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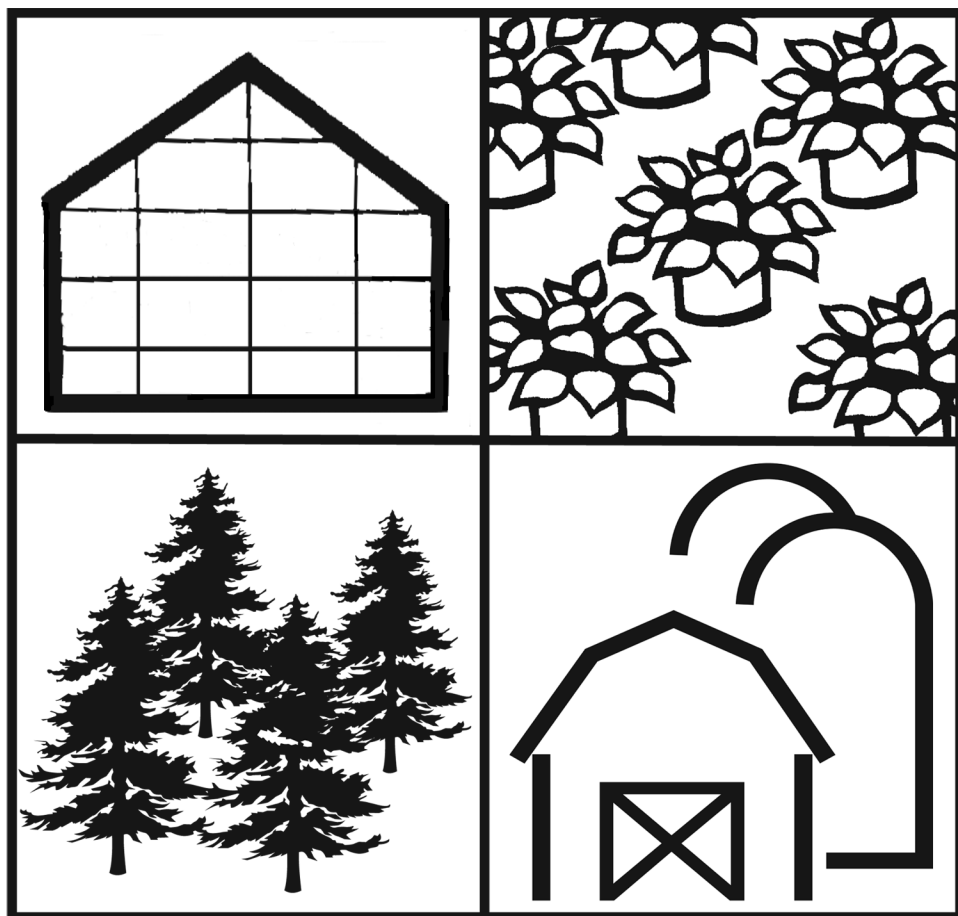
Colorado Private Pesticide Applicator Training Manual



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Introduction

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) sets minimum standards for persons handling restricted use pesticides (RUPs). This Federal law requires that some pesticides be classified as restricted use. RUPs may be sold only to and used by certified applicators because they pose an increased risk to humans and/or the environment.

In Colorado, "private applicator" means any person who uses or supervises the use of a pesticide for purposes of producing any agricultural commodity on property owned or leased by the applicator or the applicator's employer or, if the pesticide is applied without compensation other than trading of personal services between producers of agricultural commodities, on the property of another person. "Agricultural commodity" means any plant, or part thereof, or animal, or animal product, produced by a person (including farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animals.

A person seeking a private applicator certification must take and pass an exam administered through the Colorado Department of Agriculture. More information is available on the CEPEP website. Private applicator certification does NOT authorize you to apply pesticides on someone else's property and charge a fee for the service. If you wish to apply pesticides for hire, you must first obtain a commercial applicator certification and a pesticide applicator business license from the Colorado Department of Agriculture (CDA). (Website: colorado.gov/agplants)

This manual contains useful information that will help you learn about applying pesticides safely and help you to meet the Colorado private pesticide applicator certification requirements. It does not include all the information that you need to know about the pests you wish to control.

How to Use This Manual

The chapters within this guide follow the subject areas on which you will be tested. Learning Objectives precede the body of each chapter. These objectives highlight the key information contained in the chapters.

A list of "Additional Resources" is also included at the end of each chapter. The section is included only to provide you with additional information above and beyond what is presented in this study guide.

The "Appendix" contains information that will NOT be included on the exam but included for reference. The Appendix contains information on calibrating equipment that is not commonly used, an example of a private applicator record keeping form and a list of acronyms used throughout the guide.

The "Glossary" near the end of the guide will familiarize you with terminology used in the text. Terms that appear in the glossary are in boldface type upon first use in the guide.

Preparing for the Exam

To prepare for the private applicator exam, read this study guide and accompanying materials. The private applicator exam consists of true-false and multiple-choice questions drawn from the following subject areas:

- Laws and regulations
- Pesticide labeling
- Pesticide toxicity to humans
- Using pesticides safely
- Environmental hazards
- Pesticide storage, disposal and transportation
- General pests
- Integrated pest management
- Pesticide classifications and formulations
- Basic application
- Application equipment and calibration

Additional Resources

- Colorado Department of Agriculture, Division of Plant Industry, 305 Interlocken Parkway Broomfield, CO 80021. Phone: (303) 869-9063. <https://www.colorado.gov/agplants> *CDA develops and administers exams, issues licenses, conducts inspections, investigates complaints of misapplication of pesticides by pesticide applicators.*
- Colorado Environmental Pesticide Education Program (CEPEP), 1177 Campus Delivery, Colorado State University, Ft. Collins, CO 80523-1177. Phone: 970-491-3947. <http://cepep.agsci.colostate.edu/> *Pesticide education resources including licensing, factsheets, handbooks and training guides, and training videos.*
- EPA Region 8, 999 18th Street, Suite 200, Denver, CO 80202. 1-800-227-8917, <http://www.epa.gov/aboutepa/epa-region-8-mountains-and-plains> *Many pesticide related topics.*

General Pests

Learning Objectives

After reviewing this chapter, you should be able to:

- Describe how to identify different types of pests:
 - a) Insect pests.
 - b) Weeds.
 - c) Plant diseases.
 - d) Snails and slugs.
 - e) Vertebrates.
- Identify damage caused by different types of pests.

Whether in the home, the garden, on the farm, in a lake or pond, on lawn and ornamental plants, or in countless other places, we tend to favor one or a few species of plants and animals over others. In each case, the unwanted species are considered to be pests. Pests are organisms which attack or otherwise adversely affect our crops, bodies, homes, pets and livestock, or which compete with or attack our plants.

The first step in solving any problem is to understand what is causing the problem. Before trying to control a pest, you need to identify it. Identifying a pest problem is often not a simple job. When a person is unfamiliar with a pest, or what pest may be causing damage, it is necessary to correctly identify the pest before deciding if any management or control program should be undertaken.

Failure to properly identify the pest may result in wasted time, money, chemicals, and effort. Proper identification will make it possible for you to understand more about the pest, to make appropriate selection and application of management techniques, and to minimize your control efforts.

Pests can be divided into five main groups:

- Insects and their close relatives: **mites**, **ticks**, and **spiders**
- **Weeds**
- **Plant disease** agents
- **Vertebrates**
- Snails and slugs

Insects

There are over one million species of insects, which means that there are more kinds of insects than any other kind of organism. Of these million-plus species, fewer than 100,000 are found in the U.S., and of these, only a few hundred are considered to be significant pests.

General Pests

In Colorado, we have approximately 100 common pest insect species which cause an estimated \$800 million in damage to the state's agricultural industry each year. Insects that are agricultural pests wreak havoc at various stages of growth. They may attack the seed before or after it is placed in the ground; the seedlings before they emerge; seedlings, or leaves, stems, roots, buds, and fruit of the mature plants; the crop at harvest; and even harvested crops during storage.

Ways Insects May Cause Damage

- | | |
|---|--|
| • Direct chewing on leaves | • Feeding on the flesh and blood of animals and people |
| • Feeding on the roots and crowns of plants | • Transmitting diseases of animals and people |
| • Boring or tunneling into the plant leaves, stems, or fruits | • Causing allergic reactions in animals and people |
| • Direct feeding on the fruits, nuts, or berries | • Feeding on stored products |
| • Sucking plant juices from leaves, stems, etc. | • Feeding on buildings (e.g., termites) |
| • Causing malformations such as galls on plants | • Causing fright and nuisance |
| • Transmitting plant diseases, including viruses | |

A troublesome insect must first be identified before control measures are undertaken. Insect species identification often requires the assistance of a person with highly specialized knowledge. In many cases, however, it is possible for the pesticide applicator to recognize the major group to which the insect belongs. This small amount of knowledge about the insect can help you understand important facts about its biology, behavior, and whether it is likely to be a pest. Knowledge of the development and form of insects is a basic requirement for identification.

To diagnose insect pest problems, it is necessary to look for clues such as the presence of insects (egg, larva, nymph, pupa, or adult stages), cast skins, insect products (honeydew, frass), or the type and pattern of damage. It is necessary to be able to separate insects from non-insects and to be able to identify insects to order.

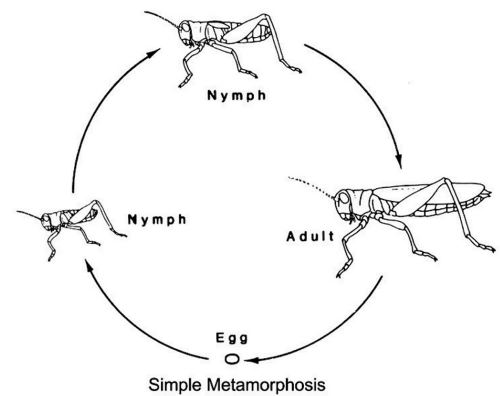
Insect Anatomy

Insects are identified by having their body divided into three regions – the **head, thorax, and abdomen**. **Adult** insects have three pairs of legs and usually have developed wings. The head functions mainly for food and sensory intake and information processing. Insect mouthparts have evolved for chewing (beetles, caterpillars), piercing-sucking (aphids, bugs), sponging (flies), siphoning (moths), rasping-sucking (thrips), and chewing-lapping (wasps). Both wings and legs are attached to the middle region, the thorax. The thorax provides structural support for the legs and, if present, for one or two pairs of wings. Often times, immature insects do not have six legs or developed wings. The three pairs of jointed legs may be adapted for running, grasping, digging, or swimming. The third region, the abdomen functions in digestion and reproduction. Insects are divided further into subgroups (orders) based on types of wings, mouthparts, and the type of development, or **metamorphosis**, they undergo.

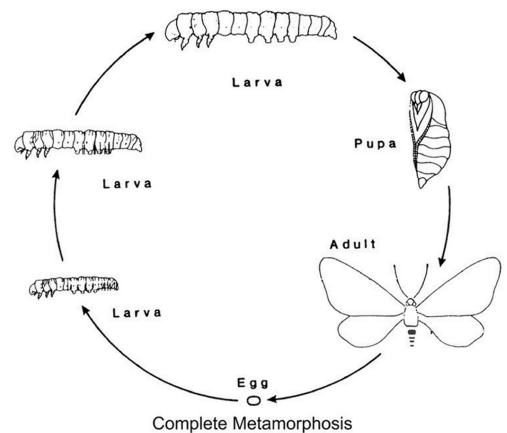
Development of Insects

As insects develop, they undergo changes in shape, form, and size, a process known as *metamorphosis*. Two general types of metamorphosis take place in insects: simple or complete.

Insects that undergo **simple metamorphosis** progress from eggs, to immature stages called **nymphs**, and to adults. Nymphs of insects with simple metamorphosis feed in the same manner as the adult stage and are generally similar in form, although smaller and lack wings. Typically nymphs go through three to five stages (**instars**), progressing to the adult form in the last stage. As the nymphs feed and grow, they shed their skin several times - a process called molting. When they complete their development, they are full-sized adults. Insect pests that undergo simple metamorphosis include termites, sucking lice, chewing lice, aphids, leafhoppers (Homoptera), true bugs (Hemiptera), crickets and grasshoppers (Orthoptera), and thrips (Thysanoptera).



The more complex type of insect development is called **complete metamorphosis**. This developmental pattern involves several complete changes in form during the growth of the insect. Insects that undergo complete metamorphosis progress from eggs, to immature stages known as larvae, to a transition form known as **pupae**, and, finally to the adults. Normally, larvae are the most damaging to crops because they are trying to feed, grow, and become adults. Larvae may have special names, such as "white grubs", "sod webworms" or "cutworms". When full grown, the larvae then transform to the pupal stage, and this is later followed by the adults. Beetles (Coleoptera), caterpillars (Lepidoptera), fleas, bees, ants, and flies (Diptera) are insect groups that undergo complete metamorphosis.



Five of the more primitive groups of insects undergo no distinct metamorphosis, including silverfish, firebrats, and springtails.

Insects Relatives

Insects have several important relatives. The insects, together with spiders, mites, centipedes, millipedes, and **crustaceans** belong to a larger group (phylum) of animals, the **arthropods**. The word arthropod means "jointed foot", a characteristic shared by all arthropods. Other characteristics are:

- A body that is segmented
- Appendages that are jointed
- An **exoskeleton** for protection from the environment and natural enemies
- The need to periodically shed and regrow the exoskeleton (**molting**) in order to grow

Arachnids (spiders, ticks, mites) are most easily distinguished from insects by having four pairs of legs. Also their body is usually separated into only two body regions. The head and the area of the body containing the legs is fused together into the **cephalothorax**. They also possess a large abdomen on the hind end that contains most of the organs needed to digest food and to reproduce. Arachnids go through simple metamorphosis.

Weeds

A weed is simply a plant growing where it is not wanted. A successful weed control program depends upon identifying the weed, which in turn often requires the help of a specialist.

Weeds are damaging because they may:

- Compete with other plants for water and nutrients, resulting in reduced crop yields and impaired crop quality
- Interfere with cultural practices and harvest
- Increase production costs to control them
- Serve as reservoirs of insects and plant diseases
- Pose hazards to animal and human health through their poisonous properties
- Reduce water flow in irrigation systems
- Reduce biodiversity

There are more than 400 species of plants in Colorado that may cause such problems. Some of these plants have been defined by law as **Noxious Weeds** because they are especially undesirable, troublesome, and difficult to control. For a list of Colorado noxious weeds visit the noxious weed website at CDA (additional resources), or contact your county weed supervisor.

Common Forms of Weeds

While there are a great many species of weeds, most may be placed into one of two groups based on their structure.

Monocots are plants having a single cotyledon or seed leaf. These narrow-leaved weeds include grasses, sedges, rushes, cattails, and a few others. The narrow-leaved weeds generally have parallel veins in the leaves.

Dicots are plants with two cotyledons or seed leaves. Dicots are also called “broadleaves” and include most other weeds, such as the mustards, curly dock, pigweed, purslane, and bindweed. These weeds may be recognized by the presence of a net-like pattern of veins in the leaves.

Common Life Cycles of Weeds

Plants can also be classified according to their life cycle as **annuals**, **biennials**, or **perennials**. These are not strict botanical divisions, but groupings that are important in determining how to control the plants, based on their most susceptible growth stage.

Annuals mature in one season and are propagated by seed. **Summer annuals** grow from seeds which sprout in the spring, mature, and reproduce before dying in the winter. Among the common summer annuals are barnyard grass, puncturevine, Russian thistle, and lambsquarters. **Winter annuals** germinate in the fall or winter, go through a dormant period, and grow until spring when they flower, produce seed and die. Among the common winter annuals are common chickweed, mustard, cheatgrass, and wild oats.

Biennials require two years to develop and complete their life cycles. These plants grow vegetatively (without flowering in a rosette form) through the first year. In the second year the

plant flowers, produces seed, and dies. Common biennials are common burdock, musk thistle, common mullein, and houndstongue.

Perennials are plants that live three years or longer. These plants flower and set seed without dying. They live indefinitely; they may lose their foliage during the winter and die back to the ground, but they recover in the spring. Common examples are Canada thistle, Johnsongrass, field bindweed, dandelion, and plantain.

Perennial plants are members of many major plant groups, and they may take many forms. Some are **herbaceous** soft-bodied plants, others are shrubs, and some are fully developed woody trees. Perennials store food underground in a variety of structures including **rhizomes**, bulbs, or tubers. These structures make plants difficult to kill by **mechanical** or **chemical controls**.

Plant Diseases

A plant disease is any harmful condition that makes a plant different from a normal plant in appearance or function. Diseased plants exhibit some malfunction or abnormality in their development and often appear unhealthy.

Symptoms of Plant Diseases

Diseased plants may form swellings, galls, leaf curls, or other types of over development of tissues. The plants may also be stunted, lack chlorophyll, fail to develop some organ, tissues may die, or show **blights**, mottling, leaf spots, wilting, or **cankers**.

Abiotic Plant Diseases

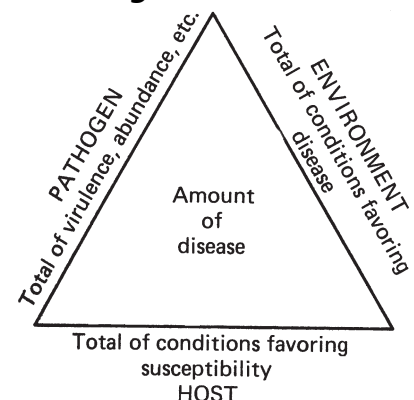
Plant diseases may result from non-living (**abiotic**) factors such as unfavorable growing conditions, nutrient deficiency, extremes of weather, and toxic chemicals including air pollution, pesticides, salts, and excessive fertilizer. Abiotic diseases caused by such conditions cannot be passed from one plant to another and often occur on many unrelated plant species in a location.

Biotic Plant Diseases

Plant disease may also result from the effects of living agents, known as **pathogens**. These **biotic** plant diseases are caused by **fungi, bacteria, mycoplasma-like organisms, viruses, nematodes**, or **parasitic plants**.

Although relationships resulting in disease are often complex, three factors interact and are necessary for disease development: a **pathogen**, a susceptible **host**, and the proper environment permitting **infection** of the host. This is known as the **disease triangle** (diagram right).

The development of a biotic plant disease depends on the life cycle of the pathogen, which depends in turn upon the temperature and moisture of the environment. An infection begins with **inoculation**, that is, when the infectious agent



Disease triangle

General Pests

enters the plant. The pathogens then develop in the plant until symptoms begin to show, at which time the plant may be recognized as being diseased.

Many disease pathogens are present in the soil or in the environment wherever plants grow. When environmental conditions are right the disease organisms will grow.

Necessary ingredients for infection are presence of inoculum, favorable temperatures and moisture, a susceptible host plant, and the means of transmission of the pathogen, i.e., rainfall, insects, or humans. Means of entry could include damage to the plant from mechanical injuries (i.e., cutting) or other plant injuries.

Fungi

Fungi are the largest group of plant pathogens. This group of organisms includes mushrooms, **molds**, and yeasts. These are simple plants which live on other living organisms, or in decaying organic material, because they lack chlorophyll with which to manufacture their own food. Some fungi are found on the skin of animals and humans, inside insects, and in or on plants. It is the fungi which live on other plants that are frequently the most concerning to the pesticide applicator.

Fungi reproduce sexually by means of **spores** which spread the disease when they move from one host to another. Fungi also reproduce asexually by **conidia**. The parasitic plant fungi are transmitted from one plant to another through mechanical means. Movement of plants, plant parts, and soil from one area to another may also spread the disease. Some examples of fungi-caused plant diseases are rusts, smuts, powdery mildews, downy mildews, and scabs.

Bacteria and Phytoplasmas

Bacteria and phytoplasma organisms are parasites that are microscopic, one-celled organisms that lack chlorophyll and require an external source of organic matter for their food. Bacteria reproduce by cell division, and generally enter a host plant through natural openings or through wounds. Bacteria often are transmitted from plant to plant by human activity, contaminated equipment, wind and rain, or by insects. Common bacterial diseases are canker of stone fruits, walnut blight, crown gall, fire blight, and bacterial wilt of beans.

An unusual type of bacteria are the phytoplasma organisms. They are the cause of many plant diseases formerly attributed to viruses. These diseases are all transmitted by insects, mainly leafhoppers. Included among the mycoplasma-like plant diseases caused by phytoplasmas are pear decline, aster yellows, and Western-X disease of peach.

Viruses

Viruses are extremely small organisms that cannot be seen with an ordinary light microscope. They cannot grow outside the cells of the living host. Viruses are transmitted by insects, mites, nematodes, or fungi; through mechanical means during pruning or harvesting; or through infected seed. Once introduced into the host plant, the virus may cause visible symptoms, although some viruses are symptomless.

Common types of virus-caused plant diseases are **mosaics**, yellows, curly top, ringspots, and stunt. The viruses themselves are generally named for a common host and the symptoms they

cause. For example, cucumber mosaic virus, prunus ringspot, sugar beet curly top, and lettuce mosaic are all important plant viruses.

Nematodes

Nematodes are members of a group of animals that include roundworms, threadworms, and eelworms. They are generally microscopic, elongate, cylindrical animals tapering at the two ends. They may be free-living, parasitic in animals and people, or parasitic in plants. Those which are parasitic in plants may attack either the stem or foliage, or they may live in the roots and tubers. Nematodes feed by sucking the cell contents of the host plants. They reproduce by laying eggs and during development they pass through several juvenile stages. Nematodes are frequently transported from place to place along with soil, plants, and plant parts. Common nematode-caused plant diseases include root knot nematode, cyst nematode, root **lesion** nematode, and seed and leaf gall nematode.

Parasitic Plants

Parasitic seed plants include the mistletoes, which may be found growing on the stems and branches of trees and shrubs, and the dodders, which form tangled masses of yellow, orange, or purple vine-like foliage as they grow over their host plants. Dodder is a common pest on alfalfa, sugar beets, tomatoes, and other crops. Parasitic seed plants are often considered weeds.

Snails and Slugs

Snails and slugs are members of the large group of animals called **molluscs**. They often become pests around the home garden, in lawns, greenhouses, and ornamental plantings. These animals may damage plants by feeding on the foliage, by their presence in the plant after harvest, and by the slime trails they make as they move from place to place on their muscular “foot”.

Snails are soft animals whose bodies are protected by a characteristic coiled shell. Because of the shell, snails are able to survive in fairly dry conditions. They generally reproduce by laying eggs, and small snails are frequently found in considerable abundance.

Slugs are closely related to snails, but they lack the snail’s coiled shell. Without this protection, they generally require a moist, cool environment, such as in the soil, under debris, or in foliage.

Vertebrates

All vertebrate animals have a jointed backbone. They include fish, snakes, turtles, birds, and mammals. Animals considered to be pests in some situations may be highly desirable in others. A muskrat, for instance, is a furbearing animal, but its burrows may weaken man-made earthen dams.

Fish

Humans have caused harmed native fish populations by introducing fish species which may outcompete desirable native species. Conversely, fish may cause problems for humans by serving as intermediate hosts of parasites.

Reptiles and Amphibians

Reptiles (snakes and turtles) and amphibians (frogs, toads, and salamanders) may cause local problems. Although most of them do little damage, many people fear or dislike them. Poisonous snakes, as well as snakes and turtles in fish hatcheries or waterfowl production areas, can cause damage to the desired species.

Birds

Bird damage can be quite varied. It includes:

- structural damage by woodpeckers
- destruction of feed, fruit, nut, grain, timber, and vegetable crops by seed and fruit eating birds
- hazards to animal and human health through disease transmission and other serious health problems caused by birds like pigeons and parakeets
- annoyance caused by birds roosting near dwellings

Peck marks, location of damage, tracks, feathers, and droppings are signs of bird damage.

Mammals

Damage by mammals is varied. Some cause serious health problems to livestock and humans. Disease agents that mammals transmit to humans can cause rabies and food poisoning.

Some mammals damage fruit, vegetable, nut, grain, range, and tree crops. The damage they do to dams and ditches can be very costly. They damage such things as lawns, clothing, furniture, and buildings by gnawing and burrowing. Mice and rats annoy us by living in our homes, offices, and factories.

You can often determine which mammal has caused damage if you know which animals are found in Colorado, what kinds of places they live in, and what their habits are.

Animal signs (tracks, droppings, tooth-marks, diggings, burrows, hair, and scent) plus the type of damage will give you further clues.

Additional Resources

- Colorado Department of Agriculture Noxious Weed Program. <https://www.colorado.gov/agconservation/noxiousweeds>
- Colorado State University Extension Publications. <http://extension.colostate.edu/publications-2/>. *Two to four page articles on a variety of topics.*
- Colorado State University Identification and Diagnostic Services, Dept of Bioag Sci and Pest Mgmt, Colorado State University, Ft. Collins, Colorado 80523-1177. Phone: 970-491-6950. <http://plantclinic.agsci.colostate.edu/>. *Disease, arthropod, and plant identification, other non-infectious problems, and control recommendations for a fee.*

Integrated Pest Management

Learning Objectives

After reviewing this chapter, you should be able to:

- Review: Identify the four main groups of pests and list examples of each.
- Define "Integrated Pest Management (IPM)".
- List and describe the components of an Integrated Pest Management plan.
- Describe ways to identify pests.
- Describe why correct identification of target pests is important.
- List types of beneficial organisms.
- Explain why it is important to know about the life cycle and behavior of pests, beneficial species, and hosts.
- Explain economic and action threshold levels.
- List different methods used for pest control.
- Explain how chemical controls are used to manage pests.
- Describe how to select the appropriate control method for a site and pest (see IPM strategies triangle).
- Explain why conducting a post-treatment evaluation is important.

What is Integrated Pest Management?

Pests are **organisms** that cause problems in various ways. Some compete with people for food or fiber. Others interfere with the raising of **crops**, livestock, or poultry. Certain types of pests damage property and personal belongings or disfigure ornamental plantings. Others transmit or cause plant, animal, or human diseases.

The Four Main Groups of Pests

- **Insects** and their relatives (insects, **mites**, **ticks**, **spiders**, snails, and slugs)
- **Vertebrates** (birds, **reptiles**, **amphibians**, fish, and **rodents** and other **mammals**)
- **Weeds** (undesirable plants)
- Disease agents or **pathogens** (**bacteria**, **viruses**, **fungi**, **nematodes**, **mycoplasmas**, and other microorganisms)

Integrated Pest Management (IPM) is a strategy of using multiple techniques to solve pest problems while minimizing the **risk** to people and the environment. It uses the knowledge of the pest's habits, **life cycle**, needs, and what conditions are unfavorable to the pest. It also relies on using the least **toxic** methods first, but allows the use of pesticides when necessary. It requires monitoring of the pest's activities and making adjustments to the pest management plan over time. IPM does not imply total elimination of most pests, but sets a threshold to help determine when action is needed. Some pest levels are tolerable and may be essential to maintain a population of **natural enemies** to keep those pests in check.

IPM can be used in a variety of **sites** to help **control** pests. IPM plans have been developed for use against pests in many agricultural sites. Information on IPM in these environments can be

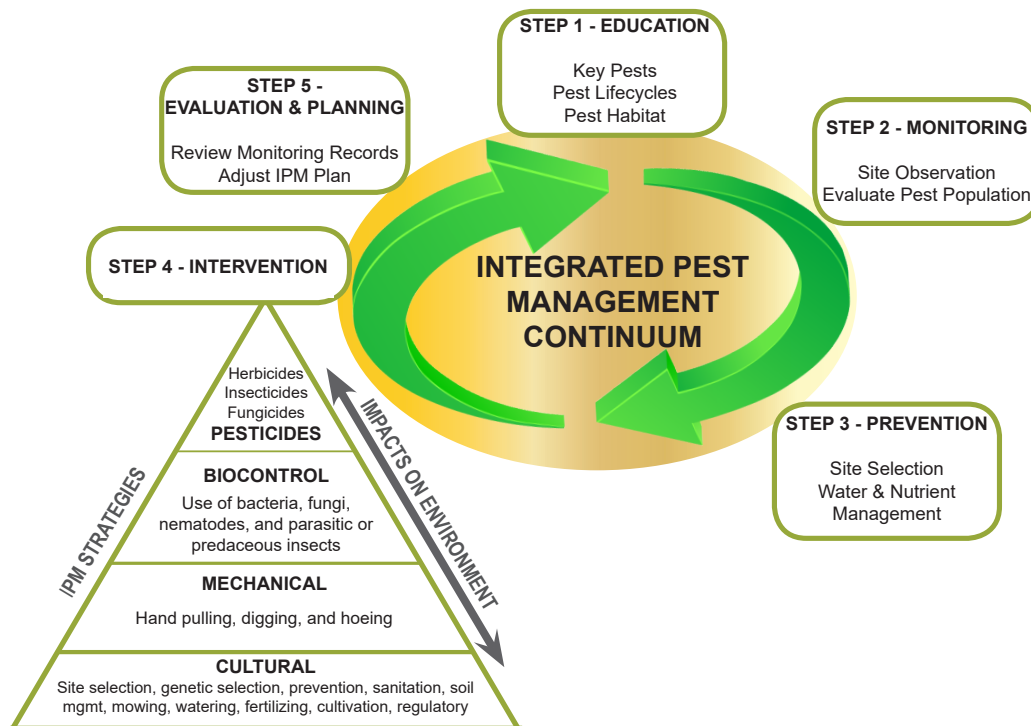
found by searching for IPM through the National Pesticide Information Center (NPIC) (found in the Additional Resources).

IPM is a process which is a continuum as summarized in the diagram to the right. Once you have completed the cycle, you repeat it.

The following components are common to all IPM programs:

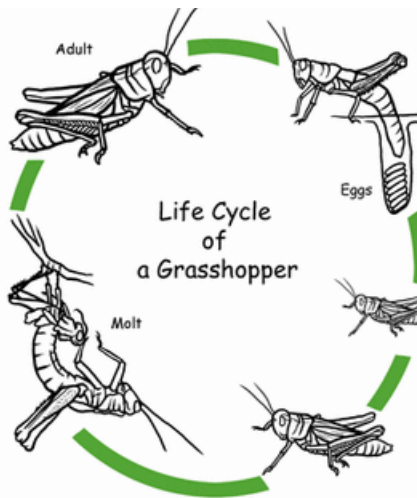
1. Education
2. Pest Monitoring
3. Prevention
4. Intervention/Control
5. Evaluation and Planning

1. Education: The first step in solving any problem is to understand what is causing the problem. Before trying to control a pest, you need to identify it. Be certain any injury or observed damage is actually due to the identified pest and not some other cause.



Ways to Identify Pests

Identifying a pest problem is often not a simple job. When you are unfamiliar with a pest or what is believed to be a pest, it is necessary to obtain a correct identification before deciding if any management or control program should be undertaken. Identify a pest by consulting reference materials such as identification books, Extension bulletins, and field guides that contain pictures and biological information on the host or pest. Another option is to have pests examined and identified by the CSU Plant Diagnostic lab (Additional Resources) or by pest management specialists, such as CSU Extension Specialists. The difficulty in identifying certain insects and most mites, nematodes, and plant pathogens in the field is their small size. Accurate identification requires the use of a hand lens or microscope, special tests, or careful analysis of damage. Often the pest's host and location are important to making positive identifications. Information on the environmental conditions where you collect pests and the time of year of collection provides clues to the pest's identity. Host and pest **species** may have different physical forms depending on their stage in their life cycles or the time of year. Weed seedlings, for example, often do not resemble the mature plant.



Source: <http://www.education.com>

Many insect species undergo changes in appearance (**metamorphosis**) as they develop from eggs through immature stages (**nymph, larva, pupa**) to the adult form.

Information about a pest's life cycle, damage potential, importance, and control options can be obtained after a pest has been properly identified. Early detection, achieved through frequent and regular inspection, provides time to get the problem corrected before the plant suffers permanent injury.

Host and Pest Classification

While many pests are referred to by their **common name**, sometimes it is important to know the **scientific name** so you can find the proper information to help you manage the pest. A few names like human, kochia, and dandelion are so common that they are recognized as the same organisms throughout the world. Many common names are not universally recognized and the same name may characterize entirely different organisms in different parts of the world. Using scientific names prevents confusion among geographic regions of the world. Consequently the scientific name *Musca domestica* refers to the same fly species in the U.S. as it does anywhere else in the world. Common names for pests are often used on pesticide labels.

After you have identified the pest and confirmed that it is causing damage, become familiar with its life cycle, growth, and reproductive habits. Once you have this information, you can decide if the pest can be tolerated or whether it warrants control and develop a pest management plan that supports your decision. Misidentification and lack of information about a pest could cause you to choose the wrong control method or apply the control at the wrong time resulting in wasted time, money, chemicals, and effort. These are the most frequent causes of pest control failure. It is important to also realize that some plants are damaged by non-living agents, including weather extremes, air **pollutants**, road salt, inadequate or excessive fertilization, drought, or excessive moisture. Sometimes this damage is mistaken for that caused by living pests.

Sometimes **natural controls** like climatic factors (wind, temperature, precipitation) or topographic features (rivers or mountains) can influence pest survival or movement. It is also important to be able to recognize any **beneficial** organisms (**predators, parasites, or pathogens**) that may be present that may help in controlling the pest.

If human intervention is needed to control a pest, information about the pest helps you select the most effective management methods and the proper time



Sweep nets are used to monitor pests in many crops
Photo by Dr. Frank Peairs, CSU

to use them. For example, the application of an **insecticide** should coincide with the presence of the most **susceptible** life stage. In some cases, the susceptible stage is only the adult or larva. Additionally, pesticides vary in their **mode of action**; some can be applied ahead of the presence of the pest, but others must be applied after the pest is present.

2. Monitor for Pests: You must regularly check your field, forest, nursery or **enclosed space production** site to learn what pests are present, how many there are, or what type of damage they may be causing. Monitoring, scouting and trapping are tools used to monitor insects.

3. Prevention: IPM focuses on long-term prevention of pests or their damage by managing the ecosystem to create conditions that are unfavorable to the pest. Some examples include managing water and nutrients to grow healthy plants that can withstand pests, or using disease-resistant plants.

4. Intervention/Control: Thresholds are the levels of pest populations at which you should take pest control action if you want to prevent the pests in an area from causing unacceptable injury or harm. Thresholds may be based on aesthetic, health, or economic considerations.

An **economic threshold** is set at the level where the economic losses caused by pest damage would be greater than the cost of controlling the pests. It's important to not use pesticides unless necessary and it's important to avoid pesticide applications when their cost is greater than the damage caused by the pest.

Some factors that influence economic thresholds are the current value of the product being produced, its stage of development, the degree of damage caused by the pest under various environmental conditions, the cost and effectiveness of control measures, and the anticipated yield.

An **action threshold** is the pest level at which some pest management action must be taken. It is a predetermined pest level which is considered unacceptable due to health or aesthetic reasons. Sometimes the action threshold is 'zero' (no pest level is tolerable) as in the case of pests that can create a public health concern such as insects or toxin producing fungi in stored grain. Sometimes action thresholds are based on economic, ecological, or aesthetic roles in the nursery or in commodities produced under enclosed spaces where clients are unwilling to accept any level of damage.

While it is easy to understand the concept of an action threshold, determining them can be difficult. In a new IPM program, the action threshold may have to be arbitrarily established and then adjusted up or down based on experience with the pest.

Control Methods

When the guidelines indicate that human intervention is necessary, the long-term solution is to use a combination of methods. Control methods can include a combination of biological, mechanical, cultural, physical, genetic, and regulatory methods, as well as the use of chemicals. Applying multiple control tactics minimizes the chance that the pest will adapt to any one method.

Cultural Control

The goal of **cultural control** is to alter the environment, the condition of the host plant or site, or the behavior of the pest to prevent or suppress an **infestation**. It disrupts the normal relationship between the pest and the host or site and makes the pest less likely to survive, grow, or reproduce. Cultural practices, plant selection, sanitation, and regulatory control are examples of cultural control.

Cultural practices that can influence the survival of pests include irrigation, mowing, crop rotation, mulching, and use of trap or cover crops. Sanitation involves eliminating food, water, shelter, or necessities important to the pest's survival. Examples include removing weeds, destroying diseased plant material, or manure management to reduce fly populations around livestock operations.

Pests that occur in enclosed areas may sometimes be suppressed by altering physical and environmental conditions such as water, air movement, temperature, light, and humidity. Lowering the humidity of stored grains and other food products reduces damage from molds and some insects. Increasing air movement in greenhouses or other types of enclosed spaces, can often suppress fungal diseases on plants.

Mechanical and Physical Control

Mechanical control involves the use of **devices**, machines, and other physical methods to control pests or alter their environment. Traps, barriers, fences, and nets are examples of devices used to prevent pest activity or remove pests from an area. Exclusion is a mechanical control technique that uses barriers to prevent pests from getting into an area. Examples of exclusion include using window screens, wire mesh, fences, or netting over the crop to keep pests out. Traps physically catch pests within an area or building. Several commonly used traps include pheromone or light traps. Sticky traps can be used in enclosed structures. While traps are typically used in monitoring, they may also provide some limited control of the pest.



Mowing weeds
Source: <http://www.rpcity.org>

Biological Control (Biocontrol)

Biological control uses a beneficial organism to influence the activities or life cycle of the pest. Many pests have natural enemies that control or suppress them effectively in some situations. Natural enemies can include predators, parasites, pathogens, and competitors which can be used to manage certain insect, mites, fungi, and weed pests.

Biocontrol is often used against introduced pests that lack natural enemies to help control them. Finding a successful biocontrol agent for an introduced species is often complicated because it involves finding the native home of the pest and assuring that the introduced natural enemy will not become a pest themselves. Laws have been enacted that strictly control the importation of all organisms, including biological control agents, into the United States.

Biocontrol also involves the mass release of large numbers of natural enemies into fields, orchards, enclosed space structures, or other locations. This often requires periodic release to

supplement the existing population. Several natural enemies are cultured or reared commercially but, in many cases, their effectiveness has not been established. If biocontrol and pesticides are both part of the IPM plan, it is important to remember to select pesticides that are less toxic to natural enemies, if possible.

Many natural enemies have been successfully introduced into Colorado to combat noxious or problem weed species and insect pests. The Colorado Department of Agriculture Insectary is responsible for rearing and releasing many of the plant and insect pests. More information about their program can be found through their website (Additional Resources). In addition to the successful releases of biocontrol agents for **noxious weeds**, the CDA Insectary has had success with releases to control tamarisk, alfalfa weevil and oriental fruit moth.

Host Resistance and Genetic Control

Sometimes plants and animals can be bred or selected to resist specific pest problems. For example, some livestock breeds have been selected for physical characteristics that prevent attack by pests or provide physiological **resistance** to disease or parasitic organisms. Certain plant varieties are naturally resistant to insects, pathogens, or nematodes. Many plants can 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 offers great promise for the future as gene manipulation techniques continue to improve.

Regulatory Control

Sometimes pest problems cannot be controlled at a local level and governmental agencies apply quarantine or eradication programs, according to federal and state laws, to prevent the introduction and spread of these pests. These programs usually involve pests that pose a public health concern or are likely to cause widespread damage to agricultural crops or animals, forests, or ornamental plants.

Quarantines are used to prevent entry of pests into pest-free areas. Some states maintain inspection stations at major entry points to prevent pests or plant materials that may harbor pests from entering the state. Regulatory agencies also monitor airports and ocean ports. Nursery stock, plant cuttings, and budding/grafting material are also regulated to prevent the spread of pests.

Eradication is total elimination of a pest from a designated area. If eradication is required, the geographical distribution of the pest is determined and control measures are used to eliminate the pest from this defined area. The methods used may include area-wide spray programs, mechanical or cultural practices, and intensive monitoring for pests within and around the borders of the infested area.

Chemical Control

Chemical control involves the use of pesticides that are either naturally derived or synthesized. Pesticides can play a key role in pest management programs and sometimes may be the only



Source: <http://www.aphis.usda.gov>

effective control method available. Advantages of using pesticides are their effectiveness, speed at controlling pests, and, in many cases, reasonable cost compared with other control options.

Questions To Consider Before Using A Pesticide

When considering any pesticide application, the question that needs to be answered is: *“Is this treatment necessary and can it be done without causing unnecessary risk to others or the environment?”* Several factors need to be considered in making this determination.

- Has the problem been identified correctly?
- Is use of a pesticide the most cost-effective or environmentally sound means of controlling this problem?
- Is this the proper time to use a pesticide?
- Is the pesticide being considered registered for the intended use?
- Are there any **preharvest intervals (PHI)** that would affect its use at this time?
- Are there any **restricted entry interval (REI)** restrictions that might affect necessary site work after application?
- Do conditions exist at the application site that might cause the pesticide to be unusually **hazardous**? Especially if people or non-target organisms are in the area!

5. Evaluation and Planning: One of the most important steps in an IPM program is to record what strategies were used in the IPM program and to evaluate the effectiveness of the program. This can be done in several ways, such as monitoring pest populations, or **infection** before and after treatment, comparative damage ratings, etc. Frequent monitoring prevents and/or minimizes problems and can save money. Take note of the conditions during your pest management activities such as timing, pest numbers, temperature and any other factor that may influence the outcome of your efforts. Record the results from the evaluation for future reference.

Licensed private pesticide applicators in CO are required to keep records of all restricted use pesticide applications for at least 2 years. Application records can be kept longer and may be useful to evaluate the long term results. It is important to record and evaluate other non-chemical procedures used in the IPM program and to remember that some strategies may take a while to demonstrate measurable results. IPM programs should be reviewed at least annually for revision. Remember that IPM is a continuum (page 12).

Record Keeping

Accurate and detailed record keeping is what ties the entire IPM program together. It is important to keep good records of all IPM activities including monitoring, preventive measures, IPM methods used, and management results. Records can improve your IPM program and eliminate ineffective and unnecessary treatments. Careful IPM record keeping leads to better-educated and informed decision-making in managing pest problems.

Summary

It is important to remember that IPM programs are very site-specific and should be updated frequently. Applying IPM to any pest management program can have many benefits. IPM can help maintain a balance in the ecosystem, minimize the likelihood of developing pesticide

resistance, maintain a healthy environment, and even save money. Perhaps one of the most important benefits of using IPM in a pest management program is that it promotes a positive public image for pest management advisors!

Additional Resources

- Colorado Department of Agriculture Biological Pest Control Program. <https://www.colorado.gov/pacific/agconservation/biocontrol> *Certain biological pest control agents are seasonally available from CDA to help suppress weed and insect pests. They can be requested by Colorado private landowners or other governmental agencies. Fees may apply. Supplies can be limited and vary from one year to the next.*
- Colorado State University Extension Publications. <http://extension.colostate.edu/publications-2/> *Two to four page articles on a variety of topics.*
- Colorado State University Identification and Diagnostic Services, Dept of Bioag Sci and Pest Mgmt, Colorado State University, Ft. Collins, Colorado 80523-1177. Phone: 970-491-6950. <http://plantclinic.agsci.colostate.edu/>. *Disease, arthropod, and plant identification, other non-infectious problems, and control recommendations for a fee.*
- High Plains Integrated Pest Management Guide for Colorado, Western Nebraska, Wyoming, and Montana. http://wiki.bugwood.org/HPIPM:Main_Page *Provides current management options for arthropod pests and plant pathogens affecting all major field crops grown in Colorado, Montana, Wyoming, and Western Nebraska.*
- National Pesticide Information Center (NPIC), <http://npic.orst.edu/pest/ipm.html>. *Information on IPM for various sites.*
- USDA Sustainable Agriculture Research and Education (SARE). <http://www.sare.org> *Provides grants and information to Improve profitability, stewardship and quality of life.*

Laws and Regulations

Learning Objectives

After reviewing this chapter, you should be able to:

- Describe the scope and importance of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).
- List and describe the laws and regulations that affect private pesticide applicators.
- Describe why it is important to have up-to-date knowledge about how to comply with all laws and regulations affecting your operation.
- List record keeping requirements for Colorado private applicators.
- Describe the requirements of the Worker Protection Standard (WPS) and list who it affects.
- List employer responsibilities regarding WPS.
- Describe the Endangered Species Act (ESA).
- Describe the other Federal laws and regulations that pertain to pesticides:
 - a) Federal Emergency Planning and Community Right-to-Know Act (EPCRA), also known as the Superfund Amendment and Reauthorization Act (SARA) Title III.
 - b) Federal Food, Drug, and Cosmetic Act (FFDCA).
 - c) Food Quality Protection Act (FQPA).
 - d) Safe Drinking Water Act (SDWA).
 - e) National Pollution Discharge Elimination System (NPDES)
- Describe the major State laws affecting pesticides and their use, including the
 - a) Colorado Pesticide Applicators' Act and associated Rules;
 - b) Colorado Pesticide Act;
 - c) Agricultural Chemicals and Groundwater Protection Act;
 - d) Transportation, solid waste, and hazardous waste laws.
 - e) Agricultural Chemicals and Groundwater Protection Act

Various Federal and State laws and regulations affect the production, **labeling**, **use**, storage, and handling of **pesticides**. Many of these laws are designed to insure the safety and effectiveness of pesticides by setting **registration** standards. Other laws also regulate uses of pesticides to minimize harmful effects to humans, **wildlife**, and other **organisms**.

FEDERAL LAWS AND REGULATIONS

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

The primary law that governs pesticide applications and applicator certification, is the **Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)**. Originally enacted in 1910, FIFRA set standards for labeling of pesticides. Since that time this law has been updated and amended to its current form.

Enforcement

Various penalties can be invoked for violations of FIFRA. For private applicators under FIFRA, civil penalties of up to \$1,200 per offense may be assessed following a warning letter. Violations can also result in criminal penalties.

Pesticide Classification

An important part of the present law is the **classification** of pesticides into two categories: **restricted use pesticides** (RUP) or **general use pesticides** (GUP). Whether a pesticide is classified as a RUP or GUP determines who may purchase and apply the pesticide. Labels of Federal RUPs prominently display the statement "Restricted Use Pesticide" followed by a statement referring to the special hazards of the product, such as "Due to Acute Human, Avian, and Aquatic Invertebrate **Toxicity.**"

The decision to classify a pesticide as a RUP is based on a finding that substantial adverse effects to the applicator or environment may occur without additional regulatory **restrictions**. Pesticides may also be classified as RUPs if unreasonable harm to humans or the environment may occur even if the pesticide is used as directed on **label** instructions. However, it is important to remember that all pesticides, restricted or general use alike, must be handled in a safe manner to minimize adverse effects.

In addition, under the Colorado Pesticide Act Rules and Regulations (Title 35, Article 9, Part 13) there are also **state restricted use pesticides**. At present, the pesticides restricted by Colorado are **residual soil herbicides** that have caused serious plant injury through misuse. State RUPs also are for sale to and for use only by certified applicators or persons under their direct supervision. There is no label statement indicating that they are State RUPs.

Prior to the enactment of laws establishing restricted use classifications, the only available legal action of the EPA against a pesticide with demonstrated human toxicity or environmental effects was to ban it. Restricted use regulation permits the continued use of many pesticides which might otherwise be subject to cancellation.

When considering whether or not to classify a pesticide for restricted use, several factors are considered:

- The accident history associated with the pesticide.
- The known **acute** (short-term) or **chronic** (long-term) **toxicity** of the pesticide.
- The **hazards** associated with the pesticide to **nontarget species**.

When reviewing the accident history of a pesticide, a review is made of all available information on the past use of the pesticide, including accident information. Research data from the manufacturer, independent research from private companies, as well as from Extension personnel are included in this review. State regulatory agencies, wildlife agencies, and poison centers are also contacted. Data collected are analyzed to determine if any patterns of hazard have been associated with the use of the product.

The toxicity of the pesticide to humans is a fundamental consideration in determining restricted use classifications. Highly toxic pesticides pose special risks to an applicator or farm workers and these increased risks are often sufficient to require special training for the applicator.

Assessment of toxicity may also consider hazards associated with long term **exposure** such as health problems including cancer, reproductive disorders, and allergenic potential.

Nontarget effects are hazards associated with use of the pesticide against species not directly targeted by **application** of the pesticide. For example, highly **persistent pesticides** that move into water, or pesticides which are concentrated in wildlife, are types of hazards that are given special regulatory attention.

Pesticides may be classified based on the percentage of the **active ingredient** (a.i.), how it is formulated, or where it may be applied. For example, concentrated **formulations** of highly toxic pesticides are typically classified as RUPs while low percentage **granules** or **wettable powders** of the same active ingredient may be GUPs. As more information becomes available, current GUPs may become RUPs.

Additional pesticides may be classified as RUPs under federal or state law as they are reviewed for registration or when new information indicates a high degree of hazard associated with the pesticide. Information on current status of pesticide registrations is available from CEPEP, the CDA, and the EPA. Only certified applicators or persons under their direct supervision may purchase or apply RUPs.

Colorado Restricted Use Pesticides by Active Ingredient	
• bromacil	• sodium chlorate
• diuron	• sodium metaborate
• monuron	• tebuthiuron
• prometon	

Certification of Applicators

Several types of applicators are recognized under the Colorado Pesticide Applicators' Act (Title 35, Article 10). A private applicator is a person who uses or supervises the use of RUPs in the production of agricultural commodities on land owned or rented by him/her or his/her employer. Farmers, ranchers, orchardists and greenhouse operators are common private applicators in Colorado. A private applicator may also apply RUPs in production of agricultural commodities on the property of another person, if the pesticides are applied without compensation. However, trading of personal services as a form of compensation is permitted under private applicator certification. A Colorado private applicator license authorizes the purchase and use of RUPs when producing an agricultural commodity, as described under the above definition of "private applicator." Licensing of private applicators is a responsibility of the CDA, and they can be reached at 303-869-9064.

Applicators whose use situation does not fit the definition of a private applicator should contact CDA regarding procedures to obtain a commercial applicator license. Under Colorado law a commercial applicator is a person engaged in the business of applying pesticides and receiving anything of value for compensation. Common commercial applicator groups in Colorado include **custom agricultural applicators** (ground and **aerial**), landscape maintenance professionals, ditch and power company employees, government workers, grain elevator operators, and other applicators who apply pesticides as a condition of their employment.

Labeling

FIFRA defines a label as the written, printed, or graphic matter on, or attached to, the pesticide or **device** or any of its containers or wrappers. Labeling is defined as all labels and all other written, printed, or graphic matter accompanying the pesticide or device at any time; or to which reference is made on the label or in literature accompanying the pesticide or device. FIFRA makes it unlawful to use any pesticide in a manner inconsistent with its labeling. **Therefore, the pesticide applicator has a legal obligation to read and follow not only the label instructions attached to the product, but also all material to which the label refers (i.e., Worker Protection Standard).**

Record Keeping Requirements

Colorado private applicators applying Restricted Use Pesticides must maintain records in accordance with the record keeping requirements outlined in 35-10-111 of the Colorado Pesticide Applicators' Act, which states:

“Each licensed private applicator shall keep and maintain records of each pesticide application in the form and manner designated by the CDA. Such records shall be retained for a period of two years after the date of the pesticide application and shall be kept at the address of record on file.”

You can get details about the record keeping requirements from CEPEP or from the CDA. The records you keep must include:

- **Brand or product name** of the RUP
- **EPA registration number**
- Location of application (county/range/township/section; map or written description);
- **Crop**, commodity, stored product, or **site** to which the pesticide was applied
- Day, month, and year of the application
- Size of the area treated (acres, square feet, etc., or “spot treatment”)
- Total amount of product applied (pints, quarts, gallons, etc.) (Total amount = rate x area applied)
- Name and certification number of applicator who applied or supervised the application.

There is no required form that you must use for the required record keeping. Any form is acceptable as long as the required information is included. However, a sample record keeping form is included in the Appendix of this study guide. **You must record your information within 14 days after the pesticide application and keep the records for 2 years, according to the Pesticide Applicators' Act of 2015.** A copy of various recordkeeping forms is available at the CEPEP website. A private pesticide applicators record keeping book published by CSU Extension in cooperation with CDA is available at no charge. (Additional Resources)

For example, a Private RUP application record may look like:

Field Name and Location: Circle 2, Weld Co. SW 1/4 Sec 30; T4NR65W		
Crop: Grain Corn	Applicator: John Smith (include certification number)	
Application Date:	4-25-17	4-25-17
Brand Name:	BalancePro	Atrazine4L tank mixed
EPA Reg. #:	264-600	34704-69
Size of area treated:	120 acres	120 acres
Total amount of product applied:	360 oz	60 lbs

If a commercial applicator performs work for you, that applicator must provide you with a written copy of the necessary information about the application within 30 days after each application. This information must be kept by the commercial applicator for 3 years in Colorado. If the establishment has agricultural workers or pesticide handlers, the establishment must keep a record of the application for 2 years.

If you do not comply with the record keeping requirements, you may be fined up to \$2,000 for any and each offense. This includes failure to comply with Worker Protection Standard (WPS). WPS is described in the following section.

Fumigation Management Plan

In addition to RUP records, the EPA requires applicators of fumigants to complete a **Fumigation Management Plan** (FMP) prior to application. Fumigants requiring FMPs include those used for stored commodities (stored grain), structures (grain bins), or to control burrowing rodents (prairie dogs, pocket gophers). The FMP requirements and its elements can be found in the product's labeling. Examples of FMPs can be found at: <https://www.colorado.gov/pacific/agplants/fumigation-management-plans>. Fumigant application records and FMPs must be kept by the applicator for 2 years from the date of application.

How Does Keeping Records Benefit Me?

Keeping pesticide records is good business practice and has numerous benefits:

- Saves money. Accurate pesticide records will enable you to know and buy the correct amount of pesticides for each growing season.
- Shows what is working. Good records will help you determine how a pesticide application achieved the best results or why a pesticide may have performed poorly and prevent future repeated failures.
- Documents correct use. Should a question arise concerning pesticide use, your records may provide liability protection.
- Improves management decisions. Since some pesticides have restrictions on what can be planted the following year in the same field, good records can help you plan your crop rotation.

Are Pesticide Records Ever Inspected?

Yes. The CDA has the authority to inspect your application records at any time to determine if you are applying the products according to the label.

Worker Protection Standard

The Worker Protection Standard (WPS) is a federal regulation that was originally passed in 1974 to provide protections to agricultural workers who perform hand labor tasks in fields after a pesticide application. It has been revised several times since its original version, most recently in 2015, to increase protections to pesticide handlers and workers as well as provide protections to others. WPS applies if workers or handlers are on the establishment when a pesticide that contains WPS-labeling is used in the production of agricultural commodities on farms, forests, nurseries or in enclosed space production facilities (indoors or in a structure or space that is covered in whole or part by a non-porous covering and large enough to permit a person to enter). The WPS-labeling is found under the "DIRECTIONS FOR USE" in the 'AGRICULTURAL USE REQUIREMENTS' box. This box may be found on both general use and RUP pesticide labels. (See the Chapter on Pesticide Labels for an example.)

WPS defines several types of employers that may be required to comply with WPS. This includes:

- Owners or managers of agricultural establishments (more information about types of agricultural establishments is found below)
- Commercial pesticide handling establishments that provide pesticide handler or crop advising services to agricultural establishments (custom applicators)
- Labor Contractors (seasonal agricultural workers, etc.)

Types of Agricultural Establishments Covered by WPS

The WPS applies to any establishment involved in growing, maintaining or producing agricultural plants (includes, but is not limited to, grains, fruits and vegetables; wood fiber or timber products; flowering and foliage plants and trees; seedlings and transplants; and turf grass produced for sod) for commercial and/or research or experimental purposes. Commercial production includes production of plants for sale, trade or in-house use on the establishment or another facility.

This means the following facilities or operations that are not generally recognized as traditional agricultural production establishments may be considered an agricultural establishment for the purposes of the WPS and are covered by the rule if they use WPS-labeled pesticide products:

- Nurseries, garden centers or other similar operations where nursery and ornamental bedding plants are maintained for sale (retail or wholesale).
- Dairy farms that produce hay for feed for their cattle.
- Golf course establishments that also produce sod and/or ornamentals in one area on their facility/establishment for transplanting into the golf course portion of the facility.
- Public park operations/facilities and/or privately-held ornamental garden operations/facilities that produce ornamental plants in one area on their establishment for transplanting into the permanent park or ornamental planting portion of the facility.
- Theme park operations (e.g., Disney World, Universal Studios, Sea World, etc.), hotels, and/or other entertainment operations that produce ornamental plants in one area on their establishment for transplanting into the permanent theme park grounds or ornamental planting portions of the facility.
- Prisons that have "prison farms" where agricultural plants are produced and the prisoners are employed as workers and handlers.
- University extension agricultural research facilities that conduct research on agricultural plants.

- Educational classes or vocational agriculture programs where agricultural plants are produced as part of a class or program, students act as workers and/or handlers, and students receive monetary compensation such as a stipend, or free or reduced tuition.

The Worker Protection Standard requires employers to protect two types of agricultural employees: agricultural workers and pesticide handlers, as well as others who may be in the area during a pesticide application.

- **Agricultural workers** - any person, including someone who is self-employed, that performs activities directly relating to the production of agricultural plants on a an agricultural establishment. For example, weeding, pruning or harvesting.
- **Pesticide Handler** - any person, including someone who is self-employed, or working for an agricultural establishment or commercial pesticide handling establishment, that performs activities such as mixing, loading or applying pesticides, disposes of a pesticide, handles open containers of pesticides (including rinsing empty containers), acts as a flagger, cleans, adjusts or repairs application equipment that may have residues; or assists with the application in any manner. It also includes crop advisors during a pesticide application or entering a field under a restricted entry interval (REI).

Key Provisions

The entire WPS regulation will not be reviewed here. To find out how to comply, check out the resources in the Additional Resources section of this chapter. However, here are some of the key provisions in the 2015 revised WPS for owners/ managers of agricultural establishments:

- Provide annual WPS pesticide safety training to workers and/or handlers. Workers must be trained before they work in an area where a pesticide has been used or a restricted-entry interval has been in effect in the past 30 days. Handlers must be trained before any pesticide handling task.
- Keep records of WPS worker and/or handler training for 2 years and provide the record to the worker or handler if requested.
- Ensure handlers and early entry workers are a minimum age of at least 18 years old.
- Display the pesticide safety poster at **Central Location** and decontamination locations, if applicable.
- Display application information, and hazard information (safety data sheets or SDSs) at the Central Location.
- Keep records of pesticide applications and SDSs for two years.
- Provide establishment specific-information about pesticide applications and location of the Central Location to workers and handlers.
- Provide workers or handlers pesticide application and hazard information upon request to worker/handler, medical personnel or designated representative.
- Notify workers of applications - posting, oral warning or both.
- Provide information to Commercial Pesticide Handler Employer (i.e. custom application or crop advisor).
- Follow restrictions DURING applications to keep workers and other persons out of certain areas (treated area and **Application Exclusion Zone** or AEZ, or enclosed production space).
- Follow restrictions AFTER applications (REI, label restrictions, etc.).

- Provide decontamination supplies at required locations.
- Make emergency assistance available (information about pesticide applications and transportation).
- *Some* additional requirements for handlers include:
 - Provide training on safe use of application equipment
 - Review label statements related to human hazards, first aid and safety precautions in a manner they can understand.
 - Have the pesticide label available to handler at all times during an application.
 - Provide clean PPE to handlers.
 - If respirator is required by label, follow respirator requirements for medical evaluation, fit testing and respirator training and keep records of these tasks for 2 years.
 - Train the handler on the AEZ and their responsibility to suspend applications if anyone is in the AEZ (for more information on AEZ, see Additional Resources).

Exemptions for Owners and Immediate Family Members

While no agricultural establishments that use WPS-labeled pesticides are completely exempt from WPS requirements, owners and their **immediate family members** who work on the agricultural establishment are exempt from *some* requirements when a majority of the establishment (more than 50%) is owned by immediate family members. However, the ag establishment must still provide full WPS protections for workers and handlers who are not in the owners' immediate family. Refer to the "How to Comply with the 2015 Revised Worker Protection Standard" for Agricultural Pesticides" manual for more information on the exemptions.

Resources on WPS

Further information on how to comply with the 2015 Revised WPS, as well as training materials and safety posters, can be found at the CEPEP website (Additional Resources)

The Endangered Species Act

The Endangered Species Act is designed to protect animal and plant species threatened or endangered with extinction. Through a cooperative effort with the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, EPA can issue emergency suspensions of certain pesticides to cancel or restrict their use if an **endangered species** will be adversely affected. If the USFWS determines that a pesticide jeopardizes a listed species, EPA will provide users with geographically-specific pesticide use limitations found in an Endangered Species Protection Bulletin. Labels of certain pesticides direct users to Bulletins containing species maps and pesticide use limitations.

Emergency Planning and Community Right-to-Know Act (SARA Title III)

The Federal Emergency Planning and Community Right-to-Know Act (EPCRA), also known as the Superfund Amendment and Reauthorization Act (SARA) Title III, requires that storage of certain pesticides, designated as "Extremely Hazardous Substances," that exceed the minimum amount

or "Threshold Planning Quantity" must be reported to local and state authorities. This is done to assist in handling potential accidents in pesticide storage areas. Threshold planning quantities for Extremely Hazardous Substances, including most RUPs, are provided in the US EPA Title III List of Lists, available from EPA at <http://www.epa.gov/ceppo/pubs/title3.pdf>. Please note that the threshold planning quantity for all of the Extremely Hazardous Substances is either the threshold planning quantity listed or 500 pounds, whichever is lower. The threshold planning quantity is 10,000 pounds for any chemical that is not an Extremely Hazardous Substance, but is a Hazardous Chemical under Occupational Safety and Health Administration (OSHA) regulations and therefore requires the preparation and availability of a **Safety Data Sheet** (SDS).

Notification must be given to both state and county agencies when pesticides are stored in amounts above the Threshold Planning Quantity. State notification should be given to the Colorado Emergency Planning Commission, c/o Colorado Department of Public Health & Environment (CDPHE), SARA Title III Reports, 4300 Cherry Creek Drive South, Denver, Colorado 80246-1530. You must also notify your Local Emergency Planning Committee (call CDPHE at 303-692-2000 for more information) and your local fire department.

EPCRA also sets requirements for reporting pesticide spills and includes Community Right-to-Know provisions to help increase the public's knowledge and access to information about the presence of hazardous chemicals in their communities and releases of these chemicals into the environment.

The Federal Food, Drug, and Cosmetic Act (FFDCA)

Under the FFDCA, the EPA establishes tolerances for pesticide **residues** in food. **Tolerances** are the maximum legally permissible levels of pesticide residue allowed in or on raw agricultural products and in processed food. A tolerance, or a **temporary tolerance**, must be established for every agricultural commodity on which a particular pesticide is used or could come in contact with through the food chain. Tolerances are enforced by the U.S. Food and Drug Administration (FDA) for most foods.

The Food Quality Protection Act (FQPA)

FQPA, passed in 1996, amended both FIFRA and FFDCA, setting a tougher standard for pesticides used on food. FQPA established a single, health based standard to be used when assessing the risks of pesticide residues in food or feed. The new safety standard is measured considering the aggregate risk from dietary exposure and other nonoccupational sources of exposure, such as drinking water and residential lawn uses. In addition, when setting new, or reassessing existing tolerances under the FQPA standard, EPA must consider whether tolerances are safe for children. When appropriate, an additional safety factor is applied to account for uncertainty in data.

Under FQPA, EPA may only establish a tolerance if there is "a reasonable certainty" that no harm will result from all combined sources of exposure to pesticides (aggregate exposures). FQPA also considers the combined effects of human exposure to different pesticides that may act in similar ways on the body (cumulative exposure).

Safe Drinking Water Act (SDWA)

SDWA was established to protect the quality of drinking water in the U.S. for both underground and above ground sources. In 1996, Congress amended the law to require the development of a screening and testing program for chemicals and pesticides for possible endocrine disrupting effects. The Endocrine Disruptor Screening Program focuses on providing methods and procedures to detect and characterize endocrine activity of pesticides, commercial chemicals, and environmental contaminants.

National Pollution Discharge Elimination System (NPDES)

The NPDES permit program addresses water pollution by regulating point sources that discharge pollutants to waters of the United States. Created in 1972 by the Clean Water Act, the NPDES permit program is authorized to state governments by EPA to perform many permitting, administrative, and enforcement aspects of the program.

The Clean Water Act prohibits anybody from discharging “pollutants” (which include pesticides) through a “point source” into a “water of the United States” unless they have an NPDES permit. The permit will contain limits on what you can discharge, monitoring and reporting requirements, and other provisions to ensure that the discharge does not hurt water quality or people’s health. In essence, the permit translates general requirements of the Clean Water Act into specific provisions tailored to the operations of each person discharging pollutants.

“Point source” means any discernible, confined, and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. It also includes vessels or other floating craft from which pollutants are or may be discharged. By law, the term “point source” also includes concentrated animal feeding operations, which are places where animals are confined and fed. By law, agricultural stormwater discharges and return flows from irrigated agriculture are not “point sources”.

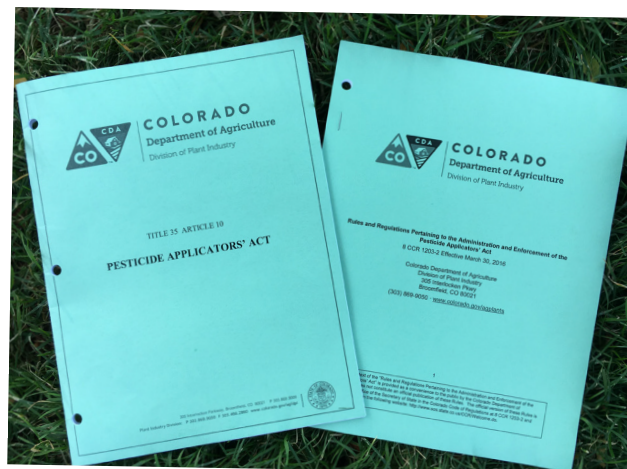
Whether or not you need a NPDES permit depends on where you send your pollutants. If you discharge from a point source into the waters of the United States, you need an NPDES permit. If you discharge pollutants into a municipal sanitary sewer system, you do not need an NPDES permit, but you should ask the municipality about their permit requirements. If you discharge pollutants into a municipal storm sewer system, you may need a permit depending on what you discharge. You should ask the NPDES permitting authority.

COLORADO LAWS AND REGULATIONS

Usually states have some leeway in deciding how implementation of a federal statute, such as FIFRA, is best achieved on the state level. However, as a general rule, state programs that are derived from a delegation of federal regulatory authority can be more, but cannot be less, stringent than the federal law. This leads to state and local laws and regulations that mirror their federal counterparts and allow for enforcement on the local level.

Colorado Pesticide Applicators' Act

In addition to regulating private applicators, the Colorado Pesticide Applicators' Act (PAA), Title 35, Article 10, and associated rules and regulations (administered by the Colorado Department of Agriculture Pesticide Program) also includes the licensing and regulation of any individual or business who applies pesticides or uses certain pest control devices, on property other than their own, and for hire, or any form of compensation in Colorado. (PAA Rules Part 2, Subpart A).



Colorado Pesticide Applicators' Act and its associated Rules and Regulations
Photo by Pierce Hansen, CEPEP

Why Must I be Licensed?

According to the Colorado PAA and the Colorado PAA Rules and Regulations, Part 2, Subpart B,

a private applicator is any person who uses or supervises the use of a restricted use pesticide for purpose of producing an **agricultural commodity** on property owned or leased by the applicator or the applicator's employer.

According to the PAA Rules, the definition of an agricultural commodity means any plant, or part thereof, or animal, or animal product, produced by a person (including farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animal.

As Cannabis production meets the description of 'producing an agricultural commodity', a cannabis grower may also hold a Private Applicator License. While the current list of 'Pesticides Allowed for Use on Cannabis' does not include any RUPs, cannabis producers may choose to acquire a private applicator license so they are qualified to train both agricultural workers and pesticide handlers under the 2015 Revision of the Federal WPS regulation. Part 17 of the PAA Rules includes the criteria for pesticides to be included on the list. (Additional Resources).

Colorado Pesticide Act

The Colorado Pesticide Act is administered by the CDA. It regulates the registration, labeling, transportation, distribution, storage, use, and the disposal of any pesticide and of certain pesticide devices in the state.

Registration

In addition to federal pesticide registration requirements, every pesticide distributed, sold, or advertised in Colorado must be registered with CDA as required by the Pesticide Act, sections 35-9-106 through 35-9-108, sections 35-9-110 through 35-9-112, and the Pesticide Act Rules and Regulations, Part 3. Any pesticide used by a commercial applicator must also be registered with CDA. Certain devices, as determined by the Commissioner, used to control, repel or mitigate pests also must be registered with CDA.

Emergency Exemptions (Section 18)

Section 18 of FIFRA authorizes EPA to allow States to use a pesticide for a limited time if EPA determines that emergency conditions exist. For example, EPA granted a Section 18 to Colorado in 2017 for the use of sulfoxaflor in sorghum to control Sugarcane aphids. The uses are requested for a limited period of time to address the emergency situation only. You must have a permit from CDA in your possession when applying a Section 18 pesticide, as outlined in the Colorado Pesticide Act Rules and Regulations, Part 12.

Special Local Needs Label (Section 24c)

Under Section 24c of FIFRA, Colorado can register additional uses of a federally registered pesticide. These additional uses are for distribution and use within a particular state to meet a “special local need” (SLN). This is designed to allow states to register uses for needs that may be specific to a small region. Often the potential use area does not represent a large enough market to justify the effort required by a registrant to obtain a full national registration.



Bayer CropScience LP
P.O. Box 12014, 2 T.W. Alexander Drive
Research Triangle Park, NC 27709
1-866-99BAYER (1-866-992-2937)
<http://www.bayercropscienceus.com>

BALANCE® FLEXX Herbicide
For Control of Broadleaf Weeds and Grasses
in Field Corn.
EPA Reg. No. 264-1067
SLN #: CO-090001

24(c) Supplemental Label

FOR DISTRIBUTION AND USE ONLY WITHIN THE STATE OF COLORADO

Section 24c labels are valid only in the state of issue. The supplemental 24c labeling prepared by the manufacturer must be obtained from the dealer that supplies the product. 24c labels must be at the application site during the application.

Minimum Risk Pesticides (Section 25b)

Pesticides with active ingredients that are considered minimum risk fall under Section 25b of FIFRA. These pesticides can have only a very limited set of active and **inert ingredients** specified by the EPA, but are not required to have an **EPA registration number**. The EPA exempts these minimum risk pesticides from federal registration. The exemption is limited to a list of 31 active ingredients and minimal risk inert ingredients. However, these products must be registered with CDA in order to be sold and used in Colorado.

State Restricted Use Pesticides

Under the Colorado Pesticide Act Rules and Regulations, Title 35, Article 9, Part 13 there are **state restricted use pesticides**. Currently, the pesticides restricted by Colorado are **residual soil herbicides** that have caused serious plant injury through misuse. State RUPs are for sale to and for use only by certified applicators or persons under their direct supervision. There is no label statement indicating that they are State RUPs.

Colorado Restricted Use Pesticides by Active Ingredient	
• bromacil	• sodium chlorate
• diuron	• sodium metaborate
• monuron	• tebuthiuron
• prometon	

Agricultural Chemicals and Groundwater Protection Act

The Agricultural Chemicals and Groundwater Protection Act, also known as “126,” imposed rules for mixing and loading areas for pesticides, where they are handled in quantities that exceed

set minimum thresholds. The Act defines agricultural chemicals as all pesticides and commercial fertilizers used in both urban and rural settings.

A mixing and loading pad is required if you mix and load more than 500 gallons of liquid formulated product, 3,000 pounds of dry formulated product, or 1,500 pounds of active ingredient of a combination of liquid and dry product at one site annually. Secondary containment is required if you store pesticides in containers larger than 55 gallons for liquid pesticides or 100 pounds for dry pesticides for more than 15 consecutive days. Secondary containment and a mixing and loading pad is required if you store pesticides in containers larger than 55 gallons that are not DOT-approved or if you store pesticides in containers larger than 660 gallons.

Colorado Transportation Laws

The Colorado State Patrol Hazardous Materials Section regulates hazardous material (HAZMAT) transportation by:

- Ensuring safe and efficient movement of hazardous materials on Colorado roadways through enforcement of permitting and routing.
- Providing prompt emergency response for on-highway hazardous incidents and support of local government through mutual aid agreements or other formal requests for assistance.
- Designation and maintenance of hazmat transportation routes.
- Enforcement of applicable laws, rules, and regulations.

Colorado Solid Waste and Hazardous Waste Laws

The Colorado Hazardous Materials and Waste Management Division of CDPHE administers the regulation of solid and hazardous wastes in the state. The Division shares the responsibility of siting, permitting, and regulation of solid waste disposal sites with local governments who also have jurisdiction.

Treating and disposing of hazardous waste is expensive and carries with it serious legal responsibilities. If you generate hazardous waste you must follow many state and federal rules and requirements, including:

- Identifying all hazardous waste generated.
- Obtaining and using an EPA identification number.
- Packaging, labeling, marking, and placarding wastes.
- Keeping accurate records for a minimum of three years.
- Ensuring that wastes meet treatment standards prior to disposal.

Other Colorado laws and regulations that are important to pesticide applicators, but are not covered in this guide include the Colorado Chemigation Act, Colorado Water Quality Control Act, the Colorado Nongame, Endangered, or Threatened Species Conservation Act, the Colorado Consumer Protection Act, and the Colorado Noxious Weed Act.

LOCAL REGULATIONS AND ORDINANCES

Local governments must follow federal and state regulations. Local governments must work with CDA when enacting any ordinance that concerns pesticides.

Additional Resources

- 40 CFR Part 170 Worker Protection Standard Regulation. <https://www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps>. *Information and full text of the Worker Protection Standard.*
- Colorado Department of Agriculture, Division of Plant Industry, <http://www.colorado.gov/agplants>. *CDA conducts exams, issues licenses, conducts inspections, investigates complaints of misapplication of pesticides by private applicators. Call for information on the following:*
- Colorado Pesticide Act, Title 35, Part 9 Access through LexisNexis, Colorado Revised Statutes. <http://www.lexisnexis.com/hottopics/Colorado/>
- Colorado Rules and Regulations pertaining to the Administration and Enforcement of the Pesticide Act. 8 CCR 1203-1. Access through LexisNexis, Colorado Revised Statutes. <http://www.lexisnexis.com/hottopics/Colorado/>
- Colorado Pesticide Applicators' Act, Title 35, Article 10. Dec. 2015 Access through LexisNexis, Colorado Revised Statutes <http://www.lexisnexis.com/hottopics/Colorado/>
- Colorado Rules and Regulations pertaining to the Administration and Enforcement of the Pesticide Applicators' Act. 8 CCR 1203-2, Effective March 30, 2016 Access through LexisNexis, Colorado Revised Statutes <http://www.lexisnexis.com/hottopics/Colorado/>
- Colorado Department of Public Health and Environment, Environmental Divisions, <https://www.colorado.gov/pacific/cdphe/categories/services-and-information/environment>. *Information on air pollution, consumer protection, hazardous materials/waste management, and water quality.*
- Colorado Environmental Pesticide Education Program (CEPEP) at Colorado State University, <http://cepep.agsci.colostate.edu/>. *Pesticide education resources including factsheets, handbooks, and training guides. Information on WPS including 'How to Comply' and training resources.*
- Colorado State University Extension Water Quality Program. *Link to the Pesticide Record Book for Private Applicators App or to request a hard copy of the Record Keeping book.* <http://waterquality.colostate.edu/pestrecordbook.shtml>
- Colorado State Patrol Hazardous Materials Section, <https://www.colorado.gov/pacific/csp/hazardous-materials>. *Includes rules and regulations for transporting hazardous waste in Colorado.*
- Environmental Protection Agency, <http://www.epa.gov/>. *Information on Federal laws designed to promote public health by protecting air, water, and soil from pollution.*
- Environmental Protection Agency, Region 8, <https://www.epa.gov/aboutepa/epa-region-8-mountains-and-plains>. *Information on Colorado environmental laws and regulations.*
- Environmental Protection Agency Endangered Species Protection Program. <https://www.epa.gov/endangered-species>. *Information on the Endangered Species Act.*
- Resource Conservation and Recovery Act (RCRA), <https://www.epa.gov/rcra>. *Summary and full text of the Resource Conservation and Recovery Act.*
- Safe Drinking Water Act, <https://www.epa.gov/sdwa>. *Summary and full text of the Safe Drinking Water Act.*
- U.S. Fish and Wildlife Service Endangered Species Program. <http://www.fws.gov/endangered/>. *Information on the Endangered Species Program.*

Pesticide Labeling

Learning Objectives

After reviewing this chapter, you should be able to:

- Explain why the label is considered a legal document.
- Identify the difference between mandatory and advisory statements on the label.
- Describe the parts of the label (brand/trade name, type of pesticides, re-entry interval, formulation, ingredients statement, etc.).
- Define label terminology (other ingredients, signal words, etc.).
- List and describe items included on a Safety Data Sheet (SDS).

Reading and Understanding the Pesticide Product Label

Each time you buy a pesticide, you also receive instructions telling you how to use it. Because the pesticide is registered under FIFRA, the pesticide label is the law and is a legal document. When pesticides are not used according to label directions, they are being used illegally.

The pesticide product label provides a way for the manufacturer to communicate with the user about how to use, store, and dispose of the product. It is the material printed on or attached to the pesticide container. ***By law, pesticide users are required to comply with all the instructions and directions on the pesticide product label.***

Sometimes manufacturers will provide additional information such as brochures, leaflets, or other information that is not attached to the container. Labeling includes the label AND all other information referenced on the label or provided by the manufacturer when the product is purchased. Labeling provides additional instructions on how to use the product safely and correctly.



Pesticide Product Labeling
Photo by Pierce Hansen, CEPEP

- To the dealer and user, the label indicates whether the pesticide is for restricted or general use and whether certification is required for purchase and use.
- To the buyer or user, the label is a main source of facts on how to use the product correctly, legally, and what safety measures are needed.
- To dealers and pest control personnel, the label is an aid in making recommendations to buyers and users.
- To physicians, the label is a way to determine what **antidote** or **first aid** procedure to treat poisoning cases.

The time you invest in reading the label is the most valuable few minutes you can spend in pest management.

This small investment in time will help you avoid injuring yourself or the environment by misusing the pesticide.

When to Read the Label

1. BEFORE buying the product to:

- ◆ Make sure the pesticide is registered for the intended use and there are no restrictions that would prohibit using it at your site. Be sure to read PRECAUTIONARY STATEMENTS and DIRECTIONS FOR USE sections thoroughly!
- ◆ If the formulation can be used with the application equipment available.
- ◆ Find out what **personal protective equipment (PPE)** is required.

2. BEFORE mixing and applying the product to:

- ◆ Review personal protective equipment requirements and precautions when mixing or applying.
- ◆ Read DIRECTIONS FOR USE (rate, precautions, use restrictions, if **tank mixing** is allowed, etc.).
- ◆ Read first aid and emergency response information should an accident occur.

3. BEFORE storing or disposing of pesticides and containers to:

- ◆ Know how to store the pesticide properly (temperatures, what should not be stored with it).
- ◆ Know how **decontaminate** and dispose of the container.
- ◆ Know how to dispose of unused pesticides.

Mandatory vs. Advisory Statements

When reading the label, pay attention to the language being used. Pesticide labels use mandatory statements and advisory statements. Mandatory statements are intended to be enforceable; they are NOT optional instructions. Mandatory statements are written to ensure the proper use of the pesticides and to prevent “unreasonable adverse effects on the environment” from happening. They are usually written in imperative or directive sentences.

Examples of mandatory statements include:

- Wear long-sleeved shirt and long pants.
- Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.
- Keep pesticide in original container only.

Advisory statements are intended to be informative to the applicator. They are usually written in factual or non-directive terms. Advisory statements provide additional information to the applicator, such as pesticide characteristics, how to reduce risk, and how to maximize product **efficacy**. Advisory statements must never conflict with the label’s mandatory statements and it should be clear that the intent is to be non-enforceable and strictly informational.

Examples of advisory statements include:

- Personnel should use clothing and equipment consistent with good pesticide handling.
- Nitrile gloves provide the best protection for this product.

Parts of the Label

Use the fictitious label to learn about the various parts of the label. Some labels are easy to understand, while others are more complicated. Federal regulations require certain information to appear in certain locations on the label (e.g., ingredient statement). However, other information may be placed wherever the manufacturer chooses. Somewhat different formats are used for certain classes of products (e.g., **rodenticide** baits). Therefore, it is important to read the ENTIRE label every time you use a pesticide.

A

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. THIS PRODUCT IS A RESTRICTED USE HERBICIDE DUE TO GROUND AND SURFACE WATER CONCERNS.

B

WEED-OUT 4L
HERBICIDE

C

ACTIVE INGREDIENTS:
 Hexanine (1-methylacetyl-4-aminopropylamine acetate).....12.0%
INERT INGREDIENTS:.....88.0%
 TOTAL 100.0%

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

I

I

1

WEED-OUT 4L CONTAINS 4 LBS. HEXANINE PER GALLON

D

KEEP OUT OF REACH OF CHILDREN

CAUTION

EPA REG. NO. 34890-69
 EPA EST. NO. 34890-CL-2

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 enclosed space production facilities, 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 PPE and restricted-entry interval. These requirements only apply to uses of Weed-Out that are covered by the Worker Protection Standard.

E

STATEMENT OF PRACTICAL TREATMENT

IF IN EYES: Flush with plenty of water. Call a physician.
 IF ON SKIN: Wash with plenty of soap and water. Get medical attention if irritation persists.
 IF SWALLOWED: Drink large quantity of milk or water. Avoid alcohol.
 IF INHALED: Remove victim to fresh air. If not breathing, give artificial respiration, preferably by mouth. Get medical attention.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.

I

2

PPE required for early entry to treated areas is: coveralls, chemical-resistant gloves and chemical-resistant footwear plus socks.

F

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION: Harmful if swallowed or absorbed through the skin. Avoid contact with skin, eyes, or clothing. Keep away from food and feedstuffs. Wear long-sleeved shirt and long pants, chemical-resistant gloves, and chemical-resistant footwear plus socks. Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separate from other laundry.

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170).

Residential areas, parks, hotels and resorts, forest habitats, and natural areas are not within the scope of the Worker Protection Standard.

Do not allow people (other than applicator) or pets to enter treated areas until sprays have dried.

G

ENVIRONMENTAL HAZARDS

This pesticide is toxic to fish and aquatic invertebrates. Do not apply directly into water. Drift and runoff may be hazardous to aquatic organisms in areas near the application site. Do not clean equipment or dispose of equipment wash waters in a manner that will contaminate water resources.

STORAGE AND DISPOSAL

STORAGE: Store in safe manner. Keep pesticide in original container only. Keep container tightly closed when not in use. Personnel should use clothing and equipment consistent with good pesticide handling.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of at an approved waste disposal facility.

CONTAINER DISPOSAL: Triple rinse. Offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill.

J

H

CHEMCO CHEMICAL COMPANY
 1234 Main St., Hoodsville, CO 80523

NET CONTENTS 2.5 GAL. (9.46 L)

K

Pesticide Labeling

A Statement of Use Classification

EPA classifies every pesticide as either unclassified/general use or restricted use pesticide (RUP). If a pesticide is federally classified as restricted use, it 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.

The RUP statement will also indicate the specific hazard to using the pesticide. It may be due to a **groundwater** hazard, or toxicity to humans or wildlife. A State designated RUP will not have a statement at the top of the label but will be listed on the Colorado Department of Agriculture (CDA) website. (Additional Resources).

B Brand or Trade Name

A **brand** name (also known as **trade name**) is a name used by a manufacturer to identify a pesticide as its product. It is the most identifiable name for the product. Pesticides with the same active ingredient may not have the same brand name. A brand name cannot be used in the ingredient statement but usually appears in large, boldfaced letters on the packaging. The same pesticide may be available in more than one formulation (such as liquid, **dusts**, or **wettable powder**).

WEED-OUT 4L

HERBICIDE

The Brand name often indicates the type of formulation and the percentage of active ingredients present. For example WEED-OUT 4L is a herbicide with a trade name of WEED-OUT, has 4 lbs active ingredient per gallon, and is a liquid formulation.

C Ingredient Statement

Every pesticide label must list what is in the product. The list is written so that you can see quickly what **active ingredients** (the chemical in the product responsible for controlling the target pest) it contains. The list tells you the total amount of active pesticide material and **other ingredients** in the formulation. The ingredient statement is found on the front panel of the pesticide label.

ACTIVE INGREDIENTS:	
Hexanine (1-methylacetyl-4-aminopropylene acetate).....	12.0%
INERT INGREDIENTS:	88.0%
TOTAL	100.0%

Hexanine is the common name for the herbicide sold under the brand name Weed-Out. 1-methylacetyl-4-aminopropylene acetate is the chemical name for hexanine. It is the active ingredient in the formulation.

Chemical Name: The name given by scientists for an active ingredient. Example: 1-methylacetyl-4-aminopropylene acetate.

Common Name: A well-known, made-up name accepted by the EPA to identify an active ingredient. When an accepted common name is available, it must be used with the chemical name in the active ingredients section on the label. If there is no common name, the chemical name alone must be used. Common names are usually not capitalized. Example: hexanine.

The amount of each active ingredient is given as a percentage by weight or as pounds per gallon of concentrate. The active ingredient must be listed by chemical name and common name, if available. Application rates are based on the percentage of active ingredient. Some pesticides have

specific maximum-per-year application rates that cannot be exceeded; these rates are usually listed in terms of the total amount of active ingredient that can be applied per year.

Other (inert) ingredients need not be named, but the label must show their percentage of the total contents. EPA is encouraging pesticide manufacturers to use the term "other" instead of "inert" ingredients. They believe that this term is less confusing to the consumer and does not imply that these chemicals are risk free. Information on other ingredients may be available through the safety data sheet.

The ingredient statement (to the right) shows that there is 66.2% 2-ethylhexl ester of 2,4-dichlorophenoxyacetic acid (active ingredient) and 33.8 % OTHER INGREDIENTS. Note that the ingredient statement talks about **acid equivalent** and how many pounds of 2,4-dichlorophenoxyacetic acid is in the product.

Ingredient Statement for 2,4-D LV 4	
ACTIVE INGREDIENT:	
2-ethylhexl ester of 2,4-dichlorophenoxyacetic acid*	66.2%
OTHER INGREDIENTS:	33.8%
	100.0%
* 2,4-dichlorophenoxyacetic acid equivalent 44.0%. Contains 3.8 pounds 2,4-dichlorophenoxyacetic acid per U.S. gallon.	

Most applicators are familiar with the term active ingredient (AI) but acid equivalent may be a new term. If the **herbicide** active ingredient is made from an **acid** it may be modified to form either an ester, amine or salt to make it more water soluble and increase it's ability to move into the plant. Acid equivalent is the acid portion of the active ingredient in the formulation that is responsible for the herbicidal activity and can be used for direct comparisons of different formulations containing the same acid. Some employers and organizations keep track of the amount of acid that they have applied so they know how much acid has entered the environment.

Many herbicides have maximum use rates per season that cannot be exceeded or it is a violation of the label. Maximum use rates may be expressed as lbs AI or acid equivalent on the label.

To calculate how much ACTIVE INGREDIENT applied per acre:

$$\text{Pounds of active ingredient applied per acre} = \frac{\text{gallons or lbs product applied}}{\text{acre}} \times \frac{\text{lbs AI}}{\text{gallon or lb of product}}$$

Example: Trifluralin 4 E.C. (4 lbs AI/gallon)

$$1.0 \text{ lb of AI applied per acre} = \frac{0.25 \text{ gal product applied}}{\text{acre}} \times \frac{4 \text{ lbs AI}}{\text{gallon}}$$

To calculate how much ACID EQUIVALENT was applied per acre, you have to first calculate the amount of acid equivalent in one gallon:

$$\text{Pounds of acid equivalent per gallon product} = \% \text{ acid equivalent} \times \frac{\text{lbs AI}}{\text{gallon or lb of product}}$$

Example using the 2,4-D LV ingredient statement (previous page)

$$1.67 \text{ lbs acid equivalent per gallon product} = 44\% \text{ acid equivalent} \times \frac{3.8 \text{ lbs AI}}{\text{gallon or lb of product}}$$

Then you can determine how acid equivalent (AE) you applied per acre using the same type of formula as you did to calculate the pounds active ingredient:

$$0.42 \text{ lbs of AE applied per acre} = \frac{0.25 \text{ gallon product applied}}{\text{acre}} \times \frac{1.67 \text{ lbs AE}}{\text{gallon or lb of product}}$$

Obviously it would be simpler if a label stated the maximum use rate per season by product rates per acre. However, if it does not, this is a good reference on how to calculate it. For more information on active ingredient versus acid equivalent, see Additional Resources.

D Signal Words

Pesticides are designed to be toxic to a target pest and in some cases may be hazardous to people as well. The signal word and the symbol on the label indicate the pesticide's **acute toxicity** to humans.

KEEP OUT OF REACH OF CHILDREN

CAUTION

The child hazard warning statement, "Keep out of reach of children" must appear on all labels. The signal word indicates how toxic the product is to humans.

There are four general categories of pesticides based on toxicity. Signal words warn users of potential hazards associated with the pesticide. However, these are only categories, and the acute toxicity of pesticides within each category can vary greatly. Detailed information on toxicity and signal words is covered in the Safety and Protection chapter of this guide.

- **DANGER-POISON** - These words signal you that the pesticide is very toxic from **oral, dermal, or inhalation** exposure, and can be fatal or cause irreversible eye damage. The skull and crossbones symbol is used on the label along with the signal word "DANGER" and the word "POISON" (in red). PELIGRO, the Spanish word for danger, must also appear on the label.
- **DANGER** - This word signals you that the pesticide is highly toxic and is very likely to cause acute illness from oral, dermal, or inhalation exposure, or to cause severe eye or skin irritation.
- **WARNING** - This word signals you that the product is **moderately toxic** and likely to cause acute illness from oral, dermal, or inhalation exposure or that the product is likely to cause moderate skin or eye irritation. AVISO, the Spanish word for warning, must also appear on the label.
- **CAUTION** - This word signals you that the product is **slightly toxic** or relatively **nontoxic**, has only slight potential to cause acute illness from oral, dermal, or inhalation exposure, and would cause little, if any, skin or eye irritation.

Signal words are set by law and each manufacturer must use the correct one on every label. Signal words must appear on the front panel of the label.

All labels must bear the statement "**KEEP OUT OF REACH OF CHILDREN.**" This statement must appear on the front panel and usually appears on a separate line above the signal word. Different formulations may have different signal words.

E Registration and Establishment Numbers

The EPA Registration number and the **EPA Establishment number** are required on all pesticide labels and labeling of products registered with the EPA.

EPA Registration number: The registration number shows that the product has been registered with the EPA and is assigned to all pesticide formulations. It usually is found on the front panel of the label and will be written as "EPA registration No. 0000-00."

EPA Establishment number: The EPA Establishment Number number tells what factory made the chemical. Most pesticide containers will also have a lot number printed on the outside. This number identifies the specific batch as it progressed through the manufacturing process. The batch number may appear anywhere on the pesticide label or on the outer container or packaging of the product.

EPA REG. NO. 34890-69
EPA EST. NO. 34890-CL-2

The EPA registration number show the product has been reviewed by the EPA. The EPA establishment number indicates where the final phase of production took place.

F STATEMENT OF PRACTICAL TREATMENT

If swallowing or inhaling the product or getting it in your eyes or on your skin would be harmful, the label will give you emergency first aid measures. It will also tell what types of exposure require medical attention. Statements of practical treatment usually appear on the front panel of the label. The pesticide label is the most important information you can take to the physician or veterinarian when you think a person or an animal has been poisoned. Do not take a contaminated label or leaky jug with you to the physician.

If you are unable to take the label to the physician, provide as much information as possible about the pesticide(s), the active ingredients of the pesticide(s), the EPA registration number(s), and the manufacturer(s) of the pesticide.

G PRECAUTIONARY STATEMENTS

Pesticide labels highlight three types of hazards associated with the use of the product: Hazards to Humans and Domestic Animals, Environmental Hazards, and Physical and Chemical Hazards. These precautionary statements may appear on any panel of the label.

Hazards to Humans and Domestic Animals

This section on the label will tell you the ways in which the product may be poisonous to humans and animals. This section will usually indicate which route or routes of entry (mouth, skin, lungs) are particularly hazardous. It also will tell you of any special steps you need to take to avoid poisoning, such as the kind of Personal Protective Equipment (PPE) required. If the product is highly toxic, this section will inform physicians and veterinarians of the proper treatment for poisoning.

STATEMENT OF PRACTICAL TREATMENT

IF IN EYES: Flush with plenty of water. Call a physician.
IF ON SKIN: Wash with plenty of soap and water. Get medical attention if irritation persists.
IF SWALLOWED: Drink large quantity of milk or water. Avoid alcohol.
IF INHALED: Remove victim to fresh air. If not breathing, give artificial respiration, preferably by mouth. Get medical attention.

The statement of practical treatment lists what to do if someone ingests, inhales, or gets pesticide on the skin or in the eyes

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION: Harmful if swallowed or absorbed through the skin. Avoid contact with skin, eyes, or clothing. Keep away from food and feedstuffs. Wear long-sleeved shirt and long pants, chemical-resistant gloves, and chemical-resistant footwear plus socks. 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.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to fish and aquatic invertebrates. Do not apply directly into water. Drift and runoff may be hazardous to aquatic organisms in areas near the application site. Do not clean equipment or dispose of equipment wash waters in a manner that will contaminate water resources.

Precautionary statements identify potential hazards and recommend ways that the risks can be minimized or avoided

Environmental Hazards.

Pesticides are useful tools, but wrong or careless use of them could cause undesirable effects. To help prevent problems, the label contains environmental precautions that you should read and follow. Some examples include:

- “Do not apply when bees are likely to be in the area.”
- “Do not contaminate water when cleaning equipment or when disposing of wastes.”
- “This product is toxic to fish and wildlife.”

Labels may contain broader warnings against harming birds, fish, wildlife, and endangered and threatened species.

Endangered Species: It is a Federal offense to use any pesticide in a manner that results in the death of an endangered species. Use of this product may pose a hazard to endangered species. When using this product, you must follow the measures contained in the Endangered Species Protection Bulletin for the county in which you are applying the product. To obtain Bulletins, no more than six months before using this product, consult <https://www.epa.gov/endangered-species> or call 1-800-447-3813. You must use the Bulletin valid for the month in which you will apply the product.

(Excerpt from Rozol® Prairie Dog Bait label).

Some pesticides carry a Groundwater Advisory (GWA) statement on the label. This information will help the applicator to apply the pesticide in a manner that will minimize the risk for **groundwater** contamination. Examples of pesticides with groundwater advisory statements include atrazine and 2-4,D. In addition, many pesticide labels carry a **Surface Water** Advisory (SWA) statement on the label. This advisory statement informs applicators of the danger of surface water contamination. Metolachlor and sulfentrazone are examples of pesticides that carry a surface water advisory.

Physical and Chemical Hazards.

This section lists any special fire, explosion, or chemical hazards that the product may pose.

H Name and Address of Manufacturer

The law requires the manufacturer or distributor of a product to put the name and address of the company on the label. This way, you will know who made or sold the product. The name and address of the manufacturer may be found anywhere on the label, but is most commonly found on the front panel.

CHEMCO CHEMICAL COMPANY
1234 Main St., Hoodsville, CO 80523

*The name and address of the manufacturer
or distributor tells you
who made or sold the product*

I DIRECTIONS FOR USE

The use directions will tell you:

- The crop, animal, or site the product is intended to protect.
- The pests the product is registered to control.
- Proper mixing instructions.
- Where and when to apply.

- How much to use (rate) and how often.
- How close to harvest the product can be applied (preharvest interval).
- **Phytotoxicity** (damage to desirable plants) and other possible injury.
- Other restrictions like recropping, composting, grazing.
- How to minimize **drift**.
- Limitations on the number of applications and/or the total amount applied.

I 1 *Misuse Statement.*

“It is a violation of federal law to use a product in a manner inconsistent with its labeling.”

It is also a violation of Colorado law. Do not use a product on a plant or site not listed on the label. Do not use it at more than the recommended rate. Before the product can be registered, EPA requires the manufacturer to conduct many tests to be sure the label directions are correct. By following them exactly, you will get the best results the product can give and avoid breaking the law.

No pesticide may legally be used or recommended in any way that conflicts with the recommendations on the registered label.

Illegal Uses:

- Increase the rate of application over the maximum shown on the label
- Change the time of application, or other conditions of use shown on the label
- Include a site or crop to be treated that is not shown on the label
- Failing to wear label-required PPE

However, it is NOT ILLEGAL to use a pesticide in certain situations as described below.

Legal Uses:

- At rates *less* than those recommended on the label unless the label specifically prohibits it
- For a pest not listed on the label if the site of application is listed on the label (e.g., interior of a home, food-handling establishments, exterior ornamental plants, corn, etc.)
- In combination with fertilizers
- In combination with other pesticides, providing that labeled rates for each pesticide are not exceeded and the combination of products is not prohibited by any of the pesticide labels
- With an application method that is not listed on the pesticide label, as long as the method is NOT prohibited on the pesticide label

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

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 PPE and restricted-entry interval. These requirements only apply to uses of Weed-Out 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.

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). Residential areas, parks, hotels and resorts, forest habitats and natural areas are not within the scope of the Worker Protection Standard. Do not allow people (other than applicator) or pets to enter treated areas until sprays have dried. PPE required for early entry to treated areas is: coveralls, chemical-resistant gloves and chemical-resistant footwear plus socks.

1 2 AGRICULTURAL USE REQUIREMENTS / NON-AGRICULTURAL USE REQUIREMENTS

These sections are found on product labels that are covered by the EPA Worker Protection Standard (WPS). More information on WPS can be found under Additional Resources. WPS includes requirements for the protection of agricultural workers on farms, in forests, nurseries, and greenhouses, as well as handlers of agricultural pesticides. If the intended application falls under 'AGRICULTURAL USE' based on the sites above, the applicator must follow the additional information in the AGRICULTURAL USE REQUIREMENTS box. This section of the label contains requirements for training, decontamination, notification, emergency assistance, restricted-entry intervals (REI), and personal protective equipment (PPE) if entry into the field is necessary before the REI expires.

Restricted entry intervals. This section on the label indicates how much time must pass before a pesticide-treated area is safe for entry by a person without appropriate protective clothing. Carefully observe restricted entry intervals (REIs) to avoid unnecessary pesticide exposure and possible pesticide poisoning. If no REI or other restricted-entry statement is found on the label, then all persons should wait at least until sprays have dried or dusts have settled before reentering the treated area.

The information in the NON-AGRICULTURAL USE REQUIREMENTS section applies to pesticide uses that do not fall under the scope of WPS. Some examples include applications to lawns, golf courses (except the turf nursery), ornamental plantings, structures (non-greenhouse), aquatic areas, and rights-of-way. Specific REI are not usually listed for these uses, though the label generally will caution people and pets not to enter the treated area until the spray has dried or settled.

DIRECTIONS FOR USE by Reference.

In addition to label directions, pesticide users must also obey directions contained in documents that are only referred to on the product labeling. This practice has become necessary because there is no longer room on the traditional label to explain the requirements of all laws and regulations. Examples of DIRECTIONS FOR USE *by Reference* on the label include statements about Endangered Species requiring you to refer to Endangered Species Protection Bulletins, or statements for Pollinator Protection which refer you to a State Managed Pollinator Protection Plan (beginning in 2016).

Waiting Periods. If required for the product, this section will tell you how much time must pass between pesticide application and harvest, slaughter, or grazing. The preharvest interval (PHI) is the time that must elapse between the last pesticide treatment and harvest of the crop. Preharvest intervals are required by law. Carefully observe them to prevent harvesting an illegally contaminated product.

As the pesticide applicator, you are responsible for determining whether the regulation, bulletin, or other document referred to on the pesticide product labeling applies to your situation and your intended use of the product. If the document is applicable, you must comply with all the specific directions for use and other requirements that it contains. These documents do not always accompany the pesticide product when it is sold. Instead, you may have to get the additional directions and requirements from other sources, such as pesticide

dealers or company representatives, industry or commodity organizations, universities, the Internet, or your county extension office.

Limiting Pesticide Residues on Crops

- *Follow preharvest interval (PHI) requirements listed on the pesticide label.* The PHI is the minimum amount of time that must elapse between the last application and harvest. PHIs are established for all pesticide uses on crops fed to humans and livestock. The length of the PHI is determined following studies on the **degradation** of the pesticide under labeled use conditions and varies with different pesticides.
- *Apply pesticides only to labeled crops.* All pesticides can only be applied to crops that are specifically included in the label instructions. For example, greenhouse tomatoes and field grown tomatoes are considered to be separate crops.
- *Apply pesticides only by labeled methods.* Only specifically listed methods may be used (e.g., **chemigation, aerial application**).
- *Apply pesticides at rates that do not exceed labeled rates.* It is illegal to apply more than the label allows. Some pesticides also have restrictions on the number of applications that can be made during a season and/or their frequency and total amount applied over the season.
- *Do NOT apply pesticides where they will drift onto unlabeled crops or gardens.*

J Storage and Disposal Directions

Every pesticide should be stored and disposed of correctly. This required section, found near the beginning or end of the "DIRECTIONS FOR USE" section, will tell you how to store and dispose of the pesticide and empty containers. Sometimes this information is found under other headings such as "Important", "Note", or "General Instructions". Additional information on storing the pesticides can be found on the Safety Data Sheet (next section).

K Net Contents

The net contents statement tells how much is in the container. This can be expressed in pounds or ounces for dry formulations, and as gallons, quarts, or pints for liquids. Liquid formulations may also list the pounds of active ingredient per gallon of product. Net content is always stated in terms of the largest suitable units, such as "1 pound" rather than "16 ounces." The net contents statement is usually found on the bottom of the label's front panel.

STORAGE AND DISPOSAL

STORAGE: Store in safe manner. Keep pesticide in original container only. Keep container tightly closed when not in use. Personnel should use clothing and equipment consistent with good pesticide handling.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of at an approved waste disposal facility.

CONTAINER DISPOSAL: Triple rinse. Offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill.

All pesticide labels contain general instructions for the appropriate storage and disposal of the pesticide and its container

NET CONTENTS 2.5 GAL. (9.46 L)

Net contents indicate the amount of formulated pesticide in the package

Reading and Understanding the Safety Data Sheet (SDS)

The Safety Data Sheet (SDS) is a technical bulletin which provides workers and emergency personnel with proper procedures for handling the substance. The SDS, previously known as the Material Safety Data Sheet (MSDS), is a useful document for learning about properties of a pesticide product including composition, physical and chemical properties and hazards, toxicological and ecological information, first aid procedures and safety precautions for handling, storing, and transporting the chemical. The SDS is available from the pesticide manufacturer or supplier. EPA considers the SDS that accompanies the pesticide product to be part of the pesticide's labeling. Commercial applicators are required to keep the SDS for products they use and make them available to workers or any end-user who may come into contact with the formulated material, the diluted product, or residues. SDS can be used in combination with a product label, but should NEVER be used in place of the actual product label. Both the label and the SDS provide valuable information in case of a pesticide emergency. Remember that the SDS represents the actual end-use formulation and, except for applicators, most people would be exposed to diluted product or residues.

Occupational Safety & Health Administration (OSHA) requires that:

- Employers must maintain copies of the required SDS sheets for each hazardous chemical in the workplace
- Employers must ensure that the SDS is readily accessible to personnel
- Personnel must be able to interpret and apply the information in the SDS

In 2012, OSHA revised the Hazard Communication Standard (HCS) to require chemical manufacturer, distributor, or importer to provide SDSs for each hazardous chemical to downstream users to communicate information on these hazards. The information contained in the SDS is largely the same as the MSDS, except now the information in the SDS must be presented in a consistent 16-section format shown below.

- (i) Section 1, Identification;
- (ii) Section 2, Hazard(s) identification;
- (iii) Section 3, Composition/information on ingredients;
- (iv) Section 4, First-aid measures;
- (v) Section 5, Fire-fighting measures;
- (vi) Section 6, Accidental release measures;
- (vii) Section 7, Handling and storage;
- (viii) Section 8, Exposure controls/personal protection;
- (ix) Section 9, Physical and chemical properties;
- (x) Section 10, Stability and reactivity;
- (xi) Section 11, Toxicological information.
- (xii) Section 12, Ecological information;
- (xiii) Section 13, Disposal considerations;
- (xiv) Section 14, Transport information;
- (xv) Section 15, Regulatory information; and
- (xvi) Section 16, Other information, including date of preparation or last revision.

What type of information is covered in the sections of the SDS?

- (i) Section 1, Identification; Product identifier and common name of chemical
- (ii) Section 2, Hazard(s) identification; Hazard classification (ex. flammable, category), Signal word, Hazard statement, pictograms or hazard symbols, precautionary statements. OSHA only recognizes two signal words (DANGER, WARNING) while EPA recognizes three signal words (DANGER, WARNING, CAUTION) so there may be inconsistency between signal words on the label and the SDS.
- (iii) Section 3, Composition/information on ingredients; Information on chemical name, common name, the exact percentage of all ingredients [active ingredients and other (inert) ingredients]. Other ingredients are often considered proprietary information so they are not required to be listed.
- (iv) Section 4, First-aid measures; Information on first aid instructions by route of exposure, most common symptoms, and recommendations for immediate medical care and special treatment needed, when necessary.
- (v) Section 5, Fire-fighting measures; Recommendations for fighting a fire caused by the chemical, or the chemical in storage including special protective equipment or precautions for firefighters
- (vi) Section 6, Accidental release measures; Information on appropriate response to spills, leaks, or releases including containment and clean up practices.
- (vii) Section 7, Handling and storage; Guidance on safe handling practices and conditions for safe storage of the chemical.
- (viii) Section 8, Exposure controls/personal protection; Although this section contains information on personal protective measures, **NEVER USE THIS FOR THE PPE REQUIREMENT FOR THE PRODUCT. ALWAYS USE THE PPE REQUIRED BY THE LABEL!** This section can be useful for PPE for spill cleanup or equipment cleanup.
- (ix) Section 9, Physical and chemical properties; Physical and chemical properties of the substance. Information that would be useful for the applicator includes freezing point which can be used when determining where to store the product.
- (x) Section 10, Stability and reactivity; Describes the reactivity hazards of the chemical and chemical reactivity.
- (xi) Section 11, Toxicological information. Identifies toxicological and health effects, including likely routes of exposure (inhalation, ingestion, skin, and eye contact); delayed, immediate, or chronic effects from short- and long-term exposure; **LD₅₀**; description of symptoms of exposure, whether the chemical is a **carcinogen** or possible carcinogen.
- (xii) Section 12, Ecological information; (non-mandatory) Information on the environmental impact of the chemical. May include toxicity data on aquatic or terrestrial organisms (such as bees), potential to move into groundwater, etc.
- (xiii) Section 13, Disposal considerations; (non-mandatory) Guidance on proper disposal of the container and/or chemical.

(xiv) Section 14, Transport information; (non-mandatory) Information on transportation hazard and transporting in bulk.

(xv) Section 15, Regulatory information; (non-mandatory) Information from Manufacturer relating that the product is registered by EPA and is subject to labeling requirements under FIFRA. Contains hazard information that is required on the pesticide label, which may differ from the hazard information from the SDS (especially signal words).

(xvi) Section 16, Other information; including date of preparation or last revision.

Additional Resources

- Agrian Label Lookup, <http://www.agrian.com>. *Links to online labels and SDS.**
- Colorado Environmental Pesticide Education Program (CEPEP). <http://cepep.agsci.colostate.edu/2-regulations/pesticide-label-search/>. *Links to online labels and SDS.*
- Crop Data Management Systems, Inc. <http://www.cdms.net/Label-Database>. *Links to online labels and SDS.**
- EPA Website on Worker Safety and Training, <https://www.epa.gov/pesticide-worker-safety/safety-training-pesticide-workers-and-handlers>.
- Greenbook. <http://www.greenbook.net/>. *Links to online labels and SDS.**
- National Pesticide Information Center (NPIC), Oregon State University, 333 Weniger Hall, Corvallis, OR 97331-6502. Phone: 1-800-858-7378. <http://npic.orst.edu/>. *Call and ask questions about pesticides and pesticide related topics.*
- OSHA Hazard Communication Standard: Safety Data Sheets, <https://www.osha.gov/>. *Search for Safety Data Sheets.*
- Pesticide Product Label System (PPLS) <http://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1>. *EPA search engine by Product name, Company name, or EPA registration number.*

**** IMPORTANT NOTE ****

Copies of Pesticide Labels can be viewed at these sites. However, they usually represent 'SPECIMEN LABELS' for viewing and are not be used, as legal copies of the label. Actual labels may contain specific information for the distribution area. If the container label is destroyed or unreadable, additional or replacement copies of pesticide labels can be obtained from the dealer or manufacturer.

Pesticide Classifications and Formulations

Learning Objectives

After reviewing this chapter, you should be able to:

- List and describe the common types of pesticides and the target pests controlled by each.
- Describe how pesticides can be grouped by chemical structure, mode of action, and by how or when they work.
- Explain what chemical families and classes are and why knowledge of families and classes is helpful.
- Describe the special hazards that fumigants pose.
- Explain pesticide resistance and how to prevent it from developing.
- Define "pesticide formulation".
- Distinguish between "active" and "inert/other" ingredients.
- List the types and abbreviations of pesticide formulations available (EC, WP, SP, etc.).
- Identify factors to consider when choosing a formulation.
- List the different types of adjuvants and describe their purposes.
- Describe a compatibility test for when creating tank mixes with multiple pesticides.
- Define phytotoxicity and how to minimize/prevent it.

A pesticide is a chemical substance produced and sold for the control of a pest species. The ending of the term is derived from the Latin "cida," meaning "to kill," although some pesticides may merely inhibit the development of a pest rather than kill it. Chemicals used to repel or attract pest species may also be regulated as pesticides. In the current version of FIFRA, the legal definition of a pesticide has further been expanded to include **defoliants**, **plant growth regulators**, and **desiccants**.

Pesticide Types

"Pesticide" is an umbrella term and various types of pesticides are named depending on the type of pest they are used to control as shown in the Table below.

Common Pesticide Types	
• Defoliant - a chemical substance used to produce leaf drop	• Desiccant - a chemical substance used to promote drying as a harvest aid
• Fungicide - a chemical substance used to kill undesirable fungi	• Herbicide - a chemical substance used to kill undesirable plants
• Insecticide - a chemical substance used to kill undesirable insects	• Nematicide - a chemical substance used to kill nematodes
• Miticide (also called acaricide) - a chemical substance used to control mites and ticks	• Molluscicide - a chemical substance used to kill pest molluscs such as slugs and snails
• Insect growth regulator (IGR) - a chemical substance used to desirably alter the growth processes of insects	• Plant growth regulator (PGR) - a chemical substance used to desirably alter the growth processes of plants
• Bactericide - a chemical substance used to kill bacteria (sometimes referred to as sanitizers, germicides, or disinfectants)	• Rodenticide - a chemical substance used to kill rodents

Pesticide Classification

Pesticides can be grouped by chemical structure (called pesticide families) or mode of action, but can also be grouped by mobility in plant, how they work on a pest, how selective the action is, timing of application, how **persistent** they are or where they are applied.

Classification by Chemical Structure

Pesticides are often classified into pesticide families based on their chemical structure. Some of the prominent insecticide families include:

- organophosphates (e.g., acephate)
- carbamates (e.g., carbaryl)
- neonicotinoids (e.g., imidacloprid)
- pyrethroids (e.g., bifenthrin)
- various insect growth regulators

Some prominent herbicide families include:

- benzoic acid, (e.g., dicamba)
- imidazolinones (e.g., imazapyr)
- dinitroanilines (e.g., trifluralin)
- carboxylic acids (e.g., picloram)
- phenoxy (e.g., 2,4-D)
- triazines (e.g., atrazine)
- bipyridyliums (e.g., paraquat)
- and some with no accepted family name (e.g., glyphosate)

Some prominent fungicide families include:

- benzene (e.g., chlorothalonil)
- benzimidazole (e.g., benomyl)
- dithiocarbamates (e.g., mancozeb)
- phenylamide (e.g., metalaxyl)
- sterol Inhibitor (e.g., bayleton)
- strobilurin fungicides (e.g., azoxystrobin)

Classification by Mode of Action (MOA)

Pesticides can be grouped according to their mode of action or the way a pesticide destroys or controls the target pest. It refers to the specific system(s) in the pest that are affected by the pesticide. For example, one insecticide may affect the insects **nervous system** while another may affect **molting**. One herbicide may mimic plant **hormones** while another may interfere with **photosynthesis**. One fungicide may affect cell division while another may slow

the creation of important compounds in the fungi. One rodenticide may interfere with blood clotting while another may act as a neurotoxin.

It is important to know the MOA of a pesticide to preserve its effectiveness and to prevent/minimize pests from developing resistance to the pesticide. Applicators should learn how to identify the MOA for the pesticide used in the pest management program so that MOA can be alternated to avoid resistance developing (more information on resistance management is available at the end of this chapter.). Many manufacturers now voluntarily provide a MOA group code on the pesticide label. It will contain a number or letter and what type of pesticide. Applicators may see the designation on the front of the label as shown in the example below:

GROUP	11	FUNGICIDE
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If a formulation contains two or more active ingredients with differing MOA, it will list a MOA for each active ingredient as seen below:

GROUP	3	11	FUNGICIDE
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Classification by Mobility

Contact pesticides only kill parts of the organism they physically come in contact with. To be effective they must be absorbed through the external body surface or the exposed plant tissue. For example, paraquat is a contact herbicide used to “burn down” crops for harvest or weeds and dormant oils and insecticidal soaps only kill the insects that they come into contact with during the application.

Systemic pesticides move (**translocated pesticides**) from the site of application to another site within the plant or animal where they become effective. For example, systemic insecticides are absorbed by foliage or roots and translocated throughout the plant where they kill chewing or sucking insects. Some insecticides used for control of livestock pests are also systemic after being fed, topically applied, or **injected** into an animal. Applied to herbicides, the term translocated herbicide is sometimes used when they move systemically in a plant. For example, glyphosate herbicide applied to leaves may move into and kill the plant roots.

How the Pest is Exposed

Pesticides can work either as a contact poison when sprayed on the insect, or as a **stomach poison** when applied to a substance and eaten by the pest. Stomach poisons must be swallowed to cause death. They may be formulated as liquids, dusts, pastes, granules, or **baits**. In the case of liquids and dusts, the pesticide is usually applied to some substance on which the animal will chew or walk through. The animals then groom themselves and swallow the pesticide. Pastes, baits, and granules may be formulated with a feeding **attractant** which is consumed by the pest.

Classification by Selectivity

Some pesticides have **broad spectrum** (or **nonselective**) activity, meaning they control many species. This can be a desirable feature when several different pests infest a crop or site. On the other hand, broad spectrum insecticides often damage beneficial insects, such as biological control organisms, **pollinators**, or earthworms. **Fumigants** are an example of nonselective pesticides.

Selective pesticides only work on certain species. For example, a broad spectrum herbicide will kill any plant, while certain selective herbicides will kill only **broadleaf** plants and not grasses.

Classification by Application Timing

Pesticides work best if applied when the target pests are most **susceptible** or the crop or site is most resistant to injury. Applying pesticides too early or too late may reduce or even eliminate their effectiveness and may damage the crop or site. Terms that describe when to apply pesticides include:

- **Pre-plant** - Applying the pesticide before planting
- **Pre-emergence** - Applying the pesticide before the seedlings come up (emerge)
- **Post-emergence** - Applying the pesticide after the seedlings come up
- **Protectant** - Applying the fungicide prior to infection

Persistence of Pesticide

How long the pesticide remains active against pests after it is applied is called its residual effect. Some pesticides remain active for days or weeks, while others, such as soap or oil sprays, act only on pests hit by the spray and have no residual activity after the spray has dried. **Residual pesticides** are also persistent, meaning they remain active in the environment for a period of time, even if rain or wind has carried them away from the target site.

Residual herbicides are non-selective herbicides applied to soil. They control growing plants and prevent growth of new plants for as long as the compound remains active, often several years. Long-term residual herbicides were called "soil sterilants." This term is misleading because they did not **sterilize** the soil. A better term is "bareground treatments," since residual herbicides only control plants. Residual herbicides are primarily used in maintaining right-of-way areas or in areas where no vegetation is desired.

Classification by Application Location

Foliar pesticides are applied to plant leaves, stems, and branches. They may be either contact or systemic pesticides.

Soil applied pesticides are applied to the soil. Some are taken up by roots and translocated inside the plant. Others kill weed seedlings by contact with young shoots or leaves as they break through the soil.

Basal applications of herbicides to bark are made to control undesirable woody plants, especially around sensitive sites.

Insect Growth regulators, or IGRs, (juvenile hormone analogs) prevent the insect from properly developing. Others (chitin synthesis inhibitors) interfere with the process of molting. Because the method by which IGRs affect insects involves hormones unique to them, they are among the least toxic insecticides to humans and other mammals.

Antibiotics

Antibiotics (e.g., streptomycin and tetracyclines) are substances produced by one organism that are toxic to another organism. Most antibiotics in use today are products of bacteria-like

soil organisms known as actinomycetes. Antibiotics are used in medicine as well as in pest management. Control of the bacterial fruit tree disease fire blight with streptomycin is one of the greatest non-veterinary uses of antibiotics in agriculture.

Fumigants

Fumigants (e.g., aluminum phosphide, metam sodium, and paradichlorobenzene) are pesticides which are primarily used as toxic gases. Most fumigants kill susceptible pests that breathe the gases into lungs (mammals) or spiracles (insects and mites). Some fumigants may also enter through the skin and be corrosive to eyes. Many fumigants, particularly those used for control of stored grain insects and in rodent control are extremely toxic and hazardous to apply. Less common uses of fumigants in Colorado include control of nematodes, soilborne fungal diseases, and weeds in cropland.

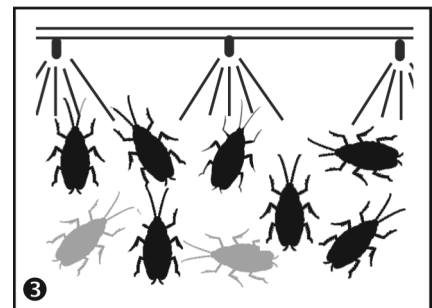
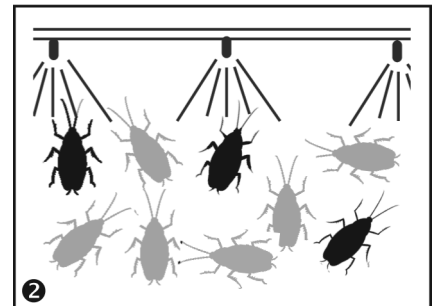
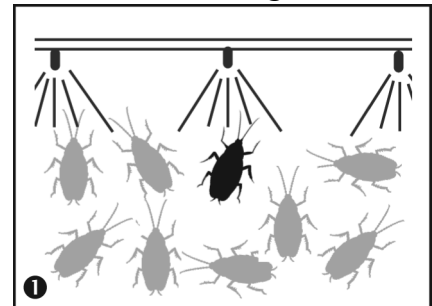
Some pesticides applied to soil or foliage have some fumigant activity. For example, some of the ethyl-parathion applied to a crop will volatilize into a gas state and act as a fumigant. Several soil applied herbicides move through the soil in a gaseous state. However, these pesticides are generally not considered to be fumigants since they are not primarily used as a gas for pest control.

Because of the special hazards involved in the application of the more hazardous fumigants, special training is required. The use of these products requires special protective equipment and supervision and completion of a fumigation management plan.

Pesticide Resistance

Pesticides can play a significant role in pest management programs but their use requires certain precautions to avoid the development of resistant pest populations. Although pest resistance can occur, it is not the cause of every pesticide failure.

Pesticide resistance is the ability of an insect, fungus, weed, rodent, or other pest to tolerate a pesticide that once controlled it. Resistance develops because recurring or frequent pesticide use kills susceptible individuals in the population, leaving only resistant individual to reproduce. Initially, higher rates and more frequent applications are used to control the pest but eventually the pesticide has little or no effect on the population. Resistance develops in a similar manner in all pests whether they are rodents, insects, weeds, or plant pathogens. The development of pesticide resistance from repeated applications using the same MOA is described in the diagram at right.



- ❶ Some individuals in a pest population have genetic traits that allow them to survive pesticide application (black insects in this example).
- ❷ A proportion of the survivor's offspring inherit the resistance traits. At the next spraying, these resistant individuals survive.
- ❸ If pesticides are applied frequently, the pest population will soon consist mostly of resistant individuals.

Pest resistance can develop to only a single pesticide. However, it is more common for pest populations to become resistant to other pesticides in the same **chemical class** that have the same MOA. This is referred to as **class resistance**. When a pest develops resistance to closely related pesticides that have the same MOA, it is referred to as **cross resistance**. These types of resistance can be prevented or overcome by alternating the MOA of the pesticides used against the pest. By alternating MOAs, applicators can prevent or delay the development of **multiple resistance** where a pest becomes resistant to more than one class of pesticides that have different MOAs. For example, in Colorado, the weed *Kochia* has developed multiple resistance to atrazine (Group 5 MOA) and glyphosate (Group 9 MOA). When multiple resistance occurs, controlling pests will become difficult or unachievable. to atrazine (Group 5 MOA) and glyphosate (Group 9 MOA). When multiple resistance occurs, controlling pests will become unachievable

How to Manage to Avoid Resistance Development

The best strategy to avoid pest resistance is prevention. Pesticide resistance management programs are one part of the larger IPM approach. Here are some strategies that can be used to minimize the likelihood of pesticide resistance developing:

- Monitor pest populations to determine if and when control measures should be used. Also consider natural enemies when deciding whether to use chemical control. After treating for a pest, continue to assess pest populations and the effectiveness of the control measure.
- Use economic or action thresholds to prevent the indiscriminate use of pesticides.
- Use IPM so that many different control measures are applied to manage the pest. Protect natural enemies by choosing IPM strategies that will conserve their populations whenever possible.
- Schedule applications to control the pest at its most vulnerable stage.
- Mix and apply pesticides carefully. Make certain to use the proper rate and that application equipment has been properly **calibrated** and is in good working order. Apply at the recommended rate and avoid using lower rates.
- Use pesticides with short residuals to avoid placing long-term pressure on pest populations.
- Alternate MOAs. If you have to use pesticides on the same site or crop, rotate to a pesticide with a different MOA. If the product label does not indicate the Group MOA, the information can be found at the Fungicide Resistance Action Committee website, the International Survey of Herbicide Resistant Weeds website, or the Insecticide Resistance Action Committee website. Although not as well-developed as the previous sites, there is also a site for Rodenticide Resistance Action Committee (under Additional Resources).
- Keep good application records so if a pesticide resistance problem is suspected, the records can be reviewed to see if pesticides with the same or closely related MOA have been used repeatedly at the site or on the crop. Although private applicators are only required to keep pesticide records for 2 years in Colorado, keeping records longer can be of benefit when trying to determine if pesticide resistance is an issue.

As pesticides become ineffective, the costs of overcoming resistance can be very high. Sometimes there are no effective alternatives and losses from pests can be severe. Since development of new pesticides is a very long and costly process, it is in the best interest of the applicator to minimize the development of pest resistance by properly managing the use of pesticides.

If all other integrated pest management tactics are unable to keep a pest population below the economic or action threshold, then the use of a pesticide to control the pest is justified. Remember, pesticides are selected based on the type of pest they control: insecticide, herbicide, etc.

Pesticide Formulations

A pesticide formulation is a mixture of chemicals which effectively control a pest. The pesticide formulation contains an active ingredient and inert ingredients. The terms “active ingredient” and “inert ingredient” are defined by FIFRA.

Active ingredients (AI) are the chemical portion of the formulation that can kill, repel, attract, mitigate or control a pest or that acts as a **plant growth regulator**, desiccant, or nitrogen stabilizer. Some formulations may contain more than one active ingredient to increase the effectiveness of the product or to help applicators manage to avoid the pest developing resistance to the pesticide.

Inert ingredients, also known as “other ingredients”, do not have pesticidal activity. They may include ingredients such as water, petroleum distillates, corn meal, talc, or soap. Or there may be other ingredients that stabilize, improve or enhance the pesticidal activity. EPA maintains a list of acceptable inert ingredients for manufacturers to select from when formulating products. EPA is encouraging manufacturers to use the term “other ingredients” instead of inert ingredients because they do not want to imply that these ingredients are non-toxic.

Some formulations may also contain a **synergist** which is a type of active ingredient that may be added to a pesticide formulation to enhance another active ingredient’s efficacy. A synergist does not possess any pesticidal properties. For example, insecticides containing pyrethrins often contain piperonyl butoxide as a synergist.

A single active ingredient is often sold in many different formulations due variations in the active ingredient **solubility**, ability to control the pest, and ease of handling/mixing or transport. If you find more than one formulation of an active ingredient, remember NOT ALL FORMULATIONS ARE LABELED FOR ALL USES! Some formulations may require special equipment and some formulations can damage equipment or surfaces that may be exposed to the spray. Always choose the least hazardous formulation that would still be effective against the pest.

Formulations can be divided into solid, liquids or gases. Commonly used abbreviations on the label are often used to describe the type of formulation. These abbreviations are summarized below.

- A = Aerosol
- B = Bait
- D = Dust
- DF = Dry Flowable
- E, EC = Emulsifiable concentrate
- F = Flowables (liquid)
- G = Granules
- L = Liquid (flowable)
- LV = Low volatile
- M = Microencapsulated
- P = Pellets
- RTU = Ready-to-use
- S = Solution
- SP = Soluble powder
- ULV = Ultra low volume
- W, WP = Wettable powder
- WDG = Water dispersible granules
- WSL = Water soluble liquid
- WSP = Water soluble powder or water soluble packet

Liquid Formulations

Liquid formulations are usually mixed with water as a carrier, but some labels may allow or recommend the use of **crop oil**, diesel fuel, kerosene, or some other light oil as a carrier.

Liquid formulations include:

Emulsifiable concentrates	Flowables/Liquids
Solutions	Invert Emulsions
Ready-to-Use	Aerosols
Ultra-low Volume	

Emulsifiable Concentrates (E or EC)

An **emulsifiable concentrate** usually contains a liquid active ingredient **dissolved** in an organic **solvent** such as oil or petroleum and an **emulsifier** so the formulation can be mixed with water or oil for spraying. The solvent gives the EC formulation a strong odor. EC formulations are used in agriculture, ornamental, turf, forestry, structural, food processing, livestock, and public health pest control.

Advantages

- Relatively easy to handle, transport, store
- Requires little **agitation**
- Not abrasive, won't plug screens or **nozzles**
- Little visible residue



Source: <http://www.sstack.com>

Disadvantages

- May cause damage to desirable plants (phytotoxicity)
- Easily absorbed by through skin of humans or animals
- Solvents may cause plastic or rubber surfaces or parts to deteriorate
- May be **corrosive**
- May cause pitting or discoloration of painted surfaces

Solutions (S)

Solutions readily dissolve in a liquid carrier like water or a petroleum-based solvent. Because the active ingredients readily dissolve in the carrier, they do not require agitation. Solutions are used in both indoor and outdoor applications.

Advantages

- Easy to handle and mix
- Agitation not required
- No residues

Disadvantages

- None

Ready-to-Use Low Concentrate Solutions (RTU)

These formulations are **ready to use** and do not require any further dilution before application. They usually contain a small amount of active ingredient (usually <1% per unit volume) dissolved in an organic solvent. They are useful for structural and institutional pest control and household use.

Advantages

- Easy to use, no mixing required
- Relatively safe to handle
- Disadvantages
- Limited availability
- Expensive (high cost per unit of active ingredient)
- Organic solvents may harm plant foliage



Source: <http://www.roundup.com.au/>

Ultra-low Volume (ULV)

Ultra-low volume pesticides use formulations approach **concentrations** of 100% active ingredient. They may be used 'as is' or may be diluted with small quantities of a specified carrier. These are used mostly for outdoor applications in agriculture, forestry, ornamental, or in mosquito control programs.

Pesticide Classifications & Formulations

Advantages

- Easy to handle and mix
- Little or no agitation required
- Easy on equipment
- No residues

Disadvantages

- High drift potential
- Special application equipment required
- Solvents may wear rubber and plastic parts
- Proper equipment calibration is critical

Flowables/Liquids (F or L)

Manufacturers use **flowable**/liquid formulations when the active ingredient, a solid, does not dissolve in either water or oil. The active ingredient is impregnated on a fine carrier like clay, then ground to a fine powder, and suspended in a small amount of liquid. The resulting formulation is quite thick.

Advantages

- Easy to handle and mix

Disadvantages

- May settle out of **suspension** so requires shaking prior to pouring and mixing
- Requires moderate agitation once mixed
- Abrasive to nozzles and pumps
- Leave visible residues

Invert Emulsions

Invert emulsions contain a water-soluble pesticide dispersed in an oil carrier. Due to the thickness or viscosity of the oil-based mixture, spray droplets are large and heavy, so they don't drift. Invert emulsions also evaporate more slowly than water-based mixtures resulting in reduced drift and runoff. The oil carrier acts as a sticker-spreader helping to improve the **coverage** and **absorption** of the product. Invert emulsions are most commonly used in areas where drift to susceptible non-target plants and sensitive areas is of concern, like along right-of-ways.

Advantages

- Good for sensitive sites, like roadsides, where drift is a concern

Disadvantages

- Limited sites for applications

Aerosols (A)

These formulations contain a low percentage of one or more active ingredients and a solvent. There are two types of **aerosols**: ready-to-use and formulations for smoke or **fog** generators.

RTU Aerosols: These are usually small self-contained units that release the pesticide when the nozzle valve is triggered. They are used in greenhouses, small areas inside buildings, or in localized outdoor areas.

Advantages

- Convenient way to buy a small amount of pesticide
- Typically can store for a long period of time

Disadvantages

- Limited uses
- Risk of inhalation injury
- Difficult to confine to target area

Fog or Smoke Aerosols: These formulations require special equipment to break the liquid formulation into a fine mist or fog. These are used mainly for insect control in structures like greenhouses and warehouses or for mosquito and biting fly control outdoors.

Advantages

- Convenient way to fill an enclosed space

Disadvantages

- Highly specialized use and equipment is required
- Risk of inhalation injury
- Difficult to confine to target area



Source: <http://www.plantcareinfo.com/>

Dry or Solid Formulations

There are two types of dry formulations: ready-to-use and concentrates that must be mixed with water to apply as a spray.

Dry or solid formulations include:

Dusts	Wettable Powders
Baits	Soluble Powders
Granules	Water Dispersible Granules
Pellets	

Pesticide Classifications & Formulations

Dusts (D)

Most dusts are ready-to-use and contain a low percent of active ingredient (<10% by weight) with a very fine, dry inert carrier like talc, chalk, clay or nut hulls. There are a few dust formulations that have high concentrations of active ingredients and should be mixed with dry inert carriers before applying.

Dusts are always applied dry and are used as seed treatments in agriculture, as crack and crevice treatments in structures, and on pets and livestock to control fleas, lice, and other parasites.



Source: <http://www.homedepot.com>

Advantages

- Requires simple equipment to apply
- Effective in hard-to-reach areas
- Effective where a liquid spray (moisture) would cause damage

Disadvantages

- May drift off target during application
- Residue may move off target with air movement or water
- May irritate nose, eyes, throat, and skin
- Difficult to get even distribution
- Doesn't stick to surfaces like liquids

Baits (B)

Baits are active ingredients mixed with food or an attractive substance. Pests are killed when they eat the bait containing the pesticide. The amount of active ingredient in most bait formulations is usually low (usually <5%). Baits are used in buildings to control ants, roaches, flies, other insects, and rodents. They are sometimes used outdoors to control snails, slugs, ants and termites. However, they are mainly used to control vertebrate pests such as rodents, some mammals, and birds. Federal regulations require that certain rodenticides must be placed in tamper-resistant bait stations. Pastes and **gels** are now being used in pest control for ants and cockroaches and are applied using syringes or bait guns.

Advantages

- Ready to use
- Entire area doesn't have to be covered as pest comes to bait
- Can control pests that move in/out of the area

Disadvantages

- Can be attractive to children and pets
- May kill domestic animals and non-target wildlife outdoors
- Pests may prefer another available food source to the bait
- Dead vertebrate pests may cause an odor problem



Source: Flickr user 'UNL PSEP'

Granules (G)

Granular formulations are similar to dusts but the particles are larger and heavier. The active ingredient either coats the outside of the granules or is absorbed into them. Granules are made from materials like clay, corncobs, or walnut shells. They are usually applied to the soil to control weeds, nematodes, and insects living in the soil, or for absorption into plants through roots. Once applied, granules release the active ingredient slowly and some require soil moisture to release the active ingredient. Granular formulations can also be used to control larval mosquitoes and other aquatic pests. Granules are used in agriculture, turf, ornamental, structural, aquatic, right-of-way, and public health pest control.

Advantages

- Ready to use
- Low drift hazard
- Little hazard to applicator
- Uses simple application equipment

Disadvantages

- Can be difficult to calibrate equipment and apply uniformly
- Does not stick to foliage or uneven surfaces
- May need to be incorporated in soil
- May need moisture to activate the pesticide so it may not work under drought conditions
- May be hazardous to non-target species if mistaken for a seed food source



Source: <http://www.agrochemical-pesticide.com>

Pellets (P or PS)

Pellets are similar to granules except the particles are of the same weight and shape. Because the particles are uniform, uniform applications can be made with precision equipment. A few fumigants are formulated as pellets but are clearly labeled as fumigant and should not be confused with non-fumigant pellets.

Wettable Powders (WP or W)

Wettable powders are one of the most widely used pesticide formulations. They are finely ground formulations that look like dust but usually have to be mixed with water for application as a spray. However, some may be applied as a dust or wettable powder. Wettable powders contain from 5 to 95% active ingredient, most usually 50% or more. The particles do NOT dissolve in water and require agitation to keep them suspended. They usually have excellent residual activity.

Advantages

- Easy to store, transport, and handle
- Easy to mix and measure



Source: <http://www.amazon.com>

Pesticide Classifications & Formulations

- Less likely than EC and other petroleum-based pesticides to harm treated plants, animals and surfaces
- Less hazard of skin and eye absorption than ECs and other liquid formulations

Disadvantages

- Pose an inhalation hazard to applicator during measuring and mixing
- Difficult to mix in hard, alkaline water
- Requires constant agitation in the spray tank
- Abrasive to pumps and nozzles
- Often clogs nozzles and screens
- Residues may be visible on treated surfaces

Soluble Powders (SP or WSP)

Soluble powders look like wettable powders but when mixed with water, they dissolve readily and form a true solution. The amount of active ingredient in soluble powders ranges from 15 to 95% by weight, and is usually 50% or more. Few pesticides are available in this formulation because few active ingredients are readily soluble in water. They have all the same advantages of wettable powders and the **ONLY** disadvantage is due to an inhalation hazard during measuring and mixing.

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

Water dispersible granules, also called **dry flowables**, are formulated as small, easy to measure granules. The granules must be mixed with water for application and requires constant agitation to keep the particles suspended. The percent active ingredient is usually high, often as much as 90% by weight. They share the same advantages and disadvantage of wettable powders except they:

- Are more easily measured and mixed than wettable powders
- Pose less of an inhalation hazard during handling

Other Types of Formulations

Some formulations cannot be clearly classified as a liquid or dry/solid formulation.

Microencapsulated (M)

This formulation is made by covering liquid or dry pesticide particles in a plastic coating. They are mixed with water and sprayed. After spraying, the plastic coating breaks down and slowly releases the active ingredient. This breakdown is sometimes dependent on weather conditions and under certain conditions may break down more slowly than expected. For this reason, some **microencapsulated** formulations require long restricted-entry intervals to protect fieldworkers. These applications are often used in agriculture, residential, industrial, and institutional applications.

Advantages

- Highly toxic materials are formulated so they are safer for applicators to mix and apply
- Slow release of the active ingredient prolongs its effectiveness

- The pesticide volatilizes more slowly so less is lost from the site
- Often see reduced injury to plants from this formulation

Disadvantages

- May pose a hazard to bees which may confuse capsules with pollen
- Long restricted-entry intervals

Water-soluble Packets (WSP)

Manufacturers package precise amounts of wettable powders or soluble powder formulations in a special type of plastic bag, called a **water-soluble packet**. The bags are dropped into a spray tank with water where the plastic bag dissolves.

Advantages

- Reduced hazard from mixing/handling highly toxic materials
- No inhalation risk

Disadvantages

- Pre-measured packets do not allow for mixing smaller quantities
- If exposed to water accidentally, poses high hazard

Attractants

Attractants include pheromones, yeasts, rotting meat, and sugar or protein hydrolysate syrups. These attractants are placed in a sticky trap or capture bag. Some attractants are combined with pesticides and sprayed in a treatment area or on foliage.

Repellents

Various insect repellents are used to repel biting or nuisance pests. Other repellents are mixed with water and sprayed onto ornamental plants and agricultural crops to prevent damage from deer, dogs, and other animals.

Impregnates

Manufacturers may impregnate (saturate) pet collars, livestock ear tags, adhesive tape, plastic pest strips, and other products with pesticides. The pesticide evaporates over time and **vapor** control nearby pests. Some paints and wood finishes are also impregnated with pesticides to kill insects or retard fungal growth.

Fumigants

Fumigants are pesticides that form poisonous gases when applied. Some active ingredients are liquids packaged under high pressure and change to gases when released. Other active ingredients are **volatile** liquids enclosed in regular containers. Others are solids that release a gas when applied under high humidity or when exposed to water vapor. Fumigants are used for structural pest control, in food and grain storage facilities, and in ports of entry at state and national borders. In agriculture, fumigants are used in soil, greenhouses, and grain bins.

Advantages

- Toxic to a wide range of pests
- Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grain
- Single treatment is often effective in killing most pests

Disadvantages

- Target site must be enclosed or covered to prevent the gas from escaping
- Non-specific – highly toxic to humans and all other living things
- Requires specialized protective equipment, including approved **respirators**

Adjuvants

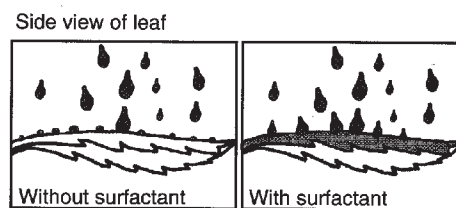
Spray **adjuvants** (additives) are added to pesticides to enhance the performance or handling of those pesticides. Adjuvant is a broad term and includes **surfactants**, crop oils, **antifoaming agents**, **stickers**, and **spreaders**. Adjuvants are usually classified according to their use rather than their chemistry. Adjuvants are not under the same guidelines for registration as are pesticides. Anyone can mix up a non-pesticidal concoction, give it a name, and sell it as an adjuvant. The best way to avoid a “snake oil” product is to buy a recognized name-brand product from a reputable dealer. If the claims sound too good to be true, they probably are.

Adjuvants are intended to enhance the performance of the pesticide but choosing the wrong adjuvant can actually reduce the performance and cause crop injury. Manufacturers sometimes add adjuvants to the formulation so it is important to read the product label to see if the addition of an adjuvant is recommended or required. Adding additional adjuvants may compromise the performance of the pesticide. For example, if the formulation already has a surfactant to reduce surface tension of the droplets and the applicator adds additional surfactant, the spray solution may runoff the plant surface during application.

The Compendium of Herbicide Adjuvants (Additional Resources) is a resource to help applicators determine available adjuvants and the contents of adjuvant products.

Surfactants (Surface-Active Agents)

Surfactants modify the surface properties of the materials they contact. They are frequently added to herbicides to increase activity on weeds. However, some surfactants may also increase injury on desirable plants. Three major types of surfactants are emulsifiers, **wetting agents**, and stickers.



A surfactant reduces the surface tension of spray droplets

Emulsifiers – promote the suspension of a liquid in another. They are usually used to disperse and oil in water.

Wetting Agents – (also called spreaders) increase the area that a droplet of a given volume of spray mix will cover on a target. Non-ionic surfactants are most commonly used as they are compatible with most pesticides and have low toxicity to plants and animals.

Stickers – cause the pesticide to adhere to the plant surface and resist wash-off. Spreader-stickers are a combination of products that provide better coverage and adhesion and are frequently used with insecticides and fungicides.

Crop Oil and Crop Oil Concentrates – aid in moving herbicides across the leaf cuticle and reduce surface tension of the spray drops. They also reduce drying times which allows for more time for the herbicide to penetrate the leaf. Crop oils are light, petroleum-based oils which may contain up to 5% surfactant while crop oil concentrates contain 17-20% surfactant.

Other Types of Adjuvants

- **Activator** – increases the biological efficacy of the pesticide.
- Antifoaming agent- eliminates or suppresses foam in spray tank.
- Buffer - added to resist changes in the spray solution pH. Most pesticide solutions are stable between pH 5.5 and pH 7.0. Above pH 7.0, the pesticide may begin to degrade.
- Colorant or dye - used to alter the color of the spray solution so the applicator can see where the solution has been applied.
- Colorant or dye - used to alter the color of the spray solution so the applicator can see where solution has been sprayed.
- **Compatibility agent** –allows the simultaneous application of a liquid fertilizer and pesticide, or two or more pesticides, or improves the uniformity of the mixture and application.
- **Drift control agent** – used in liquid spray solutions to reduce **spray drift**, usually by increasing droplet size.
- Nitrogen sources – used when product calls for ammonium sulfate.
- **Penetrant** – enhances pesticide’s ability to enter substrate or penetrate surface.
- Water conditioner – used with **hard water** having high pH as it sequesters and chelates hard water ions.

Compatibility Tests

Tank mixes of two or more pesticides are commonly applied. Sometimes these pesticides may not mix well in the tank even though each product alone mixes with the carrier well. Also, there are situations where it is desirable to use a fluid fertilizer or liquid nitrogen as the carrier. Some pesticides are compatible with fluid fertilizers and some are not. By conducting a simple compatibility test before adding the pesticides to the tank, one can usually avoid making “jello” in the tank. Before mixing, every batch of fluid fertilizer or liquid nitrogen mixed with pesticides should be tested for compatibility. Batches can vary in pH, salt concentration, or even temperature. Even minor differences between batches may affect compatibility.

Materials Required for a Compatibility Test

- Two 1-quart jars with lids (mark one “with” and the other one “without”);
- Teaspoons
- Fluid fertilizer or liquid nitrogen to be tested;
- The pesticide(s) to be tested,
- A compatibility agent (example: Blendex®, Unite®)
- Use the following table to determine how much material to add based on the label rate.

Jar Test Strategy		
<i>Combine the ingredients listed here to determine if a tank mix will save you the time and cost of a second application of a pesticide.</i>		
Material	Order of mixing	Material amount to add to jar*
Water Soluble Pouches	1	1 tablespoon (Tbs) per pound
Wettable Powders	2	1 Tbs per pound
Dry flowables/water-dispersible granules	3	1 Tbs per pound
Suspension concentrates/Flowables Capsule suspensions	4	1 teaspoon (tsp) per pint
Emulsifiable concentrates	5	1 tsp per pint
Soluble Liquids	6	1 tsp per pint
Soluble Powders	7	1 tsp per pound
Surfactants, oils, remaining adjuvants	8	1 tsp per pint
Fertilizers	9	1.1 grams** per pound
*Equivalent to underlined unit of pesticide or fertilizer per 100 gallons of final spray solution.		
**Use an inexpensive postal scale to measure this amount		

Procedure

The procedure for a compatibility test is often outlined on a pesticide label. If it is not found on the product label, you can follow these steps, in order, to perform a compatibility test.

1. Add 1 pint of the carrier (water or liquid fertilizer) to each quart jar.
2. To the jar marked "with", add 1/4 teaspoon of compatibility agent. Shake gently for 5 to 10 seconds.
3. To each jar, add the appropriate amount of pesticide(s), (Table 1). Shake gently for 5 to 10 seconds.
4. Let the jars sit for 5 minutes, then look at them. See if there are any flakes, sludge, gels, or other precipitants. Also see if there is any separation or layering, or small oil particles in solution. If incompatibility occurs in "without" jar but not in "with" jar, use a compatibility agent. If incompatibility is observed in the "with" jar, this combination is not compatible and should not be used.
5. If separate layers are formed after sitting up to 30 minutes, but can be resuspended by shaking, using agitation in the sprayer will make commercial application possible. If there is layering, an emulsifiable concentrate will normally rise to the top. Wettable powders will either settle to the bottom or float on top, depending upon the density of the fertilizer carrier.

Some labels will warn of **incompatible** mixtures and indicate mixtures that are compatible. If you mix pesticides with different signal words, always use the required safety equipment and follow all other label restrictions on the label having the greatest restrictions. For example, if you mix DANGER-POISON pesticides with WARNING or CAUTION pesticides, treat the mixture as if it is a DANGER-POISON.

Phytotoxicity

Plant damage resulting from a pesticide application to a desirable plant is known as **phytotoxicity**. Most commonly, this is seen as burning of leaves, flowers, or growing tips. Yellowing, leaf distortions, abnormal growth, and stunting are other types of phytotoxicity. Phytotoxicity is a particular concern with crops where appearance is critical to marketing (vegetables, tree fruits, flowers, and ornamental plants).

Crop injury due to phytotoxicity can occur inadvertently from certain pesticide applications. This is most important when using **selective herbicides** that are selective only by having a higher margin of safety to the crop than to the weed. Phytotoxicity is also a common problem with many insecticides and fungicides used in production of sensitive greenhouse crops. Many corn rootworm insecticides are phytotoxic if placed in contact with the seed. Occasionally, phytotoxic problems can develop when two pesticides are applied to a crop simultaneously, resulting in damage that would not occur if each pesticide was used separately.

For the most part, phytotoxicity hazards are recognized during pesticide development. Warning statements are then placed on the pesticide label giving directions to avoid injury. But not all types of plants are tested for phytotoxicity, so there is still a chance for injury.

Some types of phytotoxicity are regularly associated with the use of certain pesticides or pesticide formulations on susceptible plants. However, phytotoxicity may only irregularly occur under certain conditions. Phytotoxicity problems can be avoided by:

Precautions to Follow to Minimize/Prevent Phytotoxicity Problems

- Read the label before applying to make sure the pesticide is registered for use on a particular plant species
- Use pesticides at the recommended label rate and use the appropriate application intervals as stated on the label
- Use care when mixing pesticides to avoid compatibility problems
- Test all pesticide mixtures on a small number of plants prior to using on the entire site
- Use proper adjuvants
- Apply pesticides under favorable environmental conditions
- Avoid applying pesticides to water stressed or nutrient stressed plants
- Frequently agitate the spray solution during an application
- Thoroughly clean application equipment between uses
- Never apply insecticides and fungicides with herbicide-contaminated equipment

Careful reading of labels can help to identify many plants that may be injured by the pesticide. These warnings may be in label sections discussing crop uses. Alternatively, phytotoxicity warnings may occur in separate sections of the label. These warnings may indicate that only certain varieties are susceptible to injury. Remember, not all plants are tested for phytotoxicity.

Wettable powder and other dry formulations tend to be safer to use on sensitive plants than emulsifiable concentrate liquids. This is because the various "other" ingredients found in some emulsifiable concentrates (e.g., xylene) can be harmful to plants.

Pesticide Classifications & Formulations

Spraying plants during extremely hot, sunny conditions can increase the risk of injury by many pesticides. During sunny conditions, leaf and flower temperatures may be considerably warmer than air, allowing injury at lower air temperatures. Much of the increased damage that occurs during warmer temperatures results from associated drought stress of the treated plants. Wilted or dry plants can be extremely sensitive to spray injury. Slow growing or diseased plants may also be injured more frequently than vigorously growing plants.

Cool temperatures increase the likelihood of plant injury from some pesticides. Plants may not develop thick protective layers when temperatures are moderate. Some pesticides such as oils remain on plant surfaces longer when temperatures are cool.

Pesticides should not be applied during periods which do not allow for drying. Plants sprayed when cool humid conditions exist will remain wet for long periods, allowing increased probability of injury. Wet **foliage** also increases injury by **aerosol** formulations. Slow drying is one reason why greenhouse grown plants are particularly sensitive to spray injury.

Excessive rates of pesticides can cause injury. Plants may also be injured by repeated applications made at short intervals.

Certain mixtures of two or more pesticides can cause plant injury. For example, the use of any sulfur based pesticide will cause increased injury if combined with oils. This is an example of **incompatibility** of some pesticide mixtures. Label directions often warn of incompatible mixtures and indicate mixtures that are known to be **compatible** in tank mixes. In addition, charts illustrating incompatible pesticide combinations are included in some publications produced by Extension, manufacturers and distributors.

Applicator Safety

Learning Objectives

After reviewing this chapter, you should be able to:

- Describe the concepts of hazard, exposure and toxicity and how they relate to one another in the risk formula.
- List what toxicity information pesticide labels and SDS provide.
- Identify toxicity categories based on signal word and symbol.
- Describe the difference in acute and chronic toxicity.
- Describe basic toxicity terms (acute, chronic, LD₅₀, LC₅₀, teratogenicity, etc.)
- List the four routes your body can be exposed to pesticides and name the route that should be of most concern to applicators.
- Identify why it is important to wear gloves when you handle pesticides.
- Describe how to protect yourself from pesticide exposure.
- Describe general signs and symptoms of pesticide exposure/poisoning, as well as pesticide irritation effects.
- Provide an overview of first aid procedures for pesticide exposure.
- Describe what to do if pesticides are involved in an accident.
- Identify factors that determine how well a coverall will protect.
- Identify when you should wear protective headgear.
- Define “protective eyewear”.
- Distinguish among respirators (dust/mist filtering, vapor-removing, and air-supplying).
- Explain the importance of proper respirator fit and describe how proper fit can be achieved.
- Describe heat stress, how to avoid it, and first aid procedures for treatment.
- Explain basic guidelines for cleaning and maintaining PPE.
- Describe how to tell if PPE is degraded and needs replaced.
- Explain how to wash pesticide contaminated clothing.
- Describe your legal responsibility for following PPE requirements in pesticide labeling.

Exposure, Toxicity, and Hazard

All pesticides are poisons designed to harm pest species. As such, they have associated hazards that you must recognize and respect. Among these hazards are human poisoning, destruction of beneficial insects that aid in pollination or pest control, injury to plants, damage to wildlife, and contamination of surface and groundwater supplies.

Toxicity is defined as the capacity of any substance to produce short-term (acute) or long-term (chronic) injury or death. Toxicity is a property of the product itself.

Exposure occurs when pesticides get onto or into the body through the skin, inhalation, swallowing, or eye contact. Product formulations differ greatly in the exposure risk they present. Exposure is often associated with many routine procedures involving pesticides, such as handling opened containers; mixing and loading; 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 dusts have settled.

Hazard is the possibility that injury will result from the use of a substance in a given formulation, quantity, or manner. Hazard depends on both the toxicity of the pesticide and the exposure you will receive in any situation. Hazard can be expressed as the equation of toxicity times exposure.

$$\text{Hazard} = \text{Toxicity} \times \text{Exposure}$$

A pesticide may be extremely toxic, but present little hazard to you or others when used:

- in a very dilute formulation,
- in a formulation that is not readily absorbed through the skin or readily inhaled,
- only occasionally and under conditions to which human beings are not exposed,
- only by experienced applicators that are properly equipped to handle the chemical safely.

Or, a chemical may be low in toxicity but present a hazard because it is:

- used in a concentrated form,
- rapidly absorbed or inhaled,
- used frequently by untrained or careless persons, who become exposed to it.

Types of Toxicity

Acute Toxicity

Exposure to **toxicants** in pesticides results in either acute toxicity or **chronic toxicity**.

Acute toxicity (immediate) is a result of an accidental or intentional single or repeated short term exposure to a substantial **dose** of toxicant. Before a pesticide can be registered, EPA requires the manufacturer to submit results of toxicity tests including acute oral, dermal, and **inhalation toxicity**; acute delayed neurotoxicity; eye and dermal irritation; dermal allergic sensitization (development of allergies to pesticides or chemicals used in formulation of pesticides); subchronic oral, dermal, and inhalation and neurotoxicity; chronic toxicity, **oncogenicity** (tumor growth, not necessarily cancer), **teratogenicity** (birth defects), reproductive effects (reduced sperm count, sterility, miscarriage), and **mutagenicity** (gene defects). **The signal word on the label reflects the acute toxicity of the pesticide.**

Most chemicals are toxic if a large enough amount is taken in a short period of time. Everyone ingests many **lethal** doses of chemicals, both natural and synthetic, over the course of a lifetime. For example, caffeine is lethal if the dose is equal to 190 **mg/kg** or about 100 cups of coffee. Potatoes contain the lethal chemical solanine, but you would have to eat 400 lbs of potatoes to ingest a lethal dose. People survive ingesting these poisons because they are taken

over a relatively long period of time. Human bodies are excellent filtering devices; they can excrete or metabolize many chemicals before the substance builds up to a lethal **dosage**. However, pesticides can contain large amounts of toxic chemicals. You can be exposed to lethal doses in a very short period of time.

EPA determines toxicity (including signal words) based on the terms LD₅₀ and LC₅₀, which are used to express the acute toxicity of a pesticide. LD means lethal dose. LD₅₀ is the dose that is lethal to 50% of a group of test animals. It is based on a single exposure to the chemical. The LD₅₀ value is standardized based on the weight of the test animals being expressed as the number of parts of pesticide per million parts of body weight (milligrams of pesticide per kilogram of body weight). **Low LD₅₀ numbers indicate more toxic pesticides than do high numbers**, since less chemical is required to produce toxic effects.

When assessing the toxicity of fumigant pesticides, a slightly modified system is used. The LC₅₀ (lethal concentration) value involves the testing of animals exposed to various concentrations of the pesticide in air. A similar system is used to test effects of chemicals to organisms in water.

These means of testing chemical toxicities are only approximate since they use species other than humans as indicators of toxicity. Because they are median values, they do not indicate the effects on more resistant or susceptible individuals. Despite these limitations, the LD₅₀ system can be used to assess the relative risks when comparing different chemicals. **Both LD₅₀ and LC₅₀ values are usually found on the product SDS.**

Toxicity Categories						
Signal Word & Symbol	Toxicity Concern	Contact Injury Concern	Toxicity Level & Class	Oral LD ₅₀ (mg/kg)	Dermal LD ₅₀ (mg/kg)	Inhalation LC ₅₀ (mg/l)
Danger-Poison/Peligro Skull & Crossbones	Very low dose could kill a person (a few drops to 1 tsp)	Signal word based on oral, dermal, or inhalation toxicity	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2
Danger/Peligro	Based on the corrosive or irritant properties of the produce	Corrosive-permanent or severe skin, eye, or respiratory damage	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2
Warning/Aviso	Small to medium dose could cause death, illness, or skin, eye, or respiratory damage (1 tsp to 1 oz)	Moderate skin, eye, or respiratory damage	Moderately toxic, Hazard Class II	50 to 500	200 to 2,000	0.2 to 2
Caution	Medium to large dose could case death, illness, or skin, eye, or respiratory damage (1 oz to 1 pt or 1 lb)	Mild skin, eye, or respiratory irritation	Slightly toxic, Hazard Class III	500 to 5,000	2,000 to 20,000	2 to 20
Caution or no signal word	Slight to none (over 1 pt or 1 lb)	Slight concern for skin, eye, or respiratory injury	Hazard Class IV	Greater than 5,000	Greater than 20,000	Greater than 20

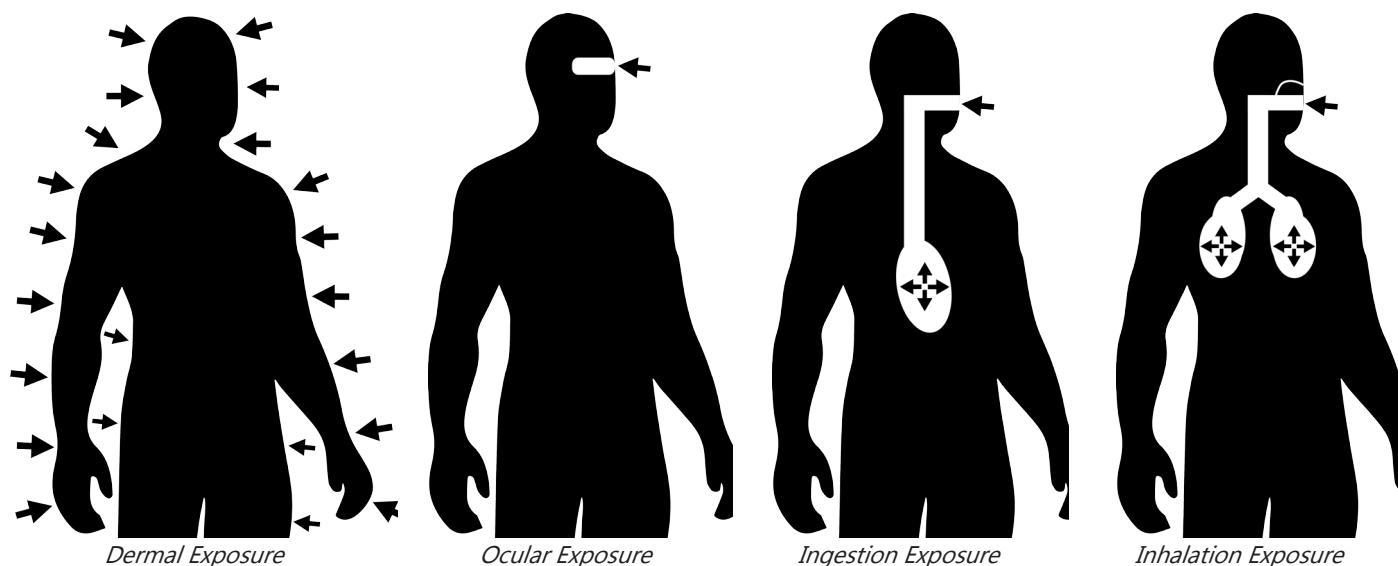
Chronic Toxicity

Chronic toxicity (long-term) is a result of a prolonged or frequently repeated exposure to lower toxicant doses. Chronic effects are not generally observable immediately following exposure and may take very long periods to produce signs and symptoms. Examples of **chronic poisoning** include: **carcinogenicity** (cancer), mutagenicity, teratogenicity, oncogenicity, reproductive disorders, liver damage, nerve damage (including cumulative effects on **cholinesterase** depression associated with organophosphate insecticides), and allergenic sensitization.

Problems with chronic toxicity, as with acute toxicity, are dose-related. Repeated exposures through carelessness and failure to follow label instructions can greatly increase chronic risks.

How Pesticides Enter the Body

A pesticide can enter the body through three common routes, absorption through the skin and eyes; mouth and stomach; and lungs. When working with pesticides, wash thoroughly before eating, drinking, smoking, or using the bathroom.



Absorption Through the Skin

Absorption through the skin, also referred to as **dermal exposure**, is the most common route of pesticide exposure for pesticide applicators. The degree of skin absorption depends upon the type and formulation of the pesticide as well as the part of the body the pesticide contacts. Areas around the genitals and thinner areas of skin such as the forehead absorb pesticides most rapidly. Any break in the skin also enhances pesticide entry. Skin areas of burns, dermatitis, and eczema also allow increased absorption.

Generally, dermal exposure can be caused by accidentally spilling or spraying a pesticide directly on your skin, wearing clothing on which a pesticide has been spilled, or by drift of pesticides applied under windy conditions. *A key to avoiding dermal exposure is to wear gloves, and then wash your hands with soap and water before eating, drinking, smoking, or using the bathroom.*

In general, wettable powders, dusts, and granular pesticides are not as readily absorbed through the skin and other body tissues as are liquid formulations such as emulsifiable concentrates.

Emulsifiable concentrates contain a high percentage of the active ingredient in a relatively small amount of solvent. Most solvents are readily absorbed through the skin.

Unless the label or regulations specify otherwise, after a liquid application, the minimum interval before people without PPE should be allowed on the application site is the length of time it takes for the application to dry.

Absorption Through the Eyes

Penetration through the eyes is also referred to as **ocular exposure**. Highly corrosive pesticides, such as lime sulfur, are extremely damaging when splashed into the eyes. Certain pesticide formulations containing corrosive solvents, such as xylene, may also damage eyes.

Absorption Through the Mouth and Stomach

Oral exposure results from the accidental ingestion of pesticide liquid or dust during mixing and application. Food and beverages should not be exposed to pesticides. To avoid the accidental drinking of a pesticide by children or other uninformed persons, always store pesticides in a secure area in their original labeled containers. Do not clean nozzles by blowing into them since this allows for oral exposure to pesticides.

Absorption Through the Lungs

Inhalation exposure is the most rapid and efficient route by which pesticides enter the body. Pesticides enter the lungs when powders, airborne droplets, or vapors are inhaled. Vapors and very fine particles represent the most serious potential for inhalation exposure. Inhalation exposure can be particularly serious because the thin lining of air sacs in the lungs are easily damaged and can allow rapid movement into the blood stream. Respirators protect against inhaling chemicals and should be worn when handling or applying highly toxic pesticides. The label will indicate if a respirator is necessary.

Signs and Symptoms of Pesticide Exposure

Anyone who may become exposed to pesticides should be aware of the signs and symptoms of pesticide poisoning. Prompt action during pesticide overexposure can prevent serious injury.

Signs of exposure, such as vomiting and sweating, are those results of exposure that can be noticed easily by others. *Symptoms* of exposure are feelings noticed only by the person who has been exposed, such as nausea or headache. Pesticide exposure symptoms may be confused with those of heat stress because they share similar symptoms. Do not waste time trying to decide what is causing the illness. Get medical help immediately.

Pesticides in the same chemical family tend to cause similar exposure signs and symptoms due to "common mechanisms of toxicity." Often these exposures produce a characteristic pattern that aids in diagnosis. For example, borates (insecticides) tend to be irritating to the skin, nose, and respiratory system, while some fungicides are irritants to the skin, eyes, and mucous membranes of the respiratory system. **Anticoagulant**-type rodenticides may cause bloody noses and bleeding gums. Symptoms associated with synthetic pyrethroid insecticides include nausea, dizziness, weakness, nervousness, eye, and skin irritation. 2,4-D and some other related herbicides (dicamba, MCPA, and MCPP) are irritating to the skin and mucous membranes, and they can also cause vomiting, headaches, diarrhea, and confusion. Organophosphate and

carbamate insecticides may cause all of the systemic symptoms in the table below that could ultimately result in respiratory failure and death.

Signs and Symptoms Associated with Organophosphate and Carbamate Exposure		
Mild exposure	<ul style="list-style-type: none"> • Fatigue • Headache • Dizziness • Excessive sweating 	<ul style="list-style-type: none"> • Salivation • Nausea, vomiting • Stomach cramps • Diarrhea
Moderate exposure	<ul style="list-style-type: none"> • Inability to walk • Weakness • Constriction of the eye pupil 	<ul style="list-style-type: none"> • Muscle twitching • Chest discomfort
Severe exposure	<ul style="list-style-type: none"> • Unconsciousness • Severe constriction of the eye pupil • Muscle twitching 	<ul style="list-style-type: none"> • Breathing difficulty • Secretions from mouth and nose • Death, if untreated

NOTE: There is extensive overlap of symptoms between stages of exposure. If poisoning is suspected, seek medical attention.

Recognizing Common Pesticide Poisonings

Pesticides in the same **chemical family** tend to cause similar kinds of poisoning. Often these poisonings produce a characteristic pattern that aids in diagnosis. Poisoning signs and symptoms related to several common groups of pesticides are described in the following pages.

Insecticides

- **Organophosphate** and **Carbamate** insecticides act on the **nervous system**, depressing levels of the chemical cholinesterase, an enzyme needed for the proper functioning of the nervous system. Signs and symptoms of poisoning are listed in the table below. **Antidotes** for organophosphate poisonings are atropine sulfate and pralidoxime. Atropine sulfate is the antidote for carbamate poisoning. Diazepam is advised for convulsions for both insecticides. Antidotes must be administered by medical personnel.

Signs and Symptoms Associated with Organophosphate and Carbamate Poisoning	
Mild poisoning	<ul style="list-style-type: none"> Fatigue Headache Dizziness Excessive sweating Salivation Nausea, vomiting Stomach cramps Diarrhea
Moderate poisoning	<ul style="list-style-type: none"> Inability to walk Weakness Chest discomfort Muscle twitching Constriction of the eye pupil

Severe poisoning	Unconsciousness Severe constriction of the eye pupil Muscle twitching Secretions from mouth and nose Breathing difficulty Death, if untreated
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NOTE: There is extensive overlap of symptoms between stages of poisoning. If poisoning symptoms are suspected seek medical attention.

- **Pyrethrins and Synthetic Pyrethroid** insecticides are mild nerve poisons. Some cause mild to severe eye and skin irritation. Some may cause mild to severe allergic reactions including dermatitis and **shock**. Respiratory symptoms include stuffy or running nose, throat irritation, and asthma. Symptoms of ingestion include irritability, tremors, and urinary incontinence.

Herbicides

- **Bipyridylum herbicides** are among the more hazardous pesticides since poisoning injuries can be irreversible. Overexposure may cause injury to the skin, nails, eye, and irritation to the nose and throat. Severe injury to the gastrointestinal tract may occur if swallowed. Kidney damage may appear and severe lung damage (up to 14 days later) may lead to death. There is no specific antidote and administration of oxygen accelerates damage to the lungs.
- **Phenoxy** herbicides most often cause skin irritation or a local burning sensation when inhaled. Dizziness or chest pain may result from prolonged inhalation. When large quantities of the pesticide are absorbed, muscle twitching, muscle tenderness, and muscle stiffness may occur. Ingestion results in vomiting and abdominal pain.
- **Chloroacetamide** herbicides result in systemic poisoning only from high dosages. Skin irritation or sensitization may occur. Nausea and abdominal distress may occur following ingestion.
- **Triazine** herbicides cause skin irritation. Ingestion produces nausea and vomiting. Kidney, liver, and nervous system damage have been reported in test animals following high dosages.

Fungicides

- **Dithiocarbamate** fungicides are known as irritants and sensitizers. **Acute poisoning** from these products is rare. Toxicity is due to the inhibition of liver enzymes. Sensitization is characterized by itching and redness of the skin. Respiratory exposure may produce congestion, hoarseness, and cough.

Other Pesticides

- **Fumigant** pesticides can be extremely hazardous to apply. Phosphine (released by the exposure of aluminum phosphide to water) damages the cells lining the air sacs in the lungs. Fluid accumulation in the lungs following injury is a major cause of death from fumigant exposure. Liver and kidney damage are associated with exposure to many

fumigant pesticides. Signs and symptoms of fumigant poisoning often resemble those associated with drunkenness (alcohol poisoning). These include poor coordination, slurring of speech, confusion, and sleepiness.

- **Anticoagulant rodenticides** of coumarin and indandione types both depress the clotting ability of the blood. In addition, the indandiones cause heart, lung, and nervous system damage in test animals. Hemorrhage is expected following massive, intentional poisonings. Vitamin K is an antidote.

Cholinesterase Inhibition

Cholinesterase inhibitors, such as organophosphates and carbamates, act on the nervous system, depressing levels of the chemical cholinesterase, an enzyme needed for the proper functioning of the nervous system. The blood cholinesterase test measures the effect of exposure to organophosphate and carbamate insecticides. Cholinesterase levels can vary considerably between individuals so a baseline must be established for each person. If you are using organophosphate or carbamate insecticides, cholinesterase tests can be periodically taken and results compared with your previously established baseline level. The purpose of routine or emergency cholinesterase monitoring is to enable a physician to recognize the occurrence of excessive exposure to organophosphate and carbamate insecticides. A significant reduction in your body's cholinesterase level indicates exposure to an organophosphate or carbamate insecticide.

First Aid Procedures

Unfortunately, pesticide exposures and poisonings do occur. Handlers or applicators who load and apply pesticides are at greater risk for pesticide exposure. Excess pesticide exposure may also occur during handling of treated produce, during accidents, or when safety precautions are not adequately followed.

Immediate and appropriate action or first aid may be necessary to prevent serious injury to a victim of pesticide poisoning. The situation can be a life-or-death matter. The product label should be one of the first sources of information in a pesticide exposure emergency, in addition to calling the Rocky Mountain Poison and Drug Center (1-800-222-1222) and 911. First aid is only the "first response" and is not a substitute for professional medical help.

In the event of a pesticide poisoning, the most important piece of information is the product label. Read the directions in the "Statement of Practical Treatment" on the label. These instructions will inform the physician or veterinarian of the proper treatment for poisoning, including antidotes used to counteract the poisoning. Unless a physician has stated that an antidote is needed, it should not be administered. Some antidotes such as atropine can be poisonous if misused.

First Aid Kit

A well-stocked first aid kit will contain some of the supplies needed for treating pesticide exposure. The label and SDS provide information on what supplies you should have in a first aid kit. Always check the label of products you use and be sure you have any additional items in your first aid kit.

Contents of First Aid Kit

- Gloves - a pair of clean, waterproof gloves to prevent skin contamination of person administering first aid
- Soap or **detergent** - to wash pesticide off skin
- Rubbing alcohol - for cleaning skin
- Clean drinking cup
- Eye wash bottle - for washing eyes
- Nail brush - for cleaning under fingernails
- Paper towels - to wipe up splashes or small spills
- Plastic face mask - for use during mouth-to-mouth resuscitation to avoid direct contact with patient's mouth if contaminated with pesticide
- Clean plastic bottle
- Antidote - any antidote indicated on the label
- **Activated charcoal** - to absorb pesticide in the stomach. Activated charcoal should only be given to the patient upon instruction from a medical person or doctor
- Telephone information - Rocky Mountain Poison and Drug Center (1-800-222-1222)
- Fresh water - must be available for drinking if pesticide is swallowed or for washing skin or eyes following exposure. Running water or a portable container with at least 10 gallons of water must be present at all mixing, loading, and application sites

General First Aid for Pesticide Poisoning

Every situation requiring first aid is different. The following are *guidelines* on what to do in a medical emergency involving pesticides:

1. Protect yourself from exposure (wear gloves, respirator, etc., as required on the label).
2. Prevent additional pesticide exposure. Move the victim from the area of contamination and remove any contaminated clothing.
3. Check if the victim is breathing. If breathing has stopped or is very weak, clear the airway and begin **artificial respiration**. Continue until the victim is breathing normally or until medical help arrives. When doing mouth-to-mouth resuscitation, use a plastic face mask to protect yourself from poison. First aid and CPR courses will teach the correct methods of artificial respiration.
4. Call the Rocky Mountain Poison and Drug Center at 1-800-222-1222. If the person is unconscious, convulsing, or having problems breathing call 911 and obtain medical help as fast as possible.
5. Tell the medical personnel the pesticide trade name, active ingredient, and EPA registration number found on the pesticide label. Also tell medical personnel when the victim was poisoned, the type of exposure, and poisoning symptoms.
6. Carefully follow all the instructions from the medical personnel.
7. Keep the patient at rest, warm and comfortable. Continue first aid treatment. Do not leave the patient alone. Arrange transportation to the emergency room of the nearest hospital. Bring the pesticide label to assist in treatment.

First Aid for Specific Types Of Poisoning Exposure

Pesticides on Skin

If you get a pesticide on your skin, remove the pesticide as quickly as possible. Remove all contaminated clothing. Prompt washing with cool water may prevent poisoning even when the spill is very large. Do not forget your hair and fingernails. Most emulsifiable concentrates, **emulsions**, wettable powders, and suspensions are easy to remove with plain water. However,

you should remove as much of the wettable powder as possible by brushing it off because water may activate the compound. Solutions of pesticides in solvents are harder to remove without soap or a detergent.

Inhalation of Pesticides

If the victim is suffering from pesticide inhalation, he/she should be carried immediately to fresh air. When the poisoning occurs in an enclosed space, such as a fumigated storage, do NOT go in without an air-supplied respirator. Failure to do this may result in poisoning of persons involved in rescue. Loosen all tight clothing on the victim and keep him/her as quiet as possible. Apply artificial respiration if breathing has stopped or is irregular. If the patient is convulsing, watch his/her breathing and protect him/her from falling and injuring themselves. Keep his/her chin up to keep the air passage free. Prevent the victim from chilling by wrapping in blankets, but do not overheat.

Ingested Pesticides

When pesticide ingestion (oral exposure) has occurred, a decision has to be made whether or not to attempt to induce vomiting. The pesticide label will include instructions if vomiting is suggested. NEVER induce vomiting if the victim is unconscious or convulsing. NEVER induce vomiting unless the pesticide label or medical personnel instruct you to. Read the label instructions and call the Rocky Mountain Poison and Drug Center at 1-800-222-1222 and get the victim to a doctor or hospital as soon as possible.

Ingested pesticides should be diluted or absorbed as quickly as possible. If the patient is conscious, administer water or, preferably, milk. Activated charcoal is very effective in absorbing many poisons and can be mixed as a thick soup with water.

When corrosive poisons (strong acid or alkali) or petroleum products (kerosene, emulsified pesticides, oil, etc.) are involved in the exposure or poisoning, first aid decisions are complex. Highly corrosive materials severely burn the mouth, throat, and esophagus and will cause additional injury when being vomited. These poisons should be treated by attempting to **neutralize** the poison by giving baking soda or milk of magnesia to the victim.

Pesticides in Eye(s)

Damage from pesticide exposure to eyes (ocular) can be very serious when corrosive pesticides are involved. If a person gets pesticides in the eye the following are suggestions for first aid:

- Wash eye quickly but gently.
- Use an eyewash dispenser, if available. Otherwise, hold eyelid(s) open and wash with a gentle drip of clean running water positioned so that it flows across the eye rather than directly into the eye.
- Position the affected eye below the uncontaminated eye, to prevent the rinse water from contaminating the good eye.
- Rinse eye for 15 minutes or more. *If you wear contact lens, first leave your contacts in while you rinse your eyes with water for five minutes, then remove contact lenses and continue to rinse eyes for 10 additional minutes.*
- Do not use chemicals or drugs in the rinse water, which could increase the injury.

Accidents

If a vehicle carrying pesticides crashes, personnel should not panic. They will not be able to think clearly or help the driver unless they are calm. There are four steps to dealing with a crash:

1. If the driver is not seriously injured, he/she should be helped out of the wreckage and moved to a safe distance. If the driver is seriously injured or unconscious, he/she should not be moved but should be checked for strangling, choking, or bleeding. If there is severe bleeding, a pad of clean cloth should be held firmly over the cut with the part of the body that is cut raised, if possible. One person should watch the victim while another goes to the nearest telephone and calls for an ambulance and emergency assistance.
2. If the wreckage is on fire, the fire should be put out with a fire extinguisher unless it is dangerous to do so.
3. The driver's clothing should be checked to see if it has been splashed with pesticides. If it has, and if the victim is not seriously injured, clothing should be removed and the person should be helped to the nearest water and washed several times with soap.
4. If the driver is not seriously injured, he/she should be taken to a doctor. The doctor will need to know that the victim has been exposed to pesticides and the name(s) of the pesticide(s) involved. If the driver is seriously injured, someone should be assigned to go with the ambulance to the hospital or doctor's office to make certain they know what pesticide(s) the victim has been exposed to. Take a copy of the label along, if possible.

Preventing Injury to Applicators

Avoiding Exposure to Pesticides

When you take a break, wash your gloves on the outside, remove your gloves, and wash your hands and face thoroughly. Then you can safely chew gum, eat, drink, smoke, or use the restroom. Avoid getting pesticide on yourself when you use the restroom. The skin in the genital area has been shown to absorb more pesticides than any other skin area. Be careful not to contaminate yourself from pesticides that may be on the outside of your clothing.

Be aware of other situations where you might be exposed to pesticides on the job. Protect yourself not only during mixing, loading, and application, but also during spill cleanup, repairing or maintaining equipment, and when transporting, storing, or disposing of pesticide containers that are open or have pesticides on their outer surface. Use PPE when necessary to keep pesticides from getting on your skin and in your mouth, eyes, or lungs.

Personal Protective Equipment (PPE)

PPE refers to clothing and devices worn to protect the body from contact with pesticides or pesticide residues. Because pesticides can enter your body through various routes, it is essential that you wear a protective barrier of clothing. No safety recommendations cover all situations; use common sense and remember that you need to take more protective precautions as the hazard increases. Protective equipment must be used *before* pesticide exposure. Always read the pesticide label for directions about the use of protective clothing or devices. Label requirements for PPE are the minimum required; however, an applicator may choose to wear more PPE than the label requires. Additional PPE information can be found on

the SDS, but NEVER use it in place of the label PPE requirements. You can use the SDS PPE listings as additions to your label-required PPE.

PPE offers various levels of protection, depending on the type of resistant material used. Some items of PPE simply act as filters by keeping dry or spray material off the skin. Others offer better protection against water-based products. Some offer protection from chemicals (solvent and/or active ingredient) that make up a concentrated pesticide product.

Gloves, boots, aprons, suits, and hoods come in a variety of chemical-resistant materials. Generally, the best choices of materials are plastics, such as polyvinyl chloride (PVC); rubber, such as butyl, nitrile, neoprene, or viton rubber; or non-woven fabrics coated with plastic or another barrier material such as Tyvek. Barrier laminate materials are resistant to most pesticides, but many pesticide handlers consider them uncomfortable to wear and difficult to use while performing many tasks.

Always read the pesticide labeling to see if it states which materials are resistant to the pesticide product. In some instances, a pesticide label's PPE description lists a code letter (A-H) for glove selection. It was developed by EPA to help the user select suitable PPE. The EPA Chemical Resistance Category Selection Chart For Gloves is below. The chart's codes letters are based on the solvents used in a pesticide product, NOT the pesticide's active ingredient. By referring to this chart, a pesticide handler can determine how long a given material can be expected to withstand chemical exposure by a given solvent. For example, if a certain pesticide label states that the user should choose gloves based on the guidelines in Category E, then select only gloves made from barrier laminate, nitrile rubber, neoprene rubber, or viton. These materials would be expected to give protection for one or more days. Polyethylene gloves and natural and butyl rubber gloves would be expected to provide protection for only 10 minutes or less.

EPA Chemical Resistance Category Selection Chart for Gloves								
Type of Resistant Material	Selection Category on Label							
	A*	B	C	D	E	F	G	H
Barrier laminate	high	high	high	high	high	high	high	high
Butyl rubber ≥14 mils	high	high	high	high	slight	high	slight	slight
Nitrile rubber ≥14 mils	high	slight	high	mod	high	high	slight	slight
Neoprene rubber** ≥14 mils	high	slight	high	mod	high	mod	slight	slight
Natural rubber ≥14 mils	high		mod		slight	slight		
Polyethylene	high	slight	mod					
Polyvinyl chloride (PVC) ≥14 mils	high	slight	high		mod	slight		
Viton ≥14 mils	high	slight	high	slight	high	high	high	high
High:	Highly chemically resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticide at breaks.							
Moderate:	Moderately chemically resistant. Clean or replace PPE within an hour or two of contact.							
Slight:	Slightly chemically resistant. Clean or replace PPE within 10 minutes of contact.							
Blackened cells:	Do not wear this type of material as PPE when contact is possible.							
* Dry & water-based formulations								
** Includes natural rubber blends and laminates								

PPE reduces exposure but does not necessarily eliminate it. If pesticide exposure has already occurred, protective equipment will not prevent injury from this previous exposure. Rather, the body may actually increase uptake of pesticides that are absorbed by skin if covered by clothing or protective equipment.

Hand and Foot Protection

The most common means of pesticide exposure is by hand contamination. The single most important PPE for most pesticide applications is a pair of gloves. Unlined liquid-proof gloves (rubber/rubberized or neoprene) used when handling pesticides or contaminated equipment greatly reduce pesticide exposure risks. Gloves should be the last piece of PPE to be removed.

Do NOT use gloves with fabric linings because fabrics are difficult to clean once contaminated. Never use cotton or leather gloves when handling liquid formulations or when working with pesticides diluted with water. Such gloves absorb pesticides and do not provide adequate protection. Leather gloves with a plastic glove as a liner may be worn in situations when the commodity being worked with would cause damage to rubber gloves. But then, never use these gloves for any other purpose. Gloves used to handle pesticides should never be used for other purposes. *Always consult the pesticide label for requirements on protective clothing.*

Be careful not to allow pesticides to run down your sleeves into your gloves. For jobs in which your arms are mostly lowered, place sleeves outside the gloves. Use gloves that go up over your wrist and at least halfway to your elbow. For jobs in which your arms are mostly raised, leave your gloves outside your sleeves. Fold the cuff of your gloves up 1-2 inches to catch the pesticide before it runs down your arm. For many jobs, you will be working some of the time with your arms raised and some of the time with them lowered. In these cases, close the glove cuff tightly outside the sleeve and put heavy-duty tape or an elastic band around the end of the glove where it meets the sleeve.

Wear lightweight rubber boots when handling or spraying pesticides. Avoid use of leather or canvas foot gear since these absorb and retain pesticides. Make sure that pants are not tucked into boots since that may funnel pesticide sprays or chemicals into the boot.

Body Protection

Most labels will require a minimum of a long sleeved shirt and pants. Some will require a coverall-type garment of closely woven fabric. The tighter the fabric weave, the more protection you will receive. Chemical-resistant coveralls can be made from a variety of chemical-resistant materials. The type of seam used in the coverall also determines how protective it is. Serged seams protect the wearer because the seams of the chemical-resistant coverall are sewed together with interlocking pieces of thread. Bound seams protect the wearer even more than serged seams because a fabric binding encloses the two seams coming together, which is then stitched - offering an extra layer of protection. Choose the appropriate coverall for the job; coveralls may or may not have elastic wrist and ankle cuffs and a hood.

Use a disposable suit designed for protection when handling hazardous materials. Fabric with a soil-repellent finish offers more protection than untreated fabrics. Soil-repellent finishes can be applied by clothing manufacturers or by consumers. An inner layer as a second layer of clothing, made with smooth t-shirt fabric, can further help to exclude pesticides from

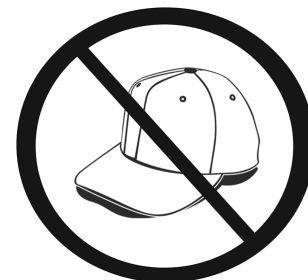
contacting the skin. Uncoated nonwoven fabrics are convenient for use with pesticides in dust, granule, or powder form. They DO NOT protect the wearer against spills, sprays, or mists and are not recommended for use with liquid pesticides. “Tyvek®” is an example of an uncoated nonwoven fabric. Coated versions of Tyvek® suits that are more chemical-resistant are also available. Wettable powder formulations of pesticides are more effectively excluded by protective clothing than are liquid formulations.

When handling pesticide concentrates or highly toxic pesticides, also wear a rubber apron for added protection. An apron protects you from splashes, spills, and billowing dust, and it protects your coveralls or other clothing. The product label may require that you wear a chemical-resistant apron when mixing or loading a pesticide, or cleaning application equipment.

Remember, if heat stress isn’t a concern, you can always wear more PPE than what the label requires. For example, if a label only requires a long-sleeve shirt and long pants, you could add gloves and protective eyewear for additional protection on the routes of exposure. When making applications, chaps and/or a protective spray vest (especially useful when wearing a backpack sprayer) also offer additional protection.

Head and Neck Protection

When applying pesticides, use a wide-brimmed, waterproof hat to protect your neck as well as your eyes, mouth, and face. Your hat should not have a cloth or leather sweatband, since these materials retain pesticide residues and are difficult to clean. Hoods of coveralls (if chemical-resistant) can act as head protection, however if the hood of coveralls isn’t being used, it should be tucked in so it does not collect spray material in the event of an accident. Hard hats can also act as head protection. *Baseball caps are a poor choice of headgear because they absorb pesticides and then applicators expose themselves every time they wear the contaminated cap. If wearing a cap, dedicate it only for applications and wash when you wash your gloves!*



Do not wear baseball caps when applying pesticides

Eye Protection

Wearing shielded safety glasses, goggles, or **face shields** when mixing, handling, or applying any pesticide is a good practice. Even if the label doesn’t specifically require eye protection, it’s good practice to wear eye protection because most pesticides are at least moderately to highly irritating and/or can cause temporary or permanent blindness. Safety glasses should be shielded on all sides (this is why sunglasses don’t count as “protective eyewear”). Goggles may be worn separately or in combination with a respirator. Half face **cartridge** respirators do not provide eye protection and face shields do not provide respiratory protection. Routine maintenance should include daily cleaning of all eye protection equipment by washing with warm soapy water after use.

Respiratory Protection

Lung tissues easily absorb pesticides and inhalation risks can be high when handling toxic pesticides that produce volatile **fumes**. Follow instructions on the pesticide label regarding respiratory protective devices. You must wear respiratory protection when the label requires it.

A respirator is a safety device that covers at least the mouth and nose. Two major groups of respirators are used when dealing with pesticides: *air-supplying* and *air-purifying respirators*. (A summary of the respirator types is found in the table on the following page)

Air-supplying respirators

Air-supplying respirators provide clean, uncontaminated air from a source other than ambient air. They are used in low-oxygen environments or where users may be exposed to toxic particulate, gases or vapors and are generally more expensive than the air-purifying type. Often their big and bulky size puts a strain on the worker.

Self-contained breathing apparatus (SCBA). As its name implies, the user carries the source of their breathable air supply with them, typically in a tank on their back. Like the SAR, air is supplied to an "inlet" facepiece, such as a full-face respirator. (NIOSH #TC-13F)

Supplied-air respirator (SAR). The supplied-air respirator supplies breathable air from a stationary source, such as a compressor, separated from the user. Breathable air is supplied to the facepiece of the respirator through a flexible hose. (NIOSH #TC-19C)

Air-purifying respirators

Air-purifying respirators use physical and chemical filters to trap and remove contaminants as they pass through the respirator with the air being breathed by the wearer. The pesticide label provides guidance on which type of filters or cartridges to use. Adequate oxygen must be present in the air that is being breathed because an air-purifying respirator does not supply oxygen; it only filters the air that is being breathed.

Air-purifying devices may be powered or non-powered. The powered air-purifying respirators use a blower to move the contaminated air through a purifying filter and can be used with either a tight-fitting facepiece or a loose-fitting hood. (NIOSH #TC-21C or #TC-23C) The non-powered devices can be either half-mask or full-face devices that place a filtration unit between your breathing passage and the contaminated air source. (NIOSH #TC-84A or #TC-14G)

Filters and cartridges are chemical specific or dust/mist specific. A combination chemical and dust/mist cartridge is also available. When handling some pesticides, an organic (OV) cartridge is required. The components of a typical non-powered air-purifying respirator are a snap-on retainer, a prefilter, an air-purifying cartridge, a facepiece that contains an exhalation valve, and a harness.

The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for testing and certifying respirators used in conjunction with pesticides (and other non-mining respiratory protection). Approval numbers beginning with the letters TC are assigned to all respirators reviewed by the agency and must be on the box containing the facepiece. Pesticide product labels often specify the type of respirator required by listing the TC number.

organic vapor cartridge - contains activated charcoal to adsorb carbon-containing gases.

particulate filter - traps solids or liquid particles like dust or mist.

In addition, filters are classified on the basis of oil degradation resistance (oils may be from the pesticide formulation and/or the adjuvants used) and filter efficiency. The classification levels for oil degradation resistance are "N" - not oil resistant; "R" - oil resistant; and "P" - oil proof or



strongly resistant to oil. The filter efficiency for each classification level represents the efficiency of that filter in removing airborne particles. The designations may be 95, 99, or 100%, which indicates the percentage of particulates that are filtered. High efficiency (HE) filters are only used on powered air-purifying respirators.

TC-84A particulate respirator with N95 filter

Respirator Types		
Respirator Type	TC code designation under NIOSH	Description
Non-powered air-purifying respirators		
Non-powered particulate respirators (N, P, and R filters)	TC-84A	Air purifying respirators that are available as either half-face or face-piece (face piece are disposable as cartridges are NOT replaceable). Half-face respirators have an external dust/mist filter and may be combined with organic vapor cartridges and N-type particulate filters.
Gas mask with canister	TC-14G	Uses a canister that is specific for the chemical contaminant (such as organic vapors)
Powered air-purifying respirators		
Powered particulate respirators only (100 series filters)	TC-21C	Use a fan to help draw air through an air-purifying cartridge and may reduce respiratory stress and heat stress, but they have a high start-up cost. The cartridge must be appropriate for the particular contaminant (organic vapor, phosphine, etc.)
Chemical cartridge respirators	TC-23C	Absorb harmful vapors or gases. The cartridge must be appropriate for the particular contaminant (organic vapor, phosphine, etc.)
Air-supplying respirators		
Supplied-air respirators (SAR)	TC-19C	Use long hoses to supply air to a full facemask. Some but not all have a blower or compressor.
Self-contained breathing apparatus (SCBA)	TC-13F	Uses a compressed-air tank and provides complete respiratory protection against toxic gases in an oxygen-deficient environment.

The product formulation, toxicity, and type of application influence the type of respirator needed. Manufacturers use criteria approved by EPA to assign PPE respirator requirements on labels. When a pesticide label requires a respirator, wear a NIOSH-approved respirator when using that particular pesticide.

Label Examples Based on the EPA Respiratory Protection Criteria	
EPA Criteria	Label Statement for Respiratory Protection
Solid pesticides with Toxicity Class II, III, or IV	Use a NIOSH-approved respirator with any N, R, P, or 100 series prefilter.
Liquid pesticides, Toxicity Class I	Use a NIOSH-approved respirator with an organic vapor (OV) cartridge or canister with any N, R, P, or 100 series prefilter.
Gas applied in enclosed area	Use an air-supplying respirator with NIOSH TC-19C, or use a self-contained breathing apparatus with NIOSH TC-13F.

If the label recommends a NIOSH/MSHA (Mine Safety and Health Administration) respirator, this reference is to an older classification system. In this system, TC-21C is designated as a mist/dust mask respirators. Under the new NIOSH system this designation is now TC-84A. Be sure to use an appropriate respirator for the pesticides you are using.

Using Respirators Properly

To work properly and provide the necessary protection, a respirator must fit your face tightly. Most respirator styles will not protect you if you have a beard or other facial hair because it does not allow the respirator to seal properly against your face.

The **fit test** is a method used to select the right size respirator for the user. Do a fit test prior to initial use or a respirator, whenever a different respirator facepiece is used, and at least annually thereafter. An additional fit test is required whenever there are changes in the user's physical condition that could affect respirator fit (e.g., facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight).

The fit test used depends on the type of respirator and the relative workplace exposure level. There are both qualitative and quantitative fit tests. In a qualitative fit test, a worker is exposed to an atmosphere containing an odorant, irritant, or taste agent and then asked to breathe normally, breathe deeply, move the head from side to side and up and down, grimace, bend at the waist, and talk. The wearer reports any noticeable odor or taste agent that leaks into the mask.

In a quantitative fit test, a particle-counting instrument is used to measure respirator fit by comparing the dust concentration in the surrounding air with the dust concentration inside the respirator. The ratio of these concentrations is called the fit factor. A modified respirator facepiece equipped with a sample port is used to collect air from inside the respirator. Having the sampler attached, the wearer is asked to make the same movements as described for the qualitative fit test. During these movements, the particle-counting device measures any leakages.

Every time you put a respirator on, conduct a **fit check** to be sure the respirator forms a complete seal around your face and air cannot leak in or out along the edges. To perform the fit check, the respirator must be put on properly. Make sure you have obtained a firm and comfortable fit against the face at all points.

There are two types of fit checks: the positive pressure check and the negative pressure check. "Positive pressure" refers to the user breathing out and exerting positive pressure on the respirator, and "negative pressure" refers to the user breathing in and exerting negative pressure on the respirator. The fit check must be performed before using a respirator in the field and may also be performed periodically while in the field.

Respirator Maintenance

The proper maintenance and care of respirators should include regular inspections for defects, cleaning and disinfecting, repair, and proper storage. Check the tightness of connections and condition of the face piece, head bands, valves, connecting tube, and canister. Respiratory devices should be cleaned after each day's use. Prior to cleaning, remove the filter, cartridge, or canister. The face piece and breathing tube should be washed with warm soapy water, rinsed in fresh water to remove all traces of soap, and if necessary, sanitized. Respirators should be air dried in a clean area, away from pesticide storage areas or other possible pesticide sources.

If you are wearing a respirator that filters out dusts and mists, change the filter or respirator when you find it is getting hard to breathe through the respirator, or if your filter gets torn,

damaged, or wet. Do not use a filtering facepiece dust/mist mask if the pesticide soaks the mask. In this case, use a full-face respirator.

If you are wearing a respirator that removes vapors and gases, change the cartridge or canister immediately if you taste or smell pesticide, or if the pesticide burns or stings your nose or throat. Follow the manufacturer's instructions on when to replace filters, cartridges, and canisters even if you do not notice a problem. If there are no instructions, then replace filters, cartridges, and canisters at the end of each 8 hour work period. To ensure the integrity of the seal between the facemask and the cartridge, make sure the manufacturer of the cartridge is also the manufacturer of the facemask.

Remember...
if WPS applies to your establishment, you must comply with the requirements for medical evaluation, annual fit-testing and annual training if the label *requires* a respirator. Refer to the WPS 'How to Comply' manual for more information.

Heat Stress

Heat stress is the buildup in the body of heat generated by muscles during work and by a warm or hot work environment. When the body's internal temperature rises, it attempts to get rid of excess heat by increasing blood flow to the skin surface and releasing sweat onto the skin surface. As a result, the body reduces blood flow to the brain which reduces mental alertness and comprehension. It also reduces blood flow to active muscles, which results in fatigue and loss of strength, as well as increases sweating, causing slipperiness.

When the body reacts to heat stress and increases sweating and blood flow, dehydration becomes a serious concern. Signs and symptoms of dehydration include fatigue, dizziness, foggy thinking, muscle cramps, dry skin, decreased urination, dark-colored urine, mood swings, chills, back or joint aches, constipation, headache, and sugar cravings. The treatment for dehydration is to drink lots of water (NOT caffeinated drinks). Sports beverages that replace electrolytes can also help with treatment.

If left untreated, heat stress and dehydration can lead to:

- Heat rash - skin irritation from excessive sweating
- Heat cramps - muscle pains or spasms
- Heat exhaustion - the condition that precedes heatstroke
- Heatstroke - a life-threatening illness

Environmental factors can also contribute to heat stress, such as air temperature, humidity, whether or not the sun is out, and air circulation. In addition, factors such as workload (type of work, level of physical activity, amount of time working), clothing (breathability, color, type of PPE being worn), and personal factors (age, weight, fitness, use of drugs and alcohol, prior heat-related illness history) can influence heat stress.

To prevent heat stress, eat properly, sleep well, and drink lots of water starting the day before you're going to make the application. Schedule the application for a cooler part of the day. Applying in the morning, before the day's peak temperature, is common for applicators. Make sure to schedule breaks during the application. Choose the proper clothing and PPE for the application - if heat stress is a concern, do not "over PPE".

Cleaning & Maintaining PPE

Carefully check coveralls, gloves, and other clothing for holes, tears, leaks, changes in color, cracks, or other damage each time you prepare to put them on. IMMEDIATELY stop wearing an item if you spot a tear, hole or other damage. When you finish an activity where you are handling pesticides or are exposed to them, remove PPE right away. When using PPE:

- Be careful where you walk or sit. Pesticide residue on clothing can rub off.
- Wash gloves and footwear with soap and water.
- Starting at the shoulders, roll protective coverall down the body.
- Put coveralls in a separate plastic bag or container.
- Remove footwear.
- Rewash gloves.
- Wash hands with soap and water.
- Shower as soon as possible.

Washing Pesticide Contaminated Clothing

Decide if Clothing Should be Kept

Never wear contaminated clothing or footwear. If liquid concentrates of pesticides are spilled on clothing, other than rubber or neoprene gloves and unlined boots, the clothing should be disposed of according to label directions. Washing will not remove enough of the pesticide to make the clothing safe to wear. Wear rubber gloves and a rubber apron when handling these highly contaminated clothes.

Before Washing

Keep items worn while applying pesticides separate from other clothing before washing. Empty pesticide granules from cuffs and pockets outdoors where the granules can be easily swept up and disposed of properly. If left in clothing, granules will dissolve in the wash water and may not be removed from the clothing in the remainder of the wash cycle.

Pre-rinse or presoak the clothing with hot water in a bucket or tub or by agitating in a washer and spinning out before the regular wash. Pre-rinsing followed by a regular wash has been found to be much more effective than washing alone in removing pesticides, especially wettable powders.

Washing

Wash clothing daily when regularly applying pesticides. Washing clothing at work is the best option. Do not use a laundromat to wash contaminated clothing. If you must wash clothes at home, store and wash them separately from uncontaminated laundry.

The longer the clothing is stored, the harder it is to remove pesticide residues. Wash a small number of items at a time, using the highest water level and longest wash time available on the washing



Using gloves to load washer
Photo by Flickr user "UNL PSEP"

machine. Use hot water for washing, cool water (86°F) removes much less pesticide than does warm (120°F) or hot (140°F) water.

If possible, use a conventional washer to launder clothing, rather than a high efficiency (HE) washer. Conventional washers use more water than HE washers, and water helps to dilute pesticide residues. Heavy duty liquid detergents should be used to remove pesticides from clothing. Where hard water conditions occur, use higher rates of detergent to get adequate cleaning action. Pre-wash cleaners can help clean pesticides from clothing. Ammonia and bleach do not effectively improve the cleaning of pesticides from clothing.

Do not dry clean pesticide contaminated clothing. Dry cleaning solutions are routinely recycled. Inclusion of pesticide contaminated clothing will result in contamination of other clothes.

After Washing

After washing clothes contaminated by pesticides, run the empty washing machine through a complete cycle using detergent. Line dry pesticide contaminated clothing outside whenever possible. Outdoor line drying is the best drying option, because UV rays from the sun help break down any remaining residues. If you can't line dry outside, line dry inside if possible. If line drying is not an option, use a dryer on its high heat setting

Additional Resources

- ASPCA Animal Poison Control Center. Phone: 1-888-426-4435. <http://www.aspca.org>. *A resource for any animal poison-related emergency. A fee may apply.*
- National Institute for Occupational Safety and Health (NIOSH), Technical Information and Assistance, 1-800-35-NIOSH (1-800-356-4674), <http://www.cdc.gov/niosh>. *Information on respirator selection and recommendations.*
- National Pesticide Information Center (NPIC), Phone: 1-800-858-7378 (limited hours) <http://npic.orst.edu/>. *Call and or visit the website for information about pesticides and pesticide related topics.*
- Recognition and Management of Pesticide Poisonings. 2013. J. Reigart and J. Roberts, 6th edition. EPA #735K13001. <https://www.epa.gov/pesticide-worker-safety/recognition-and-management-pesticide-poisonings>. *Provides information on the health hazards of pesticides and recommendations for the management of pesticide poisonings and injuries.*
- Rocky Mountain Poison and Drug Center. Phone: 1-800-222-1222. www.rmpdc.org. *Provides emergency poison and drug information.*
- Pesticide Educational Resources Collaborative. *In addition to information on Worker Protection Standard compliance and training materials, the site also has information on Respirator Protections.* <http://www.pesticideresources.org/wps/respirators.html>
- Colorado Environmental Pesticide Education Program (CEPEP) at Colorado State University, <http://cepep.agsci.colostate.edu/>. *Pesticide education resources including factsheets, handbooks, and training guides. Information on WPS including 'How to Comply' and training resources.*

Application Equipment and Calibration

Learning Objectives

After reviewing this chapter, you should be able to:

- List and describe the different methods of application.
- Identify and describe the different types of "safety systems".
- Describe the types of application equipment used for outdoor, indoor/outdoor or indoor pesticide applications.
- Identify the common application equipment components and their function.
- Explain why it is important to apply the correct amount of pesticide.
- Define calibration of pesticide spray equipment.
- Explain why it is important to calibrate equipment.
- List the steps to use when preparing to calibrate a sprayer.
- List the four factors that must be known to calibrate a sprayer.
- Describe how to calibrate broadcast boom sprayer using the Ounce Calibration Method.
- Describe how to calibrate a backpack sprayer and hand-gun application equipment.
- List the three ways of changing application spray rates and how each adjustment affects spray application rate.

Methods of Application

Applicators should choose their application method so they can get the best result while using the least amount of pesticide. The method chosen should always be consistent with the label directions and it will influence the type of application equipment that you will use. Application methods include:

- **Band application:** applying a pesticide in bands or parallel strips (such as between crop rows) rather than uniformly across the entire area or field
- **Basal application:** directing pesticides to the lower portions (base) of the plant or tree
- **Broadcast application:** uniform application across the entire area or field
- **Crack and crevice application:** placing small amounts of pesticide into cracks and crevices in buildings where pests may hide or enter the structure
- **Directed-spray application:** directing application to target the pest and avoid non-target plants and animals
- **Foliar application:** to the leafy portions of the plants
- **Rope-wick application:** pesticide is released onto a device that wipes over weeds taller than the crop or wiped onto individual weeds in an ornamental bed
- **Soil application:** pesticide applied directly to the soil
- **Soil incorporation:** tillage, irrigation, or sometimes rainfall, is used to move the pesticide into soil.
- **Soil injection:** pesticide is applied under pressure below the soil surface

- **Space treatment:** pesticide is applied to an enclosed area
- **Spot treatment:** pesticide is applied to small, distinct areas
- **Tree injection:** pesticide is implanted under the bark of trees where it moves throughout the tree via the water conducting system

Safety systems

Closed mixing/loading systems, enclosed application systems and pesticide containment systems should be considered for pesticide applicators who handle large amounts of pesticides or who are handling pesticides that are very hazardous to humans or the environment.

Closed mixing/loading systems: Closed systems prevent the pesticides from coming into contact with the handler or other persons during mixing and loading. Some pesticides may require the use of this type of system if it is very hazardous. These systems typically include systems of hoses or pipes with pumps, mini-bulk containers with hoses/pumps, or certain types of product packaging (such as water soluble packets (WSP) while still intact).

Enclosed cabs: An enclosed cab (such as a tractor cab, cockpit, or truck cab) surrounds the occupant and may prevent exposure to the pesticides being applied as long as windows, doors or hatches are kept closed during the pesticide application. Enclosed cabs do not replace PPE although some labels may indicate that PPE may be reduced while in the enclosed cab. Remember that the outside surfaces of the application equipment and cab are contaminated. Be sure to wear the PPE indicated on the label when getting in/out of the cab and performing maintenance or repairs.

Pesticide containment pads: **Containment pads** are designed to contain spills, leaks, overflow, and waste water for reuse by the applicator, or disposal by a commercial waste management collector. They are useful, and may be required, if you mix and load pesticides or clean equipment at the same location. The Colorado Agricultural Chemicals and Groundwater Protection Act calls for mandatory fertilizer and pesticide containment if certain thresholds are exceeded. To determine if this affects you, or for more information, refer to the "Best Management Practices for Pesticide and Fertilizer Storage and Handling" under Additional Resources.

ENGINEERING CONTROL STATEMENTS:

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.

IMPORTANT: When reduced PPE is worn because a closed system is being used, handlers must be provided all PPE specified above for "Applicators and other handlers" and have such PPE immediately available for use in an emergency, such as a spill or equipment break-down.

Selecting Application Equipment

Pesticide application equipment is as important to your pest control program as the selection of the pesticide itself. By proper selection and use of application equipment, you can often prevent problems such as drift, nonuniform coverage, failure of a pesticide to reach the target, and exposure to **nontarget** areas.

Choose equipment that is designed for the type of chemical being applied and appropriate for the size and type of application. Equipment will not deliver the proper amount of pesticide to the target site if it is not working correctly. Check the equipment carefully to be sure that all components are clean and in good working order before beginning to calibrate. Pay particular attention to the parts that regulate the amount of pesticide being released, such as nozzles and hopper openings. If they become clogged, not enough pesticide will be released. If they become worn, too much pesticide will be released. Pesticide application equipment is as important to your pest control program as the selection of the pesticide itself. By proper selection and use of application equipment, you can often prevent problems such as drift, nonuniform coverage, failure of a pesticide to reach the target, and exposure to nontarget areas. The following information is a general description of various types of spray equipment.

Outdoor Application Equipment

Low Pressure Sprayers

Low pressure sprayers are usually mounted on tractors, trucks, or trailers and are designed to be driven over fields or large areas, applying the pesticides in **swaths**. Low pressure sprayers generally use low to moderate volumes at a system pressure of 10-80 psi. These sprayers are used on golf courses, roadsides and rights-of-way, farms, and ranches. Low pressure sprayers use roller or centrifugal pumps; handguns can be attached for spot treatments and weed patches.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Relatively inexpensive, lightweight, and adapted to many uses • Can cover large areas rapidly • Usually low volume so one tankful will cover large area 	<ul style="list-style-type: none"> • Cannot adequately penetrate and cover dense foliage because of low pressure and gallonage rate • WPs often settle out due to bypass systems and return flow agitation

High Pressure Sprayers

High pressure sprayers are often called **hydraulic sprayers**. They operate with dilute sprays and pressures can be regulated up to several hundred pounds. They are used for spraying trees, livestock, orchards, farm buildings, and unwanted vegetation where dense foliage requires good penetration.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Useful for many different pest control jobs (i.e., brush control, livestock, orchards, etc.) • Piston pumps and mechanical agitators resist wear by gritty or abrasive materials and keep WPs well mixed in the tank • Trees, shrubs, or other targets in hard to reach places can be treated with a long hose and handgun 	<ul style="list-style-type: none"> • Tend to be heavy and costly • Typically use large amounts of water and require frequent filling

Air Blast Sprayers

Air blast sprayers are primarily designed to carry pesticide and water mixtures under pressure from a pump through a series of nozzles into a blast of air that blows into the tree by means of a fan. High volume fans supply the air which is directed to one or both sides of the sprayer as it moves between rows of trees. Nozzles operating at low, moderate or high pressure deliver the

spray droplets into the high velocity air stream. The high speed air aids in breaking up larger droplets and transporting these smaller droplets for thorough coverage. A mechanical agitator is used to agitate the spray in the tank.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Small amount of water covers a large area • Little operating time lost in refilling • Adapted to applying sprays over a large area 	<ul style="list-style-type: none"> • Must operate under calm conditions • Larger models may not be able to treat hard to get to areas

Low Volume Air Sprayers (Mist Blowers)

Mist blowers use high air velocities and somewhat lower water volumes than conventional air blast sprayers. This type of sprayer uses a metering device which may or may not be a conventional nozzle that operates at low pressures and depends on the high speed air for liquid breakup. Coverage involves wetting foliage to the drip point. See the manufacturer's manual for calibration.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Saves time and labor because less water is handled than with conventional air blast sprayers 	<ul style="list-style-type: none"> • Calibration is more critical • Coverage with very low volumes on some crops may be less satisfactory than normal volumes delivered by conventional air blast sprayers

Ultra-Low Volume Sprayers (ULV)

Ultra-low volume spraying is accomplished by applying the chemical concentrated directly without the use of water or any other liquid carrier. Many ULV ground sprayers use a fan which delivers high speed air to help break up and transport the spray droplets. See the manufacturer's manual for calibration.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Saves time and labor due to the elimination of water use 	<ul style="list-style-type: none"> • Increased risk to applicator from handling and spraying concentrated pesticide

Granular Applicators

Granular equipment is designed to apply coarse, dry particles that are uniform in size. They are very commonly used to apply fertilizer, to broadcast granular herbicides in crops, and occasionally to apply insecticides in crops (European corn borer whorl treatments). Most granular spreaders use whirling disks or multiple gravity feed outlets.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Equipment is light, relatively simple, and does not involve use of water or other diluents • Heavy particles used in granule applications reduce drift and allow precise placement and penetration through canopy 	<ul style="list-style-type: none"> • Granules do not stick to foliage and thus are rarely used for control of plant pathogens or insects on aboveground parts of plants

Miscellaneous Soil Injection Systems

Soil injection systems are used to apply systemic insecticides to trees. Soil injection systems are calibrated by determining the flow rate (gal/min) of the equipment as applications are made to introduce a set amount of the spray mixture into each injection hole.

Advantages	Disadvantages
<ul style="list-style-type: none"> Minimal drift Some soil systemic insecticides can give more persistent control than foliar treatments 	<ul style="list-style-type: none"> High amounts of insecticide needed per tree Difficult to treat root zone of trees growing at property edges or along roadsides Watering after application is required

Indoor/Outdoor Application Equipment

Hand Sprayers

Spray equipment with single nozzles or sometimes short booms with a small number of nozzles are used for spot treatments and pesticide applications to limited areas where large equipment is impractical. Hand sprayers are commonly used in spraying patches of weeds.

Advantages	Disadvantages
<ul style="list-style-type: none"> Economical, uncomplicated, lightweight, and adaptable to many different situations Ideal for spot treatments 	<ul style="list-style-type: none"> Not practical for large areas Some formulations, notably WPs, can be difficult to use due to settling and clogging

Several types of hand application equipment are available, classified according to the pressure source:

- Intermittent discharge sprayers spray material with each stroke of the pump. Small hand misters are an example of this type.
- Aerosol sprayers** use a pressurized can or small tank with a discharge valve. These can be used to apply pesticides at a fairly steady rate until the can nears depletion.
- Backpack sprayers** are carried on the back and usually have a capacity of 2.5-5 gal. A hand operated piston or diaphragm pump provides the pressure.
- Compressed air sprayers** have the pressure supplied by a CO₂ cylinder, combined with a pressure regulator, or a hand pump to provide compressed air. Compressed air sprayers typically are designed to hold 1-5 gal and the pressure source allows a uniform flow rate of the pesticide.

Chemigation

Chemigation is the process whereby agricultural chemicals are applied to land or crops in water through a **closed irrigation system**. Many pesticides may be applied this way and the label will contain specific instructions on this use as part of label directions. Many other pesticides specifically prohibit such use on labels. In Colorado, a chemigation permit is required for each irrigation system utilizing chemigation. Applications are available from the CDA, Division of Plant Industry at 303-869-9038.

Advantages	Disadvantages
<ul style="list-style-type: none"> Low cost of application Provides thorough crop coverage 	<ul style="list-style-type: none"> Can contaminate wells Provides uneven coverage if equipment is not functioning properly or is poorly designed

Indoor Application Equipment

Dusters

Dusters blow fine particles of pesticide dusts onto the target surface. They may be very simply constructed. Dusters are used mostly by home and truck gardeners for individual spot treatment of plants. See the manufacturer's manual for calibration.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Lightweight, relatively cheap, and fast acting • Do not require water 	<ul style="list-style-type: none"> • Highly visible, drift easily, and are difficult to control • Less desirable for most crops or larger outdoor jobs

Aerosol Generators (Foggers)

Aerosol generators and **foggers** break certain pesticide formulations into very small, fine droplets (aerosols). One droplet cannot be seen, but when large numbers of droplets are formed they can be seen as **fog** or smoke. In some foggers, heat is used to break up the pesticide. These are called **thermal** aerosol generators. Other foggers break the pesticide into very fine particles using rapidly whirling disks, air blast break up, or extremely fine nozzles. Foggers are usually used to fill an area such as a greenhouse or warehouse with a pesticidal fog. Insects and other pests in the treated area will be controlled when they come in contact with the aerosol fog. See the manufacturer's manual for calibration.

Advantages	Disadvantages
<ul style="list-style-type: none"> • Fine droplets can penetrate tiny cracks, crevices, and heavy vegetation to reach pests in hard to reach places 	<ul style="list-style-type: none"> • Little if any residual control • Fine droplets may drift • Inhalation hazard • Most require special pesticide formulations

Common Sprayer Components.

Sprayer components that are common to most sprayers are listed in the table below.

Sprayer Components	
Name	Description
Tank	<ul style="list-style-type: none"> -Holds the liquid pesticide being applied -Tank materials that resist chemical corrosion include aluminum, fiberglass, plastic, carbon steel, and stainless steel -Should have large openings for easy filling and cleaning, a large drain and sump, a gauge or markings to show the liquid level, and a cutoff valve for stopping liquid pesticide flow temporarily while other parts are being serviced
Pump	<ul style="list-style-type: none"> -Must be large enough to supply the volume needed for the nozzles and to the hydraulic agitator (if necessary), and to maintain the desired pressure -Available in brass, aluminum, cast iron, and corrosion-resistant alloys -Pump parts should be able to resist corrosion and abrasion if abrasive materials, such as wettable powders, are used -Select gaskets, plunger caps, and impellers resistant to swelling and chemical breakdown caused by some liquid pesticides -Various kinds, including roller, centrifugal (for low pressure sprayers) and diaphragm and piston pumps (for high pressure sprayers)
Agitator	<ul style="list-style-type: none"> -Mix the components of the spray mixture uniformly and, for some formulations such as WPs, keep the material in suspension -Agitation should create a rippling or rolling action on the water surface

Sprayer Components	
Name	Description
Strainers	<ul style="list-style-type: none"> -Also called screens -Used to prevent rust flakes and other foreign material from plugging nozzles or other working parts of the sprayer -Installed as necessary on the filler openings, on the suction or supply line to the pump, or as a part of the nozzle
Hose	<ul style="list-style-type: none"> -Keep from kinking or being rubbed -Rinse often, inside and out, to prolong hose life -Size should be matched to flow volume and pressure requirements -Store out of the sun and replace at the first sign of surface deterioration -Frequently inspect all hoses and fittings for leaks
Pressure Gauge	<ul style="list-style-type: none"> -Monitor spray system by telling you how much pressure is being used -Use a gauge designed for the pressure range of the sprayer
Pressure Regulator	<ul style="list-style-type: none"> -Control the pressure and, indirectly, the quantity of spray material delivered by the nozzles -Protect pump seals, hoses, and other sprayer parts from damage due to excessive pressure. -Pressure relief (bypass) valves maintain a constant pressure despite changes in engine speed and must be sized to handle desired flow rates and pressures
Control Valves	<ul style="list-style-type: none"> -Include valves other than the pressure regulator that regulate the flow of liquid -Place cutoff valves that stop all flow in any section of the spraying system within easy reach of the sprayer operator -Check periodically to ensure proper performance
Nozzles	<ul style="list-style-type: none"> -Atomizing devices that meter liquid, breaks liquid into droplets, & forms a pattern of distribution -4 major parts: nozzle body, strainer, cap, & tip or orifice plate. May include a separate spinner plate. -Should be able to resist corrosion & abrasion if abrasive materials, such as wettable powders, are used -Patterns come in three basic types: solid stream, fan, and cone; some special purpose nozzle tips or devices produce special patterns, including raindrop, flooding, and wide-angle fan or cone-shaped -Replace when their flow rate is greater than or equal to 10% above or below the manufacturer's spec.

Calibration of Application Equipment

Calibration is simply the adjustment of a machine to make it deliver the right amount of spray or dry material to a given area. There are several methods of calibration, but all involve determining how much spray is being delivered and then adjusting settings as needed to give the correct rate. To be sure that the equipment is releasing the right amount of pesticide, take time to calibrate it carefully and correctly. Accurate calibration is important because you need to know you are correctly applying the label rate (and not going over the rate - a violation). Applying the correct rate helps prevent pest resistance and can help to save money.

Equipment that must be calibrated includes mechanical dusters, granular **spreaders, hand sprayers, backpacks, booms**, handguns, **high-pressure**, air blast, and fumigant applicators. Although the many types of application equipment differ in the details of their operation, if the basic principles of calibration are understood, they can be applied in any situation. Study the manufacturer's instructions carefully as they explain exactly how to adjust the equipment. The instructions often contain information on the appropriate rate of travel, the range of most

efficient pump pressures, approximate settings for achieving various delivery rates, and types of nozzles that can be used.

A sprayer should be calibrated at the beginning of the season and, recalibrated if nozzles are changed, or the applicator runs out of material or has excess material left after an application. This will help detect changes caused by wear, corrosion, and aging. Sprayer calibration results are valid only for the speed, nozzles, pressure, and spray width (swath) used during the calibration process. Significant changes in any one of these factors will require another calibration check.

Select nozzles which will deliver the calculated volume at the pressure that provides the droplet size required by the label.

The most accurate way to calibrate is to fill the tank with water only. Spray one acre, and then measure the number of gallons of water necessary to refill the tank. This is the application rate in gallons per acre (GPA). Do not apply a mixed pesticide spray while calibrating a sprayer. For small sprayers spray an area of 100 or 1,000 sq ft.

When a smaller acreage is used for calibration, it is advisable to measure the amount of water in qts or pts, especially when a calibrated measuring can is not available.

Preparing for Calibration

Your equipment should be in good working order before you try to calibrate it. Use the following guidelines to prepare your equipment for calibration.

1. Be sure your sprayer nozzle tips are the right kind for the spray application. Consult the nozzle manufacturer's recommendations and the pesticide label. Nozzles are perhaps the most important tool that an applicator can use to modify their application. Nozzle type and size should be selected based on:
 - The best spray pattern for the application (nozzle type).
 - The size of droplets needed for adequate coverage (nozzle size).
 - Operating pressure of the application equipment.
 - Concerns about drift potential.

There are several manufacturers that distribute catalogs to help you choose the appropriate nozzle. Many manufacturers provide selection guides on their website, and Smartphone apps for download to help you choose the appropriate nozzle for your application.

Nozzle charts, found in nozzle manuals available from dealers, show the application rate at certain pressures and ground speeds. The application rate can be changed by varying the pressure and the ground speed, but there are limits to how much you can alter the rate. The most effective way to make large changes in application rates is to select a different nozzle!

While most applicators are familiar with the manufacturer charts based on flow rates to select nozzles, labels may require you to choose nozzles based on droplet size. Applicators may see label statements that refer to using a nozzle to produce a specific

droplet size to improve coverage and avoid drift. Nozzle manufacturers are now including drop size charts in their catalogs and on their websites.

2. Clean and inspect all nozzles, nozzle tips, and screens. Use a soft brush, not wire or any hard material. Add water to the spray tank and visually check nozzle output during sprayer operation. Discard and replace nozzle tips that produce distorted spray patterns.
3. Check all the pressure gauges. If a gauge is rusty, or seems to be inaccurate, replace it.
4. Check the spray volume output of all nozzles. Replace any nozzle tips that differ from the average output of all nozzles by more than 5%. Replace any nozzle that varies by 10% (+/-) from the manufacturer flow rate. An Innoquest SpotOn™ Sprayer Calibrator measures nozzle flow rate and can help make this step very quick and simple.

Sprayer calibration results are valid only for the speed, nozzles, pressure, and spray width (nozzle spacing) used during the calibration process. Significant changes in any one of these factors will require another calibration check. Also keep in mind that equipment under heavy use can wear quickly so it's a good idea to calibrate your sprayer frequently during periods of heavy use.

Changing Spray Application Rates

Spray application rates can be adjusted by changing nozzles, pressure settings, and speed. For large adjustments of spray rates, changing nozzles should be the first consideration. Use nozzle manufacturers' catalogs for help with selecting an appropriate tip for the application. The label below summarizes how to increase or decrease spray application rates:

Changing Spray Rates	
To Increase the Spray Rate:	To Decrease the Spray Rate:
Use a lower speed	Use a higher speed
Increase pressure	Decrease pressure
Use larger nozzles	Use smaller nozzles

Changing Sprayer Speed

The spray application rate varies inversely with the sprayer's travel speed. Doubling the ground speed of a sprayer reduces the application rate by 1/2 if the nozzle pressure remains constant. For example, a sprayer applying 10 GPA at 12 mph would apply 20 GPA if the speed were reduced to 6 mph.

Effects of Sprayer Speed on Delivery Rate (Constant Pressure)	
Sprayer Speed (mph)	Sprayer Delivery Rate (GPA)
1	40.0
2	20.0
3	13.3
4	10.0

Flotation sprayers usually have a metering system that maintains a constant application rate when operating over a range of travel speeds. All metering systems now in use vary the nozzle pressure to compensate for changes in travel speed and keep the application rate constant. All

the systems will work over a wide range of travel speeds, but the spray nozzle recommended pressure range limits the range of speeds at which precise application can be obtained. For uniform application, the travel speed should be held as constant as possible, even when using controlled metering systems.

Changing Pressure

The flow rate through a nozzle varies with the size of the tip and the nozzle pressure. Installing a nozzle tip with a larger orifice or increasing the pressure will increase the flow rate. The flow rate varies in proportion to the square root of the pressure. Doubling the pressure will not double the nozzle flow rate. **To double the flow rate, you must increase the pressure four times.** For example, to double the flow rate of a nozzle from two gal per min (GPM) at 10 psi to four GPM, the pressure must be increased to 40 psi (10 x 4).

Effects of Sprayer Pressure on Delivery Rate (Speed Constant)	
Sprayer Pressure (psi)	Sprayer Delivery Rate (GPA)
10	10
40	20
160	40

Pressure changes cannot be used to make major adjustments in application rate. To obtain a uniform spray pattern and minimize drift, maintain the operating pressure within the recommended range for each nozzle. The pressure can be changed, however, to correct for the minor variations in flow rate that result from nozzle wear.

Changing Nozzle Size

Nozzle manufacturers' catalogs provide tables and charts showing application rates (gallons per acre or gpa), given a nozzle's flow rate (gallons per minute or gpm) delivered at various pressures (psi) and travel speeds (mph). **To increase spray application rates, choose a nozzle with a larger size orifice. To decrease the application rate, choose a nozzle with a smaller orifice.**

How to Calibrate Boom Sprayers

There are many different methods to calibrate a boom sprayer. Only two will be presented here but additional methods are found in the Appendix. The Appendix also contains information on how to calibrate other types of sprayers and application equipment such as air blast sprayers and granular applicators. Regardless of the method used, sprayer calibration requires that the following information is available:

- Traveling speed of the sprayer
- Pressure settings
- Nozzle flow rate
- Nozzle spacing or spray width

Should any of the above factors change, the sprayer must be recalibrated.

Determining Ground Speed

Accurate calibration requires that the actual speed of the sprayer must be determined under field conditions. Because of wheel slippage and rough surface conditions, the actual speed is often lower than the tachometer or speedometer readings. To accurately determine travel speed, mark off 220 feet. Drive the distance in the field at the throttle setting, pressure setting, using a sprayer loaded at least 1/2 to 2/3 full. Also engage any incorporation equipment (disks, planter, etc) that will be used during spraying. Record the time. If the surface and soil conditions of the field are variable, repeat the measurement in several areas.

Use the following formula for calculating speed:

MPH =	150
	time (seconds) to travel 220 feet

Check Nozzle Discharge and Uniformity

It's important to check the condition of the nozzles prior to calibrating. While stationary, start the sprayer using the pressure the will be used during the application and observe the spray pattern from each nozzle. Large variations in spray pattern can be observed visually but for more accurate pattern check, use a digital flow meter to determine flow rate (gpm) from each nozzle and a patternator. A patternator is a device used to visualize the nozzle pattern. Poor spray patterns are often due to worn nozzles, or clogged nozzles and strainers. Use a soft brush to clean nozzles and strainers and recheck the pattern.



Patternator showing good nozzle pattern.
Source: Innoquestinc.com



Patternator showing defective nozzle pattern.
Source: Innoquestinc.com

Note: Any calibration should be done using water only! As sprayer equipment may have residues that remain, even after cleaning, personal protective equipment should be worn (minimum of long sleeve shirt, long pants, shoes, socks and perhaps goggles or safety glasses).

Refill Calibration Method

Many growers use this method to calibrate their sprayer. It requires the applicator to determine the distance to spray one acre based on the sprayer boom width and then refill the sprayer to a reference point to determine how many gallons were applied.

The following steps are used:

1. Fill the sprayer with water and mark the reference point as this will be the point that the sprayer will be refilled to.
2. Measure the effective boom width (the width covered by spray at the ground level) and divide that number into 43,560 (square feet /acre) to determine the distance the sprayer must be driven to cover an acre. This is typically a very large number so it commonly reduced to a fraction of an acre (such as 1/10th).
3. Measure and mark the distance on the ground and spray the distance at a known, constant speed that will be used to spray the field.
4. Carefully measure the amount of water used to refill the tank to the original reference point. Repeat steps 3 and 4 two or three times to improve accuracy.
5. Multiply the number of gallons required to refill the tank to the reference point by the fraction of acre sprayed (such as 1/10th) to determine GPA at the speed and pressure used.

Example of Refill Calibration Method

- The sprayer has an effective boom width of 20 feet. 43,560 divided by 20 feet is 2178 feet to cover an acre. Drive 1/10th of that, or 218 feet.
- The sprayer required 2.5 gallons to refill. Since you only covered 1/10 of an acre (Step 2), multiply by 10 to determine the spray rate is 25 GPA.

The Ounce Calibration Method for Broadcast Boom Sprayers

Nozzle manufacturer manuals include tables to show spray volumes (GPA) for various nozzles operating at specific pressures and consistent ground speeds. Use this information to initially set up the sprayer and then use the Ounce Calibration Method to evaluate and fine-tune the sprayer for accurate application.

The method described on the next page to calibrate a boom sprayer is referred to as the ounce method, or 1/128th acre method because it is based on the fact that there are 128 ounces of liquid in 1 gallon and you will determine how long it takes to spray 1/128 of an acre per nozzle, then collect the liquid from a nozzle for that period of time. This method is quick, easy, and does not require a lot of calculations.

Materials required:

- Stopwatch
- containers to collect nozzle discharge
- container that measures ounces.
- tape measure
- marking flags

The ounces of liquid caught from one nozzle EQUALS the application rate in gallons per acre (GPA).

1. Fill the sprayer at least 1/2 to 2/3 full with clean water. Measure the distance between the nozzles and determine the distance to drive using the table below.

Nozzle Spacing (in.)	Travel Distance (ft.)	Nozzle Spacing (in.)	Travel Distance (ft.)
18	227	30	136
20	204	32	127
22	185	34	120
24	170	36	113
26	157	38	107
28	146	40	102

2. Measure out the distance in the field. Using your normal spray speed and pressure, determine the time it takes to travel the distance in seconds Repeat at least three times and average the results.
3. While the sprayer is stationary, run the sprayer at the same throttle setting and sprayer pressure, catching the output from each nozzle for the time determined in Step 2. Find the average output, in ounces, by adding individual nozzle outputs and dividing by number of nozzles. If any individual output is 10 percent higher or lower than the average output for all nozzles, clean the nozzle or replace, and repeat this step.
4. The final **average output in ounces = application rate in gallons per acre (GPA).**

Example of Ounce Calibration Method

1. The sprayer is set up with 20-inch nozzle spacing, so the chart indicates that a distance of 204 feet must be marked off.
2. The course was driven three times, recording the throttle and pressure settings. The average time was 31 seconds and pressure was 40 psi.
3. In a stationary position, the sprayer was brought to 40 psi and nozzle outputs collected for 31 seconds. The average nozzle output was 15 ounces. (Remember: any nozzle that is +/- 10% of the average should be replaced and the output remeasured to determine the average. In this example, any nozzle that measures less than 13.5 ounces or more than 16.5 ounces, should be replaced).
4. The final average output, 15 ounces = 15 gallons per acre (GPA)

Using Ounce Calibration Method for Band Spraying

While a broadcast application covers the entire acreage is sprayed, a band application sprays strips or only a portion of the field. However, the same method can be used to calibrate band sprayers. A band application only covers a portion of the field so the amount of area that is treated is reduced but the total acres sprayed with the same volume as a broadcast application will be greater.

After performing an ounce calibration on the sprayer, multiply the answer (broadcast spray volume or GPA) by the appropriate conversion factor in the table that follows to determine the band rate.

Conversion Factor to convert broadcast Gallons per Acre to band (gallons per treated area)				
Band width (in.)	Row spacing (inches)			
	20	30	36	40
8	2.5	3.8	4.5	5.0
10	2.0	3.0	3.6	4.0
11	1.8	2.7	3.3	3.6
12	1.6	2.5	3.0	3.3
13	1.5	2.3	2.8	3.1
14	1.4	2.1	2.6	2.9
15	1.3	2.0	2.4	2.7
16	1.2	1.9	2.3	2.5

Backpack or Hand-held Sprayer and Hand-gun Calibration

Backpack and hand-held sprayers consist of a tank to hold the spray mix, a pump to provide pressure, and a spray wand with one or more nozzles to deliver the spray solution in the desired spray pattern. Most backpack sprayers hold 4-6 gallons of spray mix, and hand-held sprayers usually hold 1-3 gallons. The small size, transportability, and ease of use make the sprayer a versatile tool. Backpack and hand-held sprayers are good for small acreages, spot-spraying, and hard to reach locations

A handheld spray gun operates off a truck-mounted pump and spray tank. Developing a consistent walking speed, arm motion, and uniform spray pattern are the keys to successful application with a hand-gun sprayer. An overlap of one-half swath width (sprayed band) is needed for uniform coverage of parallel passes.

Calibration procedure - practice on a paved surface using water until your coverage pattern is even.

1. Measure a calibration plot that is exactly 18.5 ft X 18.5 ft (128th of an acre).
2. Spray the plot uniformly with water, keeping the sprayer pressure constant. Note the number of seconds required.
3. Spray into a bucket for the same number of seconds, again keeping the sprayer pressure constant.
4. Measure the number of ounces of water in the bucket.
5. Number of ounces of water measured from the bucket is equal to the number of gallons per acre (GPA) the sprayer is delivering.

Adjusting Calibration Rates for Carriers Other than Water

If carriers other than water, such as fertilizers, will be used to make the spray solution, conversion factors must be used to adjust the rate. Multiply the observed rate (GPA) by the conversion factor to determine actual spray rate. The following table provides some of the common conversion factors.

Density of Solution (lb/gal)	Example	Conversion Factor
7.00		1.092
8.00		1.021
8.34	Water	1.00
9.00		0.963
10.00		0.913
10.65	28% nitrogen	0.885
11.00	7-27-7 fertilizer	0.871
11.06	32% nitrogen	0.868
11.40	10-34-0	0.855
11.50	12-0-0-26 fertilizer	0.852
11.60	11-37-0 fertilizer	0.848
12.00		0.834
14.00		0.772

Example of Rate Adjustment for 10-34-0 fertilizer:

The ounce method of calibration indicated that the sprayer is applying 15 GPA using water. If using 10-34-0 as the carrier, the rate must be adjusted by applying the GPA by 0.855.

$$15 \text{ GPA} \times 0.855 = 12.8 \text{ GPA adjusted rate.}$$

Use 12.8 GPA as your application rate to determine how many acres your sprayer can cover and to determine how much pesticide to add to the spray mix. For more information on how to determine that information, refer to the next chapter on Making Pesticide Applications.

Now that you know the basics of sprayer calibration, read the next chapter to learn how to determine the amount of acres your spray tank will cover and how to calculate how much pesticide to add to the spray tank based on the label rate.

Additional Resources

Pesticide Environmental Stewardship Website. <https://pesticidestewardship.org/calibration/> *Information on how to calibrate many types of pesticide application equipment..*

Sprayers 101 Website. <http://sprayers101.com/> *Information on best practices in the safe, efficient operation of agricultural sprayers. Includes information on calibration, cleaning and maintenance of many different types of sprayers.*

Making Pesticide Applications

Learning Objectives

After reviewing this chapter, you should be able to:

- Calculate the treatment area based on a rectangular, triangular, or circular field. Remember that fields which are not uniformly shaped may be broken down into geometric shapes below.
- Calculate how much your tank can hold and how much you can treat.
- Calculate how much pesticide to add to the tank.
- Describe the steps needed to make an application.
- Describe precautions and safety practices for mixing and loading pesticides.
- List basic procedures for applying pesticides.
- Describe how to clean the different types of spray equipment.
- Explain ways to dispose of pesticides, include excess pesticide products, rinsate from cleaning, leftover spray solution, as well as cancelled and banned pesticides.

Information Needed to Make an Application

Once pests been identified and it has been determined that a pesticide application is necessary to manage the problem, the applicator's job begins. There are several steps to preparing for an application which will be covered in this chapter. An applicator must have the following information to make an application:

1. What is the area (square feet, acres, etc.) that you will be treating?
2. Decide what equipment you should use. Some labels recommend specific equipment to be used.
3. Determine the application rate of your application equipment (gallons per acre, etc.). You figure this with calibration. In general, you need the following information:
 - Nozzle flow rate
 - Traveling speed
 - Operating pressure
4. What is the total amount of solution your spray tank can hold and how much area can you treat (square feet, acres, etc.)?
5. How much of the pesticide/carrier to add to the tank? Read the label to determine the proper application rate.

STEP 1. What is the area (acres or square feet) that will be treated?

*****Remember to verify acreage with the use of maps
so you mix only what you need for the job!*****

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. Determining the size of irregular shaped areas is more difficult. One method is to determine

the general shape of the area, then impose known shapes (circles, triangles, rectangles, and squares) over segments of the area where appropriate. The area of each shape is determined and added to the rest to obtain the total area to be treated

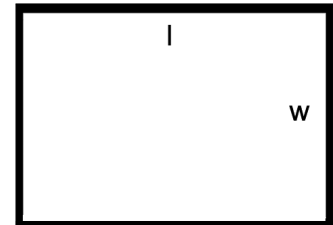
Rectangular Areas

$$\text{Area} = \text{length} \times \text{width}$$

You want to apply a pesticide to an area that measures 1,320 ft by 120 ft. What is the area in sq ft and in acres?

$$\text{Area in sq ft} = 1,320 \text{ ft} \times 120 \text{ ft} = 158,400 \text{ sq ft}$$

$$\text{Area in acres} = \frac{158,400 \text{ sq ft}}{43,560 \text{ sq ft}} = 3.6 \text{ A}$$



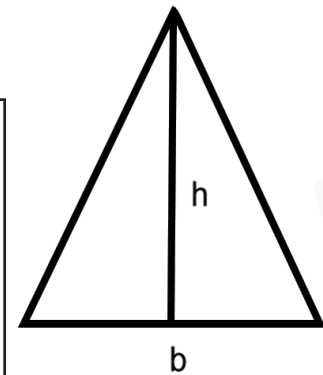
Triangular Areas

$$\text{Area} = \frac{\text{base} \times \text{height}}{2}$$

You are applying a pesticide to a triangular area that has a base of 325 ft and a height of 150 ft. What is the area?

$$\text{Area in sq ft} = \frac{325 \text{ ft} \times 150 \text{ ft}}{2} = 24,375 \text{ sq ft}$$

$$\text{Area in acres} = \frac{24,375 \text{ sq ft}}{43,560 \text{ sq ft/A}} = 0.6 \text{ A}$$



Circular Areas

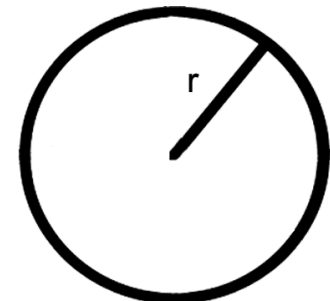
$$\text{Area} = \pi r^2$$

If you have a circular area that has a 90 ft diameter and the radius (r) is 45 ft, what is the area?

Note: 3.14 (π) is a constant. Radius (r) is 1/2 diameter.

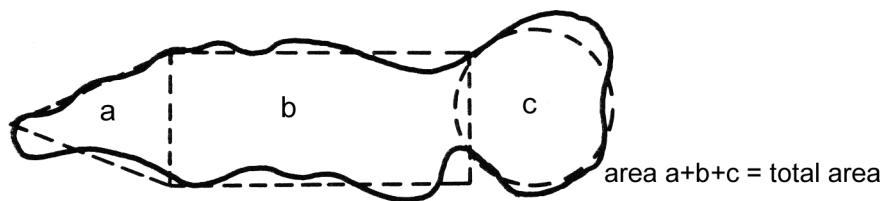
$$\text{Area in sq ft} = 3.14 \times 45^2 = 6,358.5 \text{ sq ft}$$

$$\text{Area in acres} = \frac{6,358.5 \text{ sq ft}}{43,560 \text{ sq ft/A}} = 0.15 \text{ A}$$



Irregular-Shaped Areas

If the area has an irregular shape, try to visually break the area into regular shapes and measure the areas accordingly.



Linear Feet

To calculate how many linear feet are in a perimeter, measure the length of all sides of the perimeter (structure, fence line, etc.) and add all of the sides together.

You want to apply a pesticide to a rectangular area that measures 150 ft by 120 ft. How many linear feet is the perimeter?

$$\text{Area in linear ft} = 150 + 150 + 120 + 120 = 540 \text{ linear feet}$$

STEP 2: Decide what equipment you should use.

Decide what equipment is necessary for your task. For effective pest control, application equipment should be chosen to optimize the pesticide reaching the target site at the proper rate. Check to make sure that you have all the equipment you need and that is clean and in good operating condition. Make sure that anyone who will use the equipment knows how to operate it safely and correctly. Do not allow children, livestock, pets, or unauthorized people to touch the equipment. If they become injured or poisoned, you are responsible!

STEP 3. Determine the application rate of your application equipment (gallons/acre, etc.) through calibration.

Calibration determines how much pesticide you are applying to an area and if equipment is operating properly. If using equipment that includes nozzles, you must calibrate your sprayer after choosing your nozzle type and size for your application. Calibration information and instructions are covered in Chapter Seven of this guide.

STEP 4 (Part 1). How much area can you treat (square feet, acres, etc.) per spray tank?

To find the number of acres you can treat per spray tank, divide the tank capacity by the GPA.

$$\# \text{ of acres per tanks} = \frac{\text{Tank Capacity}}{\text{Gallons per acre (GPA)}}$$

Example: If your tank can hold 200 gallons and the sprayer is calibrated to apply 5 GPA, how many acres can you cover with a full tank?

$$x = \frac{200 \text{ gal}}{5 \text{ gallons per acre}} \quad x = 40 \text{ acres}$$

STEP 4 (Part 2). If you are spraying less area than the tank will cover, how much carrier do you need in the tank?

$$\text{GPA} \times \text{\# of acres to be treated} = \text{Gallons needed in tank}$$

Example: Your sprayer is calibrated to apply 5 GPA and you determined you will be spraying 15 acres. How much carrier do you put into the spray tank?

$$5 \text{ GPA} \times 15 \text{ acres} = 75 \text{ gallons of carrier in the spray tank.}$$

STEP 5. How much of the pesticide to add to the tank? Read the label to determine the proper application rate.

Important note on making pesticide mixtures or solutions: Pesticides and other ingredients of a liquid mixture should be considered a part of the total solution. For example, if you want to make 100 gallons spray solution, you would add the amount of pesticide concentrate to the water to make up the entire solution. If you needed to make a tank load of 100 gallons, and you needed to add 2 gallons of pesticide to the tank, you would add only 98 gallons of water. (2 gallons pesticide + 98 gallons water = 100 gallons of spray solution.) If you added 2 gallons of pesticide to 100 gallons of water, the solution would be too dilute.

Making Applications

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 fertilizers and other liquids are sometimes used. The label will tell you how much of the pesticide product to apply with the carrier.

Mixing Dry Formulations

Sometimes pesticide product recommendations state the application rate in amount of active ingredient (a.i.) per acre or 1,000 sq. ft. You must determine the actual amount of product to use based on the labeled rate for the active ingredient (a.i.). The formula you use to determine the amount of product to use depends on whether it is a dry or liquid formulation. Keep in mind that the package information on dry formulations and liquid formulations means

Making Pesticide Applications

different things, and that the formula you will use to figure the amount of product will be different.

Calculating based on percentage of Active Ingredient (a.i.)

The amount of a.i. is expressed as a percentage of the weight. For example, BrandX 75WP means that 75% of the product weight is a.i.

Use the following formula to determine how much of the formulated product is actually active ingredient:

$$\frac{\text{lbs a.i. wanted}}{\% \text{ a.i. in product}^*}$$

*** convert % a.i. to a decimal**

Using the formula, you can then determine how much product to add based on the area you are treating.

$$\text{Amount of area treating X lbs a.i./area} = \text{Amount of formulated product to add}$$

Example: How much BrandZ 75WP will you need to apply at a rate of 1 lb a.i./acre on 20 acres?

$$\frac{1 \text{ lb a.i.}}{0.75} = 1.33 \text{ lbs of BrandZ 75WP per acre.}$$

0.75

$$1.33 \text{ lbs. of BrandZ 75WP X 20 acres} = 26.6 \text{ lbs of formulated product to use}$$

Mixing Liquid Formulations

Calculating ounces, pints, quarts, or gallons per 100 gallons or per acre

Dosages for liquid formulations are often listed as pints, quarts, or gallons per 100 gallons or per acre. Use the pounds per 100 gallons and pounds per acre (above) for making these calculations. Substitute the appropriate liquid measure for "lbs" in the formulas.

Example: The label rate is 2 pts of pesticide formulation per 100 gallons of water. Your spray tank holds 300 gal.

$$\frac{300 \text{ gal per tank X 2 pts per 100 gal}}{100 \text{ gal}} = 6 \text{ pts formulation needed in tank}$$

Example: Your sprayer applies 22 GPA and your tank holds 400 gallons. The label rate is 1.5 quarts per acre.

$$\frac{400 \text{ gal in tank X 1.5 qts per acre}}{22 \text{ GPA}} = 27.3 \text{ qts needed in tank}$$

Calculating pounds of Active Ingredient per Acre for liquids

The amount of active ingredient is expressed as the weight in pounds a.i. per gallon of product. For example, BrandQ 4EC will have 4 pounds a.i. in each gallon. This information is also provided as part of the ingredient statement, for example, "this product contains 4 pounds of active ingredient per gallon".

Use the following formula to determine how much of the formulated product is actually active ingredient:

$$\frac{\text{Amount a.i. from label}}{\text{lbs a.i./ gallon}} = \text{gallons of product containing a.i.}$$

Example: How much of BrandQ 4EC would you use to apply on 20 acres if the rate is 2 lb a.i./acre?

$$\frac{2 \text{ lb a.i.}}{4 \text{ lbs a.i./gal}} = 0.5 \text{ gal per acre of product}$$

$$4 \text{ lbs a.i./gal}$$

So, for 20 acres:

$$20 \text{ acres} \times 0.5 \text{ gal/A} = 10 \text{ gallons product}$$

Making an Application

Safe Mixing and Loading Practices

The greatest chance of pesticide exposure occurs during mixing and loading as applicators handle the pesticide concentrate. This is also a critical time to use practices that will protect the environment as well as the public from pesticides. Reread the label and follow the directions. Carefully read the directions for mixing before removing the material from the container each time a pesticide is used.

Select an Appropriate Mixing and Loading Area

Locate the pesticide mixing and loading area outdoors or indoors in a well-ventilated, well-lit area away from unprotected people, animals, food, and other items that might be contaminated.

Protect Water Sources

When mixing, ensure that no tank mixture can back-siphon into a water source. When filling 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. 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. If water is pumped directly from the source into a mix tank, use a check valve, **antisiphoning 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.

Making Pesticide Applications

Mix pesticides in areas where any spills, leaks, and overflows cannot flow toward a drain or into water sources. Mixing and loading areas should be at least 100 feet away from any well. In urban areas, stay away from drains and storm sewers. It may be necessary to use a containment pad (see Additional Resources). If using a permanent mixing and loading site, use a mixing/loading pad.

Select PPE

Put on the appropriate PPE *before* opening a pesticide container. By law, pesticide applicators and handlers must wear all the PPE listed on the label.

Opening Containers

To prevent spills, containers should be in a secure position when opening, and closed after each use. Do not tear paper containers to open them. Use a sharp knife to remove a seal on a liquid container or to open a paper container. Clean the knife afterwards, and do not use it for other purposes.

Measuring Pesticides

When pouring any pesticide from its container, keep the container and pesticide below eye level. If there is a breeze outdoors or strong air currents 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. Never overfill a spray tank. The cleanup could be time consuming, costly, and dangerous.

Adding Water Soluble Packets

When used properly, water soluble packets are considered to be a “closed system” and potential exposure to the mixer or handler is reduced.

Keep WSP(s) dry prior to adding to the spray tank. Handle WSP(s) in a manner to protect from breakage and/or unintended release of contents. Keep WSP(s) in outer packaging until just before use. Handle with dry hands or gloves. Keep WSP intact. Do not cut or puncture WSP. If a WSP tears or ruptures prior to or during handling, either put on the full PPE required by the label without WSP and mix as intended or clean up the spill. Reseal WSP outer packaging to protect any unused WSP(s).

If a basket or strainer is in the tank hatch, remove it prior to adding a WSP to the tank. Fill the tank with water to approximately 1/3 to 1/2 of the desired final volume of spray; do not agitate. Add WSP(s) into the tank and start mechanical and recirculation agitation from the bottom of tank without using any overhead recirculation, if possible. If overhead recirculation cannot be turned off, close the hatch before starting agitation. Do not spray water from a hose or fill pipe to break or dissolve the packet(s). Dissolving the WSP(s) may take up to 5 minutes or longer, depending on water temperature, water hardness, and intensity of agitation. After a few minutes, stop agitation and verify that the WSPs have fully dissolved and the contents have been thoroughly mixed into the solution before adding any other products. Use caution to avoid contact with dusts or spray mix. Once WSP(s) have fully dissolved and any other products have been added to the tank, resume filling the tank with water to the desired level. Use the

spray solution when mixing is complete. Maintain agitation of the diluted pesticide mix during transport and application.

Tank Mixing

Before tank mixing two or more pesticides, or a pesticide with fertilizer, read the label. Wear the “most restrictive” PPE (for example, if mixing a product with a CAUTION signal word with a DANGER signal word, select the PPE from the DANGER product’s label). Although tank mixing is a common and legal practice, the compatibility of many pesticide combinations is still unknown. There is a certain order that adjuvants and pesticides should be mixed in the spray tank. This prevents potential problems associated with mixing. Unless labels specify otherwise, ingredients should be mixed in your spray tank in the following order:

Tank Mixing Order	
1.	Fill tank 1/5 to 1/2 full with carrier (water or liquid fertilizer). Start agitation.
2.	Add compatibility agent (if needed).
3.	Add suspension products: first, dry formulations - wettable powders, dry flowables, water-dispersible granules (as a preslurry, if necessary), then liquids - flowables, liquids, microencapsulated.
4.	Add solution products - solutions, soluble powders.
5.	Add surfactants or other adjuvants (if needed).
6.	Add emulsion products - emulsifiable concentrates.

Applying the Pesticide

You have several important responsibilities when applying pesticides: protecting yourself, others, the environment, and making sure the pesticide is applied correctly. You must be sure to use the proper PPE and follow the correct application procedures. Label requirements for PPE are the minimum required; however, you may choose to wear more PPE than the label requires.

To ensure pesticides are being applied properly, follow these basic procedures:

1. Take the time to be sure that the pesticide is reaching the surface or area toward which you are directing it. In the case of granules, it may be necessary to make sure they are removed from nontarget areas such as sidewalks.
2. 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.
3. Ensure that the pesticide maintains a uniform mix or appearance during the application. Several pesticide formulations mixed with liquids require agitation to remain in suspension. Granules and dusts should appear dry and not form clumps on the target site.
4. Pay attention to the spray equipment during the application and stop if you notice a problem. Remember to put on the appropriate PPE before touching the equipment. Check the pressure gauge and speedometer frequently while spraying.

Move to an untreated area (mark where you stopped) to correct any problems with application equipment. The safest practice is to replace troublesome nozzles with an extra nozzle in the field and deal with it after the application. If that’s not possible, use a nozzle

cleaning brush, old toothbrush, or comparable soft brush to clean plugged nozzles. Do not use wire or metal that can damage the nozzle orifice. Do not remove materials clogging a nozzle or pump part by blowing it out with your mouth.

5. Turn 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). When you stop an application for any reason, depressurize spray tanks. Turn off the main pressure valve on the tank and release the pressure remaining at the nozzles.
6. Check the label for any post-application requirements, such as incorporating the pesticide into the soil.

Post-Application

After an application has been made, you may need to clean equipment and dispose of any excess pesticide.

Equipment Cleanup

Pesticide application equipment requires maintenance for continued accurate and effective operation. Maintenance saves time and prevents frustration in getting equipment into proper working order the next application or next season. Cleaning is the most important maintenance practice.

Unless pesticide equipment is dedicated to the application of a single pesticide, it should be cleaned immediately after use. Don't forget to wear proper PPE when cleaning up!

After completion of a pesticide application, the mixing, loading, and application equipment should be cleaned immediately inside and out. Thorough cleaning when changing pesticides or before applying fertilizer can prevent **cross contamination** and off-label application of pesticides that could injure crops, livestock, pets, or people, or cause **illegal residues**. The cleaning operation can be hazardous if proper precautions are not taken. Personnel who clean the equipment must know the correct procedures and wear the PPE from the pesticide label. You may choose to wear more PPE than the label requires, including goggles and gloves. If using a tank cleaner, check for PPE recommendations and wear the most protective PPE based on either the pesticide label or the tank cleaner. Many tank cleaners are irritating or corrosive. The actual cleaning should be done in a specific area, preferably on a wash rack or cement apron that has a well-designed sump to catch all contaminated wash water and waste pesticides for later disposal.

Carry a supply of water to the application site so you can rinse the application equipment and spray the rinsate on the field. Once rinsed, return to washing pad to clean sprayer. Choose the washing area carefully to avoid contamination of water supplies. After each day's use, sprayers should be flushed with water inside and out to prevent buildup of chemicals. When chemicals are changed or spraying is completed for the season, clean the sprayer thoroughly with a cleaning agent.

Cleaning Sprayers

1. Apply any leftover pesticide to a labeled site. The tank should be empty of spray solution before starting.
2. Hose down the inside of the tank and partially fill it with water. Flush the cleaning water through the nozzles by operating the sprayer and spraying rinse water onto the ground that you just applied the chemical on, or another labeled site.
3. Remove nozzle tips, nozzle bodies, screens, and washers. Clean them in ammonia or a commercial tank cleaning solution using a soft brush (such as an old toothbrush). Do not use wire, knives, or other hard objects that might scratch the orifice.
4. Partially fill the tank with water and add cleaning agent. Agitate and circulate through system and flush out of system.
5. Partially fill the tank a final time to flush the cleaning agent out of tank/sprayer. The cleaning agent could be phytotoxic or neutralize the next pesticide used.
6. *Whenever possible, steps 2 & 3 should be applied on the site to reduce the concentration of pesticide waste at the cleanup area.*

Cleaning Granular Applicators and Dusters

1. Remove all pesticide from the applicator. You may have to disassemble certain parts to do a thorough job.
2. Thoroughly clean the inside of the hopper.
3. Clean rusted or corroded parts with sandpaper, emery cloth, or a wire brush. Paint with rust preventive primer and machinery paint.
4. Wipe inside and outside with coat of oil. Oil or grease bearings, if appropriate.
5. Thoroughly clean and oil the flow control valve and adjustment.
6. Clean and oil any steel tubes that were used.
7. Wipe off oil that may come in contact with granules or dust.

Pesticide Disposal

Preplanning and anticipating pesticide needs can allow for a reduction in pesticide wastes and reduced pesticide disposal problems. Ways to reduce production of pesticide waste include:

1. Purchase only the amount of pesticide needed to accomplish the intended pest control task or to be sufficient for the application season.
2. Mix only the amount needed to cover the intended site.
3. Protect pesticides from damage and contamination. Be sure all containers have legible labels. Store pesticides in a cool location out of the sun in locked storage areas. In the winter, protect liquid pesticide formulations from freezing. Protect dry formulations from moisture.
4. Use pesticides before they are no longer effective for the intended purpose, using older products first. Write the date purchased on pesticide containers so you can use the oldest first.

The best way to avoid pesticide waste disposal problems is to avoid creating pesticide waste!

Proper disposal of pesticides and empty pesticide containers is your responsibility. Improper disposal can result in serious harm to people, pets, wildlife, and the environment. A pesticide waste is any material which contains any concentration of pesticide, including rinse material

(rinsate) from containers and spray equipment; leftover spray solutions; excess pesticides, and canceled, banned, or suspended pesticides.

Rinsates

Improperly disposed rinsates from application equipment have great potential for causing ground and surface water contamination. Do not bury or discharge rinse water to the ground, septic systems, ditches, or streams. To minimize disposal, spray rinsates on the target area just treated or on other areas listed on the product label, if application rates and amounts will not be exceeded and if allowed by product label restrictions. If you are doing a series of applications using the same formulation, reuse the rinsate to dilute the next batch of formulation, as long as the site to which the rinse water is applied is a labeled site.

Leftover Spray Solutions

The way to “dispose” of excess spray solutions is to use all of the mixed pesticide in compliance with label instructions. Make sure that application rates and amounts are not exceeded. Avoid the problem of excess mixture by measuring and calibrating carefully. Fill your spray tank with only the amount required to do the job.

Excess Pesticide Product

Assuming the excess pesticide is in its original, properly labeled container, you may use the product up according to the label or give the pesticide to another *certified applicator*. Do not give RUPs to people that are not certified to apply them.

Canceled and Banned Pesticides

If you have a canceled or banned pesticide in its original, labeled container, there may be a recall program available. The manufacturer of the pesticide may collect the pesticide for disposal. In addition, the Colorado Department of Agriculture has a ‘Pesticide Disposal Map’, which highlights disposal options for each county (see link in Additional Resources).

If legal, use the remaining product according to the pesticide label on the container. Pesticides for which the labeled uses have changed or pesticides that have been taken off the market can usually be used according to their container’s label until supplies are exhausted. However, there are exceptions to the rule. For some pesticides, EPA allows old label uses for only a short time after a product cancellation or label change. In rare cases, EPA may issue a “stop use” on a product at the time of its cancellation. Contact the pesticide manufacturer to find out whether you can still use a particular product.

Pesticide Container Disposal

Proper rinsing and handling of empty pesticide containers is very important. Mishandled empty pesticide containers can create a major problem for their owner since most unrinsed containers are considered hazardous waste, complicating disposal. Before they are rinsed or cleaned, pesticide containers can still hold enough material to harm you or the environment. When emptying or cleaning containers, protect your eyes and hands. Wear chemical-resistant gloves that will neither absorb pesticides or rinse water, nor let the material contact your skin. Wear goggles or a face shield that will protect your eyes from splashes or dust. You also may need to wear a respirator for protection from dust or fumes.

The best thing to do with rinse water is to use it in the spray mixture you are making up when the container is emptied. This is the safest way for both you and the environment and creates less waste and cost. If you collect rinse water for later use or disposal, do not mix different pesticide rinse-waters. Label each container so you know what is in it. Do not dump rinse water on the ground.

General container handling guidelines:

- Never abandon empty containers. Uncleaned containers can be very dangerous to people, animals, and the environment. Abandoning containers, even cleaned ones, is against the law.
- Burial of empty, uncleaned containers or unused product is not a safe practice. Even small amounts of pesticide can reach water supplies or contaminate the soil.
- When mixing, add container rinse water to the spray mix to avoid disposal problems.
- When purchasing pesticides, think about how you will dispose of the container. Manufacturers are putting more products in water soluble packages or in easily recycled containers to assist you in avoiding disposal problems and costs.

Metal or Rigid Plastic Pesticide Containers

Unless the pesticide label directs you otherwise, **triple rinse** containers or use pressure rinsing to clean them. Don't forget to completely rinse the hard-to-get-to areas inside the containers, such as the handle. Make sure you also rinse the outside of all the containers.

Triple Rinsing:

1. Empty as much of the pesticide into the sprayer as possible. Turn containers that are 5-gallons or smaller upside down over the spray tank and let them finish draining for at least 30 seconds after they stop dripping. Pump or drain larger containers as empty as possible.
2. Add water or the mixing liquid to fill the empty container about 1/4 full.
3. Shake smaller containers thoroughly. Add the rinse water to larger containers so that it contacts all of the inside surfaces.
4. Drain the container completely by holding it over the spray tank allowing it to drain 10 seconds after dripping begins, or pumping out the liquid. Add this rinse water to the spray tank if at all possible.
5. Repeat this process at least 2 more times, until the container is clean. When triple rinsing will not sufficiently clean the container, keep rinsing until the rinse water runs clear from the container.
6. Puncture or crush the container to prevent reuse.

Paper or Plastic Sacks and Fiber Containers

- Empty the contents completely into the application equipment. You may need to cut the container to clean out all of the material in the seams. Never rip the container, but use scissors or a knife (not your personal pocket knife). Wear appropriate PPE such as gloves, eye protection, and in some cases a respirator. Do not let material blow around.

Making Pesticide Applications

- Rinse the container if you can. Some containers have plastic or foil liners that will allow you to rinse them. Use the rinsewater in the spray mixture or collect it for disposal.
- Don't burn containers. Burning is against the law and unsafe. Burning can release toxic fumes and cause illness.

Disposal Options

Recycling Procedures - Only "pesticide container recyclers" can accept plastic pesticide containers. The Ag Container Recycling Council (ACRC) is a not-for-profit organization that works to facilitate the collection and recycling of one-way rigid HDPE plastic agricultural crop protection, specialty pest control, animal health, micronutrient/fertilizer, and/or adjuvant product containers. They will accept HDPE containers that are 55 gallons and smaller. They may also be able to accept shuttles, but contact the service provider for more information.

The ACRC website has some 'How to' videos that demonstrate the proper container rinsing procedures. (Additional Resources)

Only "clean" containers are accepted. Remove caps. Caps are a different class of plastic and can be disposed of in your normal trash. Remove plastic labels and sleeves; paper labels may remain attached. At collection sites, all containers are inspected, both inside and outside. Stains are acceptable, but residues are not.

Landfill Procedures - Check the CDA Pesticide Waste Disposal Map to view options by county (Additional Resources). Only "clean" containers are accepted. Plastic/metal containers must be triple rinsed. Paper containers must be emptied with their seams as clean as possible.

Another container disposal option may be to burn empty, rinsed containers if permitted by your county.

Additional Resources

- Best Management Practices for Pesticide and Fertilizer Storage and Handling. CSU Extension. <http://extension.colostate.edu/docs/pubs/crops/xcm178.pdf>. *Identifies and discusses BMPs and regulations for pesticide storage, handling, and containment.*
- Colorado Department of Agriculture Pesticide Waste Disposal Map. <https://www.colorado.gov/pacific/agconservation/pesticide-waste-disposal>. *Displays pesticide disposal contact information by county.*
- Ag Container Recycling Council. http://www.acrecycle.org/Where_and_How_to_Recycle/Where *For information on recycling pesticide containers.*
- Removing Herbicide Residues From Agricultural Application Equipment. By Fred Whitford. https://mdc.itap.purdue.edu/item.asp?Item_Number=PPP-108#.WJJcPVMrKUI. Available as a Free PDF or you can order a hard copy. *This publication discusses and describes the proper procedures to remove residues from pesticide application equipment.*

Protecting Others and the Environment

Learning Objectives

After reviewing this chapter, you should be able to:

- Define "environment".
- Define "endangered species" and describe how pesticides can harm endangered species.
- Describe ways to protect endangered and threatened species.
- Describe how and list ways nontarget plants and animals can be harmed by pesticides and pesticide residues.
- List types of sensitive areas and organisms that could be affected by application, drift, and runoff.
- Identify ways to prevent injury to others.
- Describe ways to prevent honey bees losses (regarding pesticide application).
- Describe how pesticides can harm biological control organisms.
- List and describe regulations that exist to limit pesticide residues on harvested crops (pre-harvest interval & label rates).
- Define "phytotoxicity" and explain how to avoid phytotoxicity on desirable plants.
- Describe pesticide drift (volatile and particle).
- List factors that affect the potential for drift.
- Describe what to do in the event of a pesticide spill.
- Identify methods of spill prevention, control, and cleanup.
- Explain how pesticide spills can pose serious threats to human health and cause significant environmental contamination.
- List factors that determine whether pesticides will reach surface water and groundwater.
- List ways how pesticide users can avoid contaminating surface water and groundwater.
- Explain how soil type as well as its solubility, adsorption, and persistence of a pesticide influence its movement into groundwater.
- List the steps to take in the event pesticides are involved in a fire.
- Explain how to safely and effectively clean and maintain equipment.

Environment is defined as the totality of circumstances surrounding an organism or group of organisms, especially the combination of external physical conditions that affect and influence the growth, development, and survival of organisms. Although pesticides often provide efficient control of insects, weeds, and diseases, they can damage the environment under certain conditions. Anyone who applies a pesticide should be aware of the potential risk to the environment and act to prevent contamination. Pesticides cause problems when they drift out of the target area to neighboring land where they may contaminate nontarget plants or wildlife, or when they move by soil runoff or erosion and move through the soil to contaminate groundwater.

Hazards to Wildlife and Endangered Species

An endangered species is a plant or animal that is in danger of becoming extinct. There are two classifications of these plants and animals in danger: “endangered species” and “threatened species.” This manual uses the term “endangered species” to refer to the two classifications collectively. Hundreds of animals (including fish, birds, **mammals, reptiles, amphibians**, insects, and aquatic invertebrates) and thousands of plants have been named as endangered species under the provisions of the Endangered Species Act.

Many pesticides have the potential to seriously injure wildlife and endangered species through direct and/or indirect contact. Pesticide use has been an important reason for the elimination or sharp reduction in populations of birds, certain mammals, and other species in many areas of intensive agriculture in Colorado. In some cases, pesticide use has even caused wildlife species to become endangered or threatened with extinction. Among the species that have been most directly affected by pesticides in Colorado are the black-footed ferret and the peregrine falcon. Indiscriminate poisoning of prairie dogs eliminated the black-footed ferret from much of its original range to the point where it is now the rarest mammal in North America. Peregrine falcons and many other birds of prey were severely affected by the accumulation of DDT and persistent industrial chemicals (PCBs) that interfered with their ability to reproduce.

Pesticides can affect wildlife populations in a number of ways:

- Pesticides can be transported in runoff and contaminate water that is ingested or inhabited by wildlife
- Pesticides can eliminate food used by wildlife
- Pesticides can accumulate in predators that feed upon plants or animals that have been exposed to pesticides
- Pesticides can damage or eliminate **habitat** required for the survival of wildlife

Be aware of protecting endangered species when applying pesticides near sensitive habitats. Carefully read the pesticide label for any information given concerning endangered species. Pesticide users may need to refer to Endangered Species Protection Bulletins.

For a list of endangered and threatened species in Colorado visit the website listed for the Fish and Wildlife Service in the “Additional Resources” section of this chapter.

Damage to Pollinating Insects

Pollinating insects, such as honeybees and leafcutter bees, are extremely important in the production of a wide variety of fruit and seed crops. Crop yields and quality are often dependent upon or improved by the activities of **pollinators**.

Often, pesticide use practices are in conflict with pollinating insects. This occurs most commonly when pesticides that are hazardous to honeybees are applied to areas visited by worker bees or when toxic pesticides drift onto bees clustered on the outside of hives. Prevention of excessive honeybee losses from bee kills is an important consideration of pesticide applicators.

Honeybees commonly visit fields, orchards, and **ornamental** plantings to collect pollen, nectar, water, and other materials needed for hive maintenance. Unfortunately, pollinating insects such as honeybees often come in conflict with crop protection practices. Pesticides, particularly certain insecticides, annually kill large numbers of honeybees in Colorado, destroying or weakening colonies. For example, treatments to control alfalfa weevil or sweet corn insects can often result in large honeybee losses. Carbaryl, if used in excessive quantities, can also lead to honeybee losses.

Extra caution needs to be taken for pollinators. Read the label:

- Look for bee hazard statements under PRECAUTIONARY STATEMENTS before using the product.
- DO NOT apply any pesticide to blooming plants.
- Mow blooming weeds before applying a pesticide to avoid exposing pollinators.
- Use DriftWatch and BeeCheck (Driftwatch.org - a sensitive site registry and map).
- Communicate and coordinate pesticide applications with area beekeepers.
- Avoid treating crops that are in bloom (this is often a label requirement for more hazardous insecticides).
- Treat plants during times when honeybees are not active (early evening).
- Avoid pesticide drift onto flowering plants and bee colonies.
- Use pesticides and pesticide formulations that are least toxic to honeybees.
- Control flowering weeds in crops that may attract honeybees.

Regular communication between pesticide applicators and beekeepers is a two-way process that can greatly limit honeybee poisonings. If applicators are aware of the location of colonies, beekeepers can be warned of planned applications. Colonies may then be moved or temporarily covered. Alternatively, beekeepers can block the main hive entrance and open a new entrance in the hive which disrupts honeybee foraging for several hours.

A wide range exists in the hazard of various pesticides in honeybee poisonings. Almost all bee poisoning problems result from insecticides, while herbicides and fungicides tend to be much less hazardous. In general, relatively slow acting insecticides cause the most accidental loss of bees because they can be carried to the hive and fed to other bees.

Crops in bloom should not be treated with pesticides that are toxic to honeybees. Some pesticide labels (e.g., Warrior II[®]) prohibit the use of the pesticide on crops in bloom when bees are visiting the area. This would be a label violation and is often difficult to avoid where bloom occurs over a limited time, as in orchard crops. Also remember that the presence of flowering weeds in fields or orchards may attract bees for extended periods. **Weed control** can therefore be an important part of honeybee poisoning prevention.

Sometimes crops must be treated in bloom because it is an essential period in crop protection. For example, the sunflower moth lays eggs during bloom and is best controlled by pesticide applications at that time. Less hazardous insecticides should be considered for these applications. In addition, pesticides can cause less honeybee poisoning if they are applied during periods when honeybees are not active. Early evening is a particularly good time to

make these treatments since the spray deposits will have settled and dried before honeybees resume foraging in the morning.

Some honeybee poisonings occur from pesticide drift. During warm periods, large numbers of honeybees may mass on the outside of the hive to help regulate hive temperatures. These exposed bees can be destroyed easily by drifting pesticides.

Damage to Biological Control Organisms

Pesticide use can negatively affect the performance of **biological control** organisms. Most damage has been associated with insecticide effects on **predators** and **parasites** of insect and **mite** pests, such as lady beetles, lacewings, and parasitic wasps. Fungicide use has also been shown to adversely affect certain spider mite predators and to inhibit fungal diseases that naturally affect insect pests.

Several consequences can occur when the existing biological control organisms are disrupted or destroyed. Normally noneconomic pest species may become serious pests when natural enemies are destroyed by pesticides. Many of the problems with spider mites in fruit crops and field corn are **secondary pest** problems; pea aphid problems in alfalfa are commonly induced by alfalfa weevil treatment.

Pest resurgences or **rebounds** occur when the pest species is only temporarily reduced by pesticide applications. If the **natural enemies** of the pest are also affected, the pest may increase rapidly after pesticide residues decline to ineffective levels.

Care in selection and use of pesticides can prevent damage to biological control organisms. Pesticides vary greatly in their potential to harm **beneficial** insects and often it is possible to use a pesticide with more selective effects. For example, insecticides containing neem (Azatin, Neemix) or *Bacillus thuringiensis* (Bt) are considered to be selective since they are effective on a narrow range of insects, thus they have little effect on most biological controls. Insecticides with short persistence, such as pyrethrins and insecticidal soaps, also tend to minimize adverse effects since the beneficial insects are able to rapidly recolonize the plants and feed on the surviving pests.

Pesticides can be applied in a manner that makes their effects more selective. Many times pest problems occur in only a limited area, such as along field edges or in hot, dry sites. **Spot treatments** can then be made which conserve many of the natural enemies of the pests. Pesticides may also be applied when the natural enemies are not present, such as a **dormant** season treatment of an orchard crop.

Pesticide Residues on Crops

Public concerns are high about pesticide residues on crops and regulations exist to limit the amounts of these residues to non-harmful levels. Prevention of excessive pesticide residues on harvested crops is essential to the continued availability of the pesticide. EPA establishes tolerances for the maximum amount of pesticide residue that may legally remain in or on a raw agricultural commodity. Pesticide residues can be limited to legal levels by:

- following preharvest interval (PHI) requirements of the pesticide use;

- applying pesticides only to crops listed on the label;
- applying pesticides only by methods listed on the label;
- applying pesticides at rates that do not exceed those appearing on the label use instructions;
- not applying pesticides where they will drift onto unlabeled crops or gardens.

The PHI is a very important aspect of pesticide use. It is the minimum amount of time that must elapse between the last application and harvest. PHIs are established for all pesticide uses on crops fed to humans and livestock. Similar intervals prior to slaughter also are established for pesticides used on livestock. The length of the PHI is determined following studies on the degradation of the pesticide under labeled use conditions.

The length of the PHI varies with different pesticides. For example, the PHI for dimethoate on wheat is 60 days; for carbaryl on wheat it is 21 days. Intervals for any individual pesticide may vary on different crops on which it is used. Carbaryl applied to apples requires that 1 day elapse between application and harvest, while a 14 day PHI exists for carbaryl on head lettuce. PHI requirements are listed on the pesticide label. Because labels may change over time, refer to the label every time you purchase a product. **Harvesting** a crop early may result in unsafe levels of pesticide residue on the crop and is a violation of state and federal law.

All pesticides can only be applied to crops that are specifically included in the label instructions. Since pesticides degrade at different rates depending on how the crop is grown, pesticide use on a crop may be defined by how the crop is produced. For example, pesticide registrations for greenhouse grown tomatoes differ from field grown tomatoes since they are considered to be separate crops.

The method of pesticide application is also limited by label instructions, and only specifically listed methods may be used. For example, many pesticides can be applied to the roots of a crop but not to the leaves (and vice versa). Aerial application to crops may be allowed while chemigation may not. Chemigation uses typically are allowed for overhead irrigation systems, but not for drip irrigation.

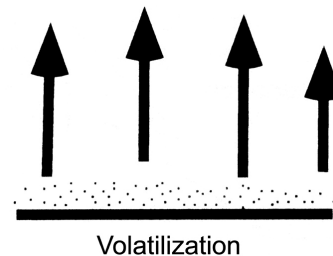
Applying more than the labeled rate of pesticides can result in harmful levels of residues in or on a harvested crop. **It is illegal to apply more than the label allows.** In any application, only apply amounts of the pesticide equal to or less than the level indicated in label instructions. Some pesticides also have restrictions on the number of applications that can be made during a season and/or their frequency.

Ensuring that excess residues do not occur in harvested crops is a major emphasis of how pesticide labels are written. It is violation of the law to use a pesticide in a manner that is inconsistent with its labeling.

Pesticide Drift

Volatile Drift

Volatilization of a pesticide occurs when it changes from a solid or liquid phase to a gaseous phase. This change in physical state occurs at a specific pressure (known as **vapor pressure**) for that pesticide. Vapor pressure is the point where solids vaporize and liquids evaporate. Volatilization increases with an increase in temperature. Volatile drift occurs when a pesticide volatilizes and moves off-site. Volatile drift can travel in the air and has the potential to damage unintended sites.



Volatilization is generally a concern when using broadleaf herbicides formulated as **esters**. Ester formulations have a greater tendency to volatilize than do **amine** forms. Sometimes additions are made to the ester molecule to make a lower volatile ester that can be used more safely. However, ester formulations should never be used when temperatures are above 80-85° F and the relative humidity is low. Herbicides formulated as amines are generally nonvolatile. You can always refer to the label to check the requirements for environmental conditions during application. Other factors that contribute to pesticide volatilization include soil properties and pesticide persistence.

Particle Drift

Particle drift is the actual movement of small spray particles away from the target area. Several factors affect particle drift, but the most important is the size of the spray droplet, which is influenced by the nozzle type and output pressure. Small droplets fall through the air slowly and are carried further by air movement. Whenever possible during application of a liquid pesticide, keep the pressure of the pesticide solution as low as practical. Droplet size is thereby kept larger and less susceptible to drift. Particle drift lowers the amount applied to the target area which reduces effectiveness, and can damage off-target sites, resulting in environmental contamination.

Be aware of excessive winds that can cause a pesticide to drift from the target area to nontarget sites. Most recommendations are to not spray if wind speeds are over ten miles per hour or when adjacent to sensitive plants. Also be aware that the presence of houses and buildings can modify wind direction and intensity. Because of this building influence on wind, particle drift potential is increased.

To reduce the chances for drift take the following precautions:

- Use the lowest practical pressure.
- Leave an untreated edge.
- Keep nozzles low to the ground if possible.
- Angle nozzles toward the ground, slightly forward in the direction of travel.
- Use nozzles with the largest practical openings.
- Use low-volatile formulations of chemicals.
- Avoid broadcast spraying.

- Spray when wind speed is 3-10 mph.
- Do not spray during a **temperature inversion** (avoid spraying in calm conditions; a sign of a temperature inversion).
- Spray when sensitive vegetation is not actively growing.

Pesticide Formulation

Low-volatile acid and **amine** formulations of 2,4-D have much less volatility drift potential than do **ester** formulations of 2,4-D. Insecticides formulated as dusts drift much more readily than liquids. Granular formulations are relatively resistant to drift.

Droplet Size

Spray nozzles and application equipment typically produce a wide range of droplet sizes. The ability of particles to drift increases greatly as the particle size decreases (see below). Applications should be made in a way that minimize the number of smallest particles while still allowing for particles sufficient to provide **coverage**. This can be achieved by a number of methods:

- As pressure increases, the number of fine particles increases. Reduce sprayer pressure.
- Use drift reducing nozzles. Nozzles that produce larger droplets such as flooding types, can greatly reduce drift. Also, larger orifice nozzles can be used at lower pressures to deliver the same application volume (Gallons per acre (GPA)) as smaller nozzles operated at higher pressure. Using higher GPA applications is an alternative means of achieving adequate coverage with minimal pressure.
- Use “thickening” or “drift control” **adjuvants**. These compounds can increase the percentage of larger droplets that are formed, but do not completely eliminate small droplets.

Height of Pesticide Release

Height and orientation of sprayer nozzles can affect the time that it takes for spray droplets to reach the soil or plant. Sprays should be made as close to the target site as possible for adequate coverage. When spraying fields with ground equipment, sprays should be directed downward so that the droplets are propelled in a manner that reduces the distance of droplet fall. Tree applications should be made so that resulting drift is not directed toward sensitive areas such as streets, gardens, ponds, playgrounds, houses, neighboring yards, or environmentally sensitive areas.

Weather

Weather conditions during application, particularly air movement, are among the most obvious and important factors affecting drift. High winds can carry pesticides away from the application site. Pesticides should never be applied at wind speeds greater than 10 mph.

Temperature and **humidity** affect **evaporation** of spray droplets. During conditions of high temperature and/or low humidity, particles evaporate most rapidly producing smaller droplets that are more likely to drift. Volatile pesticides may turn into gaseous forms during high temperatures making them very prone to drift. Drift may also increase during periods when warming air near the soil rises, producing vertical air movements. To avoid these problems,

pesticide applications should be made during cooler periods of the day when air and soil temperatures are most similar. Under some conditions, the air near the soil surface remains cooler than the air above. During these periods a **temperature inversion** condition exists. Spray particles applied during air inversions can remain **suspended** in the cool air. Later, the suspended particles move out of the target area on winds. You may have seen this effect before, especially at dawn and dusk. For example, if you ever see smoke that somewhat rises vertically and then moves horizontally for a long ways, it is an indication that an inversion is present. Pesticide applications should not occur during a temperature inversion or if you think an inversion is likely to occur.

How to Recognize an Inversion

- Inversions can occur any time, but most often in early evening hours. Avoid making applications in the early evening.
- Inversions intensify during the night and may persist until mid-morning. Do not make applications overnight.
- Use dust or smoke movement to check for an inversion.
- If dust or smoke rises only slightly from its source and tends to hang in the air, an inversion is probably developing.

Pesticide Spills

Pesticide spills can pose serious threats to human health and cause significant environmental contamination. A thorough knowledge of the appropriate steps to take in the event of a spill will allow you to minimize the potential for adverse effects and may save you a great deal of money in expensive cleanup costs. Always be prepared to handle spills before they occur. It is a good idea to have a spill kit in storage and mixing areas. Contamination can greatly increase by delaying your response to a pesticide spill.

Spills may be relatively minor, involving one or a few leaking containers. However, major spills, such as a truck or sprayer overturning, do occasionally occur. Regardless of the size of the spill, the response is the same. First, you must "control" the spill; second, you must "contain" the spill; third, you must "clean it up." These three steps are frequently referred to as the "Three C's" of spill management.

- **Control the spill** - immediate steps should be taken to control the flow of the spilled material, regardless of the source. Do everything possible to stop the leak or spill. Smaller, leaking containers can be put into larger containers to prevent further release of the chemical. Ripped or torn bags can be placed into larger plastic bags. Leaking sprayers should be turned off immediately. Stopping large leaks or spills can be difficult, so use caution to prevent unnecessary exposure to the leaking chemical. Use PPE when attempting to control the leak. Also, do not charge in blindly if someone is injured; make sure you are properly protected.
- **Contain the spill** - at the same time the leak is being controlled, contain the spilled material in as small an area as possible. Do everything possible to slow or stop spreading. Use hand tools (e.g., shovel or rake) or power equipment to construct a soil or sod dam. The important thing to remember when containing spills is to NOT allow the spilled material to enter any body of water, including storm sewers, no matter how small the spill.

Spilled liquid pesticides can be contained and absorbed by covering the entire spill area with absorbent materials such as fine sand, vermiculite, sawdust, or **absorptive clay**. For absorbing small spills and minor leaks, cat litter is particularly useful. (Note: Avoid using sawdust or sweeping compounds if the pesticide is a strong oxidizer. Such a combination presents a possible fire hazard. This information can be found on the SDS). **Do not hose down the area**; this will cause further spread of the chemical. After the spill has been contained, if possible, pump or vacuum up as much liquid as possible into a tank so that it may be applied to the labeled site. Use tanks that are designed for this purpose, another empty spray tank, or one with the same material or a compatible pesticide.

- **Clean it up** - if you have not already done so, spread absorbent material over the contaminated area, sweep it up, and place it in a heavy-duty plastic bag. Keep adding the absorbent until the spilled liquid is soaked up. Dry spills should be swept up for reuse if possible.

Reporting a Spill

When a chemical spill occurs in Colorado, there are a number of reporting and notification requirements that must be followed by the person(s) responsible for the spill. These requirements tend to be confusing, and regulations often overlap. The following briefly explains the major requirements. For more detailed information, please visit the Colorado Department of Public Health and Environment (CDPHE) Reporting Chemical Spills And Releases In Colorado website at <http://www.colorado.gov/pacific/cdphe/emergency-reporting-line>.

Releases to Water

A release of any quantity of any pesticide which may enter waters of the State of Colorado (which include surface water, groundwater and dry gullies or storm sewers leading to surface water) must be reported to CDPHE immediately using the toll-free 24-hour Environmental Emergency Spill Reporting Line at 1-877-518-5608 (25-8-601 CRS).

Written notification to CDPHE must follow within 5 days (5 CCR 1002-61, Section 61.8(5)(d)). Any accidental discharge to the sanitary sewer system must be reported immediately to the local sewer authority and the affected wastewater treatment plant.

Transportation Accidents

Call 911 or the local emergency number immediately for transportation accidents that result in a pesticide spill. Notification of the National Response Center (1-800-424-8802) and CDPHE may also be necessary. Refer to the CDPHE Reporting Chemical Spills And Releases In Colorado website at <http://www.cdphe.state.co.us/emp/spillsandreleases.htm> for more details.

Releases from Fixed Facilities and Storage Tanks

The Superfund Amendments and Reauthorization Act (SARA) Title III, a federal law with which facilities must comply in Colorado, requires reporting releases from fixed facilities (including pesticide storage areas). Fixed facilities must immediately report any release that exceeds the reportable quantity for that specific chemical to the agencies listed below. Refer to the SARA Title III List of Lists, available from EPA at <http://www.epa.gov/ceppo/pubs/title3.pdf>, for the reportable quantity. For more detailed information, refer to the CDPHE Reporting Chemical

Spills And Releases In Colorado website at <http://www.cdphe.state.co.us/emp/spillsandreleases.htm>.

Pollution of Water Resources

Contamination of surface waters has long been a recognized concern surrounding pesticide use. Such contamination can occur directly by drift or accidental application of pesticides into waters at the time of application. Extreme care must always be taken when making pesticide applications near water.

Pollution of water by pesticides may also occur from runoff following irrigation or rainfall. Wind blown soil contaminated by pesticides may also enter surface waters. These problems are most severe if substantial erosion occurs shortly after a pesticide application. Site conditions that favor erosion (slope, exposure, etc.) greatly increase the potential of unwanted pesticide movement from erosion.

Recently, attention has shifted to groundwater contamination by pesticides and industrial chemicals. Groundwater is the water source for wells and springs. About one-half of the population of the U.S. relies upon groundwater for drinking; in rural areas 90% of drinking water is from groundwater sources. Groundwater was long thought to be relatively protected from pollution sources and the discoveries of pollution have raised serious concerns. In addition, there has been increased awareness that groundwater and surface water resources are often interconnected.

Groundwater is maintained in an **aquifer**, a water saturated zone of soil, sand, gravel, or fractured bedrock. The upper layer of the aquifer is known as the **water table**. These underground water sources are maintained by percolating water, or **recharge**, that passes through soil into the water table.

When this downward percolating water contains dissolved chemicals the process is known as **leaching**. Leaching of soil salts has long been an important aspect of irrigation practice in areas of high salt content.

Groundwater becomes contaminated when recharge water carries **pollutants** with it to the water table. Once in the aquifer, water travels in a more horizontal direction. These chemicals move with the groundwater, forming a region of contaminated water known as a **plume**.

Once contaminated, groundwater may be prohibitively expensive or impossible to clean. Since pesticides **degrade** very slowly in groundwater, results of contamination may last for many years. Clearly, the best solution is to keep pesticides and other chemicals out of groundwater through careful use in application, storage, and **disposal**.

A number of factors contribute to groundwater contamination. These include site conditions, characteristics of the pesticide, the method of application, and environmental conditions following application.

Site conditions associated with groundwater contamination potential include:

- *Soil texture* is determined by the relative proportion of sand, silt, and clay. Soils with more clay and organic matter hold water and dissolved chemicals longer than soils of low

clay and organic matter content. Many dissolved chemicals are held by clay and organic matter through **adsorption**. Sandy soils increase risks of contaminated water moving into groundwater. Many Colorado agricultural areas, such as the northeast part of the state, have very sandy soils.

- *Soil permeability* is a measure of how rapidly water is able to percolate through a soil. Highly permeable soils allow for greater downward movement of waterborne contaminants. Many Colorado areas, such as the San Luis Valley, have very permeable soils.
- *Soil organic matter* - organic matter content influences how much water a soil can hold and how well the soil can adsorb chemicals, including pesticides. Soils with high organic matter contents can retain water and adsorb chemicals better than soils with low organic matter contents. Low organic matter soils are common in Colorado.
- *Soil pH* - the relative acidity or alkalinity of soil can be important in the **degradation** of the pesticides. Most pesticides degrade more rapidly under alkaline conditions.
- *Depth of water table* - water table depth influences the rapidity with which dissolved chemicals can enter the underlying aquifer. Pesticides degrade slowly in groundwater since few microorganisms are present to break down the pesticide. In areas with high water tables, such as parts of the San Luis Valley, groundwater contamination risks can be greatly increased. Areas along streams, rivers, and lakes are also at high risk of contaminating groundwater supplies through careless pesticide use.

Pesticide characteristics that affect groundwater pollution potential include:

- *Water solubility* - solubility of a pesticide affects how the pesticide dissolves in and moves with water. Highly water soluble pesticides, such as many carbamate insecticides and triazine herbicides, are among the more readily leached pesticides.
- *Environmental persistence* - this is a pesticides' ability to resist degradation. Pesticides which resist degradation are more likely to enter groundwater.
- *Electrical charge* - affects how readily a pesticide binds to soil particles. Since clay and organic matter are negatively charged, chemicals with a positive charge adhere to the soil and resist leaching. Negatively charged pesticides, or soils with few negatively charged clay and organic matter particles, increase leaching potential.

Pesticide uses and applications that can affect groundwater contamination potential include:

- *High use rates* can increase the amount of pesticide available to leach and contaminate water sources.
- *Excessive irrigation* can increase water flow and leaching.
- *Chemigation* techniques pose special potential hazards to groundwater. If power failure occurs during application, **back siphoning** of chemicals is possible. This draws large amounts of non-degraded pesticides directly into the well causing serious groundwater contamination. Appropriate protective devices, such as check valves, and label instructions to prevent accidental back siphoning pollution of wells are required by law. The Colorado Chemigation Act is available from the CDA or at <http://www.colorado.gov/pacific/agconservation/chemigation>.

Environmental conditions following pesticide application can influence the breakdown of the pesticide and groundwater contamination. For example, cold or dry conditions generally retard the breakdown of pesticides in the soil.

Carefully read the pesticide label each time a pesticide is applied. Some pesticides carry a Ground Water Advisory (GWA) statement on the label. This information will help the applicator to apply the pesticide in a manner that will minimize the risk for groundwater contamination. Examples of pesticides with groundwater advisory statements include atrazine and 2-4,D. In addition, many pesticide labels carry a Surface Water Advisory (SWA) statement on the label. This advisory statement informs applicators of the danger of surface water contamination. Metolachlor and sulfentrazone are examples of pesticides that carry a surface water advisory.

The pesticide applicator's attitude is the most important factor in protecting the environment from pesticide hazards. Pesticides will remain viable pest control alternatives only if these chemicals can be applied accurately and responsibly.

Fires

When pesticides are involved in fires, they create special hazards. Anyone in the vicinity of the fire can be exposed to toxic fumes, poisonous runoff, and concentrated pesticides from leaking or exploding storage containers. Here are some general rules that apply to pesticide fires.

- Before a fire occurs, the local fire department should be informed of what is being stored and where it is being stored. Provide the fire department with SDS sheets for all pesticides held at the location.
- Foam or **carbon dioxide**, not water, should be used to fight pesticide fires (Class B fire extinguisher). If water is all that is available, it should be applied with a fogging nozzle, not in a straight stream. Straight streams may spread the fire and scatter the pesticide.
- Evacuate and isolate downwind areas. Fires attract spectators; they should be kept away from areas where they might be exposed to smoke and fumes or to runoff from fire fighting.
- Personnel fighting the fire should wear appropriate safety equipment to protect themselves against smoke, mist, spray, and runoff from the fire.
- Personnel fighting the fire should minimize the risk of exposure by attacking the fire from a safe distance on the upwind side. They should stay clear of drums, cans, or bottles that may explode during the fire.
- Contain the fire. Both the fire and the pesticide should be kept from spreading. Water should be used to cool nearby pesticide containers. Vehicles and other mobile equipment should be moved away from the fire if it is safe to do so.
- Dikes should be constructed to prevent the excess water used in fighting the fire from running off and contaminating the surrounding areas.
- Call for help. If it is necessary to call for help to control the fire, the persons or agency called should be told what pesticides are involved. When help arrives, they should be informed again of the nature of the fire, provided with SDS sheets, and told of any special information about the pesticide involved that will aid in fighting the fire and

protecting themselves.

Cleanup after the fire is out should be carried out in the same manner as cleanup of spills previously outlined.

Additional Resources

- Colorado Department of Agriculture, Conservation Services Division, Groundwater Program, 305 CHEMTREC – provides information for emergency response of hazardous material spills (800-424-9300)
- Colorado DriftWatch map: <https://co.driftwatch.org/map>. Informational brochure: <http://webdoc.agsci.colostate.edu/cepep/docs/FieldWatch%20with%20Banner%202015%20For%20Print.pdf>
- Colorado Environmental Pesticide Education Program (CEPEP), 1177 Campus Delivery, Colorado State University, Ft. Collins, CO 80523-1177. Phone: 970-491-3947. <http://cepep.agsci.colostate.edu/4-other-programs/pollinator-protection/>. *Pollinator protection and DriftWatch/FieldWatch information.*
- EPA Endangered Species Protection Program. <http://www.epa.gov/endangered-species>. *Information on how to protect endangered and threatened species from harm due to pesticide use.*
- EPA Reducing Pesticide Drift. <http://www.epa.gov/reducing-pesticide-drift>. *Publications and information on spray drift.*
- U.S. Fish and Wildlife Service Endangered Species. <http://www.fws.gov/endangered/>. *National endangered species information.*
- U.S. Fish and Wildlife Service Region 6. <http://www.fws.gov/mountain-prairie/es/endangered.php>. *Colorado endangered species information.*

Pesticide Storage, Disposal, and Transportation

Learning Objectives

After reviewing this chapter, you should be able to:

- List necessary actions to establish and maintain a safe storage site.
- Describe what to do when a pesticide container leaks.
- List and describe ways to dispose of usable excess pesticides.
- List acceptable ways to dispose of pesticide waste.
- Identify what to do with empty pesticide containers.
- Name types of empty containers that can be rinsed.
- Describe rinsing methods.
- List safety precautions for transporting pesticides in a vehicle.
- Describe how to protect pesticide containers during transport.
- Explain how to dispose of pesticide containers and pesticides safely and legally.
- Describe why it is important to maintain a current reference file.

Pesticide Storage

Careful attention should be given to proper pesticide storage. Improper storage conditions can reduce the effectiveness of pesticides due to breakdown from container damage, freezing, excessive temperatures, or exposure to moisture. Proper storage can reduce the chances of pesticide related accidents and can allow for easier handling of accidents if they do occur. Storage rules apply to both pesticide concentrates and dilute mixtures.

Indoor pesticide storage areas should be secured from access by unauthorized persons and locked when the building is unoccupied. Outdoor pesticide storage areas should be fenced or walled, and locked. Pesticides and pesticide containers should be covered or otherwise protected from the elements.

A pesticide storage facility should have a concrete floor which is **impermeable** and easy to wash. Ideally, the structure should be fire resistant and located away from other buildings. All pesticide storage facilities should also have on site fire extinguishers rated for control of chemical fires.

Adequate ventilation is important to prevent exposure of the pesticides to extreme heat and to reduce the concentration of toxic or flammable vapors in the storage building. Insulation and supplemental heating may also be needed to protect pesticides from freezing during cold temperatures. Many pesticides, particularly liquid emulsifiable concentrates, will separate and degrade at low temperatures. Correct storage temperature ranges are found on the pesticide label or SDS. Lighting in storage facilities must be sufficient to allow for easy identification of stored materials.

Pesticides should never be stored with food, feed, seed, planting stock, fertilizers, or veterinary supplies. Fertilizers, such as ammonium nitrate, can become highly flammable when contaminated by fats, oils, acids, finely divided metals, or sulfur. Pesticides should also be stored separately from protective equipment such as respirators, goggles, and protective clothing. Since total decontamination of pesticide storage areas is often not possible, do not use pesticide storage areas for anything else.

Proper placement of pesticides within storage areas is important. Dry formulated pesticides should be stored on pallets or metal shelves to prevent possible contact by moisture on floors. Dry materials should also not be placed under or below liquid formulations to prevent contamination in case of leaks. Keep herbicides separate from fungicides and insecticides.

If metal containers are to be stored for a prolonged period, they should also be placed on pallets to prevent potential corrosion of containers. If corrosion of containers is detected, they should be immediately repaired, if possible. When this is not feasible, the contents of the container should be transferred into another container with an intact label which has held exactly the same product.

Running water and other materials needed to safely handle small-scale accidents involving pesticides should be located near storage facilities. Materials for managing pesticide spills must be available at each storage location. These materials should include ammonia, paper towels, cat litter or other absorbent material, trash bags, a sturdy trash container with a lid, and a disposable brush and dustpan. [For more information on accidents and spills, see those sections in the Protecting Others and the Environment chapter.]

Pesticide Storage Fires

Should a pesticide storage facility be involved in a fire, the local fire authorities should be allowed the clear option to allow the facility to burn. Instances occur where extensive contaminated runoff would result from fire fighting activities or where incomplete combustion would produce toxic compounds in the air. Allowing the pesticide facility to completely burn may be the best option in these instances.

Copies of the pesticide label and SDS for all pesticides in a storage facility should be stored in a location separate from the pesticides. These documents should be provided to the fire department in the event of a fire. See the "Using Pesticides Safely" chapter of this manual for more information on fires involving pesticides.

Pesticide Security: A Ten Step Review

Anyone who regularly stores and uses pesticides is encouraged to review their management practices associated with storing pesticides and pesticide application equipment. In developing a personal check-list of proper pesticide storage procedures, the following 10-step review is suggested. Review it and adapt those items that apply to your operation.

1. Ensure pesticide storage is secure and locked as appropriate.
2. Be aware of who has keys and access to pesticide storage areas.
3. Post all pesticide storage areas (i.e., "Pesticides--Keep Out").
4. Post name, address, and telephone number for a contact person at the primary entrance to the storage area in letters large enough to be read from 20 ft away.

5. Regularly inspect the storage facility and maintain an inspection log.
6. Who may have access to your pesticide storage area? Any precautions needed?
7. Keep inventory records of purchased pesticide products.
8. Secure pesticide application equipment to prevent unauthorized access.
9. Keep a pesticide label and SDS available on all stored pesticides in a separate location. Use online labels as a source to obtain these copies. (See the Additional Resources at the end of the chapter for online sources of label and SDS information or ask your dealer)
10. Keep a list of emergency telephone numbers readily available, including fire, law enforcement, and medical contacts.

Pesticide Disposal

Preplanning and anticipating pesticide needs can allow for a reduction in pesticide wastes and reduced pesticide disposal problems. Ways to reduce production of pesticide waste include:

1. Purchase only the amount of pesticide needed to accomplish the intended pest control task or to be sufficient for a season's use.
2. Mix only the amount needed to cover the intended site.
3. Protect pesticides from damage and contamination. Be sure all containers have legible labels. Store pesticides in a cool location out of the sun in locked storage areas. In the winter, protect liquid pesticide formulations from freezing. Protect dry formulations from moisture.
4. Use pesticides before they are no longer effective for the intended purpose, using older products first. Write the date purchased on pesticide containers so you can use the oldest first.

The best way to avoid pesticide waste disposal problems is to avoid creating pesticide waste!

Proper disposal of pesticides and empty pesticide containers is your responsibility. Improper disposal can result in serious harm to humans, pets, wildlife, and the environment. A **pesticide waste** is any material which contains any concentration of pesticide, including:

- Rinse material (**rinsate**) from containers and spray equipment
- Left over spray solutions
- Excess pesticides
- **Canceled**, banned, or suspended pesticides

Rinsates

Improperly disposed rinsates from application equipment have great potential for causing ground and surface water contamination. Do not bury or discharge rinse water to the ground, septic systems, ditches, or streams. To minimize disposal, spray rinsates on the target area just treated or on other areas listed on the product label, if application rates and amounts will not be exceeded and if allowed by product label restrictions. If you are doing a series of applications using the same formulation, reuse the rinsate to dilute the next batch of formulation, as long as the site to which the rinse water is applied is a labeled site.

Leftover Spray Solutions

The way to “dispose” of excess spray solutions is to use all of the mixed pesticide in **accordance** with label instructions. Make sure that application rates and amounts are not exceeded. Avoid the problem of excess mixture by measuring and calibrating carefully. Fill your spray tank with only the amount required to do the job.

Excess Pesticide Product

Assuming the excess pesticide is in its original, properly labeled container, you may use the product up according to the label or give the pesticide to another certified applicator. Do not give RUPs to people that are not certified to apply them as that would be a violation. Additionally, you cannot sell unwanted RUPs to other certified applicators without a dealer license from CDA.

Canceled and Banned Pesticides

If you have a canceled or banned pesticide in its original, labeled container, there may be a recall program available. The manufacturer of the pesticide may collect the pesticide for disposal.

If legal, use the remaining product according to the pesticide label on the container. Pesticides for which the labeled uses have changed or pesticides that have been taken off the market can usually be used according to their container’s label until supplies are exhausted. However, there are exceptions to the rule. For some pesticides, EPA allows old label uses for only a short time after a product cancellation or label change. In rare cases, EPA may issue a “stop use” on a product at the time of its cancellation. Contact the pesticide manufacturer to find out whether you can still use a particular product.

Another option to dispose of unwanted, unused, banned, or outdated pesticides is to find a local waste disposal site. CDA maintains a Pesticide Waste Disposal page with an interactive map that allow you to search for the nearest site. There is a Statewide disposal service through Clean Harbors. (Additional Resources)

Hazardous Waste Disposal

Excess pesticide and rinsates that cannot be used must be disposed of as **hazardous waste**. A hazardous waste is a solid, liquid, or a contained gaseous material that is no longer used or that no longer serves the purpose for which it was produced, and could pose dangers to human health and the environment after it is discarded. Hazardous pesticide waste may be disposed of through the Clean Harbors (Additional Resources).

Treating and disposing of hazardous waste is expensive and carries with it serious legal responsibilities. People who generate hazardous waste must follow many state and federal rules and requirements, including:

- Identifying all hazardous waste generated
- Obtaining and using an EPA identification number
- Packaging, labeling, marking, and placarding wastes
- Keeping accurate records for a minimum of three years
- Ensuring that wastes meet treatment standards prior to disposal

Empty Pesticide Containers

Proper rinsing and handling of empty pesticide containers is very important because it:

- Protects humans by removing hazardous materials
- Prevents sources of environmental contamination
- Saves you money by putting all the product into the spray tank
- Makes recycling or disposal of clean containers convenient and inexpensive

Mishandled empty pesticide containers can create a major problem for you since most unrinsed containers are considered hazardous waste, complicating disposal. Only individuals trained as handlers under WPS can handle empty pesticide containers. Before they are rinsed or cleaned, pesticide containers can still hold enough material to harm you or the environment. When emptying or cleaning containers, protect your eyes and hands. Wear chemical-resistant gloves that will neither absorb pesticides or rinse water, nor let the material contact your skin. Wear goggles or a face shield that will protect your eyes from splashes or dust. You also may need to wear a respirator for protection from dust or fumes. At minimum wear the PPE required by the label.

General container handling guidelines:

- Never abandon empty containers. Uncleaned containers can be very dangerous to people, animals, and the environment. Abandoning containers, even cleaned ones, is against the law.
- When mixing, add container rinse water to the spray mix to avoid disposal problems.
- When purchasing pesticides, think about how you will dispose of the container. Manufacturers are putting more products in water soluble packages or in easily recycled containers to assist you in avoiding disposal problems and costs.

Metal or Rigid Plastic Pesticide Containers

Unless the pesticide label directs you otherwise, **triple rinse** containers or use pressure rinsing to clean them. Do not forget to completely rinse the hard-to-get-to areas inside the containers, such as the handle. Make sure you also rinse the outside of all containers.

Triple Rinse Procedure

1. Empty as much of the pesticide into the sprayer as possible. Turn containers that are 5-gallons or smaller upside down over the spray tank and let them finish draining for at least 30 seconds after they stop dripping. Pump or drain larger containers as empty as possible.
2. Add water or the mixing liquid to fill the empty container about 1/4 full.
3. Shake smaller containers thoroughly. Add the rinse water to larger containers so that it contacts all of the inside surfaces.
4. Drain the container completely by holding it over the spray tank or pumping out the liquid. Add this rinse water to the spray tank if at all possible.
5. Repeat this process at least 2 more times, until the container is clean. When triple rinsing will not sufficiently clean the container, keep rinsing until the rinse water runs clear from the container.
6. Puncture or crush the container to prevent reuse.

After empty pesticide containers are triple rinsed, they are no longer considered hazardous waste and usually may be disposed of as trash in a sanitary landfill, but if recycled, **must be recycled in a pesticide container recycling program, not mainstream recycling.**

Paper or Plastic Sacks and Fiber Containers

- Empty the contents completely into the application equipment. You may need to cut the container to clean out all of the material in the seams. Never rip the container, but use scissors or a knife (not your personal pocket knife). Wear appropriate PPE such as gloves, eye protection, and in some cases a respirator. Do not let material blow around.
- Rinse the container if you can. Some containers have plastic or foil liners that will allow you to rinse them. Use the rinse water in the spray mixture or collect it for disposal.
- Open both ends of the container to help remove any remaining pesticide and to prevent reuse of the container.

Transportation of Pesticides

You are responsible for the safe transportation of pesticides in your possession. Carelessness can result in broken containers, spills, contamination of the environment, and harm to yourself and others. Accidents can happen even if you are transporting pesticides over a short distance. A spill kit should always be carried in the vehicle used to transport pesticides.

Contents of Spill Kit	
• Ammonia, for after the clean-up stage	• Sturdy trash container with lid
• Paper towels	• Disposable brush and dustpan
• Cat litter or other absorbent material	• Spade or diking material
• Heavy duty trash bags for contaminated wastes	

Always transport pesticides in the back of a truck in containers with intact, undamaged and readable labels. Inspect containers before loading to insure that caps, plugs and other openings are tightly closed and no pesticide is on the outside of the container. However, even unopened containers can have pesticide residue on the outside, so proper PPE should be used when loading and unloading pesticide containers from a truck. **Anchor all containers securely to avoid rolling or sliding.** Treat your vehicle as a “mobile storage area.” In other words, treat the pesticides in your vehicle as you would pesticides in your storage area: i.e., keep **original containers** properly labeled and locked in a topper or a lockable tool box when the vehicle is stopped or unattended.

When transporting pesticides:

- Never carry pesticides in the passenger section of a car, van, or truck (vapors can make the driver and passengers ill).
- Never allow children, adult passengers, or pets to ride with the pesticides.
- Never transport pesticides with food, clothing, or other items meant for consumption or contact by humans or animals.
- Never leave the vehicle unattended when transporting pesticides in unlocked compartments or open truck beds.
- Always keep PPE separate from pesticides.

The Colorado State Patrol Hazardous Materials Section works to improve the overall safety of hazardous material (hazmat) transportation. This is accomplished by:

- Safe and efficient movement of hazardous materials on Colorado roadways through enforcement of permitting and routing

Pesticide Storage, Disposal, & Transportation

- Mutual cooperation with all entities involved in the shipping and transportation of hazardous materials
- Providing prompt emergency response for on-highway hazardous incidents and support of local government through mutual aid agreements or other formal requests for assistance
- Designation and maintenance of hazmat transportation routes
- Enforcement of applicable laws, rules, and regulations

For additional information on hazmat rules and regulations, call the Colorado State Patrol Hazardous Materials Section at 303-273-1900.

Additional Resources

- Chemical Transportation Emergency Center (Chemtrec). 1-800-262-8200. www.chemtrec.org. *A resource for obtaining immediate emergency response information for accidental chemical releases.*
- Clean Harbors. Phone: (303) 371-1100 ext. 233. <http://www.cleanharbors.com/>
- Colorado Department of Agriculture, Conservation Services Division, Groundwater Program. Phone: (303) 869-9042. <https://www.colorado.gov/pacific/agconservation/groundwaterprotection>. *Information on agricultural chemical storage facilities.*
- Crop Data Management Systems, Inc. <http://www.cdms.net/Label-Database>. *Links to online labels and SDS.*
- Department of Transportation (DOT) Office of Hazardous Materials Safety, Hazardous Materials Transportation Security, <http://phmsa.dot.gov/hazmat>. *Information on hazardous materials transportation safety and security.*
- Greenbook. <http://www.greenbook.net/>. *Links to online labels and SDS.*
- National Pesticide Information Center (NPIC), Phone: 1-800-858-7378 (Limited hours). <http://npic.orst.edu/>. *Call and ask questions about pesticides and pesticide related topics.*

Appendix

- Additional Calibration and Mixing Examples
- Private Applicator Record keeping Form
- Commonly Used Acronyms

Calibration of Boom Sprayers - Alternate methods

Nozzle Method

The nozzle method of calibration is a quick and accurate way to calibrate any sprayer as long as the ground speed is known and can be accurately controlled. It can be used to calibrate in the shop or in the farmyard and is valuable as a quick check for nozzle wear. By using this method it is possible to accurately predict the spray rate at any controlled speed.

The nozzle method requires checking only one nozzle on the sprayer, but assumes all nozzles are delivering the same amount. Be sure to check that all nozzles are delivering at nearly the same rate when using this method of calibration (nozzle flow rate measurement devices are available for purchase, which greatly helps with quickly checking each nozzle). Nozzles must be replaced when their flow rate is greater than or equal to 10% above or below the manufacturer's spec.

The nozzle method using a constant is based on the formula:

$$\text{Spray rate (GPA)} = \frac{\text{One nozzle output (oz per min)} \times 46.4^*}{\text{One nozzle coverage (in)} \times \text{Speed (mph)}}$$

**This constant applies to delivery measured in ounces, derived as follows:*

$$\text{Constant} = \frac{43,560 \text{ sq ft/acre} \times 12 \text{ in/ft}}{88 \text{ ft/min}^{**} \times 128 \text{ oz/gal}} = 46.4$$

***88 ft/min = 1 mph*

Constants to use when the delivery is measured in other units of volume other than ounces:

- Pints: 742.6
- Quarts: 1,484.8
- Gallons: 5,940

Steps:

1. Set the pressure the same as is to be used in the field and collect the water from 1 nozzle for exactly 60 seconds. Measure water carefully.
2. Measure coverage of a nozzle in inches. On a boom sprayer, the coverage is the same as the nozzle spacing on the boom.
3. Multiply the amount (oz of water) collected in 1 min from Step 1 by 46.4 (a constant).
4. Multiply the forward speed that the sprayer will use (mph) by the nozzle spacing (in).
5. Divide the answer obtained in Step 3 by the answer in Step 4. This is the gallons of water the sprayer is delivering per acre.

Example: A sprayer has 16 nozzles spaced 18" apart and the boom covers a 24 ft swath. When operated at 40 psi, 1 nozzle delivers 40 oz of water in 1 min. The sprayer is to be operated at 4 mph. What is the application rate?

Steps:

1. 40 oz per min (measured)
2. Nozzle spacing = 18"
3. 40 oz X 46.4 = 1,856
4. 4 mph X 18" = 72
5. 1,856 divided by 72 = 25.8 GPA applied

Caution - Be sure all nozzles are delivering at nearly the same rate (+ or - 5% of the average) when using this method of calibration.

Nozzle Method #2 (Unit Cancellation)

Calibrating by using conversion factors is helpful because you can check yourself by canceling units as you go.

Example: A sprayer has 16 nozzles spaced 18" apart and the boom covers a 24 ft swath. When operated at 40 psi, 1 nozzle delivers 40 oz of water in 1 min. The sprayer is to be operated at 4 mph. What is the application rate?

$$\begin{array}{r}
 \text{Spray rate} \\
 \text{(GPA)} = \frac{40 \text{ oz}}{1 \text{ minute}} \times \frac{1 \text{ gal}}{128 \text{ oz}} \\
 \times \frac{4 \text{ miles}}{1 \text{ hour}} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ acre}}{43,560 \text{ sq ft}} \times \frac{5,280 \text{ ft}}{1 \text{ mile}} \times \frac{1 \text{ hour}}{60 \text{ min}} \\
 \text{Spray rate (GPA)} = \frac{0.3125 \text{ gallons/min}}{0.012121212 \text{ acre/min}} = 25.9 \text{ GPA}
 \end{array}$$

Calibrating Boomless Sprayers

1. Select a course length based on spray swath width (from chart below)

Spray Width (feet)	30	32	34	36	38	40	42	44
Course Length (feet)	182	171	161	152	144	137	130	124

*If your sprayer's spray width is not listed, divide 5,460 by your spray width to get travel distance.

2. Measure out course in field to be sprayed.
3. Measure time to drive course. Use a comfortable gear and speed. Take the average of three trips. Make note of engine speed (rpm).

4. Park tractor with engine running at same rpm, put garbage bag around nozzle and catch the output for the time found in Step 3.
5. Measure in pints. This measurement will equal sprayer output in gallons per acre.
6. Determine acres that can be covered with the tank. This will be tank volume (gallons) divided by sprayer output (gallons from Step 5).
7. Multiply acres from Step 6 by the desired herbicide rate. This total will give the amount of herbicide to add to full tank.

Example: You would like to spray 2 pints 2,4-D per acre. How much herbicide do you need to add to the tank if you have a sprayer that holds 100 gallons with a spray width of 34 feet?

- Measure a course 161 feet in length.
- You drive the course three times and average 41 seconds to drive the 161 feet.
- Park the tractor and catch the spray from the nozzle for 41 seconds, which you find measures 20 pints. You are applying 20 gallons per acre.
- The sprayer holds 100 gallons, so $100 \text{ gallons} \div 20 \text{ gal/acre} = 5 \text{ acres}$ can be covered with each tank.
- $2 \text{ pints per acre 2,4-D} \times 5 \text{ acres} = 10 \text{ pints 2,4-D}$ needs to be added to each tank.

Calibration of Air Blast Sprayers

Time/Rate Method:

1. Measure the time needed to travel the length of the preselected and pre-measured calibration plot.
2. Go to a water source and fill the tank with water to some known level.
3. Operate the sprayer, without moving, at the desired pressure and pump speed for exactly the amount of time determined in Step 1 (not necessary to operate fan).
4. Accurately measure the amount of water needed to refill the tank to the previous water level.
5. Determine the rate by dividing the amount of water used by the area sprayed (test plot size).

Example: if 15 gallons are required to refill the tank and the calibration plot is 0.3 acre, the application rate is 50 GPA ($15 \text{ gallons}/0.3 \text{ acre}$).

For more information on Air Blast Sprayers (calibration and adjustments), visit Sprayers 101 at <http://sprayers101.com/airblast-output/> sprayers101.com/airblast-output/

Mixing Concentrates for Air Blast Sprayers or Mist Blowers

Pounds or Gallons per Acre or Pounds or Gallons per 100 gallons of Carrier

If the dosage recommendations are listed as lbs or GPA or lbs or gal per 100 gal of carrier for use in boom or hydraulic sprayers, you will need to convert the dosage to the concentration factor you have chosen (usually 2X, 3X, 4X, 5X, or 10X). Simply follow the steps listed above for the dry or liquid formulation you are using. The last answer should be multiplied by the concentration factor.

$$\begin{array}{rcl} \text{lbs or gal} & & \text{Concentration} \\ \text{formulation per tank} & \times & \text{factor} \\ & & = \\ & & \text{lbs or gal formulation per} \\ & & \text{tank in concentrate form} \end{array}$$

Example: The label lists the dosage as 4 lbs formulation per 100 gal of water for dilute application. Your air blast sprayer tank holds 600 gal You wish to apply a 5X concentration.

$$\begin{array}{r} 600 \text{ gal per tank} \times 4 \text{ lbs} \\ \text{-----} \\ 100 \text{ gal} \end{array} = 24 \text{ lbs needed in tank for hydraulic sprayer}$$

$$\begin{array}{rcl} 24 \text{ lbs formulation} & & 5X \text{ concentration} \\ \text{per tank} & \times & \text{wanted} \\ & & = \\ & & 120 \text{ lbs formulation to} \\ & & \text{add to air blast tank} \end{array}$$

Calibration of Granular Applicators

Granular applicators need to be calibrated only to adjust the rate of flow or delivery. To keep the amount of pesticide released uniform, the travel rate is kept at an even pace. Whether hand-carried or vehicle-mounted, the speed of the equipment determines the amount of pesticide applied per unit area. The speed used during calibration should be the same as the operational speed, and for greatest accuracy the calibration should be conducted at a site similar to the operational target site. Companies manufacturing granular applicators include rate-guide charts in the operator manuals. These charts show the proper settings for a desired application rate. These settings are usually reliable, but make a field check to insure accuracy.

Field Calibration for Agriculture

1. Measure and mark 300 ft in the field
2. Fill one hopper with granules
3. Disconnect the delivery tubes from the applicator
4. Catch the material from the applicator in a suitable container (bucket, plastic bag, plastic sack, etc.) while driving the tractor over the 300 ft measured course at a speed that will be used in the field
5. Measure the weight of the granules discharged by the applicator in lbs

- Calculate the sq ft of the test area. For insecticide and herbicide applications, multiply the row width in ft times the distance covered (300 ft)
- Calculate the rate per acre. Multiply the lbs collected (Step 4) by 43,560 and divide the answer by the sq ft of the area (Step 6)

$$\text{Pounds per acre} = \frac{43,560 \times \text{Pounds applied over test area}}{\text{Area of measured course in sq ft}}$$

- Adjust applicator and repeat the process until the desired rate is obtained. After one hopper has been adjusted, the other hoppers may be calibrated by adjusting each one to discharge the same amount of granules over the 300 ft course.

Example: An application is applied at 5 lbs of pesticide over a test area. The swath width is 15 ft and the test run is 300 ft long. How many lbs per acre is the application?

$$\text{Pounds per acre} = \frac{43,560 \text{ sq ft/acre} \times 5 \text{ pounds}}{15 \text{ ft (swath width)} \times 300 \text{ ft (distance covered)}}$$

$$\text{Pounds per acre} = 48.4 \text{ lbs/acre}$$

Shop Calibration

Power Take-Off (PTO) driven granular applicators can be calibrated in the shop by calculating the distance that will be traveled in 1 min, then collecting granules for 1 min with the applicator running at field speed.

Example: The application will be applied at 3 mph in the field and the amount of granules collected in 1 min at this speed is 1/8 lb per tube on a 3 row distributor. The band width will be 12". The application rate will be:

$$\frac{43,560 \text{ sq ft}}{1 \text{ acre}} \times (1/8 \text{ lb} \times 3 \text{ rows})$$

$$= 20.6 \text{ lbs formulation per acre}$$

$$3 \text{ ft} \times (3 \text{ mph} \times \frac{88 \text{ ft}^*}{1 \text{ mph}})$$

*88 ft at 1 mph = Feet per minute

Calibrating for Granular Insecticide Applications

The labels for some granular insecticides recommend applying a certain number of ounces of formulated product per 1,000 ft of row. Calibration is complete when the desired amount of formulated product is collected in the prescribed distance.

Many companies offer calibration tubes for their materials which can be attached to the distributor tube and will give a direct reading for that particular formulation. These tubes can be used only for the designated chemical.

Calibrating Rotary and Drop Spreaders

The delivery rate of granular spreaders can be altered by a number of factors, including temperature, humidity, rate adjustments, and differences in the size or type of granules. Even a different lot number of the same granular formulation can make a difference. Recalibrate your spreader any time any of these conditions changes. The operator of the spreader also affects the delivery rate, so the person who will operate the device should perform the calibration procedure.

When you are using a spreader regularly, it is a good idea to calibrate the device weekly, even if none of these conditions change, because the delivery rate can drift out of calibration through everyday use (and abuse) of the spreader.

A few different methods for calibrating granule sprayers exist. The "Drop Spreader Calibration" resource listed at the end of this chapter is different from the method listed below. Take a look at a few methods before deciding which to use. Use the method that makes the most sense for you and works for you.

Granular calibration method:

1. Measure a known area. Use the formulas covered in Chapter 8 on how to calculate the target area. For calibrating granular spreaders, a rectangular target area is probably the easiest to work with.
2. Set up a collection device. This can be a tarp laid out over the target area or a catch container mounted on the spreader. If you use a catch container, be sure that the device does not interfere with the delivery rate.
3. Apply at proper speed and gate setting. The rate at which granules flow out of the spreader depends on the size of the gate opening. A larger opening allows more granules to flow, so changing the size of the gate opening significantly increases or decreases the delivery rate. The speed at which the spreader moves also affects the delivery rate. When travel speed increases, less material is applied per unit area, and when speed is reduced, more material is applied.
4. Collect and weigh the amount of chemical applied over the target area. The delivery rate is the weight of material collected per the size of the target area. For example, if the target area was 300 sq ft and the amount of chemical applied was 2.5 ounces, the delivery rate is 2.5 oz/300 sq ft.
5. Convert the delivery rate to the units specified on the label. Using the same example described above, a delivery rate of 2.5 oz/300 sq ft converts to 8.3 oz/1,000 sq ft or 22.6 lbs/acre.

- Adjust the gate setting or speed to achieve the desired delivery rate. For small changes, simply alter the speed at which the spreader travels. For larger changes, adjust the size of the gate opening to increase or restrict the flow of granules.

Calibrating Chemigation Equipment

Calibrating chemigation equipment is relatively simple, but requires time, equipment, and accurate calculations. Always calibrate the irrigation system and injection pump yourself rather than relying on data furnished by the manufacturer.

Calibration of center pivot chemigation systems involves the following steps:

- Circumference of the center pivot

$$\text{Circumference} = 2 \pi r$$

$$\pi = 3.14$$

r = distance in feet from the pivot point to the last tower, including reach of end gun

- Acres to be treated

$$\text{Acres} = \frac{\pi r^2}{43,560 \text{ sq ft/A}}$$

r = distance in feet from the pivot point to the last tower, including the reach of the end gun

- Rate of travel

To determine ft per min, measure the distance traveled by the last tower in 10 min, while the system is delivering water at the volume desired for the application

- Revolution time

$$\text{Time} = \frac{\text{Circumference in ft (Step 1)}}{\text{Ft per min (Step 3)}}$$

- Acres treated per minute

$$\text{Acres treated per min} = \frac{\text{Acres to be treated (Step 2)}}{\text{Revolution time (Step 4)}}$$

- Application rate

$$\text{Milliliters per min} = \text{Milliliters of pesticide X Acres per min applied per acre}$$

Once the application rate is known, adjust the injection pump. This is best accomplished by mounting a measuring cylinder in-line between the nurse tank and the pump. This is filled and the rate of emptying is monitored until the proper rate is achieved. Use short timings for coarse adjustments and longer intervals for the final checks. Recheck the injection pump

several times during the application.

Common Mathematical Abbreviations		
A.....acre	lb.....pound(s)	qt.....quart(s)
ft.....foot or feet	min.....minute(s)	sec.....second(s)
gal.....gallon(s)	oz.....ounce(s)	sq ft.....square feet
in.....inch(es)	pt.....pint(s)	

Conversion Tables	
Area	Volume
144 square inches.....1 square foot	1 tablespoon (tbs).....3 teaspoons (tsp)
9 square feet.....1 square yard	1 fluid ounce.....2 tablespoons
43,560 square feet.....1 acre	8 fluid ounces...16 tablespoons1 cup
4,840 square yards.....1 acre	16 fluid ounces.....2 cups.....1 pint
160 square rods.....1 acre	32 fluid ounces.....4 cups.....1 quart
640 acres.....1 square mile	128 fluid ounces.....4 quarts.....1 gallon
2.5 acres.....1 hectare	1 liter.....33.9 ounces.....1.06 quarts
Length	Weight
1 inch.....2.54 centimeters...25.5 millimeters	1 ounce.....28.3 grams
1 foot.....12 inches	1 pound.....16 ounces.....453.6 grams
1 yard.....3 feet	2.2 pounds.....1 kilogram....1,000 grams
1 rod.....5.5 yards.....16.5 feet	1 ton.....2,000 pounds....907 kilograms
1 mile...320 rods....1,760 yards...5,280 feet	1 metric ton..1,000 kilograms..2,205 pounds
1 meter.....39.4 inches.....1.09 yards	
1 kilometer.....1,000 meters.....0.62 miles	

Name of Certified Applicator:**1 _____ Certification Number:*1 _____

Description/Location of Treated Area:**2 _____

Date of Application**3	Start & End Time of Application*3	Crop, Commodity, or Site*4	Brand Name/Product Name**5	Active Ingredients*6	EPA Registration Number**7	Size of Area Treated*8	Total Amount of Pesticide Used*9	Restricted Entry Interval†10	
								Duration	Expiration

Restricted Use Pesticide (RUP) records must be completed within 14 days of application and kept for 2 years. Worker Protection Standard (WPS) records must be completed before application and kept for 30 days after the REI expiration.

* This information is required by the Federal Pesticide Record Keeping Regulation.

† This information must be provided to field workers/handlers for all pesticides with "Agricultural Use Requirements" on the label. This information must be posted at the Central Location within 24 hours before application and remain for 30 days after the end of the REI for the WPS requirement.

Description of Required Records

- ❶ Write the **name** and **certification number** of the person applying the pesticide.
- ❷ Write the **location of the field** (not the farm or business). The field may be identified on a farm map, by a USDA map and number, by a common field name (for example 33 Flander Field), or by a legal description. If the site treated is a greenhouse or storage facility, give it a unique name or number.
- ❸ Fill in the **month, day, and year** of application. WPS also requires you to post the **start and end times** of application.
- ❹ Fill in the **crop, commodity, or site**. If the location is a greenhouse, record crop and site location. If you are treating livestock, record the type of animals treated (cattle, hogs, etc.).
- ❺ Write the **brand** or **product name** of the pesticide. Multiple lines may be used to record tank mixes. Information on all products used in a tank mix is required.
- ❻ Copy the **active ingredient(s)** from the label for all products used in the application.
- ❼ The **EPA Registration Number** is located below the ingredients statement on most labels. It is NOT the same as the EPA establishment number (for example, EPA Reg. No. 241-337).
- ❽ Record the **number of units treated**. This may be acres, linear feet, bushels, cubic feet, square feet, or number of animals, etc. For special applications (for example, alternate middles, weed wicks, band applications) record the total area covered. A 20 acre field treated using a band application would still be recorded as 20 acres.

 "Spot treatments" are applications made to less than 1/10th of an acre. Application of a herbicide along a fence row or an insecticide applied on an ant mound would be examples of spot treatments. (NOTE: Greenhouse and nursery treatments do NOT qualify as spot treatments.) For spot treatments, describe location of area treated (for example, field bindweed along fence row of Harold Farm), indicate "spot treatment," and record location; month, day, and year; brand name; EPA registration number, and total amount applied.
- ❾ The **total amount applied** is figured as the amount of product multiplied by the area treated. Multiply the rate per unit (for example, 1.5 pints per acre or 1 pound active ingredient per acre) found on the pesticide label by the size of the treated area to get the total amount. Record the total quantity of pesticide used, NOT the quantity after water or carrier added.
- ❿ The pesticide label lists the **Restricted Entry Interval (REI)**. The application information for workers must remain posted until 30 days after the end of the REI. When there is no REI, the notice must remain for 30 days after the application date. IF you apply pesticides in a tank mix with different REIs, write down the longest REI.

List of Acronyms

A		G	
AEZ	Application exclusion zone	G	Granular formulation
a.i.	Active Ingredient	GPA	Gallons Per Acre
ARS	Agricultural Research Service	GPH	Gallons Per Hour
B		GPM	Gallons Per Minute
BMP	Best Management Practice	GUP	General Use Pesticide
Bt	<i>Bacillus thuringiensis</i>	GWA	Groundwater Advisory
C		H	
CDA	Colorado Department of Agriculture	HAZMAT	Hazardous Materials
CDOT	Colorado Department of Transportation	I	
CDPHE	Colorado Department of Public Health and Environment	IGR	Insect Growth Regulator
CEPEP	Colorado Environmental Pesticide Education Program	IPM	Integrated Pest Management
CFR	Code of Federal Regulations	L	
CHEMTREC	Chemical Transportation Emergency Center	L	True Liquid/Solution formulation
CPR	Cardio Pulmonary Resuscitation	LC ₅₀	Lethal Concentration to 50% of test organisms
CSU	Colorado State University	LD ₅₀	Lethal Dose to 50% of test organisms
D		M	
D	Dust formulation	MESA	Mining Enforcement & Safety Administration
DF	Dry Flowable formulation	MPH	Miles Per Hour
DOT	Department of Transportation	MRL	Maximum Residue Limit
E		N	
E or EC	Emulsifiable Concentrate formulation	NIOSH	National Institute of Occupational Safety & Health
EPA	Environmental Protection Agency	NOAA	National Oceanic and Atmospheric Administration
EPCRA	Emergency Planning & Community Right to Know Act	NOP	National Organic Program
ESA	Endangered Species Act	NPIC	National Pesticide Information Center
EW	Concentrated Emulsion	O	
F		OSHA	Occupational Safety and Health Administration
F	Flowable formulation	P	
FDA	Food & Drug Administration	PGR	Plant Growth Regulator
FFDCA	Federal Food, Drug, and Cosmetic Act	PHI	Preharvest Interval
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act	PPB	Parts Per Billion
FQPA	Food Quality Protection Act		

PPE Personal Protective Equipment
PPM Parts Per Million
PPT Parts Per Trillion
PSI Pounds per Square Inch
PTO Power Take Off

R

RCRA Resource Conservation &
Recovery Act
REI Restricted Entry Interval
RPM Revolutions Per Minute
RTU Ready To Use formulation
RUP Restricted Use Pesticide

S

SARA Superfund Amendments &
Reauthorization Act
SCBA Self-Contained Breathing
Apparatus
SDS Safety Data Sheet
SDWA Safe Drinking Water Act
SLN Special Local Need
SWA Surface Water Advisory

T

TLV Threshold Limit Value

U

ULV Ultra Low Volume concentrates
formulation
USEPA United States Environmental
Protection Agency
USDA United States Department of
Agriculture
USFWS United States Fish & Wildlife
Service

W

W or WP Wettable Powder formulation
WPS Worker Protection Standard
WSP Water Soluble Powder
formulation

Glossary

Words in this glossary appear in boldface type the first time they appear in the study guide.

Abdomen - The last of the three major body divisions of an insect.

Abiotic - A nonliving, disease-causing entity, e.g., drought, salt, air pollutants.

Absorption - The process by which pesticides are taken into plants by roots or foliage (stomata, cuticle, etc.), animals (including humans), and microorganisms.

Absorptive clay - A special type of clay powder which can take up chemicals and hold them. It is sometimes used to clean up pesticide spills.

Acaricide - A pesticide used to control mites and ticks. Same as miticide.

Accordance - Agreement. Example: to follow directions on the pesticide label.

Acid equivalent (a.e.) - The theoretical yield of parent acid from an ester of salt such as esters of 2,4-D or the amine salt of 2,4-D.

Activated charcoal - Very finely ground, high quality charcoal which absorbs liquids and gases very easily.

Activator - A material added to a pesticide to increase, either directly or indirectly, its toxicity.

Active ingredient (a.i.) - The chemical or chemicals in a product responsible for the desired effects, which are capable of preventing, destroying, repelling or mitigating insects, fungi, rodents, weeds, or other pests.

Acute dermal toxicity - Poisoning from a single dose of a chemical absorbed through the skin.

Acute inhalation toxicity - How poisonous a single dose (or exposure) of a pesticide is when breathed into the lungs.

Acute oral toxicity - Poisoning from a single dose (or exposure) of a chemical taken by mouth.

Acute poisoning - Poisoning which occurs after a single dose (or exposure) of a pesticide.

Acute toxicity - Poisoning which occurs when a large amount of a pesticide enters the body from a single or short-term exposure.

Adjuvant - A chemical or agent added to a pesticide mixture which helps the active ingredient do a better job or increases the effectiveness of the pesticide. Examples: wetting agent, spreader, adhesive, emulsifying agent, penetrant.

Adsorption - The process by which materials are held or bound to the surface in such a manner that the chemical is only slowly available. Clay and high organic soils tend to adsorb pesticides in many instances.

Aerial application - Treatment applied with the use of an airplane or helicopter.

Aerosol spray - A fine spray produced by pressurized gas that leaves very small droplets of pesticide suspended in air.

Agitation - The process of stirring or mixing to keep a pesticide or tank mix from separating or settling in the spray tank.

Agitator - A paddle, air, or hydraulic action to keep a pesticide chemical mixed in the spray or loading tank.

Agricultural commodity - Any plant, or part thereof, or animal, or animal product, produced by a person (including farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animals. Defined by the Rules and Regulations Pertaining to the Colorado Pesticide Applicators' Act.

Agricultural worker - Those who perform tasks related to the cultivation and harvesting of plants on farms or in greenhouses, nurseries, or forests. Workers include anyone employed for any type of compensation (including self-employed) doing tasks related to the production of agricultural plants on an agricultural establishment. Defined by WPS.

Air blast sprayer - A machine which can deliver high and low volumes of spray. It is used for orchards, shade trees, vegetables, and fly control.

Amine - An organic compound containing hydrogen derived from ammonia by replacing one or more hydrogen atoms by as many hydrocarbon radicals.

Amphibians - Animals of the class Vertebrata. They are cold blooded and have moist skin without scales, feathers, or hair. Examples are frogs, toads, and salamanders.

Antibiotics - Chemical compounds produced by microorganisms which are toxic to other microorganisms.

Anticoagulant - A chemical used in a bait to destroy rodents. It destroys the walls of the small blood vessels, and keeps the blood from clotting. As a result, the animal bleeds to death.

Antifoaming agent - Type of adjuvant that eliminates or suppresses foam in the spray tank.

Antidote - A practical immediate treatment including first aid in case of poisoning; a remedy used to counteract the effects of a poison.

Application - The placing of a pesticide on a plant, animal, building, or soil; or its release into the air or water to prevent damage, or destroy pests.

Application Exclusion Zone - an area of restricted entry up to 100 feet around application equipment during pesticide application on farms, forests, and nurseries.

Applicator - A person or piece of equipment which applies pesticides to destroy pests or prevent damage by them.

Aquifer - An underground bed or layer of earth, gravel, or porous stone that yields water.

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 examples of invertebrates in the phylum Arthropoda.

Attractants - Substances or devices capable of attracting insects or other pests to areas where they can be trapped or killed.

Backpack sprayer - A sprayer that can be strapped on the back and used to apply liquid pesticide chemicals. The attached hose has a nozzle at the tip that can be aimed at the spot to be treated.

Bacteria - Any of numerous, sometimes parasitic, unicellular organisms having various forms and often causing disease.

Bactericide - Any chemical used to kill bacteria.

Bait - An edible material that is attractive to the pest, which normally contains a pesticide unless used as a pre-bait.

Band application - An application to a continuous restricted area such as in or along a crop row rather than over the entire field area or around the perimeter of a building or property.

Basal treatment - A treatment applied to the stems or trunks of plants at and just above the ground line.

Beneficial - Useful or helpful to man. A lady beetle is beneficial because it feeds on other insects that damage plants.

Biennial - A plant that completes its life cycle in two years. The first year it produces leaves and stores food (in a rosette form). The second year, it produces fruits and seeds.

Biological control - Control of pests by means of predators, parasites, and disease producing organisms.

t.

Biotic - Relating to living organisms.

Blight - A general term that may include spotting, discoloration, sudden wilting, or death of leaves, fruit, flowers, stems, or the entire plant.

Brand - The name, number, trade mark, or designation of a pesticide or device made by the manufacturer, distributor, importer, or vendor. Each pesticide differing in the ingredient statement, analysis, manufacturer, or distributor name, number or trade mark is considered as a distinct and separate brand.

Broadcast spray - An application over an entire area.

Broad spectrum pesticide - One that controls a wide range of pests when applied correctly.

Buffers - Decrease break down of pesticides from exposure to alkaline water conditions in spray tanks.

Calibrate - To measure or figure out how much pesticide will be applied by the equipment to the target in a given amount of time.

Calibration - The process of measuring and adjusting the amount of pesticide that a particular piece of equipment will apply to a target site.

Canceled - A pesticide use that is no longer registered as a legal use by the EPA.

Canister - A metal or plastic container filled with absorbent material which filters fumes and vapors from the air before they are breathed in by an applicator.

Canker - A definite, localized, dead, often sunken or cracked area on a stem twig, limb or trunk, surrounded by living tissues. Cankers may girdle affected parts resulting in a die back starting in the tip.

Carbamates - A class of chemicals which inhibits cholinesterase, resulting in unregulated nerve ending activation and paralysis in insects.

Carbon dioxide - Heavy, colorless gas that does not support combustion.

Carcinogen - A substance or agent capable of producing cancer.

Carcinogenicity - The term used to describe the cancer producing property of a substance or agent.

Carrier - The liquid or solid material added to a chemical compound to facilitate its field application. An inert material which, when used with a toxic compound, improves the physical dispersion of the toxicant.

Cartridge - The part of a respirator which adsorbs fumes and vapors from the air before the applicator breathes them in.

Causal organism - The organism that produces a given disease.

Glossary

Caution - (1) A warning to the user of pesticides. (2) One of three signal words. (3) Used on labels of pesticide containers which are slightly toxic pesticides, in toxicity Category III as defined by FIFRA.

Central location - Designated area where pesticide safety and application information are maintained for that operation. Defined by WPS.

Certified applicator - Any applicator who has satisfactorily completed the certification requirements for a commercial or private applicator in Colorado.

Chemical cartridge respirator - Respirator using various chemical substances to purify inhaled air of certain contaminative gases or vapors.

Chemical control - Reduction of pest populations or prevention of pest injury by the use of materials to poison them, attract them to other devices, or repel them.

Chemical family - Group of compounds that share certain chemical characteristics and have a common name.

Chemical name - One that indicates the chemical composition and/or chemical structure of the compound being discussed.

Chemigation - The process where agricultural chemicals are applied to land or crops in or with water through a closed irrigation system.

Chlorosis - The yellowing of a plant's normally green tissue because of a partial failure of the chlorophyll to develop.

Cholinesterase - A body enzyme necessary for proper nerve function that is destroyed or damaged by organic phosphates or carbamates taken into the body by any path of entry.

Cholinesterase inhibitor - Any organophosphate, carbamate, or other pesticide chemical that can interrupt the action of enzymes which inactivate the acetylcholine associated with the nervous system.

Chronic poisoning - Resulting from long periods of exposure to a chemical.

Chronic toxicity - Ability to cause injury or death from prolonged exposure.

Classification - The process of assigning pesticides into groups according to common characteristics, such as mode of action.

Closed irrigation system - Includes any device or combination of devices having a hose, pipe, or other conduit, which connects directly to any source of groundwater or surface water, through which water or a mixture of water and chemicals is drawn and applied for agricultural or horticultural purposes.

Commercial applicator - Any person or company who engages in the business of applying pesticides or operating a device for hire. A certified applicator (whether or not he or she is a private applicator with respect to some uses) who uses or supervises the use of any pesticide which is classified for restricted use for any purpose on any property other than as provided by the definition of "private applicator."

Common name - (1) A well-known, simple name of a pesticide accepted by the Pesticide Regulation Division of the EPA. Examples: carbaryl, atrazine, benomyl. (2) Also used to describe a living thing. It is possible for two living things to have the same common name in different places. In addition, the same living thing may have several common names.

Compatible - Two compounds are said to be compatible when they can be mixed without affecting each other's properties.

Complete metamorphosis - Type of insect development characterized by four distinct stages: egg, larva, pupa, and adult.

Compressed air sprayer - Sprayer, usually 1-5 gallon capacity with extension rod, equipped with an air pump to develop pressure, often with shoulder strap for carrying. Not suitable for spraying at heights over 6-8 feet.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full-strength, but usually diluted before application.

Concentrated emulsion (EW) - Formulation consisting of a water-based emulsion and an active ingredient paste.

Concentration - The amount of a substance contained in a unit volume, i.e., 4 pounds per gallon; or the percentage of the substance, as in a 50% wettable powder.

Confined areas - Rooms, buildings, and greenhouses with limited or inadequate ventilation.

Conidia - Asexual fungal spores.

Contact pesticide - A pesticide which kills when it touches or is touched by a pest.

Contaminate - To alter or render a material unfit for a specified use, by introduction of a foreign substance (a chemical).

Control - To prevent from doing damage. To reduce or keep down the number of pests so that little disease, damage or injury occurs to a crop or property.

Corrosive - Having the power to eat away slowly. Some pesticides eat or wear away rubber hoses, nozzles, and other parts of spray machinery.

Coverage - The amount of spread of a pesticide over a surface.

Crop - Cultivated plants or agricultural produce, such as grain, vegetables, or fruit, growing where it is desired for use by humans.

Crop tolerance - The degree or the ability of the crop to be treated with a chemical but not injured.

Cross contamination - When one pesticide gets into or mixes with another pesticide, in a container or in a poorly cleaned sprayer.

Cross resistant - When a pest population which has become resistant to one pesticide also becomes resistant to other chemically related pesticides.

Crown - The point where stem and root join in a seed plant. This term is also used to describe the foliage and branches of trees.

Crustacean - A type of small animal characterized by a hard exoskeleton, two body sections and 5-7 pairs of legs. Examples: shrimp and pillbugs.

Cultural control - Control measures including modifications of the planting, growing, cultivating, and harvesting of crops aimed at prevention of pest damage.

Cumulative pesticides - Those chemicals which tend to accumulate or build up in the tissues of animals or in the environment (soil, water).

Curative pest control - Responding to pest problems as they arise or are detected by scouting, trapping, or other means of detection.

Custom applicator - Any person, who for hire, by contract or otherwise, applies by aerial, ground, or any hand or mechanical equipment, pesticides, to any waters, land, plants, farm structures, or animals.

Damaging - Harmful. Injurious.

Damping off - Rotting of seeds in the soil, or the sudden wilting and death of seedlings anytime after germination. Usually caused by fungi that attack the seed or stem of the plant.

Danger - (1) Risk, hazard. A warning to the user of pesticides. (2) One of three signal words. (3) Used on labels of pesticide containers which are highly toxic pesticides, in toxicity Category I as defined by FIFRA.

Days to harvest - The minimum number of days permitted by law between the final pesticide application and the harvest of crops. Same as preharvest interval.

Decontaminate - To make safe by removing any pesticide from equipment or other surfaces as directed on a pesticide label or by an agricultural authority.

Deflocculating agent - A substance that prevents rapid precipitation (settling out) of solids in the liquid in the spray tank.

Defoliant - A preparation intended for causing leaves to drop from crop plants such as potatoes, usually to facilitate harvest.

Degradation - Breakdown of a complex chemical by the action of microbes, water, air, sunlight or other agents.

Degree of exposure - The amount or extent to which a person has been in contact with a toxic pesticide.

Dermal - Of or pertaining to the skin.

Dermal exposure - Having pesticide on your skin.

Dermal toxicity - Dermal toxicity is the passage of pesticides into the body through the unbroken skin.

Desiccant - A compound that promotes drying or removal of moisture from plant tissues.

Desiccation - Dehydration or the removal of tissue moisture by chemical or physical action. Primarily used for preharvest drying of actively growing plant tissues when seed or other plant parts are developed but only partially mature; or for drying of plants which normally do not shed their leaves, such as potatoes, corn, small grains, and cereals.

Detoxify - To make harmless.

Device - Any instrument or contrivance intended for trapping, destroying, repelling, or mitigating any pest. Examples: water filters, black light traps, and ultrasonic rodent or insect repellents.

Dicot - A plant with two cotyledons or seed leaves. Dicots are also called broad-leaves and usually have leaf veins in a net-like pattern and a taproot.

Diluent - A material, liquid or solid, serving to dilute the technical toxicant to field strength for adequate plant coverage, maximum effectiveness and economy.

Dilute - To make less concentrated. To mix a pesticide chemical with water, oil, or other materials before it can be safely and correctly used.

Dilution rate - The amount of formulated product to be mixed with a given amount of water or other carrier to make the final mix that is applied.

Directed spray - An application to a specific area such as a row, bed, or at the base of plants.

Disease triangle - The relationship of the following three factors: a susceptible host plant, a pathogen, and the right mix of environmental conditions.

Disposal - The process of discarding or throwing away unused spray material, surplus pesticides, and pesticide containers.

Dissolve - Usually refers to getting solids into suspension and/or solution which is necessary for uniform application results.

Glossary

Distribution - The amount and way in which a pesticide is spread when applied to a plant, animal or other surface. Also, part of the U.S. or the world in which insects, fungus, or other pests are found.

Dormant - (1) Inactive. Not growing. (2) In the case of plants, it is after the leaves fall or growth stops and before the buds open in the spring. (3) The period when seeds fail to sprout due to internal controls.

Dormant spray - A spray applied when plants are in a dormant condition.

Dosage - The amount of medicine in a dose. Used in connection with pesticides it refers in general to rate of application.

Dose - (1) Amount or quantity of a pesticide which is applied to a target site or pest. (2) A measure of exposure used in animal testing to determine acute toxicities; usually expressed in milligrams per kilogram of body weight.

Drench - (1) Saturation (thorough soaking) of the soil with a pesticide. (2) An oral treatment of an animal.

Drench treatment - The application of a liquid to an area until the area is completely soaked.

Drift - The physical movement of pesticide through the air at the time of pesticide application or soon thereafter from the target site to any non- or off-target site. Pesticide drift must not include movement of pesticides to non- or off-target sites caused by erosion, migration, volatility, or windblown soil particles that occurs after application unless specifically addressed on the pesticide product label with respect to drift control requirements.

Dry flowable (DF) - Formulation made of finely ground pesticide particles, compressed into granules that can be suspended readily in water for application.

Dust (D) - 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.

Dusters - Hand applicators that blow fine particles of pesticide dusts onto target surfaces.

Economic injury level - The level of damage to a crop that is equal in value to the cost of suppressive measures.

Economic threshold - That point of pest infestation where application of a control measure would return more money than the cost of the control procedure.

Efficacy - The effectiveness of a given pesticide or pest control method at controlling a particular pest species under a given set of conditions.

Emergence - The action of a young plant breaking through the surface of the soil, or of an insect coming out of an egg or pupa.

Employ - obtain, directly or through a labor contractor, the services of a person in exchange for a salary or wages, including piece-rate wages, without regard to who may pay or who may receive the salary or wages. It includes obtaining the services of a self-employed person, an independent contractor, or a person compensated by a third party.

Emulsifiable concentrate (EC or E) - A pesticide formulation that usually contains a liquid active ingredient, one or more petroleum based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion.

Emulsify - To make into an emulsion. When small drops of one liquid are finely dispersed (distributed) in another liquid, an emulsion is formed. The drops are held in suspension by an emulsifying agent, which surrounds each drop and makes a coating around it.

Emulsifying agent - A material which facilitates the suspending of one liquid in another; for example, detergents or soaps aid in the dispersion of oil in water.

Emulsion - A mixture in which one liquid is suspended as minute globules in another liquid, e.g., oil in water.

Encapsulation - (1) A method of formulating pesticides, in which the active ingredient is encased in a material (often poly vinyl) resulting in sustained pesticidal release and decreased hazard. (2) A method of disposal of pesticides and pesticide containers by sealing them in sturdy, waterproof, chemical proof containers which are then sealed in thick plastic, steel, or concrete to resist damage or breakage so the contents cannot get out.

Enclosed space production - production that occurs indoors or in a structure or space that is covered in whole or in part by any nonporous covering and that is large enough to permit a person to enter.

Endangered species - Animals, birds, fish, plants, or other living organisms threatened with extinction by human caused or natural changes in their environment. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Environment - Water, air, land, all plants, man and other animals living therein, and the interrelationships which exist among them.

Environmental Protection Agency (EPA) - Responsible for the protection of the environment in the U.S. including registration and regulation of pesticides.

EPA establishment number - A number assigned to each pesticide production plant by EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels produced at that plant.

EPA registration number - An identification number assigned to a pesticide product when the product is registered by the EPA for use. The number must appear on all labels for a particular product.

Epidemic - A sudden, widespread increase in the incidence of a disease or organism.

Epidermis - The outer cellular tissue of an animal or plant.

Eradicant - A type of fungicide that kills a disease after it appears on or in the plant.

Eradication - The complete elimination of either weeds, insects, disease organisms, or other pests from an area.

Ester - A compound formed by the union of an organic acid and an organic base (an alcohol). An example is 2,4-D and isoctyl alcohol to form the isoctyl ester of 2,4-D.

Evaporation - The process of a solid or liquid turning into a gas.

Exclusion - Control of pest by preventing its introduction (e.g., by quarantines) into pest free areas. Keeping a pest out by the use of screens or other barriers.

Exoskeleton - The segmented, external skeleton of an insect; the insect's "skin".

Exposure - When contact occurs with a pesticide through skin (dermal), mouth (oral), lungs (inhalation/respiratory), or eyes (ocular).

Face shield - A transparent piece of protective equipment used by a pesticide applicator to protect his/her face from exposure to pesticides.

Farms - Operations, other than nurseries or forests, that produce agricultural plants outdoors. Defined by WPS.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) - Instructs the EPA to regulate: the registration of all pesticides used in the U.S.; the licensing of pesticide applicators; re-registration of all pesticide products; and the storage, transportation, disposal and recall of all pesticide products.

Fit check - On-the-spot check to ensure that a respirator is working correctly.

Fit test - Checking to see that a respirator fits properly to provide protection against pesticide exposure.

First aid - The first effort to help a victim while medical help is on the way.

Flowable pesticide (F) - Very finely ground solid material which may be suspended in a liquid or may be a dry powder or pellet and usually contains a high concentration or large amount of the active ingredient and must be mixed with water when applied.

Foaming agent - A material which causes a pesticide mixture to form a thick foam. It is used to reduce drift.

Fog - Particles between 0.1 and 50 microns in diameter which make a fine mist.

Fogger - An aerosol generator. A piece of pesticide equipment that breaks some pesticides into very fine droplets (aerosols or smokes) and blows or drifts the "fog" onto the target area.

Foliage - The leaves, needles, and blades of plants.

Foliar applied - Droplets of a pesticide applied to leaves, needles, and blades of plants.

Food chain - Phrase that describes how all living organisms are linked together and depend on each other for food; i.e., plant eaters, plant and meat eaters, or meat eaters. For example, algae are eaten by fish which are eaten by humans.

Forests - Operations that produce agricultural plants outdoors for wood fiber or timber products. Defined by WPS.

Formulation - The pesticide product containing the active ingredient, the carrier and other additives required to make it ready for sale.

Fuel oils - Petroleum fractions used for burning are used also as solvents.

Fumes - A smoke, vapor, or gas.

Fumigant - A substance or mixture of substances which produce gas, vapor, fumes or smoke intended to destroy insects, bacteria, or rodents. Fumigants may be volatile liquids and solids as well as substances already gaseous. They may be used to disinfect the interiors of buildings; objects and materials that can be enclosed so as to retain the fumigant; and the soil where crops are valuable enough to warrant the treatment.

Fungi - Small, often microscopic plants without chlorophyll (green coloring). Fungi produce tiny thread like growths. They grow from seedlike spores. Some fungi can infect and cause disease in plants or animals; other fungi can attack and destroy nonliving things.

Fungicide - A chemical used to kill fungi; a compound used to destroy or inhibit fungi (usually plant diseases).

Gas mask - A device which filters out chemicals in the spray dust or gas from air breathed by the wearer. A full face gas mask must be worn to protect from gases; it should be equipped with adequate canisters of absorbent materials (or with oxygen supply).

Glossary

Gels - Semi-liquid emulsifiable concentrates that are used with water soluble packaging.

General use pesticide (GUP) - A pesticide which can be purchased and used without undue hazards to the applicator and the environment as long as the instructions on the label are followed carefully. GUPs do not require an applicator license to purchase, store or apply.

Granular pesticide (G) - A pesticide mixed with or coating small pellets or a sand like material. They are applied with seeders, spreaders, or special equipment.

Granule - A type of formulation in which the active ingredient is mixed with, adsorbed, absorbed, or pressed on an inert carrier forming a small pellet.

Groundwater - Water that flows in aquifers underground rather than in rivers, streams, and lakes on the surface. Groundwater is generally accessed via wells and is frequently used for drinking.

Growth regulator - An organic substance effective in minute amounts for controlling or modifying plant or insect processes. Organic compounds, other than nutrients, which in small amounts promote, inhibit, or otherwise modify any physiological process in plants or insects.

Hand sprayer - Small, portable, pesticide sprayers that can be carried and operated by a single individual.

Habitat - The places where a plant or animal lives, feeds, and breeds.

Handler - See pesticide handler.

Hard water - Water with minerals such as calcium, iron, and magnesium dissolved in it. Some pesticides added to hard water will curdle or settle out.

Harvest aid - A material used to remove the leaves from cotton plants, kill potato vines, and in any other way, facilitate machine harvesting of a crop. Examples: defoliants and desiccants.

Harvest - Cutting of the crop, or when the plant ceases to be a living growing organism.

Hazard - The probability that injury will result from use of a substance in a proposed quantity and manner. The sum of the toxicity plus the exposure to a pesticide. Sometimes referred to as negative effects.

Hazardous - Dangerous, risky. Pesticide chemicals that may cause injury or death if not used as directed on the label.

Hazardous waste - Substances, including pesticides, that are potentially damaging to the environment and harmful to humans and other living organisms.

Head - The frontal body region; the section which bears the antennae, eyes, and mouthparts of an insect.

Heat stress - The buildup in the body of heat generated by muscles during work and by a warm or hot work environment.

Herbicide - A pesticide used for killing or inhibiting plant growth. A weed or grass killer.

High pressure sprayer - A machine which applies pesticides by using water at high pressure and volume to deliver the pesticide to the target. Same as hydraulic sprayer.

Highly volatile - A liquid that quickly forms a gas or vapor (evaporates) at room temperature.

High volume sprays - Spray applications of more than 50 gallons per acre.

Hormone - A naturally occurring substance in plants or animals that controls growth or other physiological processes. It is used with reference to certain synthetic chemicals that regulate or affect growth activity.

Host - The living plant or animal a pest depends on for survival. The term "host" means any plant or animal in which another lives for nourishment, development, or protection.

Humidity - Refers to the dampness or amount of moisture in the air.

Hydraulic agitator - A device which keeps the tank mix from settling out by means of water flow under pressure.

Hydraulic sprayer - A machine which applies pesticides by using water at high pressure and volume to deliver the pesticide to the target. Same as high pressure sprayer.

Illegal residue - Residue that is in excess of a pre-established government enforced safe level.

Immediate family - According to WPS regulations, immediate family includes spouses, children, stepchildren, grandchildren, foster children, parents, stepparents, foster parents, grandparents, brothers, sisters, all in-laws, aunts, uncles, nieces, nephews, and first cousins.

Impermeable - Not capable of being penetrated.

Inactive - Not involved in the pesticide action; not reacting chemically with anything.

Incinerator - A special high heat furnace or burner which reduces everything to a non toxic ash or vapor. Used for disposing of some highly toxic and moderately to slightly toxic pesticides.

Incompatibility - Not capable of being mixed or used together; in the case of pesticides, the effectiveness of one or more is reduced; or they cause injury to plants or animals.

Incorporate into soil - The mixing of a pesticide into the soil by mechanical means.

Induce vomiting - To make a person or animal throw up.

Inert ingredient - An ingredient in a formulation which has no pesticidal action.

Infection - The development and establishment of a pathogen (e.g., a bacterium) in its host which will produce a disease.

Infestation - Pests that are found in an area or location where they are not wanted.

In furrow - An application to or in a furrow in which a crop is planted.

Ingestion - Taken into the digestive system.

Ingredients - The simplest constituents of the pesticide product which can reasonably be determined and reported.

Inhalation - To take air into the lungs; to breathe in.

Inhalation exposure - Breathing in a pesticide.

Inhalation toxicity - Poisoning through the respiratory system.

Inject - To force a pesticide chemical into a plant, animal, building or other enclosure, or the soil.

Inoculation - The introduction of an infective agent (the inoculum) into or on living tissues producing a specific disease.

Inorganic pesticide - Chemical compounds which do not contain carbon.

Insect - Any of the numerous small invertebrate animals generally having segmented bodies and for the most part belonging to the class Insecta, comprising six legs and usually wings.

Insect Growth Regulator (IGR) - A synthetic, organic pesticide which mimics insect hormonal action so that the exposed insect cannot complete its normal development cycle, and dies without becoming an adult.

Insecticide - A pesticide used to control insects.

Instar - The form of an insect between molts, numbered to designate the various periods; e.g., the first instar is a stage between the egg and the first molt, etc.

Integrated Pest Management (IPM) - The use of pest and environmental information in conjunction with available pest control technologies to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to persons, property, and the environment.

Interval - Period of time. The time between two applications. The distance between two points.

Invert emulsion - One in which oil is the continuous phase and water is suspended in it.

Label - All written, printed, or graphic matter on or attached to the pesticide product, or the immediate container thereof, and the outside container or wrapper to the retail package of the pesticide product.

Labeling - All information and other written, printed, or graphic matter upon the pesticide product or device or any of its accompanying containers or wrappers to which reference is made on the label or in supplemental literature accompanying the pesticide product or device.

Larva - The worm like or grub like immature or growing stage of an insect. It hatches from an egg and later goes into a resting stage called the pupa. The larva looks very different from the adult. Many insects cause most or all or their damage as larvae. Example: caterpillar.

Larvicide - An insecticide used to kill larvae of insects.

Latent - Dormant.

Lateral movement - Chemical movement in a plant or in the soil to the side, or horizontal movement in the roots or soil layers.

Lay-by treatments - Applications of pesticides after the last cultivation.

LC₅₀ - A means of expressing the toxicity of a compound present in air as a dust, mist, gas, or vapor. It is generally expressed as micrograms per liter ($\mu\text{g}/\text{l}$) as a dust or mist but in the case of a gas or vapor as ppm. The LC₅₀ is the statistical estimate of the dosage necessary to kill 50 percent of a very large population of the test species.

LD₅₀ - A common method of expressing the toxicity of a compound. It is generally expressed as milligrams of the chemical per kilogram (mg/kg) of body weight of the test animal. An LD₅₀ is a statistical estimate of the dosage necessary to kill 50 percent of a very large population of the test species under stated conditions (e.g., single oral dose of aqueous solution). If a compound has an LD₅₀ of 10 mg/kg it is more toxic than one with an LD₅₀ of 100 mg/kg. This can be found on the SDS, but not on the pesticide label.

Leaching - Movement of a substance downward or out of the soil as the result of water movement.

Lesion - A small, diseased or abnormal area on a plant or an animal. It can be a spot, scab, canker, or blister, often caused by fungi, bacteria, viruses, or nematodes.

Lethal - Fatal or deadly.

Life cycle - The complete succession of developmental stages in the life of an organism.

Low pressure boom sprayer - A machine which can deliver low to moderate volumes of pesticide at pressures of 0-60 psi. The sprayers are most often used for field and forage crops, pastures, and rights of ways.

Glossary

Low volatile - A liquid or solid that does not evaporate quickly at normal temperatures.

Low volatile ester - An ester with a high molecular weight and a low vapor pressure.

Low volume spray - A spray application of 0.5 to 5.0 gallons per acre. It should not wet all foliage to the drip point.

Mechanical agitation - The stirring, paddling, or swirling action of a device which keeps a pesticide and any additives thoroughly mixed in the spray tank.

Mechanical control - Control of pests by physical means such as the use of barriers and mulching.

Metamorphosis - The series of changes through which an insect passes in its growth from the egg through the larva and pupa to the adult; complete metamorphosis when the pupa is inactive and does not feed; incomplete metamorphosis when there is no pupa or when the pupa is active and feeds.

Microbial insecticide - Bacteria or other tiny plants or animals used to prevent damage by or destroy insects. Example: milky spore disease of Japanese beetle.

Microencapsulated pesticides - Active ingredients that are contained in a microscopic polyurea shell. The shell extends the life of the pesticide by slowing the rate at which the pesticide vapors escape.

Mist blower - Spray equipment in which hydraulic atomization of the liquid at the nozzle is aided by an air blast past the source of spray.

Mite - Tiny, eight-legged arthropod with a body divided into two parts. It has no antennae. During the nymphal stage it has six legs.

Miticide - A chemical used to control mites (arachnids).

Mode of action - Manner in which pesticides kill or inhibit an organism.

Mold - A fungus caused growth often found in damp or decaying areas or on living things.

Molluscicide - A compound used to control slugs and snails which are intermediate hosts of parasites of medical importance to man or damaging plants.

Molluscs - Any of a large family of invertebrate animals, including snails and slugs.

Molting - The process of shedding the exoskeleton.

Mosaic - A virus type plant infection showing patchwork of discolored areas on a leaf.

Mutagenicity - Capable of producing genetic change.

Mycoplasma-like organisms - Organisms recently discovered to be the cause of many plant diseases formerly attributed to viruses; organisms smaller than bacteria and larger than viruses.

Narrow leaf species - Botanically, those plants classified as monocotyledonae; Morphologically, those plants having narrow leaves and parallel veins. Examples: grasses, sedges, and rushes.

Natural enemies - The predators and parasites in the environment which attack pest species.

Necrosis - Localized death of living tissue, i.e., death of a certain area of a leaf or of a certain area of an organ.

Necrotic - A term used to describe tissues exhibiting varying degrees of dead areas or spots.

Negligence - Failure to do a job or duty; an act or state of neglectfulness.

Nematicide - A material, often a soil fumigant used to control nematodes that infest roots of crop plants.

Nematode - A member of a large group (phylum Nematoda), also known as threadworms, roundworms, etc. Some larger kinds are internal parasites of humans and other animals. Nematodes may be injurious to crop plants and are slender, free-living, microscopic, and soil dwelling.

Neoprene - A synthetic rubber often used to make gloves and boots which offer protection against most pesticides.

Neutralize - To destroy the effect of or to counteract the properties of something.

Non corrosive - Opposite of corrosive.

Nonionic - Chemically inert. A surfactant that does not ionize.

Non persistent - Only lasts for a few weeks or less. Rapid breakdown.

Nonselective pesticide - A pesticide that is toxic to most plants or animals.

Nontarget - A plant or animal other than the one against which the pesticide is applied.

Nontoxic - Not poisonous.

Non volatile - A pesticide chemical that does not evaporate (turn to a gas or a vapor).

Noxious weed - An alien plant or parts of an alien plant that have been designated by rule as being noxious or has been declared a noxious weed by a local weed advisory board, and meets one or more of the following criteria: (a) Aggressively invades or is detrimental to economic crops or native plant communities; (b) Is poisonous to livestock; (c) Is a carrier of detrimental insects, diseases, or parasites; (d) The direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems.

Nozzles - Devices which control drop size, rate, uniformity, thoroughness, and safety of a pesticide application. The nozzle type determines the spray pattern and is a factor in the safety of a pesticide application.

Nurseries - Operations that produce agricultural plants outdoors for transplants to another location, or flower or fern cuttings. Examples include flowering and foliage plants or trees; tree seedlings; live Christmas trees; vegetable, fruit, and ornamental transplants; and turfgrass produced for sod. Defined by WPS.

Nymph - The early stage in the development stage of insects which have no larva stage. It is the stage between egg and adult during which growth occurs. Examples: grasshoppers and aphids.

Ocular exposure - Pesticide gets in the eye.

Oils - Usually refers to aromatic paraffinic oils used as diluents in formulating products as carriers of pesticides or for direct use.

Oncogenicity - The property to produce tumors (not necessarily cancerous) in living tissues.

Operating speed - The constant rate at which a pesticide sprayer moves during application; usually measured in mph or feet per minute.

Oral exposure - To swallow or ingest a pesticide.

Oral toxicity - Ability of a pesticide chemical to sicken or kill an animal or human if eaten or swallowed.

Organic compounds - A large group of chemical compounds that contain carbon.

Organic pesticide - (1) A pesticide that is an organic chemical, meaning that the molecule consists mainly of a carbon skeleton plus other elements such as hydrogen, oxygen, nitrogen, sulfur, phosphorus or chlorine. (2) A pesticide which is not produced synthetically, but is a naturally-occurring compound derived from plant or animal sources.

Organism - Any living thing; plant, animal, fungus, bacteria, insect, etc.

Organophosphate - A synthetic organic pesticide containing carbon, hydrogen and phosphorus. Examples: parathion and malathion.

Orifice - The opening or hole in a nozzle through which liquid material is forced out and broken up into a spray.

Original container - The package (can, bag, or bottle, etc.) in which a company sells a pesticide chemical. A package with a label telling what the pesticide is and how to use it correctly and safely.

Ornamentals - Plants used to add beauty to homes, lawns, and gardens. They include trees, shrubs, and small colorful plants.

Other ingredients - See active ingredient.

Parasite - An organism that lives and feeds on or in an organism of another species, which it usually injures.

Parasitic plant - A plant that lives off another host plant. Example: mistletoe.

Pathogen - Any microorganism which can cause disease.

Pathology - Branch of science of the origin, nature, and course of diseases.

Penetrant - Wetting agents that enhance the ability of a liquid to enter into pores of a substrate, to penetrate the surface, are termed penetrating agents or penetrants.

Percent by weight - A percentage which expresses the active ingredient weight as a part of the total weight of the formulation. Example: one pound of active ingredient added to and mixed with three pounds of other materials results in a formulation which is 25% pesticide by weight.

Percent concentration - The weight or volume of a given compound in the final mixture expressed as a percentage.

Perennial - A plant that normally lives for more than two years. Trees and shrubs are perennial plants. Some perennials die back to the roots each winter but new shoots grow again in the spring.

Persist - To stay. To remain.

Persistent pesticide - A pesticide chemical (or the metabolite(s)) that remains active in the environment more than one growing season.

Personal protective equipment (PPE) - Devices and clothing worn to protect the body from exposure to pesticides or pesticide residues. Includes such items as long-sleeved shirts, long pants, coveralls, hats, chemical resistant gloves, shoes, respirators, and other safety items as specified on the label.

Pest - Any insect, rodent, nematode, fungus, weed, or other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other microorganism (except viruses, bacteria, or other microorganisms on or in living man or in other living animals) which the administrator of the EPA declares to be a pest.

Pesticide - Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, or weeds, or any other forms of life declared to be pests; and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Glossary

Pesticide handlers - Persons who mix, load, or apply or do other tasks that bring them into direct contact with pesticides (including working on spray equipment). Defined by WPS.

Pesticide waste - Any material which contains any concentration of pesticide, including rinsate from containers and spray equipment, leftover spray solutions, excess pesticides, and cancelled, banned, or suspended pesticides.

Pest resurgence - The rapid reappearance of a pest population in injurious numbers, usually brought about after the application of a broad-spectrum pesticide has killed the natural enemies which normally keep a pest in check.

Pesticide tolerance - The amount of pesticide residue which may legally remain in or on a food crop. Federal residue tolerances are established by the EPA.

Pheromones - Chemicals produced by insects and other animals to communicate with and influence the behavior of other animals of the same species. Most pheromones used today in pest management are synthetic and are used to monitor or disrupt insect populations.

Photodecomposition - Destroyed by light.

Physical properties - Examples are solubility, volatility, inflammability, state of being solid, liquid, or gas.

Phytotoxicity - Injurious to plants.

Plant diseases - Harmful conditions or sicknesses which negatively affect plant life; fungi, bacteria, and viruses most often cause plant diseases.

Plant growth regulator (PGR) - A substance that alters the growth of plants. The term does not include substances intended solely for use as plant nutrients or fertilizers.

Plume - A well defined, usually mobile area of contamination in groundwater, soil or the air.

Poison - A chemical causing a deleterious effect when absorbed or ingested by a living organism (biocide).

Poison control center - An agency which has current information as to the proper first aid techniques and antidotes for all poisoning emergencies. The Rocky Mountain Poison and Drug Center's telephone number is 1-800-222-1222.

Pollinators - Bees, flies, and other insects which visit flowers and carry pollen from flower to flower in order for many plants to produce fruit, vegetables, buds, and seeds.

Postemergence - After the appearance of a specified weed or crop.

Potable - Water suitable for drinking.

Potency - The measure of a chemical's effectiveness as a poison. The more potent the chemical, the less it takes to exert its effect.

Precipitate - To settle out. A solid substance that forms in a liquid and sinks to the bottom of the container.

Predator - An insect or other animals that attacks, feeds on, and destroys other insects or animals. Predators help to reduce the number of pests which cause disease, damage, and destruction.

Pre-emergence - Prior to emergence of the specified weed or crop.

Preharvest - The time just prior to the picking, cutting, or digging up of a crop.

Preharvest interval (PHI) - Restrictions that indicate the amount of time that must elapse between the last application and harvest.

Preplant - Application of a pesticide prior to planting a crop.

Private applicator - A certified applicator who uses or supervises the use of any restricted use pesticide for purposes of producing any agricultural commodity on property owned or rented by him/her or his/her employer or (if applied without compensation other than trading of personal services between producers of agricultural commodities) on the property of another person. In Colorado, the Colorado Department of Agriculture issues the certification.

Product - A term used to describe a pesticide as it is sold. It usually contains the pesticide chemical plus other ingredients.

Prolonged exposure - Contact with a pesticide or its residue for an extended period.

Protectant - A chemical applied to the plant or animal surface in advance of the pest (or pathogen) to prevent infection or injury by the pest.

Protective equipment - Clothing or any other materials or devices that shield against unintended exposure to pesticides.

Pupa - The resting stage of many insects. The stage between the larva (caterpillar or maggot, etc.) and the adult (butterfly or fly, etc.). Some caterpillars spin a silk cocoon before they change to a pupa inside.

Quarantine - Regulation forbidding sale or shipment of plants or plant parts, usually to prevent disease, insect, nematode, or weed invasion of an area.

Rate - The amount of active ingredient or acid equivalent of a pesticide applied per unit area (such as 1 acre). Rate is preferred to the occasionally used terms, dosage and application.

Ready-to-use formulations (RTU) - Formulations containing small amounts (often 1 percent or less) of active ingredient per gallon. No further dilution is required before application.

Rebound - See pest resurgence.

Recharge - The replacement of water to an aquifer.

Repellent - A compound that is annoying to a pest, causing it to avoid the area in which it is placed.

Residual pesticide - A pesticide that can destroy pests or prevent them from causing disease, damage, or destruction for more than a few hours after it is applied.

Residual soil herbicide - A chemical that prevents the growth of plants, microorganisms, etc., when present in soil.

Residue - The amount of chemical which remains on the harvested crop or other surfaces contacted during the application.

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

Respirator - A face mask used to filter out poisonous gases and dust particles from the air so that a person can breathe and work safely. A person must use a respirator as directed on the pesticide label.

Respiratory toxicity - Intake of pesticides through air passages into the lungs. Pesticides may reach the lungs as a vapor or as extremely fine droplets or particles. Most compounds are more toxic by this route. Safety equipment is essential to protect the pesticide handler or applicator from the hazards of respiratory exposure whenever it is recommended on the label.

Restricted entry interval (REI) - The length of time between the pesticide application and entry into the field to conduct hand labor.

Restricted use pesticide (RUP) - A pesticide that is classified for restricted use under the provisions of FIFRA. A pesticide that can be sold to or used by only certified applicators.

Rinsate - Pesticide-containing water (or another liquid) that results from rinsing a pesticide container, pesticide equipment, or other pesticide-containing materials.

Risk - The likelihood that an adverse effect will occur.

Rodenticide - A substance or mixture of substances intended to prevent, destroy, repel or mitigate rodents.

Runoff - The movement of water and associated materials on the soil surface. Runoff usually travels to bodies of surface water.

Safety data sheet (SDS) - Formerly known as the Material Safety Data Sheet (MSDS). A document required for each hazardous chemical, including pesticides, by the Occupational Health and Safety Act. It contains health and safety data as well as physical properties pertinent to the chemical which will aid in an emergency situation. A SDS can be obtained through the distributor or the manufacturer of the pesticide.

Scientific name - The one name used throughout the world by scientists for each animal and plant. These names are made up of two words indicating the genus and species.

Secondary pest - A pest that resurges following disruption of control by a natural enemy.

Seed protectant - A chemical applied to seed before planting to prevent disease and insect attack of seeds and new seedlings.

Selective pesticide - A chemical that is more toxic to some species (plant, insect, animal, microorganisms) than to others.

Sensitivity - Susceptible to effects of toxicant at low dosage; not capable of withstanding effects.

Shielded sprays - Pesticide applications that help confine pesticides to more localized areas of a field or orchard by putting the spray precisely where it is needed.

Shock - The severe reaction of the human body to a serious injury which can result in death if not treated even if the actual injury was not a fatal one.

Signal words - Words which must appear on pesticide labels to denote the relative acute toxicity of the product. The signal words are "Danger-Poison" and "Danger" (for highly toxic), "Warning" (for moderately toxic), and "Caution" (for low order toxicity).

Sign - Some evidence of exposure to a dangerous pesticide; an outward signal of a disease or poisoning in a plant or animal, including people.

Simple metamorphosis - Type of insect development characterized by three distinct stages: egg, nymph, and adult.

Site - An area, location, building, structure, plant, animal, or other organism to be treated with a pesticide to protect it from or to control the target pest.

Slurry - A thick suspension of a pesticide made from wettable powder and water.

Soil application - Application of a chemical to the soil rather than to vegetation.

Glossary

Soil drench - To soak or wet the surface of the ground with a pesticide. Generally, fairly large volumes of the pesticide preparation are needed to saturate the soil to any depth.

Soil incorporation - Mechanical mixing of the pesticide with the soil.

Soil injection - Mechanical placement of the pesticide beneath the soil surface.

Solubility - The ability of a chemical to dissolve in another chemical or solvent; a measure of the amount of substance that will dissolve in a given amount of another substance.

Soluble powder (SP or S) - A powder formulation that dissolves and forms a solution in water.

Solution - A preparation made by dissolving a solid, liquid, or gaseous substance into another substance usually a liquid without a chemical change taking place.

Solvent - A liquid which will dissolve a substance forming a true solution (liquid in molecular dispersion).

Species - A group of living organisms which are very nearly alike, are called by the same common name, and interbreed successfully.

Spiders - Small arthropods closely related to insects; they have eight legs, two body regions, no antennae, and no wings.

Spore - An inactive form of a microorganism that is resistant to destruction and capable of becoming active again.

Spot treatment - A treatment directed at specific plants or areas rather than a general application.

Spray - A mixture of a pesticide with water or other liquid carrier, applied in droplets.

Spray concentrate - A liquid formulation of a pesticide that is diluted with another liquid before using.

Spray drift - The movement of airborne spray particles from the intended area of application.

Spreader - A substance which increases the area that a given volume of liquid will cover on a solid or on another liquid.

Stage of development - A defined period of growth.

State restricted use pesticides - Pesticides designated by the state of Colorado as restricted.

Sterilize - Treat with a chemical or other agent to kill every living thing in a certain area.

Sticker - A material added to a pesticide to increase adherence rather than to increase initial deposit.

Stomach poison - Pesticide that must be eaten by an insect or other animal in order to kill the animal.

Sump - A tank that resembles a pit or reservoir, usually below ground level and made of concrete. Sumps may have troughs or trenches to collect waste. Sumps are used as secondary containment in areas where hazardous materials are stored and can also be found outside, with access through a manhole cover or grate.

Surface water - Rivers, lakes, ponds, streams, etc., which are located above ground.

Surfactant - A chemical which increases the emulsifying, dispersing, spreading, and wetting properties of a pesticide product. **Surface active agent**.

Susceptibility - The degree to which an organism is affected by a pesticide at a particular level of exposure.

Susceptible - Capable of being injured, diseased, or poisoned by a pesticide; not immune.

Suspended - (1) A pesticide use that is no longer legal and the remaining stocks cannot be used. This order is more severe than Cancelled. (2) Describes particles that are dispersed (or held) in a liquid.

Suspension - A system consisting of very finely divided solid particles dispersed in a liquid.

Swath - The width of a treated area when a ground rig or spray plane makes one trip across a field.

Symptom - (1) A warning that something is wrong that can be detected by a person who has been poisoned, such as nausea or headache. (2) Any indication of disease or poisoning in a plant or animal. This information is used to figure out what insect, fungus, other pest, or pesticide is causing the disease, damage, or destruction.

Synergist - A chemical that when mixed with a pesticide increases its toxicity. The synergist may or may not have pesticidal properties of its own.

Systemic pesticide - A pesticide that is taken into the blood of an animal or sap of a plant and moves within the animal or plant. It kills the pest without harming the host.

Tank mix - The mixture of two or more compatible pesticides in a spray tank in order to apply them simultaneously.

Target - The plants, animals, structures, areas, or pests to be treated with a pesticide application.

Technical material - The pesticide as it is manufactured by a chemical company. It is then formulated with other materials to make it usable.

Temperature inversion - When temperature increases with elevation from the ground, an inversion condition exists.

Teratogenicity - Structural abnormalities of prenatal origin, present at birth or manifested shortly thereafter.

Thermal - Of or pertaining to heat.

Thorax - The second or intermediate region of the insect body bearing the true legs and wings, made up of three sections, named in order; prothorax, mesothorax, and metathorax.

Tolerance - (1) By law, a regulation that establishes the maximum amount of a pesticide that may remain on a raw agricultural commodity. (2) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides.

Topical application - Implies application to the top or to the upper surface of the plant; thus applied from above.

Toxicant - An agent capable of being toxic; a poison.

Toxicity - The natural capacity of a substance to produce injury. Toxicity is measured by oral, dermal and inhalation studies on test animals.

Toxin - A poison produced by a plant or animal.

Trademark - A word, letter, device, or symbol, used in connection with merchandise and pointing distinctly to the origin or ownership of the article to which it is applied.

Trade name - Same as Brand name.

Translocated pesticide - One that is moved within the plant or animal from the site of entry. Systemic pesticides are translocated.

Treated area - A field, forest, garden, or other place where a pesticide has been applied.

Triple rinse - Rinsing a pesticide container three times in order to ensure that it is legally empty.

True liquid/solution (L) - When the active ingredient is mixed with water, the water remains clear.

Ultra-low-volume concentrates (ULV) - Undiluted formulations applied at very low rates.

Uniform coverage - The application of a pesticide evenly over a whole area, plant, or animal.

Use - All aspects of the handling of pesticides, including but not limited to the mixing, loading, application or administration, spill control, and disposal of a pesticide or its container.

Vapor - Gas steam, mist, fog, or fume.

Vapor drift - The movement of vapors of a volatile chemical from the area of application.

Vapor pressure - The property which causes a chemical compound to evaporate. The lower the vapor pressure, the more volatile the compound.

Vector - An insect or other animal that carries a disease organism from one host to another.

Vertebrate - An animal with a bony spinal column. Examples: mammals, fish, birds, snakes, frogs, toads.

Virus - A sub microscopic pathogen that requires living cells for growth and is capable of causing disease in plants or animals. Plant viruses are often spread by insects.

Viscosity - A property of liquids that determines whether they flow readily or resist flow.

Volatile - A compound is said to be volatile when it evaporates (changes from a liquid to a gas) at ordinary temperatures on exposure to air.

Volatility - The ability of a solid or liquid to evaporate quickly at ordinary temperatures when exposed to the air.

Volatilization - The chemical process of passing from a liquid state to a vapor or gas, such as when vapors are released from a liquid pesticide.

Warning - (1) Beware. A warning to the user of pesticides. (2) One of three signal words. (3) Used on labels of pesticide containers which are moderately toxic pesticides, in toxicity Category II as defined by FIFRA.

Water dispersible granules (WDG) - A pesticide formulation in which finely-divided powders are formulated into concentrated, dustless granules which form a suspension in water.

Water soluble packet (WSP) - A package for wettable powders, soluble powders, and gels. The package dissolves in water.

Water solubility - Capable of being uniformly mixed with water.

Water table - The dividing line between the unsaturated zone and the saturated zone. Water below the water table is groundwater.

Weathering - The wearing away of pesticides from the surfaces they were applied to because of rain, snow, ice, and heat.

Wettable powder (WP) - A solid (powder) formulation which, when added to water, forms a suspension used for spraying. It is prepared by adding water soluble agents to the formulation.

Wetting agent - A compound which reduces surface tension and causes a liquid to contact plant surfaces more thoroughly.

Worker - See agricultural worker.

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