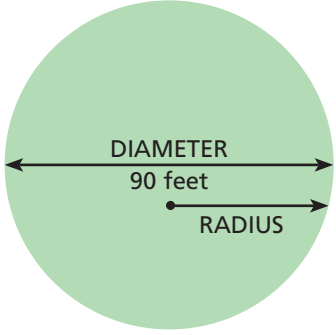
$$\textbf{Area} = \frac{\textbf{base x height}}{\textbf{2}}$$

$$\text{Area in square feet} = \frac{325 \text{ ft. x } 150 \text{ ft.}}{2} = 24{,}375 \text{ sq. ft.}$$

$$\text{Area in acres} = \frac{24{,}375 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 0.6 \text{ A}$$

Circular Areas

If you have a circular area that has a 90-foot diameter, the radius (r) is 45 ft. What is the area?



Area = $3.14r^2$

Note: 3.14 (π) is a constant.
Radius is 1/2 diameter.

Area in square feet =

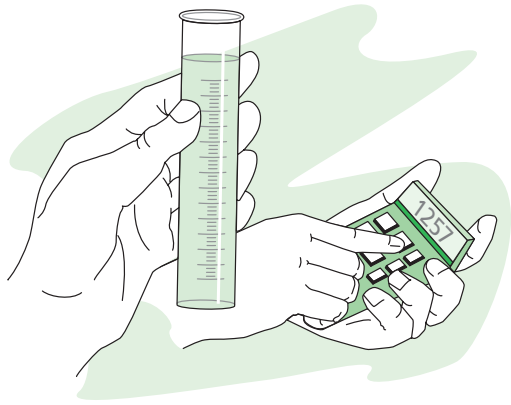
$3.14 \times 45^2 = 6{,}358.5$ sq. ft.

$$\text{Area in acres} = \frac{6{,}358.5 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 0.15 \text{ A}$$

CALCULATING THE APPLICATION RATE

Use the volume from your calibration test area to determine the amount of pesticide product and total spray mixture needed for your application area. First, convert your calibrated rate to one based on the area units found on the label. For example, assume that when you calibrated the sprayer, it delivered 2 gallons of water over a 250-square-foot test area. Your application area measures 1,000 square feet (i.e., four times the test area). Therefore, you need to use 8 gallons of spray mixture to cover 1,000 square feet (multiplying 2 gallons of water by 4).

Check the pesticide label to determine the amount of pesticide to add to the spray mixture. For example, if the label recommends adding 4 ounces of a liquid pesticide product to give a desired finished spray mixture of 1 gallon, you



Calculate the application rate and measure the amount of pesticide needed.

Calculating the Application Rate

You determined from a calibration test that your boom sprayer delivered 10 gallons of water over a one-quarter (0.25) acre test area. You need to apply a pesticide product to a 10-acre field (43,560 square feet = 1 acre). The pesticide label recommends that 4 ounces of liquid product be added to give a desired finished spray mixture of 1 gallon (there are 128 fluid ounces = 1 gallon). How much spray volume and how much product are needed?

Step 1. How much spray mixture is needed for the 10-acre application area? Always use information from the calibration test. In this example, 10 gallons of water was used over a 0.25-acre calibration test area.

$$\frac{10 \text{ gallons}}{0.25 \text{ acre}} = \frac{Y \text{ gallons}}{10 \text{ acres}}$$

Cross multiplication:

$$Y = \frac{(10 \text{ gallons} \times 10 \text{ acres})}{0.25 \text{ acre}} = 400 \text{ gallons of spray mixture needed}$$

Step. 2. How much pesticide product is needed to make up 400 gallons of spray mixture? Use the label rate of 4 oz. product per 1 gal. spray.

400 gallons spray mixture x 4 ounces of liquid pesticide product per gallon = 1,600 ounces of product needed

Step 3. How many gallons of product are needed? Remember, 128 ounces = 1 gallon.

$$\frac{1{,}600 \text{ ounces of product}}{128 \text{ ounces/gallon}} = 12.5 \text{ gallons of product}$$

Final result: To treat 10 acres, you need a total final spray mix of 400 gallons that includes 12.5 gallons of the concentrated product.

would add 4 ounces of product to 124 ounces of water (1 gallon equals 128 fluid ounces). If you needed to apply 8 gallons of spray mixture to cover 1,000 square feet, then you must add 32 ounces (8 times 4 ounces) of pesticide product to 7.75 gallons of water. If the tank capacity of the sprayer is 4 gallons, you need to fill up the tank twice, using 16 fluid ounces of product each time.

Labels vary in how they recommend pesticide application rates. Some examples include ounces of product per 1,000 square feet, pints/quarts/gallons per 100 gallons, pounds of product per acre, or percent product in the tank. Be sure you understand how to calculate the correct amount of pesticide product and diluent needed before making the final mixture See Appendix C, Conversions and Calculations, for more information.

TECHNIQUES TO MINIMIZE DRIFT

Application techniques and equipment greatly influence the amount of spray drift that occurs. Off-target movement is affected by the type of nozzle, nozzle orifice size, sprayer pressure, and the height or distance of the nozzles from the target. It is important to review the pesticide label for specific information on drift reduction techniques or requirements. You must also check weather conditions (such as air stability, wind direction, and speed) at the time and place of the application and follow all weather-related restrictions on the label.



Bob Wolf, Kansas State University

A wind meter is useful for determining when to spray.

Of the many nozzle types available for applying pesticides, several are specifically designed to reduce drift. Select nozzles to give the largest droplet size that provides adequate coverage at the intended application volume and pressure.

In addition to the size of the nozzle orifice, some new nozzle designs help reduce drift by incorporating air into the spray to form an air-fluid mix. These air-induction nozzles, known as venturi nozzles, form a larger spray droplet, produce fewer fine particles, and provide energy to help transport the droplets to the target. These nozzles, however, require higher spray pressures (40 to 100 pounds per square inch) to be effective. Even at these higher pressures, venturi nozzles still dramatically reduce the likelihood of drift.

Operating pressure also affects the droplet size and output volume of the sprayer. Doubling the pressure does not double the flow rate. To double the flow rate, you must increase the pressure four times. Pressure cannot be used to make major changes in application rate, but it can be used to correct minor changes due to nozzle wear. To obtain a uniform spray pattern and to minimize drift, keep the operating pressure within the recommended range for each nozzle tip. Exceeding the recommended pressure range often results in more drift potential. To maintain a proper spray pattern, adjust nozzles according to the manufacturer's recommendations on nozzle spacing and spray angle.

Applications made with an electronic rate controller are subject to pressure changes as the operating speed varies. Even though the purpose of the rate controller is to help make





Pat Hipkins, Virginia Tech Pesticide Programs

A demonstration of a method to determine the uniformity of a nozzle spray pattern.

application volumes more uniform as sprayer speed changes, major adjustments in speed can affect pressure. For example, doubling the speed will result in a fourfold pressure increase in an attempt to maintain the correct volume. The increased pressure without changing nozzle orifice size will dramatically increase the potential for drift. Likewise, reduced speed can lower the pressure, which may affect coverage and, ultimately, pattern quality.

Spray height, or distance from the target site, is also an important factor in reducing drift. The closer the boom or spray nozzle is to the ground or target site, the less chance for drift. However, watch for pattern uniformity.

Table 11.1. Recommended Techniques to Reduce Drift

Recommended Technique	Explanation
Follow label directions for reducing drift.	Read the label and reference the nozzle manufacturer's guide to determine which nozzle and pressure combinations are needed.
Select a nozzle to increase droplet size.	Large droplets are less prone to drift. Use the largest droplets that provide necessary coverage.
Increase nozzle size resulting in higher application volumes.	Larger capacity nozzles can reduce the amount of spray deposited off-target.
Consider using new technologies.	Certain nozzles (e.g., air-induction and venturi nozzles) may help reduce drift.
Lower boom height.	The higher the boom height is above the target, the greater the potential for drift. Lowering the boom height a few inches can reduce off-target drift.
Maintain appropriate travel speed.	High travel speeds may result in an unstable boom, high boom positions and increased drift potential.
Keep nozzle close to the target.	When using hand-held equipment, keeping the nozzle close reduces the potential for drift.
Avoid high application ground speeds or major speed changes across the field.	Speed changes may result in pressure adjustments, causing droplet size variability. Sudden increases in speed may create high pressure that results in more drift potential.
Avoid applications during times of high wind speeds.	More of the spray volume moves off-target as wind increases. Wind currents can drastically affect spray droplet deposition.
Do not spray in the presence of a temperature inversion.	Temperature inversions prevent the dissipation of spray particles.
Consider using buffer zones/no-spray zones near sensitive areas.	Leave a buffer zone/no-spray zone if sensitive areas are downwind.
Use a drift-control additive when needed.	Drift-control additives increase the average droplet size produced by the nozzles. These additives must not become your only drift reducing technique. They do not make up for poor spraying practices.

To maintain uniformity, most nozzle types require some amount of overlap. Maintaining a 1:1 ratio of boom height above the target to the nozzle spacing on the boom will satisfy most overlap requirements. For air-blast sprayers, reduce drift by minimizing spraying over the canopy top. Use the minimum airspeed that will still give good penetration into the canopy, and consider the use of tower sprayers.

Another way to minimize drift is to use drift control additives. Tests indicate that the use of some additives reduces downwind drift deposits by 50% to 80%. Drift control additives are a specific type of chemical adjuvant. They must be mixed and applied according to label directions to be effective. Research, however, has shown that some products intended to reduce drift in fact increase drift potential. This research also shows that although some of these additives dramatically increase droplet size, they may also reduce coverage and lessen the overall effectiveness of the pesticide. Thoroughly evaluate drift control additives before using them. Using approved application techniques and adopting new technologies designed to reduce spray drift can improve the performance of spray mixes, benefit the environment, and be more cost-effective. Any one practice used alone may not sufficiently reduce drift. Therefore, incorporate as many drift-reduction techniques as practical into your spray program (Table 11.1).

SUMMARY

To choose the most suitable pesticide application method, you must consider factors such as the target site, target pest, and which pesticide formulation you intend to use.

Further, you must wear all PPE specified on the label for a specific task and, when required, use closed mixing and loading systems, enclosed cabs, and pesticide containment systems. Even if not required, using these safety systems will help protect humans and the environment from exposure to pesticides.

Your application equipment must be able to deliver the correct amount of pesticide to the intended target. The most common type of application equipment used in pest management is the hydraulic sprayer. Regardless of what type of sprayer you use, you must understand its parts and how they work. This includes how to adjust nozzles, spray volume, and pressure to reduce off-target drift. Spraying under the right weather conditions using proper application procedures can help reduce drift.

Before making an application, be sure your equipment is properly calibrated and know how to use the label information to calculate the correct amount of pesticide.



Review Questions

CHAPTER 11: Pesticide Application Procedures

Write the answers to the following questions, and then check your answers with those in Appendix A.

1. **Which application method involves uniformly applying a pesticide to an entire area or field?**
   - **A.** Broadcast.
   - **B.** Band.
   - **C.** Directed spray.

2. **Which type of pesticide application would you use to control cockroaches inside buildings?**
   - **A.** Basal.
   - **B.** Band.
   - **C.** Crack and crevice.

3. **Which statement about containment pads is *true*?**
   - **A.** Pads make spill cleanup more difficult.
   - **B.** Pads should be made of permeable materials.
   - **C.** Pads should be used where large quantities of pesticides are handled or mixed.

4. **Which statement about sprayer nozzles is *true*?**
   - **A.** A nozzle that mainly produces fine droplets is likely to minimize off-target drift.
   - **B.** Coarse-sized droplets provide maximum coverage of the target.
   - **C.** Nozzles control the amount of material applied and type of pattern created.

5. **Which statement about granular applicators is *true*?**
   - **A.** Ground speed has no effect on the application rate.
   - **B.** In a rotary spreader, lighter granules are thrown farther than heavier ones.
   - **C.** Drop spreaders are superior to rotary spreaders when more precise placement of the pesticide is desired.

6. **Which technique would help minimize off-target drift?**
   - **A.** Spraying during a temperature inversion.
   - **B.** Using the largest droplets practical to provide necessary coverage.
   - **C.** Increasing the height of the nozzles above the target.

7. **You are applying a pesticide to a triangular area that has a base of 60 feet and a height of 30 feet. How many square feet is the area?**
   - **A.** 450.
   - **B.** 900.
   - **C.** 1,800.

8. **You are applying a pesticide to a circular area with a 20-foot diameter. How many square feet is the area?**
   - **A.** 128.
   - **B.** 314.
   - **C.** 400.

9. **You have calibrated your equipment to spray 50 gallons per acre. You need to spray 1 acre. The label calls for 3 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank to make 50 gallons of finished spray?**
   - **A.** 1.5.
   - **B.** 3.
   - **C.** 6.

APPENDIX A

ANSWERS TO REVIEW QUESTIONS

CHAPTER 1 PEST MANAGEMENT

1. B. **2.** B. **3.** A. **4.** A. **5.** A.
6. A. **7.** A. **8.** A. **9.** B. **10.** B.

CHAPTER 2 FEDERAL PESTICIDE LAWS AND REGULATIONS

1. B. **2.** A. **3.** B. **4.** C. **5.** C.
6. B. **7.** A.

CHAPTER 3 PESTICIDE LABELING

1. B. **2.** C. **3.** B. **4.** A. **5.** A.
6. A. **7.** A. **8.** C. **9.** C.

CHAPTER 4 PESTICIDE FORMULATIONS

1. A. **2.** C. **3.** B. **4.** C. **5.** C.
6. B. **7.** C. **8.** A. **9.** C. **10.** C.

CHAPTER 5 PESTICIDE HAZARDS AND FIRST AID

1. A. **2.** A. **3.** A. **4.** A. **5.** A.
6. B. **7.** B. **8.** B. **9.** A. **10.** C.

CHAPTER 6 PERSONAL PROTECTIVE EQUIPMENT

1. A. **2.** C. **3.** C. **4.** B. **5.** A.
6. C. **7.** A. **8.** C. **9.** A.

CHAPTER 7 PESTICIDES IN THE ENVIRONMENT

1. A. **2.** B. **3.** C. **4.** C. **5.** B.
6. C. **7.** B. **8.** C.

CHAPTER 8 TRANSPORTATION, STORAGE, AND SECURITY

1. B. **2.** B. **3.** A. **4.** C. **5.** B.
6. A.

CHAPTER 9 EMERGENCY OR INCIDENT RESPONSE

1. C. **2.** A. **3.** B. **4.** A. **5.** C.

CHAPTER 10 PLANNING THE PESTICIDE APPLICATION

1. A. **2.** A. **3.** C. **4.** B. **5.** B.
6. C. **7.** C. **8.** C. **9.** A. **10.** C.

CHAPTER 11 PESTICIDE APPLICATION PROCEDURES

1. A. **2.** C. **3.** C. **4.** C. **5.** C.
6. B. **7.** B. **8.** B. **9.** A.

APPENDIX B

GLOSSARY

ABIOTIC FACTORS Related to nonliving elements, such as air pollutants, wind, water, and temperature.

ABSORPTION The movement of a chemical into plants, animals (including humans), microorganisms, or soil.

ACARICIDE A pesticide used to control mites and ticks. A miticide is a type of acaricide.

ACIDIC Having a pH less than 7.

ACTION THRESHOLD A predetermined level of pest infestation or damage at which some type of pest management action must be taken.

ACTIVATED CHARCOAL A finely ground charcoal that adsorbs chemicals.

ACTIVATOR An adjuvant added to a pesticide to increase its toxicity.

ACTIVE INGREDIENT The chemical or chemicals in a product responsible for pesticidal activity.

ACUTE EFFECTS Illnesses or injuries that occur shortly (within 24 hours) after exposure to a pesticide.

ACUTE EXPOSURE An exposure to a single dose of pesticide.

ACUTE TOXICITY An injury or illness produced from a single pesticide exposure. LD_{50} and LC_{50} are common indicators of the degree of acute toxicity.

ADJUVANT (ADDITIVE) A substance added to a pesticide to improve its effectiveness or safety. Examples include penetrants, sticker-spreaders, and wetting agents.

ADSORPTION The process whereby chemicals are held or bound to a surface by physical or chemical attraction. Clay and high-organic soils tend to adsorb pesticides.

ADULTERATED PESTICIDE A pest control product that does not conform to the specified standard or quality documented on its label or labeling.

ADVISORY STATEMENTS Manufacturer recommendations or best management practices for optimal use of a pesticide product. Pesticide handlers are not legally required to follow advisory statements.

AEROSOL A chemical stored in a container under pressure. An extremely fine mist is produced when the material, dissolved in a liquid, is released into the air.

AGITATION SYSTEM A device that stirs or mixes a pesticide product in a sprayer.

AIR-BLAST SPRAYER A type of pesticide application equipment that uses a large volume of air moving at high speed to break up and disperse spray droplets from the nozzles.

AIR-PURIFYING RESPIRATOR (APR) A safety device that uses filters or sorbents to remove hazardous substances, including pesticides, from the air.

ALGAE Relatively simple plants that are photosynthetic and contain chlorophyll.

ALGAECIDE (ALGICIDE) A pesticide used to kill or inhibit algae.

ALKALINE Having a pH greater than 7 (also called basic).

ALLERGIC EFFECTS/ALLERGY A hypersensitivity to a specific substance, often called the allergen. An allergy may cause dermatitis, blisters, or hives. It could also cause illness, asthma, or life-threatening shock. Often the entire body is affected. Pesticide allergy symptoms are similar to other allergy symptoms—reddening and itching of the eyes, respiratory discomfort, and asthma-like symptoms.

ANIMAL SYSTEMICS Pesticide products that are absorbed by, enter the tissues of, and move within the treated animal.

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

ANTAGONISM The reduction of pesticide activity when two or more different pesticides are mixed together.

ANTIBIOTIC Chemical produced by a microorganism that is toxic to other microorganisms. Examples include streptomycin and penicillin.

ANTICOAGULANT A chemical that prevents normal blood clotting; the active ingredient in some rodenticides.

ANTIDOTE A practical treatment used to counteract the effects of pesticide poisoning or some other poison in the body.

ANTI-SIPHONING DEVICE A hose attachment designed to prevent backflow of a pesticide mix from the spray tank into a water source.

APPLICATION RATE The amount of pesticide that is applied to a known area, such as an acre or 1,000 square feet or linear feet.

AQUIFER A geologic formation from which groundwater may be drawn. An aquifer can be a layer of sand, gravel, or other soil materials or a section of bedrock with fractures through which water can flow.

ARACHNID A wingless arthropod with two body regions and four pairs of jointed legs. Spiders, ticks, and mites are arachnids.

ARTHROPOD An invertebrate animal characterized by a jointed body and limbs and usually a hard body covering that is molted at intervals. Insects, mites, and crayfish are arthropods.

ATMOSPHERE-SUPPLYING RESPIRATOR A safety device that provides a supply of breathable air from a clean, independent outside source. Examples include SCBA and supplied-air respirators.

ATROPINE (ATROPINE SULFATE) An antidote used to treat organophosphate and carbamate poisoning.

ATTRACTANT A substance or device used to lure insects or other pests to a trap or poison bait.

AVICIDE A chemical used to kill or repel birds.

BACK-SIPHONING The movement of a liquid pesticide mixture from a spray tank through the filling hose into the water source.

BACTERIA (singular: **BACTERIUM**) Microscopic organisms, some of which can produce diseases in plants and animals.

BACTERICIDE A chemical used to control bacteria.

BAIT A food or other substance used to attract a pest to a pesticide or a trap.

BAND APPLICATION A pesticide or other material applied in or beside a crop row instead of over the entire field.

BASAL APPLICATION An herbicide applied to plant stems or trunks at or just above the ground line.

BENEFICIAL An insect that is useful or helpful to humans. Examples include pollinators, parasites, and pest predators.

BIENNIAL A plant that completes its life cycle in two years.

BIOACCUMULATION The ability of organisms to accumulate or store chemicals in their tissues.

BIOLOGICAL CONTROL Pest management using predators, parasites, and disease-causing organisms. It may be naturally occurring or introduced.

BIOLOGICAL DEGRADATION The breakdown of chemicals due to the activity of living organisms, especially bacteria and fungi in the soil.

BIOMAGNIFICATION The process whereby some organisms accumulate chemical residues in higher concentrations than those found in the organisms they consume.

BIOPESTICIDE A pest control product derived from naturally occurring materials.

BOOM A pesticide application device attached to a truck, tractor, aircraft, or other vehicle (or held by hand) to which multiple spray nozzles are attached.

BOTANICAL PESTICIDE A pest control product produced from naturally occurring chemicals in plants. Examples include nicotine, pyrethrum, and rotenone.

BRAND NAME The registered or trade name, number, or designation given to a specific pesticide product or device by the manufacturer or formulator.

BREAKTHROUGH The penetration of pesticide through PPE, such as a liquid through gloves or a gas through a respirator. If this happens, the PPE is no longer protective.

BROADCAST APPLICATION A pesticide or other material uniformly applied over an entire field or area.

BROADLEAVES (DICOTS) Plants with broad, rounded, or flattened leaves with netted veins. Examples include dandelions and roses. Different from grasses, sedges, rushes, and onions (monocots), which have narrow, bladelike leaves with parallel veins.

BROAD-SPECTRUM PESTICIDE A pest control product that is effective against a wide range of pests.

BUFFERS Adjuvants used to slow chemical degradation of some pesticides by lowering the pH of alkaline water and maintaining the pH within a narrow range, even with the addition of acidic or alkaline materials.

CALIBRATE/CALIBRATION To properly adjust equipment; to determine the correct amount of material to be applied to the target area.

CARBAMATES A group of pesticides commonly used to control insects, mites, fungi, and weeds. N-methyl carbamate insecticides, miticides, and nematicides are cholinesterase inhibitors.

CARCINOGEN A substance or agent able to produce malignant tumors (cancer).

CARRIER An inert liquid, solid, or gas added to an active ingredient to make a pesticide formulation. A carrier is also the material, usually water or oil, used to dilute the formulated product for application.

CAUSAL ORGANISM The pathogen that produces a given disease.

CAUTION The signal word associated with pesticide products classified as slightly toxic. These pesticides have an oral LD_{50} greater than 500mg/kg and a dermal LD_{50} greater than 2,000mg/kg.

CERTIFIED APPLICATOR A person qualified to apply or supervise the application of restricted-use pesticides.

CHEMICAL CARTRIDGE/CHEMICAL CANISTER For air-purifying respirators, the type of purifying element that removes specific gases or vapors by absorbing or adsorbing them.

CHEMICAL DEGRADATION The breakdown of chemicals that do not involve living organisms, usually by a chemical reaction with water.

CHEMICAL NAME The technical term for the active ingredient(s) found in the formulated product. This complex name is derived from the chemical structure of the active ingredient.

CHEMICAL INCOMPATIBILITY What occurs when mixing certain pesticides in a spray tank alters the activity of one or more of them.

CHEMICAL-RESISTANT PPE When specified by the pesticide label, a legal definition that the PPE "shall be made of material that allows no measurable movement of the pesticide being used through the material during use" [U.S. EPA. 40 CFR 170.240 Personal protective equipment].

CHEMIGATION The application of pesticides or fertilizers to a target site in irrigation water. Also known as injector systems when used in greenhouses.

CHEMOSTERILANT A chemical used to sterilize insects or pest vertebrates without altering mating habits or life expectancy.

CHEMTREC The Chemical Transportation Emergency Center. It supports a toll-free number (800-424-9300) that provides 24-hour information for chemical emergencies, such as a spill, leak, fire, or accident.

CHLORINATED HYDROCARBON (ORGANOCHLORINE) A pesticide containing chlorine, carbon, and hydrogen. Many are persistent in the environment. Examples include chlordane, DDT, and methoxychlor.

CHLOROSIS The yellowing of a plant's normally green tissue.

CHOLINESTERASE A chemical catalyst (enzyme) found in humans and many other animals that regulates the activity of nerve impulses by deactivating the chemical neurotransmitter acetylcholine.

CHRONIC TOXICITY The ability of small amounts of pesticide from repeated, prolonged exposure to cause injury.

COMMERCIAL APPLICATOR A certified applicator who uses or supervises the use of pesticides for purposes other than those covered under a private applicator certification.

COMMON NAME A name given to a pesticide active ingredient by a recognized committee on pesticide nomenclature. Although many pesticides are known by a number of trade or brand names, each active ingredient has only one recognized common name. For example, the common name for Sevin insecticide is carbaryl.

COMPATIBILITY AGENT An adjuvant used to enhance the mixing of two or more pesticide products and/or fertilizers.

COMPATIBLE A mixture of two or more chemicals that does not reduce the effectiveness or characteristics of any individual chemical.

CONCENTRATE See **PESTICIDE CONCENTRATE**.

CONCENTRATION The amount of active ingredient in a given volume or weight of formulated product.

CONTACT (LOCAL) EFFECTS Injury at the point of contact, including skin discoloration and irritation (dermatitis), such as itching, redness, rashes, blisters, and burns. Swelling; stinging; and burning of the eyes, nose, mouth, or throat are all contact effects.

CONTACT PESTICIDE Any pest control product that affects pest organisms upon contact. These may be insecticides, miticides, fungicides, or herbicides.

CONTAINMENT PAD An impermeable mat used for mixing and loading pesticides and cleaning equipment that is designed to catch spills, leaks, overflows, and wash water for reuse or disposal.

CONTAMINATION The presence of an unwanted substance in or on a plant, animal, soil, water, air, or structure.

CORROSIVE POISON A substance containing a strong acid or base that will severely burn the skin, mouth, stomach, or respiratory tract.

CRACK-AND-CREVICE APPLICATION Small amounts of pesticide placed into cracks and crevices in buildings (such as along baseboards and in cabinets).

CROSS-CONTAMINATION The accidental mixing of one pesticide with another, usually in an improperly cleaned sprayer or in storage because of the airborne movement of a volatile pesticide.

CROSS-RESISTANCE When a pest population that is already resistant to one pesticide becomes resistant to a related chemical with a similar mode of action.

CURATIVE PESTICIDE A pest control product that can inhibit or kill a disease-causing organism after it is established in the plant or animal.

DANGER The signal word associated with pesticide products classified as highly toxic by at least one route of entry.

DANGER—POISON The signal word associated with pesticide products classified as highly toxic, corrosive, or highly irritating to skin and eyes.

DAYS TO HARVEST (PREHARVEST INTERVAL) The minimum number of days permitted by law between the last pesticide application and the harvest date of the crop.

DAYS TO SLAUGHTER (PRESLAUGHTER INTERVAL) The minimum number of days permitted by law between the last pesticide application and the date the food animal is slaughtered.

DECONTAMINATE To remove or degrade a chemical residue from the skin or a surface.

DEFOAMING AGENT An adjuvant used to reduce the foaming of a spray mixture due to agitation.

DEFOLIANT A chemical that initiates the premature drop of leaves, often as an aid in harvesting a crop.

DEGRADATION The process by which a chemical compound is broken down into simpler compounds by the action of microorganisms, water, air, sunlight, or other agents. Degradation products are usually—but not always—less toxic than the original compound.

DELAYED EFFECTS Illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. The effects may be delayed for weeks, months, or even years.

DEPOSIT The presence of a pesticide on a treated surface after application.

DERMAL Pertaining to the skin.

DERMAL LD_{50} The amount of a pesticide that can kill 50% of a population of test animals when absorbed through the skin.

DERMAL TOXICITY The ability of a pesticide to injure a human or animal when absorbed through the skin.

DERMATITIS The inflammation, itching, irritation, or occurrence of a rash after exposure to a chemical.

DESICCANT A chemical that promotes drying or loss of moisture from leaves or other plant parts. Also, a chemical that removes water from arthropods or destroys the waxy covering that protects these organisms from water loss.

DETOXIFY To render a pesticide active ingredient or other poisonous chemical harmless.

DIAGNOSIS The positive identification of a problem and its cause.

DILUENT Any inert liquid, solid, or gaseous material that is combined with a pesticide active ingredient during the manufacturing process. Also, the water, petroleum product, or other liquid in which the formulated product is mixed before application.

DIRECTED APPLICATION A pesticide precisely applied to a specific area or site. Examples include a basal application to woody plants or a crack-and-crevice treatment in a building.

DISINFECTANT (ANTIMICROBIAL) A chemical or other agent that kills or inactivates disease-producing microorganisms in animals, seeds, or other plant parts. Also commonly refers to chemicals used to clean or surface-sterilize inanimate objects.

DISPERSING AGENT An adjuvant that facilitates the mixing and suspension of a pesticide formulation in water.

DORMANT SPRAY A pesticide application made in late winter or early spring before plants resume active growth.

DOSE/DOSAGE The quantity of pesticide applied to a given site or target.

DRIFT The airborne movement of a pesticide spray, dust, particle, or vapor beyond the target area.

DRIFT CONTROL ADDITIVE An adjuvant added to a spray mixture to reduce drift.

DROP SPREADER A common type of granular applicator with an adjustable sliding gate that opens holes in the bottom of the hopper. Granules flow out by gravity feed.

DRY FLOWABLE A granular pesticide formulation that forms a suspension when added to water.

DUST A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent, such as clay or talc.

ECONOMIC INJURY LEVEL (EIL) The pest population density (number of pests per unit area) that causes losses equal to the cost of control measures.

ECONOMIC THRESHOLD (ET) The pest population density (number of pests per unit area) at which control measures are needed to prevent the pest from causing economic injury.

EDUCTOR Also referred to as an inductor or a jet pump, it is a device that enables small pumps to circulate large volumes of tank solution. When pumping is used for solution agitation, the use of an eductor will circulate 4 to 5 gallons of solution in the tank for every 1 gallon that is pumped. They also are used to add the pesticide into the tank for automated field mixing.

EMERGENCY EXEMPTION A Section 18 exemption that allows the sale and use of a registered pesticide product for a specific nonregistered purpose during a specified period if no feasible alternative is available.

EMULSIFIABLE CONCENTRATE (EC) A pesticide formulation produced by mixing an active ingredient and an emulsifying agent in a suitable petroleum solvent. When combined with water, a milky emulsion is usually formed.

EMULSIFYING AGENT (EMULSIFIER) A chemical that aids in the suspension of one liquid in another that normally would not mix together.

EMULSION A mixture of two liquids that are not soluble in each other. One is suspended as very small droplets in the other with the aid of an emulsifying agent. An example is emulsifiable concentrate in water.

ENCAPSULATED PESTICIDE A formulation with the active ingredient enclosed in capsules of polyvinyl or other synthetic materials, mainly used for slow release and to prolong the effectiveness of the materials. May also refer to a method of disposal of pesticides and pesticide containers by sealing them in a sturdy, waterproof container to prevent leakage.

ENCLOSED CAB Tractor cab, cockpit, or truck/vehicle cab that surrounds the occupant(s). It may help to prevent exposure to pesticides as long as all doors, hatches, and windows remain closed during the pesticide application.

ENDANGERED SPECIES Organisms (plants or animals) whose population has been reduced to near extinction.

ENVIRONMENT All the features that surround and affect an organism or group of organisms.

ENVIRONMENTAL PROTECTION AGENCY (EPA) The federal agency responsible for implementing pesticide rules and regulations and registering pesticides.

EPA ESTABLISHMENT NUMBER A number assigned to each pesticide production facility by EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels of that product.

EPA REGISTRATION NUMBER A number assigned to a pesticide product by EPA when the product is registered by the manufacturer or the designated agent. The number must appear on all labels for a particular product.

ERADICANT A chemical or other agent (e.g., steam or heat) used to eliminate an established pest from a plant, animal, or specific site (e.g., soil, water, or buildings).

ERADICATION A pest management strategy that attempts to eliminate all members of a pest population from a defined area.

EXPOSURE Unwanted contact with pesticides or pesticide residues by people, other organisms, or the environment.

FACEPIECE (TIGHT-FITTING) A respirator that forms a complete seal with the face. Examples include particulate-filtering facepieces, half masks, and full facepiece masks.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA) A federal law dealing with pesticide regulations and use.

FILTER (HEPA) High-efficiency particulate air filter. A high-efficiency filter is used in powered air-purifying respirators. The P100 cartridge used in nonpowered APRs is equivalent to a HEPA filter.

FILTER (PARTICULATE) For nonpowered air-purifying respirators, a purifying element that removes aerosols (solid or liquid particulates) from the air. Particulate filters are rated N, R, or P for oil degradation and 95, 99, or 100 for filtering efficiency.

FILTER EFFICIENCY For air-purifying respirators, the collective efficiency of a filter to resist penetration by particulates. Nonpowered APR filters are tested and rated at 95%, 99%, and 99.7% efficiency. The higher the number, the more efficient the filter. Powered APR filters are tested and rated as "high efficiency" (HE).

FILTERING FACEPIECE RESPIRATOR A type of nonpowered APR in which a particulate filter is an integral part of the facepiece (or the entire facepiece is composed of the filtering medium).

FIT TEST (QUALITATIVE) A method to assess whether a particular size and brand of respirator adequately fits an individual's face using a test agent. If the person can detect inside the mask an agent that is outside the mask, there is leakage at the seal and the mask does not fit properly.

FIT TEST (QUANTITATIVE) A method to assess whether a particular size and brand of respirator adequately fits an individual's face using instrumentation to numerically measure leakage into the respirator.

FLAMMABLE Capable of being easily ignited.

FLOWABLE A pesticide formulation in which a very finely ground solid particle, composed of both active and inert ingredients, is suspended in a liquid carrier. These formulations are mixed with water before spraying.

FOAMING AGENT An adjuvant designed to reduce pesticide drift by producing thick foam.

FOG TREATMENT The application of a pesticide as a fine mist or fog.

FOLIAR APPLICATION A pesticide applied to the leaves of plants.

FOOD CHAIN A sequence of species within an ecological community. Each member serves as a food source for the species next higher in the chain.

FORMULATION A pesticide product as purchased, containing a mixture of one or more active ingredients, carriers (inert ingredients), and other additives diluted for safety and ease of application.

FUMIGANT A pesticide that forms gases or vapors toxic to plants, animals, and microorganisms.

FUNGI (singular: **FUNGUS**) Nonchlorophyll-bearing plants that live as saprophytes or parasites. Some infect and cause diseases in plants, animals, and humans or destroy wood and fiber products. Others are beneficial, such as decomposers and human food sources. Examples include rusts, mildews, molds, and smuts.

FUNGICIDE A chemical used to control fungi.

FUNGISTATIC AGENT A chemical that inhibits the germination of fungal spores or the growth of mycelium but does not kill the fungus.

GENERAL-USE PESTICIDE A pest control product that can be purchased and used by the public.

GERMINATION The sprouting of a seed or the production of a germ tube (mycelium) from a fungus spore.

GPA Gallons per acre.

GPM Gallons per minute.

GRANULE A dry pesticide formulation. The active ingredient is either mixed with or coated onto an inert carrier to form a small, ready-to-use, low-concentrate particle that is not normally a drift hazard. Pellets differ from granules only in their precise uniformity, larger size, and shape.

GROUNDWATER Water located in aquifers beneath the soil surface from which well water is obtained or surface springs are formed.

GROWTH REGULATOR A chemical that alters the growth processes of a plant or animal.

HABITAT A place where plants or animals live, feed, and reproduce.

HARVEST AID CHEMICAL A chemical material applied to a plant before harvest to reduce the amount of plant foliage.

HAZARD The likelihood that injury or death will occur from a given level and duration of exposure to a toxic chemical.

HEAT STRESS Overheating of the body that, if severe, may be life-threatening.

HERBACEOUS PLANTS Plants that do not develop woody tissues.

HERBICIDE A pesticide used to control weeds.

HIGH-EFFICIENCY FILTER See **FILTER (HEPA)**.

HOST A plant or animal on or in which a pest lives and feeds.

HOST RESISTANCE The ability of a host plant or animal to resist attack by pests or to be able to tolerate the damage caused by pests. (Also called **PEST RESISTANCE**.)

HYDRAULIC SPRAYER A type of pesticide application equipment that uses water under pressure to deliver the pesticide to the target site.

HYDROLYSIS Breakdown of a chemical in the presence of water.

ILLEGAL RESIDUE A quantity of pesticide remaining on or in the crop/animal at harvest/slaughter that is either above the set tolerance or may not be used on the crop/animal.

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH) Used to describe an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Environments that have less than 19.5% oxygen by volume are considered IDLH by OSHA.

IMPREGNATES Pet collars, livestock ear tags, adhesive tapes, plastic pest strips, and other products with pesticides incorporated into them. These pesticides slowly emit vapors over time and provide control of nearby pests.

INCOMPATIBLE Two or more materials that cannot be mixed or used together.

INERT INGREDIENTS Inactive materials in a pesticide formulation without pesticidal activity. Some inert ingredients, however, may be toxic or hazardous to humans.

INGREDIENT STATEMENT The portion of the label on a pesticide container that gives the name and amount of each active ingredient and the total amount of inert ingredients in the formulation.

INHALATION TOXICITY The ability of a pesticide to harm humans or animals when breathed in through the nose and mouth into the lungs.

INOCULUM That part of a pathogen that can cause disease in a host.

INORGANIC PESTICIDES Pest control products of mineral origin that do not contain carbon.

INSECT GROWTH REGULATOR (IGR) A type of insecticide that controls certain insects by disrupting their normal growth process from immature to adult.

INSECTICIDE A pesticide used to control or prevent damage caused by insects and related arthropods.

INSECTS Arthropods characterized by a body composed of three segments and three pairs of legs.

INSOLUBLE A chemical that does not dissolve in a liquid. For example, a wettable powder does not dissolve in water but instead forms a suspension.

INTEGRATED PEST MANAGEMENT (IPM) The use of all suitable pest control methods to keep pest populations below the economic injury level. Methods include cultural practices; use of biological, physical, and genetic control agents; and the selective use of pesticides.

INVERT EMULSION A mixture in which water droplets are suspended in an oil instead of oil droplets being suspended in water.

INVERTEBRATE A class of animals that lack backbones. Examples include insects, spiders, nematodes, snails, and slugs.

KEY PEST An organism that may cause major damage on a regular basis unless it is controlled.

LABEL All the printed material attached to or part of a pesticide container. The label is a legal document.

LABELING The pesticide product label and all supplemental pesticide information. Labeling complements the label information but may not necessarily be attached to or part of the container.

LARVAE (singular: **LARVA**) Immature forms of insects that undergo complete metamorphosis: developmental stages are egg, larva, pupa, and adult.

LARVICIDE A pesticide used to kill insect larvae. Commonly used to control mosquito and black fly larvae.

LC_{50} The concentration of a pesticide, usually in air or water, that can kill 50% of a population of test animals. LC_{50} is usually expressed in parts per million (ppm). The lower the LC_{50} value, the more acutely toxic the chemical.

LD_{50} The dose or amount of a pesticide that can kill 50% of a population of test animals when eaten or absorbed through the skin. LD_{50} is expressed in milligrams of chemical per kilogram of body weight (mg/kg) of the test animal. The lower the LD_{50} value, the more acutely toxic the chemical.

LEACHING The movement through soil of a pesticide or other chemical that is dissolved in water.

LETHAL CONCENTRATION See **LC_{50}**.

LETHAL DOSE See **LD_{50}**.

LIFE CYCLE The series of stages that an organism passes through during its life. Many pest species, both plants and animals, pass through several life stages during which their susceptibility to or tolerance of pesticides varies greatly.

LOCAL EFFECTS See **CONTACT (LOCAL) EFFECTS**.

MANDATORY STATEMENTS Label directions that a pesticide handler must follow to legally use the pesticide.

METABOLITE In pesticides, a compound derived from changes in the active ingredient through chemical, biological, or physical reactions. The metabolite may be simpler or more complex and may or may not be more poisonous than the original chemical.

METAMORPHOSIS A change in the shape, size, and/or form of animals as they develop from eggs to adults.

MICROBIAL DEGRADATION Breakdown of a chemical by microorganisms.

MICROBIAL PESTICIDE (BIORATIONAL) Bacteria, viruses, fungi, and other microorganisms used to control pests.

MICROENCAPSULATED PESTICIDE A formulation in which the pesticide active ingredient is encased in plastic capsules. When the capsules start to break down after application, the pesticide is slowly released.

MICROORGANISM An organism that is so small it cannot be seen without the aid of a microscope.

MINIBULK A container that ranges in volume from 40 to 600 gallons and is adapted to closed systems. A minibulk container can be returned to the dealer for refilling.

MINIMUM-RISK PESTICIDES Products that pose a minimal risk to humans and the environment and thus are exempt from federal registration.

MISCIBLE LIQUIDS Two or more fluids that can be mixed and will remain mixed under most conditions. Water and ethyl alcohol are miscible; water and oil are not.

MITE A small arthropod similar to an insect but with eight legs, two body parts, and no antennae.

MITICIDE A pesticide used to control mites.

MODE OF ACTION The way in which a pesticide affects the target plant, animal, or microorganism.

MOLLUSCICIDE A chemical used to control snails and slugs.

MOLTING In invertebrates (such as insects, spiders, and mites), the process of shedding the outer body covering or exoskeleton. Molting allows the animal to grow larger.

MUTAGEN A substance or agent able to cause genetic changes in living cells.

MYCELIUM The mass of filaments that forms the body of a fungus.

MYCOPLASMA A microorganism possessing many virus- and bacteria-like properties. Some cause plant diseases.

NARROW-SPECTRUM PESTICIDE A pest control product that is effective against only one or a few species of pests. Usually associated with insecticides and fungicides.

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) A federal agency that conducts research on health and safety concerns, tests and certifies respirators, and trains occupational safety and health professionals.

NATURAL ENEMIES The predators, parasites, and pathogens that attack and often kill other organisms.

NECROSIS The death of plant or animal tissues that causes the formation of discolored, sunken, and dead (necrotic) areas.

NEMATICIDE A pesticide used to control nematodes.

NEMATODES Microscopic, colorless, wormlike animals that live as saprophytes or parasites. Many cause diseases of plants or animals.

NEUROTOXIN A substance or agent able to cause disorders of the nervous system.

NO OBSERVABLE EFFECT LEVEL (NOEL) The maximum dose or exposure level of a pesticide that produces no observable toxic effect on test animals.

NONPERSISTENT PESTICIDE A pest control product that does not remain active in the environment more than one growing season.

NONPOINT-SOURCE POLLUTION Contamination that comes from a widespread area. An example is the movement of pesticides into streams or groundwater following a broadcast application to an agricultural field, large turf area, or right-of-way.

NONSELECTIVE PESTICIDE A pest control product that is toxic to a wide range of plants or animals without regard to species. For example, a nonselective herbicide can kill or damage all plants it contacts.

NONTARGET ORGANISMS Plants or animals within or near a pesticide-treated area that are not the intended targets of the application.

NOXIOUS WEED A plant defined by law as being particularly troublesome, undesirable, and difficult to control.

NOZZLES Atomizing devices that produce droplets that form the spray pattern.

NUISANCE DUST Dust that is relatively harmless to the lungs. It does not produce significant organic disease or toxic effects when exposures are kept at reasonable levels.

NYMPH The developmental state of insects with gradual metamorphosis that hatch from the egg. Nymphs become adults.

OCCASIONAL PEST An organism that causes intermittent damage as a result of changing environmental conditions or fluctuations in populations of natural enemies.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) A federal agency that issues and enforces regulations for workplace health and safety.

OCULAR Pertaining to the eyes.

ONCOGEN A substance or agent able to induce tumors (not necessarily cancerous) in living tissues.

ORAL LD_{50} The dose of a pesticide that can kill 50% of a population of test animals when eaten.

ORAL TOXICITY The ability of a pesticide to injure a human or animal when taken by mouth.

ORGANOPHOSPHATES A large group of pesticides that contain the element phosphorus. Most are nonpersistent insecticides, miticides, and nematicides. Many are highly toxic. Examples include malathion, parathion, diazinon, and chlorpyrifos.

ORIFICE A precisely sized opening in a spray nozzle.

OVICIDE A material that destroys eggs.

OXIDIZER A highly reactive chemical that is potentially explosive and a fire hazard under certain conditions.

PARASITE A plant, animal, or microorganism living in, on, or with another living organism from which it obtains all or part of its food.

PARTICLE DRIFT The airborne movement of particles such as pesticide dusts and pesticide-contaminated soil from the application site.

PARTICULATE A particle of solid or liquid matter.

PARTICULATE FILTER See **FILTER (PARTICULATE)**.

PARTICULATE MATTER A suspension of fine solid or liquid particles in air, such as dust, fog, fume, mist, smoke, or sprays. Particulate matter suspended in air is commonly known as an aerosol.

PARTS PER BILLION (PPB) A way of expressing amounts of chemicals in or on food, plants, animals, water, soil, or air. One part per billion equals 1 pound in 500,000 tons.

PARTS PER MILLION (PPM) See **PARTS PER BILLION**. One part per million equals 1 pound in 500 tons.

PATHOGEN A disease-causing organism.

PELLET A pesticide formulation consisting of dry active and inert ingredients pressed into a uniformly sized and shaped ready-to-use material. Pellets are larger than granules.

PENETRANT An adjuvant added to a spray mixture to enhance the absorption of a pesticide.

PERCOLATION The downward movement of water through soil.

PERENNIAL A plant that lives for more than two years.

PERMEABILITY The ease with which water and dissolved pesticides can flow through porous materials, such as soil, gravel, or sand.

PERSISTENCE The amount of time that a pesticide remains active to control pests.

PERSISTENT PESTICIDE A pesticide chemical (or its metabolites) that remains active in the environment more than one growing season. Some compounds can accumulate in animal and plant tissues or remain in the soil for years.

PERSONAL PROTECTIVE EQUIPMENT (PPE) When specified on a pesticide label, PPE is legally defined as "devices and apparel that are worn to protect the body from contact with pesticides or pesticide residues, including, but not limited to, coveralls, chemical-resistant suits, chemical-resistant gloves, chemical-resistant footwear, respiratory protection devices, chemical-resistant aprons, chemical-resistant headgear, and protective eyewear" [U.S. EPA. 40 CFR 170.240 Personal protective equipment].

PEST An undesirable organism (e.g., insect, bacterium, fungus, nematode, weed, virus, or rodent) that injures or harms humans, desirable plants or animals, manufactured products, or natural products.

PESTICIDE Any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest. Also, any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

PESTICIDE CONCENTRATE A pesticide formulation before it is diluted.

PESTICIDE CONTAINMENT PAD See **CONTAINMENT PAD**.

PESTICIDE HANDLER A person who works directly with pesticides, such as during mixing, loading, transporting, cleaning, storing, disposing, and applying, or who repairs pesticide application equipment.

PESTICIDE LABEL See **LABEL**.

PESTICIDE RESISTANCE The ability of an insect, fungus, weed, rodent, or other pest to tolerate a pesticide that once controlled it.

pH A measure of acidity and alkalinity; acid below pH7, basic or alkaline above pH7.

PHEROMONE A substance emitted by an animal to influence the behavior of other animals of the same species. Some are synthetically produced for use in insect traps.

PHOTODEGRADATION Breakdown of a chemical by sunlight.

PHYSICAL INCOMPATIBILITY The failure of pesticide products to stay uniformly mixed in a spray tank.

PHYTOTOXICITY Chemical injury to plants.

PISCICIDE A chemical used to control pest fish.

PLACARDS Diamond-shaped warning signs placed on all vehicles that transport certain types and quantities of hazardous materials, as required by the U.S. Department of Transportation.

PLANT GROWTH REGULATOR (PGR) A pesticide used to regulate or alter the normal growth of plants or the development of their parts.

POINT OF RUNOFF When a spray starts to run or drip from the leaves and stems of plants, or the hair or feathers of animals.

POINT-SOURCE POLLUTION The contamination of water and soil from a specific, identifiable place or location, such as a spill site or a permanent mixing, loading, and cleaning site.

POISON CONTROL CENTER An agency (generally a hospital) that provides current information on proper first aid techniques and antidotes for poisoning emergencies.

POSTEMERGENCE HERBICIDE A pesticide that is applied after the weed or crop plants have appeared through the soil. Usually used to specify the timing of herbicide applications.

POWERED AIR-PURIFYING RESPIRATOR (PAPR) A safety device that uses a blower to force contaminants through purifying elements.

PRECIPITATE A solid substance that forms in a liquid and settles to the bottom of a container; a material that no longer remains in suspension.

PREDACIDE A pesticide used to control predaceous animals, usually mammals.

PREDATOR An animal that attacks, kills, and feeds on other animals. Examples include bears, wolves, coyotes, hawks, owls, snakes, fish, spiders, and many insects and mites.

PREEMERGENCE HERBICIDE A pesticide that is applied before the weed or crop plants have appeared through the soil. Usually used to specify the timing of herbicide applications.

PREHARVEST INTERVAL See **DAYS TO HARVEST**.

PREMIX A pesticide product formulated by the manufacturer with more than one active ingredient.

PREPLANT PESTICIDE A pest control product applied before planting a crop.

PRESLAUGHTER INTERVAL See **DAYS TO SLAUGHTER**.

PRESSURE RINSE The process of decontaminating an empty pesticide container with water by using a special high-pressure nozzle to rinse the container.

PRIVATE APPLICATOR A certified applicator who uses or supervises the use of restricted-use pesticides to produce an agricultural commodity on his or her own land, leased land, or rented land or on the lands of his or her employer.

PROPELLANT The inert ingredient in self-pressurized products that forces the active ingredient from the container.

PROTECTANT A pesticide applied to a plant or animal before infection or attack by a pest to prevent infection or injury by the pest.

PROTECTIVE EQUIPMENT See **PERSONAL PROTECTIVE EQUIPMENT (PPE)**.

PUMP A device that moves liquid pesticide through hoses and out of the spraying system.

PUPA A developmental stage of insects that undergo complete metamorphosis that occurs between the larva and the adult.

PYRETHROID A synthetic insecticide that mimics pyrethrin, a naturally occurring pesticide derived from certain species of chrysanthemum flowers.

QUARANTINE A regulatory method to prevent the introduction and dissemination of plant and animal pests into new areas. Involves inspections, treatments, and destruction of contaminated plants and animals or their parts.

RATE OF APPLICATION The amount of pesticide applied to a plant, animal, unit area, or surface. It is usually expressed as per acre or per 1,000 square feet, linear feet, or cubic feet.

READY-TO-USE (RTU) Low-concentrate formulations that require no further dilution before application.

REGISTERED PESTICIDES Pest control products that have been approved by the U.S. Environmental Protection Agency for the uses listed on the label.

REPELLENT A compound that keeps insects, rodents, birds, or other pests away from plants, domestic animals, buildings, or other treated areas.

REGISTRATION REVIEW An EPA program that periodically reevaluates pesticides to ensure that products currently sold are safe to use.

REREGISTRATION An EPA program to review older pesticides (registered before November 1984) to ensure that they meet current scientific and regulatory standards.

RESIDUAL PESTICIDE A pest control product that remains effective on a treated surface or area for an extended period following application.

RESIDUE The pesticide active ingredient or its breakdown product(s) that remain in or on the target site or in the environment after treatment. Pesticide residues may be on treated crops, feed products, or livestock that are moved from the treatment site.

RESISTANT A characteristic of some organisms that are uninjured or unaffected by a certain dosage of pesticide chemical used to successfully control other populations of the same organism. Also, plants and/or animals that are unaffected by a pest species.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) The federal law regulating the transport, storage, treatment, and disposal of hazardous wastes.

RESPIRATOR A safety device that covers at least the mouth and nose and that protects the wearer from inhaling hazardous substances, including pesticides.

RESTRICTED-ENTRY INTERVAL (REI) The amount of time that must elapse between treatment of a crop and the time when a person can reenter and handle the crop without wearing protective clothing and equipment or receiving early-entry training. (Also called **REENTRY INTERVAL**.)

RESTRICTED-USE PESTICIDE A pest control product that can be purchased only by certified pesticide applicators and used only by certified applicators or persons under their direct supervision. Not available for use by the public because of high toxicities and/or environmental hazards.

RINSATE A liquid obtained from rinsing pesticide containers and application equipment.

RODENTICIDE A chemical used to control rodents.

ROPE-WICK (WIPER) TREATMENT A pesticide that is released onto a device that is wiped onto weeds taller than the crop, or wiped selectively onto individual weeds.

ROTARY SPREADER A common type of granular applicator that distributes granules to the front and sides of the spreader, usually by means of a spinning disk or fan.

RUNOFF The movement of water and associated materials on the soil surface.

SAFENER An adjuvant used to reduce the phytotoxic effects of a pesticide.

SAFETY DATA SHEET (SDS) An information sheet available from the manufacturer that provides details on chemical properties, toxicity, first aid, hazards, personal protective equipment, and emergency procedures to be followed in the event of a spill, leak, fire, or transportation crisis. Formerly known as Material Safety Data Sheet.

SAPROPHYTE An organism that obtains its food from dead or decaying organic matter.

SATURATED ZONE The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water.

SECONDARY PEST An organism that may become a serious problem when a key pest or natural enemy is controlled or eliminated.

SECONDARY POISONING Harmful effects to a predatory bird or mammal that feeds on an animal killed by a pesticide.

SECTION 3 REGISTRATION A standard federal (EPA) registration. Most pesticides are registered this way and contain an official EPA registration number.

SEED PROTECTANT A pesticide applied to seeds before planting to protect them from insects, fungi, and other soil pests.

SELECTIVE PESTICIDE A pest control product that is toxic to some pests but has little or no effect on other, similar species. Examples include some fungicides that control only powdery mildews and no other fungi.

SELF-CONTAINED BREATHING APPARATUS (SCBA) A type of atmosphere-supplying respirator where the user carries a supply of breathable air. A pressure-demand SCBA is required when the environment is immediately dangerous to life or health (IDLH).

SERVICE CONTAINER A receptacle designed to hold concentrate or diluted pesticide mixtures; not the original pesticide container.

SHELF LIFE The maximum amount of time that a pesticide concentrate can remain in storage before losing some of its effectiveness.

SIGNAL WORDS Terms that must appear on every pesticide label to denote the relative acute toxicity of the product. The signal words are DANGER—POISON used with a skull and crossbones symbol for potentially lethal products, DANGER for severe skin and eye damage, WARNING for moderately toxic, and CAUTION for slightly toxic compounds.

SILVICIDE An herbicide used to destroy brush and trees.

SITE The crop, animal, structure, commodity, or area where a pesticide is applied.

SITE OF ACTION The biochemical site/process within the pest with which the pesticide interacts and disrupts functions.

SLURRY A thick suspension of a pesticide made from a wettable powder and water.

SOIL APPLICATION A pesticide applied directly on or in the soil instead of on a growing plant.

SOIL DRENCH To soak or wet the ground surface with a pesticide. Large volumes of the pesticide mixture are usually needed to saturate the soil to any depth.

SOIL INCORPORATION The movement of a pesticide into soil by either mechanical means or irrigation.

SOIL INJECTION The placement of a pesticide below the surface of the soil. This is a common application method for fumigants and termiticides.

SOIL RESIDUAL PESTICIDE A chemical or agent that prevents the growth of all organisms present in the soil; a nonselective pesticide. Soil persistence may be temporary or permanent, depending on the chemical.

SOLUBILITY The ability of a chemical such as a pesticide to dissolve in a solvent, usually water.

SOLUBLE POWDER A finely ground dry pesticide formulation that will dissolve in water or some other liquid carrier.

SOLUTION A mixture of one or more substances in another substance (usually a liquid) in which all the ingredients are completely dissolved. An example is sugar in water.

SOLVENT A liquid such as water, oil, or alcohol that will dissolve another substance (solid, liquid, or gas) to form a solution.

SPACE SPRAY A pesticide applied as a fine spray or mist to a confined area.

SPACE TREATMENT See **SPACE SPRAY**.

SPECIAL LOCAL NEED (SLN) REGISTRATION A Section 24(c) registration allows states to expand or limit the uses of certain registered pesticides within their jurisdictions.

SPORE The reproductive unit of a fungus. A spore is analogous to a plant seed.

SPOT TREATMENT An application to a small, localized area where pests are found.

SPRAY DEPOSIT The amount of pesticide chemical that remains on a sprayed surface after the droplets have dried.

SPRAY DRIFT The off-target movement of a pesticide during a liquid application.

SPREADER An adjuvant used to enhance the spread of a pesticide over a treated surface, thus improving the coverage.

STABILITY The ability of a chemical such as a pesticide to resist breaking down into metabolites. A highly stable pesticide can be stored for long periods without loss of activity.

STATE LEAD AGENCY (SLA) The agency within a state or territory designated by EPA as having the authority to carry out the provisions of FIFRA.

STERILANT A pesticide that prevents pests from reproducing.

STICKER An adjuvant used to improve the adherence of spray droplets to a plant, animal, or other treated surface.

STOMACH POISON A pesticide that must be eaten by an animal to be effective (does not kill on contact).

STRUCTURAL PESTS Organisms that attack and destroy buildings and other structures, clothing, stored food, and manufactured or processed goods. Examples include termites, cockroaches, clothes moths, rats, and dry-rot fungi.

SUMMER ANNUAL Plant that germinates in the spring or summer and completes its life cycle within one year.

SUPPLEMENTAL LABELING EPA-approved written, printed, or graphic material supplied by the pesticide manufacturer that provides additional product information not present on the container label. The additional information may include new application sites and rates, safety guidelines, Worker Protection Standard and PPE requirements, and endangered species advisories.

SUPPLIED-AIR (AIRLINE) RESPIRATOR A type of atmosphere-supplying respirator with a facepiece that delivers air through an air hose connected to a compressor, blower, or compressed-air tank. The air supply is not designed to be carried by the user.

SURFACTANT An inert ingredient that improves the spreading, dispersing, and/or wetting properties of a pesticide mixture.

SUSCEPTIBLE The degree to which a plant, animal, or site is affected by a pest. Also refers to pest populations that can be controlled by pesticides.

SUSPENSION A pesticide mixture consisting of fine particles dispersed or floating in a liquid, usually water or oil. Examples include wettable powders or flowables in water.

SWATH The width of the area covered by one sweep of an airplane, ground sprayer, spreader, or duster.

SYMPTOM Any detectable change in an organism resulting from the activities of a pathogen or other pest. Also, an indication of pesticide poisoning in humans and other animals.

SYNERGISM The effect of two or more pesticides applied together that is greater than the sum of the individual pesticides applied separately. Here is an example: say Pesticide X kills 40% of an insect population and Pesticide Y kills 20%. When applied together, X and Y kill 95%.

SYSTEMIC EFFECTS Poisoning effects that occur at sites other than the entry point into the body.

SYSTEMIC PESTICIDE A chemical that is absorbed and translocated within a plant or animal.

TANK A part of a sprayer that holds the finished spray mix.

TANK MIX A mixture of two or more crop-production products in a spray tank.

TARGET The plants, animals, structures, areas, or pests to which the control method is directed.

TECHNICAL MATERIAL The pesticide active ingredient in pure form as it is manufactured by a chemical company. It is usually combined with inert ingredients or additives in formulations such as wettable powders, dusts, emulsifiable concentrates, or granules.

TEMPERATURE INVERSION A weather-related event that occurs when cool air is trapped near the surface under a layer of warm air. Under these conditions very little vertical mixing of air occurs. Small spray droplets or vapors may remain suspended in the cool air layer for long periods and move with any airflow. Damage from spray drift often occurs under such conditions.

TERATOGEN A substance or agent able to produce abnormalities or defects in living human or animal embryos and fetuses. These defects are not usually inheritable.

TERMITICIDE An insecticide used to control termites.

THICKENER A drift control adjuvant, such as cellulose or gel, used to promote the formation of a greater proportion of large droplets in a spray mixture.

THREATENED SPECIES Organisms (plants or animals) likely to become endangered.

TIGHT-FITTING FACEPIECE See **FACEPIECE (TIGHT-FITTING)**.

TOLERANCE The maximum amount of a pesticide residue that may legally remain on or in food or feed commodities at harvest or slaughter. Established by EPA for each crop and every pesticide used on a specific crop.

TOLERANT A characteristic of organisms (including pests) that are able to withstand a certain degree of stress, such as weather, pesticides, or attack by a pest.

TOXIC Poisonous to living organisms.

TOXICANT A poisonous substance, such as the active ingredient in a pesticide formulation.

TOXICITY The degree or extent to which a chemical or substance is poisonous.

TOXICOLOGY The study of the effects of toxic substances on living organisms.

TOXIN A naturally occurring poison produced by plants, animals, or microorganisms. Examples include the poison produced by the black widow spider, the venom produced by snakes, and the botulism toxin.

TRADE NAME A brand name that is registered as a trademark by the manufacturer.

TRANSLOCATION The movement of materials within a plant or animal from the site of entry. A systemic pesticide is translocated.

TRANSPORTATION SECURITY PLAN A plan required of all operations that transport pesticides in containers that are larger than 119 gallons or in quantities greater than 1,000 pounds. The U.S. Department of Transportation requires the plan to include protection against unauthorized access, a security check for employees that pick up and transport placarded hazardous materials, and a security plan for the intended travel route. Vehicles that transport pesticides in these quantities must be placarded.

TREE INJECTION The placement of a pesticide under the bark of trees.

TRIPLE RINSE The process of decontaminating an empty pesticide container by partially filling it with water, replacing the lid, shaking the container, and then pouring the rinsate into the spray tank. This process is performed three times.

ULTRA-LOW VOLUME (ULV) Sprays that are applied at 0.5 gallon or less per acre, often as an undiluted formulation.

UNCLASSIFIED-USE PESTICIDES Pest control products that are often referred to as general-use pesticides. They can be bought and used by the public without special permits or restrictions.

USER SEAL CHECK For tight-fitting respirators, a check performed by the wearer to ensure that the mask has been put on correctly and adjusted to fit properly. This check is necessary each time these respirators are worn.

VAPOR DRIFT The movement of chemical vapors from the application site. Like pesticide spray drift, vapor drift can injure nontarget plants or animals.

VAPOR PRESSURE The property that causes a chemical to evaporate. The higher the vapor pressure, the more volatile the chemical—and the more easily it will evaporate.

VECTOR An animal (e.g., insect, nematode, or mite) or plant (e.g., dodder) that can carry and transmit a pathogen from one host to another.

VERTEBRATE An animal characterized by a segmented backbone or spinal column.

VIRUS Ultramicroscopic parasite. Viruses can multiply only in living tissues and cause many animal and plant diseases.

VOLATILITY/VOLATILE The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.

WARNING The signal word associated with pesticide products classified as moderately toxic. These pesticides have an oral LD_{50} between 50 and 500mg/kg or a dermal LD_{50} between 200 and 2,000mg/kg.

WATER-DISPERSIBLE GRANULE A dry, granular formulation that breaks apart and disperses to form a suspension when added to water.

WATER-SOLUBLE BAG See **WATER-SOLUBLE PACKET/PACKAGING**.

WATER-SOLUBLE CONCENTRATE A liquid pesticide formulation that dissolves in water to form a true solution.

WATER-SOLUBLE PACKET/PACKAGING Wettable powder or soluble powder formulation packaged in a special type of plastic bag that dissolves and releases its contents when placed in water.

WATER TABLE The boundary between the overlying unsaturated rock or soil and the saturated zone.

WATERPROOF As specified by the pesticide product label, PPE that is "made of material that allows no measurable movement of water or aqueous solutions through the material during use" [U.S. EPA. 40 CFR 170.240 Personal protective equipment].

WEED A plant growing where it is not wanted or where it is in direct conflict with the well-being of humans and their activities.

WETTABLE POWDER A dry pesticide formulation in powder form that forms a suspension when added to water.

WETTING AGENT An adjuvant used to reduce the surface tension between a liquid and the contact surface for more thorough coverage.

WINTER ANNUAL Plant that germinates in the fall or winter and completes its life cycle within one year.

WORKER PROTECTION STANDARD (WPS) A federal regulation that is meant to reduce the risk of pesticide poisoning and injuries among agricultural workers and handlers. The WPS requires agricultural employers to provide protections to workers and handlers, including but not limited to safety training, posting of application sites, and decontamination supplies.

APPENDIX C

Conversions & Calculations

Effective application of pesticides depends on many factors. One of the more important is to correctly calculate the amount of material needed. Unless you have the right amount of pesticide in your tank mix, even a correctly calibrated sprayer can apply the wrong rate.

Manufacturers provide application rate instructions on every pesticide label. Due to the variety of ways in which these recommendations are stated (such as pounds of active ingredient [a.i.] per acre, pounds of formulation per 100 gallons of spray, or ounces of a.i. per 1,000 square feet), it is often necessary to adapt the recommendations to different areas and volumes, or even other units. Sometimes the amount of active ingredient must be converted to the amount of actual product. This process can be very confusing.

Conversion Factors

To use this conversion table, multiply the number in the left-hand column by the conversion factor in the center column. This converts your original number to the units in the right-hand column.

Examples:

1.0 gallon equals how many ounces?
1.0 gallon x 128 = 128 fluid ounces

2.5 gallons equals how many ounces?
2.5 gallons x 128 = 320 fluid ounces

Multiply	By	To get	Multiply	By	To get
Acres	43,560	Square feet	Gallons	128	Ounces (liquid)
Acres	4,840	Square yards	Gallons	8	Pints (liquid)
Acres	0.405	Hectares	Gallons	4	Quarts (liquid)
Bushels	64	Pints	Gallons, H_2O	8.345	Pounds of water
Bushels	32	Quarts	Grams	0.001	Kilograms
Cubic feet	1,728	Cubic inches	Grams	1,000	Milligrams
Cubic feet	0.037	Cubic yards	Grams	0.035	Ounces
Cubic feet	7.481	Gallons	Grams per liter	1,000	Parts per million
Cubic feet	59.84	Pints (liquid)	Hectares	2.47	Acres
Cubic feet	29.92	Quarts (liquid)	Inches	2.54	Centimeters
Cups	8	Ounces (liquid)	Kilograms	1,000	Grams
Cups	16	Tablespoons	Kilograms	2.205	Pounds
Feet	30.48	Centimeters	Kilometers	3,281	Feet
Feet	12	Inches	Kilometers	0.621	Miles
Feet	0.305	Meters	Liters	0.264	Gallons
Feet	1/3 or 0.333	Yards	Liters	2.113	Pints (liquid)
Gallons	3.785	Liters	Liters	1.057	Quarts (liquid)

Multiply	By	To get	Multiply	By	To get
Meters	100	Centimeters	Pints (liquid)	0.5	Quarts (liquid)
Meters	3.281	Feet	Pounds	453.592	Grams
Meters	39.37	Inches	Pounds	16	Ounces
Meters	0.001	Kilometers	Pounds	0.0005	Tons
Meters	1,000	Millimeters	Quarts	2	Pints
Meters	1.094	Yards	Quarts	0.25	Gallons
Miles	5,280	Feet	Quarts	0.946	Liters
Miles	1,760	Yards	Quarts (liquid)	32	Ounces (liquid)
Miles per hour	88	Feet per minute	Quarts (liquid)	2	Pints (liquid)
Miles per hour	1.467	Feet per second	Rods	16.5	Feet
Miles per minute	88	Feet per second	Square miles	640	Acres
Miles per minute	60	Miles per hour	Square yards	9	Square feet
Ounces (dry)	28.35	Grams	Square yards	1,296	Square inches
Ounces (dry)	0.063	Pounds	Tablespoons	3	Teaspoons
Ounces (liquid)	0.063	Pints (liquid)	Temperature (°C) + 17.98	1.8	Temperature °F
Ounces (liquid)	0.031	Quarts (liquid)	Temperature (°F) – 32	0.555	Temperature °C
Parts per million	0.001	Grams per liter	Tons	907.185	Kilograms
Pecks	16	Pints (dry)	Tons	2,000	Pounds
Pecks	8	Quarts (dry)	Yards	3	Feet
Pints	0.125	Gallons	Yards	36	Inches
Pints	0.473	Liters	Yards	0.914	Meters
Pints	2	Cups			
Pints (liquid)	16	Ounces (liquid)			

PESTICIDE CALCULATIONS

Formulations such as wettable and soluble powders, emulsifiable concentrates, and flowables are sold as concentrates and must be diluted in the spray tank with an appropriate carrier. Water is the most common carrier, but kerosene, oil, and other liquids are sometimes used. Below are examples of how to properly calculate how much pesticide should be added to a spray tank.

Mixing Soluble and Wettable Powders

Pounds per 100 gallons: Directions for wettable or soluble powders may be given in pounds of pesticide formulation per 100 gallons of carrier. You must know the capacity in gallons of your spray tank (or the number of gallons you will be adding to your spray tank if the job requires only a partial tank load). Then use the following formula:

$$\frac{\text{Gallons in tank} \times \text{pounds per 100 gallons recommended}}{\text{100 gallons}} = \text{pounds needed in tank}$$

Example:
Your spray tank holds 500 gallons. The label calls for 2 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank?

$$\frac{\text{500 gallons} \times \text{pounds per 100 gallons (2)}}{\text{100 gallons}} = \text{pounds needed in tank (10)}$$

$$500 \times 2 \div 100 = 10$$

You should add 10 pounds to the tank.

Example:
You need to spray only 1 acre, and your equipment is calibrated to spray 60 gallons per acre. The label calls for 2 pounds of formulation per 100 gallons of water. How many pounds of formulation should you add to the tank to make 60 gallons of finished spray?

$$\frac{\text{Gallons in tank (60)} \times \text{pounds per 100 gallons (2)}}{\text{100 gallons}} = \text{pounds needed in tank (1.2, or 19.2 ounces)}$$

$$60 \times 2 \div 100 = 1.2$$

Number of pounds to add is 1.2, or 19.2 ounces.

Pounds per acre: The label may list the recommended dosage as pounds per acre. If the job requires a full tank, you must know how many gallons your equipment applies per acre and spray tank capacity. Use these formulas:

$$\frac{\text{Gallons in tank}}{\text{gallons applied per acre}} = \text{acres sprayed per tankful}$$

Acres sprayed per tank X pounds formulation per acre = pounds of formulation needed in tank

Example:
Your sprayer applies 15 gallons per acre and your tank holds 400 gallons. The label rate is 3 pounds of formulation per acre.

$$\frac{\text{Gallons in tank (400)}}{\text{gallons per acre (15)}} = \text{acres sprayed per tankful (26.7)}$$

400 ÷ 15 = 26.7

Acres sprayed per tankful (26.7) X pounds formulation per acre (3) = pounds formulation needed in tank (80.1)

26.7 X 3 = 80.1

Add 80 pounds of pesticide formulation to the tank.

If the job requires less than a full tank, you must know how many acres you wish to treat and how many gallons your sprayer is pumping per acre. You must figure both the number of gallons needed in the tank and the pounds of formulation to add. Use these formulas:

Gallons per acre X acres to be treated = gallons needed in tank

Acres to be treated X pounds formulation per acre = pounds of formulation needed in tank

Example:
You wish to spray 3.5 acres, and your equipment is applying 15 gallons per acre. The label rate is 3 pounds per acre.

Gallons per acre (15) X acres to be treated (3.5) = gallons needed in tank (52.5)

15 X 3.5 = 52.5

Acres to be treated (3.5) X pounds of formulation per acre (3) = pounds of formulation needed in tank (10.5)

3.5 X 3 = 10.5

If the recommended dosage is given as pounds of active ingredient per acre, you must first convert that figure to pounds of formulation per acre. Use the following formula:

$$\frac{\text{Pounds of a.i. per acre X 100}}{\text{percent of a.i. in formulation}} = \text{pounds of formulation per acre}$$

Then follow the formulas listed above under "pounds per acre" to find the pounds of formulation to add to your tank.

Example:
You wish to apply 2 pounds of active ingredient per acre. Your formulation is 80% WP.

$$\frac{\text{Pounds of a.i. per acre (2) X 100}}{\text{percent a.i. in formulation (80)}}$$
= pounds of formulation per acre (2.5)

2 X 100 ÷ 80 = 2.5

Mixing Liquid Formulations

Rates for liquid formulations (e.g., EC and F) are often listed as pints, quarts, or gallons per 100 gallons or per acre. Make these calculations as you did in the formulas above for pounds per 100 gallons or pounds per acre, but substitute the appropriate liquid measure for "pounds."

Example:
The label rate is 2 pints of pesticide formulation per 100 gallons of water. Your spray tank holds 300 gallons.

$$\frac{\text{Gallons in tank (300) X pints per 100 gallons (2)}}{\text{100 gallons}}$$
= pints of formulation needed in tank (6)

300 X 2 ÷ 100 = 6

Example:
Your sprayer applies 22 gallons per acre, and your tank holds 400 gallons. The label rate is 1.5 quarts per acre.

$$\frac{\text{Gallons in tank (400) X quarts per acre (1.5)}}{\text{gallons per acre (22)}}$$
= quarts needed in tank (27.3)

400 X 1.5 ÷ 22 = 27.3

If the recommendation for a liquid formulation is listed as pounds of active ingredient per acre, you must first convert that figure to gallons of formulation to apply per acre. The label of a liquid formulation always tells how many pounds of active ingredient are in 1 gallon of the concentrated formulation (e.g., 4 EC has 4 pounds of active ingredient per gallon; 6 EC contains 6 pounds of a.i. per gallon). Use the following formula:

$$\frac{\text{Pounds of a.i. needed per acre}}{\text{pounds of a.i. per gallon of formulation}} = \text{gallons of formulation per acre}$$

Example:
The recommendation is for 1 pound of active ingredient per acre. You purchased an 8 EC, which contains 8 pounds of active ingredient per gallon. Your tank holds 500 gallons and is calibrated to apply 25 gallons per acre.

$$\frac{\text{Pounds a.i. needed per acre (1)}}{\text{pounds of a.i. per gallon (8)}} = \text{gallons per acre (1/8, or 1 pint)}$$

1 ÷ 8 = 0.125 (1/8)

$$\frac{\text{Gallons in tank (500)}}{\text{gallons per acre (25)}} = \text{acres per tankful (20)}$$

500 ÷ 25 = 20

Acres per tankful (20) X gallons per acre (1/8 or 0.125) = gallons to add to tank (2.5)

20 X 0.125 = 2.5

Square Feet vs. Acre Mixing

The label rate is sometimes given in pounds, pints, quarts, or gallons per 1,000 square feet. If you have calibrated your equipment in terms of 1,000 square feet, you must adjust the formulas above from an acre to 1,000 square feet. The following formulas may be used with either liquid or dry formulations:

$$\frac{\text{Gallons per tank}}{\text{gallons applied per 1,000 square feet by equipment}} = \text{number of 1,000-square-foot sections per tankful}$$

Number of 1,000-square-foot sections sprayed per tankful X pints, quarts, gallons, or pounds of formulation needed per 1,000 square feet = amount of formulation to add to tank.

However, if you have calculated the target area in acres, you must convert the 1,000-square-foot rate to a rate per acre as follows:

$$\frac{\text{43,560 square feet per acre}}{\text{1,000 square feet}} = 43.5$$

Pints, quarts, gallons, or pounds per 1,000 square feet X 43.5 = pints, quarts, gallons, or pounds of formulation to apply per acre.

To convert from the rate per acre to a rate per 1,000 square feet (or 100 square feet):

$$\frac{\text{Pints, quarts, gallons, or pounds of formulation recommended per acre}}{\text{43.5 (435 for 100 square feet)}} = \text{pints, quarts, gallons, or pounds of formulation per 1,000 square feet (or 100 square feet)}$$

From Penn State *Pesticide Education Manual*, third edition

The section on conversion tables was adapted from the *Pocket Pesticide Calibration Guide*, compiled by Frank Boys and Frank Murphey, University of Delaware.

The section on pesticide calculations was adapted from *Applying Pesticides Correctly: A Guide for Private and Commercial Applicators*, North Carolina State University.

APPENDIX D

Safety Data Sheets

The Occupational Safety and Health Administration (OSHA)'s Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, and importers to provide Safety Data Sheets (SDSs) for each hazardous chemical to communicate information on these hazards. (Safety Data Sheets were formerly known as Material Safety Data Sheets.) As of June 1, 2015, the new SDSs must be in a uniform format and include section numbers, headings, and associated information to help users find the information they need about a specific chemical.

A brief description of all 16 sections of the SDS, along with their contents, is presented below. OSHA itself will not enforce Sections 12 to 15 because they concern matters handled by other agencies. For example, Section 15 details what is found on the pesticide label enforced by the U.S. Environmental Protection Agency. The SDS may have a different signal word than the pesticide label, and it will include pictograms not found on the label.

For more details about SDSs, go to: https://www.osha.gov/Publications/OSHA3514.html

Section 1: Identification

This section includes product identifier; manufacturer or distributor name, address, and phone number; emergency phone number; recommended use; and restrictions on use.

Section 2: Hazard(s) Identification

This section includes all hazards regarding the chemical and required label elements.

Section 3: Composition/Information on Ingredients

This section includes information on chemical ingredients and trade secret claims.

Section 4: First Aid Measures

This section includes important symptoms, acute and delayed effects, and required treatment.

Section 5: Firefighting Measures

This section lists suitable extinguishing techniques, equipment, and chemical hazards from fire.

Section 6: Accidental Release Measures

This section lists emergency procedures, protective equipment, and proper methods of containment and cleanup.

Section 7: Handling and Storage

This section lists precautions for safe handling and storage, including incompatible products.

Section 8: Exposure Controls/Personal Protection

This section lists OSHA's permissible exposure limits, threshold limit values, appropriate engineering controls, and personal protective equipment.

Section 9: Physical and Chemical Properties

This section lists the product's physical and chemical characteristics.

Section 10: Stability and Reactivity

This section lists the product's chemical stability and the possibility of hazardous reactions.

Section 11: Toxicological Information

This section includes routes of exposure, related symptoms, acute and chronic effects, and numerical measures of toxicity.

Section 12: Ecological Information

This section provides information to evaluate the environmental impact of the chemical(s) if it were released outside the target area.

Section 13: Disposal Considerations

This section provides guidance on proper disposal practices, recycling or reclamation of the chemical(s) or its container, and safe handling practices.

Section 14: Transport Information

This section provides guidance on classification information for shipping and transporting hazardous chemical(s) by road, air, rail, or sea.

Section 15: Regulatory Information

This section identifies the safety, health, and environmental regulations specific for the product that are not indicated elsewhere on the SDS.

Section 16: Other Information

This section indicates when the SDS was prepared or when the last known revision was made.

APPENDIX E

SELECTED PESTICIDE REFERENCES

Applying Pesticides Correctly—A Guide for Private and Commercial Applicators. 1991. Sally A. McDonald. The Ohio State University and Information Impact.

Buying and Wearing Protective Clothing for Applying Pesticides. Revised 1990. Wanda W. Olson, Sherri A. Gahring, and Dean Herzfeld. HE-FO-3877-C. Minnesota Extension Service, University of Minnesota.

Category E: Turf & Ornamentals Pesticide Safety Education Manual. 2014. Carolyn Dindorf. Pesticide Safety and Environmental Education, University of Minnesota Extension Service.

Field Comparisons for Drift-Reducing/Deposition-Aid Tank Mixes. 2003. R. Wolf, D. Gardisser, and C. Minihan. Paper No. AA03–002. Presented at the Joint ASAE/NAAA Technical Meeting, Reno, Nevada.

How to Read a Material Safety Data Sheet. 1999. Amy E. Brown. Pesticide Information Leaflet No. 29. University of Maryland Extension.

Illinois Pesticide Applicator Training Manual, General Standards. 1995. P.L. Nixon, C.D. Anderson, N.R. Pataky, R.E. Wolf, R.J. Ferree, and L.E. Bode. Special Publication 39. University of Illinois Cooperative Extension Service, in cooperation with the Illinois Natural History Survey.

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Maryland Pesticide Applicator Training Series—Core Manual. Revised 1999. W.M. Curtis and A.E. Brown. University of Maryland Extension.

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Pesticide Laws and Regulations. 1991. Edward F. Vitzhum and Larry D. Schulze. NebGuide G79-479. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

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Pesticides and Formulation Technology. 1994. Andrew Martin, Fred Whitford, Tom Jordan, and Arlene Blessing. PPP-31. Purdue Pesticide Programs, Purdue University Cooperative Extension Service.

Private Pesticide Applicator Study Guide. Revised 1997. Julie Todd. PAT 1. Chapter 8: Pesticides in the Environment. Iowa State University Extension (Ames).

Recognition and Management of Pesticide Poisonings (5th ed.). 1999. J.R. Reigart and J.R. Roberts. U.S. EPA Office of Pesticide Programs.

Record Keeping Requirements for Private and Commercial Applicators. Revised 2001. Amy E. Brown. Pesticide Information Leaflet No. 14. University of Maryland Extension.

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Training Manual for the Private Pesticide Applicator (4th ed.). 1998. Dan Wixted, Roger Flashinski, Chris Boerboom, and John Wedberg. Pesticide Applicator Training, University of Wisconsin-Extension.

Washington Pesticide Laws and Safety. 2003. Carol Ramsay and Carrie Foss. Washington State University.

When Clients Have Questions: A Guide for Professional Pesticide Applicators. 2013. Frederick M. Fishel. Pesticide Information Office. Institute of Food and Agricultural Sciences, University of Florida. Online: http://edis.ifas.ufl.edu/pi161

APPENDIX F

PESTICIDE-RELATED RESOURCES

RELEVANT WEBSITES

Ag Container Recycling Council
http://www.acrecycle.org

American Association of Pesticide Safety Educators
http://aapse.org

Association of American Pesticide Control Officials
http://aapco.org

Association of Structural Pest Control Regulatory Officials
http://aspcro.org

Chemtrec (24-hour HAZMAT Communications Center)
http://www.chemtrec.org

Earth 911 (environmental information, including local community data)
http://www.earth911.org

eXtension
http://extension.org

National Association of State Departments of Agriculture
http://www.nasda.org

National Association of State Departments of Agriculture Research Foundation
http://foundation.nasda.org

National Pesticide Information Center
http://npic.orst.edu

Natural Resources Conservation Service
http://www.nrcs.usda.gov

Pesticide Environmental Stewardship
http://pesticidestewardship.org

Poison Control Centers (State and Regional)
http://npic.orst.edu/poison.htm

Regional IPM Centers
http://www.ipmcenters.org

U.S. Centers for Disease Control
http://www.cdc.gov

U.S. Department of Agriculture
http://www.usda.gov

U.S. Department of Transportation, Pipeline and Hazardous Materials Safety
http://hazmat.dot.gov

U.S. Environmental Protection Agency
http://www.epa.gov/

U.S. Environmental Protection Agency, Office of Pesticide Programs
http://www.epa.gov/pesticides

To search for regional offices, go to http://www.epa.gov or search online by typing in the agency name and pesticide program.

EPA REGIONAL PESTICIDE PROGRAM OFFICES

Region 1 (serves Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont)

1 Congress Street
Suite 1100
Boston, MA 02114-2023
Tel. (617) 918-1111

Region 2 (serves New Jersey, New York, Puerto Rico, and the U.S. Virgin Islands)

290 Broadway
New York, NY 10007-1866
Tel. (212) 637-3000

Region 3 (serves Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia)

1650 Arch Street
Philadelphia, PA 19103-2029
Tel. (215) 814-5000

Region 4 (serves Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee)

61 Forsyth Street, SW
Atlanta, GA 30303-8960
Tel. (404) 562-9900

Region 5 (serves Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin)

77 West Jackson Boulevard
Chicago, Il 60604-3507
Tel. (312) 353-2000

Region 6 (serves Arkansas, Louisiana, New Mexico, Oklahoma, and Texas)

1445 Ross Avenue
Dallas, TX 75202-2733
Tel. (214) 665-6444

Region 7 (serves Kansas, Missouri, Nebraska, and Iowa)

901 N. 5th Street
Kansas City, KS 66101
Tel. (913) 551-7003

Region 8 (serves Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming)

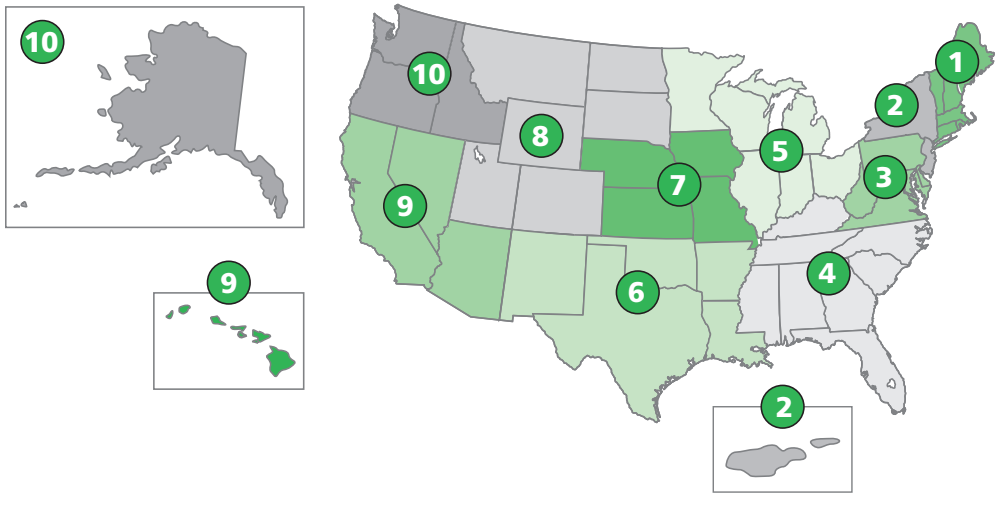
999 18th St., Suite 300
Denver, CO 80202-2466
Tel. (303) 312-6312

Region 9 (serves Arizona, California, Hawaii, Nevada, and the territories of Guam and American Samoa)

75 Hawthorne St.
San Francisco, CA 94105
Tel. (415) 947-8021

Region 10 (serves Alaska, Idaho, Oregon, and Washington)

1200 Sixth Avenue
Seattle, WA 98101
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