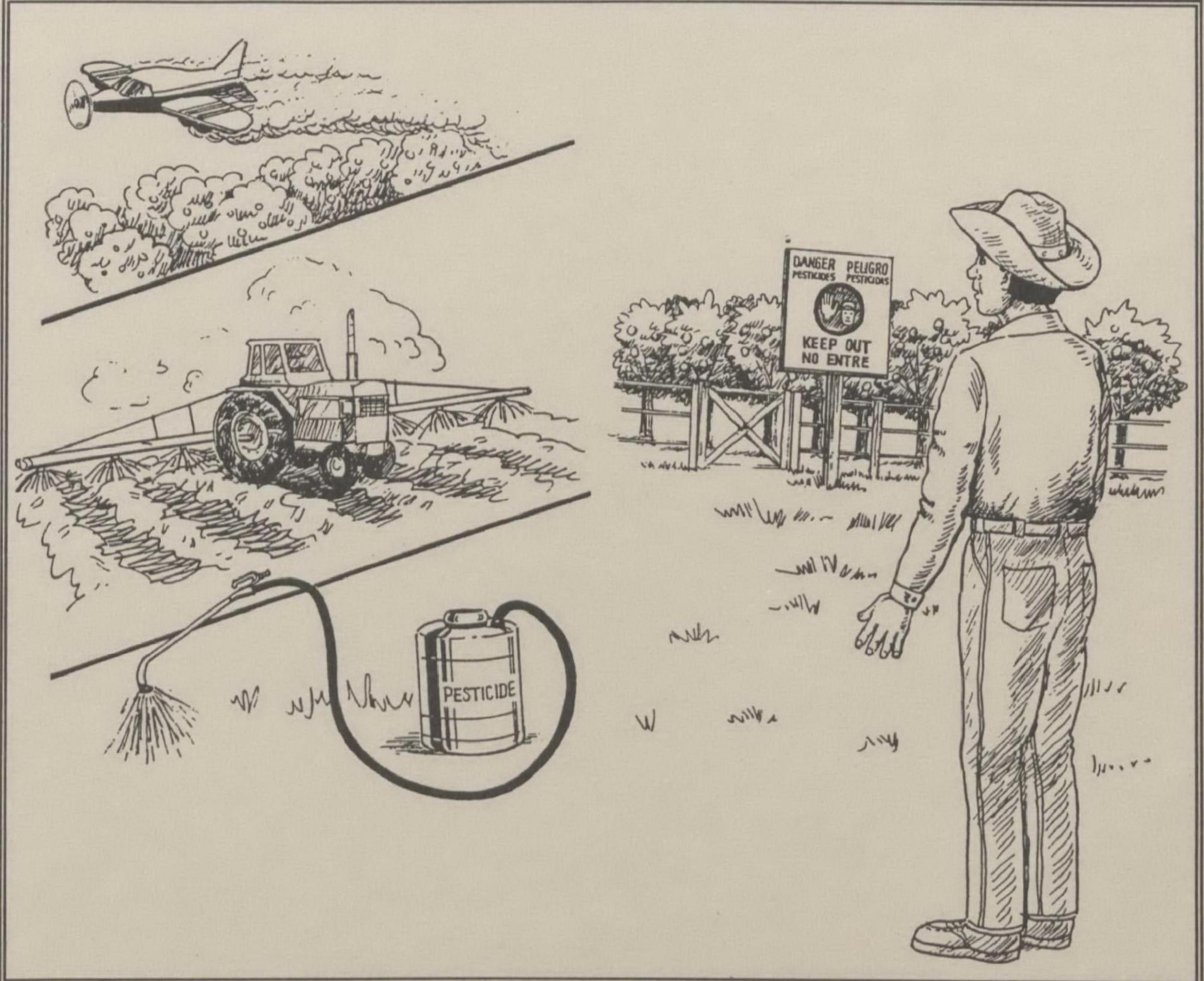
PRIVATE PESTICIDE APPLICATOR

TRAINING MANUAL

Revised 1994



U. S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII

INTRODUCTION

The U.S. Environmental Protection Agency regulates the distribution and use of pesticides under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended in 1988. Under this law, all pesticide uses are classified as either general use or Restricted Use. Those classified as Restricted Use can be bought and used only by persons who are Certified after training. In Colorado private pesticide applicators -- farmers, ranchers and greenhouse growers -- are certified by the EPA Region 8 in Denver.

This Private Pesticide Applicator Training Manual can be used by individuals as a home study course and is also the basis for training sessions held by Extension offices and pesticide dealers. Reading the manual, successfully completing the accompanying questionnaire and sending it to EPA will qualify you for certification as a private pesticide applicator. A card will be issued to you which will allow you to buy and use Restricted Use Pesticides. **Keep the manual for a quick reference whenever you have questions about using pesticides.**

Pesticide products are designated as Restricted Use by EPA when they have been found to be hazardous to people, animals and/or the environment unless applied by or under the supervision of persons who are qualified to use them in a safe manner following the label.

EPA is responsible for the registration and regulation of use for pesticides. The Agency does not endorse or discourage the use of pesticides but strongly urges the use of alternative methods of pest control as well as integrated pest management. EPA is in the process of reregistering all pesticides that were registered before November 1984. Many products are disappearing from the market in this process. Also, there are new regulations to protect workers, groundwater and endangered species from the hazards of pesticides. The future availability of pesticides to support agricultural production depends on responsible use. This training manual is designed to assist you in that effort.

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Chapter I

LAWS AND REGULATIONS

Many Federal laws and regulations have been adopted to help protect the public, the environment, pesticide handlers, and agricultural workers from possible adverse effects caused by pesticide use. This chapter briefly describes some of those that are likely to affect many private pesticide applicators. You may need to learn more about the laws and regulations that apply to your specific situation.

Most States, Tribes, and many local areas have their own legal requirements concerning pesticide use. You are responsible for knowing about these requirements and complying with them.

Be sure to keep up to date with legal requirements at all governmental levels -- laws and regulations are constantly evolving as pesticide application becomes more complex and more learned about potential hazards. Ignorance of the law is never an accepted excuse for a violation.

FIFRA A law passed by Congress in 1947 and substantially amended in 1972, 1975, 1978, and 1988 regulates the registration, manufacture, sale, transportation, and use of pesticides. The Federal Insecticide, Fungicide, and Rodenticide Act is commonly referred to by its initials -- FIFRA. It is administered by the U.S. Environmental Protection Agency (EPA).

Major Provisions of FIFRA

FIFRA affects certified applicators in many ways. For example, it provides that:

- EPA must register pesticides and pesticide uses.
- All pesticides must be used only as directed on the labeling.
- EPA must classify as "restricted use" those pesticides which, even when used as directed on the product labeling, may cause unreasonable adverse effects to the environment, including humans.
- *Anyone who buys or uses a restricted-use pesticide must be certified in an applicable pest* control category or be directly supervised by a person with such certification.
- States may establish stricter standards governing pesticides, but not more permissive standards.
- Persons who use pesticides in a way that is "inconsistent with the pesticide labeling" are subject to penalties.

Penalties Under FIFRA If you violate FIFRA, or regulations issued under it, you are subject to civil penalties. Penalties can be as much as $1,000 for each offense for private applicators ($5,000 for commercial applicators). Before EPA can fine you, you have the right to ask for a hearing in your won city or county. Some violations of the law also may subject you to criminal penalties. These can be as much as $1,000 and/or 30 days in prison for private applicators ($25,000 or 1 year in prison, or both, for commercial applicators). States may establish higher penalties.

RESTRICTED or GENERAL USE An important part of the current law is the classification of pesticides as either Restricted Use or General Use. This classification determines who may purchase and apply the pesticide. This designation appears prominently on the pesticide label.

The Environmental Protection Agency determines whether a pesticide will be classified for Restricted Use. This decision is based on its potential for substantial adverse effects to the applicator or environment. Certification of pesticide applicators, and restricting sale and use to those applicators, provides a measure of assurance that a product will be used in a safe manner and in accordance with the label. The restricted use regulation permits the continued use of many pesticides that might otherwise be subject to cancellation.

When determining the Restricted Use classification for a pesticide, EPA studies information provided by the manufacturer, research from other sources, and documented accident information on the chemical. They also study the toxicity of the pesticide to humans and other life (animals and plants), including potential for causing cancer, reproductive disorders and allergies. The EPA also considers the effects on nontarget organisms through water pollution, drift, or buildup in animal tissues.

Some active ingredients of commonly used agricultural pesticides that are currently classified for Restricted Use are:

Aldicarb (Temik)
Atrazine
aluminum phosphide
azinphosmethyl (Guthion)
amitraz (Baam)
brodifacoum (Talon)
chlorophacinone (Rozol)
cycloheximide
carbofuran (Furadan)
chloropicrin (Chlor-o-Pic)
cypermethrin (Ammo, Cymbush)
diallate (Avadex)
diclofop methyl (Hoelon)
disulfoton (DiSyston)
esfenvalerate (Asana)
ethoprop (Mocap)
ethion
fenvalerate (Pydrin)
fenamiphos (Nemacur)
fonfos (Dyfonate)
methiocarb (Mesurol)
methyl bromide
mevinphos (Phosdrin
oxamyl (Vydate)
paraquat (Gramoxone)
picloram (Tordon)

The Restricted Use classification can be declared at the time pesticides are registered, re-registered, or when new information indicates a high degree of hazard exists with use of the pesticide. One pesticide formulation with a high concentration of a highly toxic chemical may be classified as Restricted Use; whereas, a formulation with a lesser concentration of the same chemical may be classified as General Use. Also, a pesticide unclassified for agricultural uses may be restricted for uses in more sensitive environments, such as indoors, around livestock, near water, etc.

PESTICIDE APPLICATORS: COMMERCIAL/PRIVATE Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), there are two types of pesticide applicators -- Commercial or Private

A **commercial applicator** is a person who uses or supervises the use of restricted use pesticides in a situation other than as a private applicator. Commercial applicator groups in Colorado include agricultural pilots, landscape maintenance personnel, ditch and power company employees, government workers, grain elevator operators, and other applicators who apply pesticides as a **condition of their employment**. Pesticide applications made to agricultural commodities that have entered commercial channels and are no longer in production are also commercial applications. **Licensing of commercial applicators is by the Colorado Department of Agriculture.**

A **private applicator** is a person who uses, or supervises the use of, restricted use pesticides in the production of agricultural commodities on land owned or rented by him or his employer. Farmers, ranchers, orchardists and greenhouse operators are private applicators in Colorado. A private applicator may also apply restricted use pesticides in production of agricultural commodities on the property of another person, if the work is done without compensation. Trading of personal services as a form of compensation is exempted under this regulation.

DIRECT SUPERVISION The pesticide law, FIFRA, says that a Restricted Use pesticide may be applied by a Certified Pesticide Applicator or a person under the "direct supervision" of a Certified Applicator. Environmental Protection Agency policy states that the Certified Applicator is responsible for the application practices used by the person being supervised and is liable for any violations that are committed.

In Colorado, a grower/rancher is certified as a private applicator following successful completion of a Home Study Course administered by the U.S. Environmental Protection Agency. This manual provides the prescribed training, and successful completion of the questionnaire enables EPA to determine that a card can be issued that will allow the applicator to buy and use restricted use pesticides. NOTE: A COLORADO PRIVATE APPLICATOR CERTIFICATION CARD AUTHORIZES THE PURCHASE AND USE OF RESTRICTED USE PESTICIDES ONLY AS DESCRIBED UNDER THE ABOVE DEFINITION OF "PRIVATE APPLICATOR". Applicators whose use situation does not fit the definition of a private applicator should contact the Colorado Department of Agriculture regarding procedures to obtain a commercial applicator certification.

OTHER LAWS

ENDANGERED SPECIES ACT The Endangered Species Act was first passed in 1973 to protect animal and plant species that were threatened or in danger of becoming extinct, and to conserve their habitats. The latest amendments were passed in 1988, and full implementation is planned by 1994. Colorado is host to 17 endangered species -- 3 birds, 4 fish, and 10 plants. **Some pesticide use practices may be affected where endangered species occur.**

SARA/EPCRA The Superfund Amendments and Reauthorization Act (SARA) regulates storage of pesticides and handling pesticide spills. One section of this law, the Emergency Planning and Community Right-to-Know Act (EPCRA), requires that storage of certain pesticides in amounts above a specified minimum be reported to local and state authorities so they can respond to any accident at the storage site. Failure to report may result in a court injunction or **fines of up to $25,000 for each day** the violation continues. Enforcement of this law is by the Hazardous Materials and Waste Management Division of the Colorado Department of Health.

PESTICIDE LABELS

A pesticide label includes all the printed information either on the container or included in or on the package. It provides a description of the product and how it must be used. It is a legal document that is approved by the U. S. Environmental Protection Agency before the product can be placed on the market. **Use of a pesticide in a manner that is inconsistent with the label instructions is a violation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).** (Except for four specific exceptions described on Page 9.) The label is the law. Civil penalties can be levied against private applicators for misuse of any pesticide.

The label of a pesticide includes the actual affixed label and all brochures, flyers, handouts, and advertising materials distributed by the manufacturer or dealer. These materials must conform to those approved by EPA during the registration process.

LABEL CONTENT

FIFRA requires that all pesticide labels must contain the following information:

1. Brand name, common name, and chemical name
2. Use classification (Restricted or unclassified)
3. Ingredient statement
4. Registered uses
5. Directions for use
6. Safety information, signal words and precautions
7. Net contents
8. Name and address of manufacturer or registrant
9. EPA Registration number and establishment number.

Restricted Use Pesticide

For retail sale to and use ONLY by certified applicators or persons under the direct supervision of a certified applicator.

Contents: 50 Pounds
Active Ingredients..25.0%

(arthrodie) 1,2,3-benzylchlorofluoromethane.................................21.0%

(arthrobury) 1,2,3-benzylchlorofluoroethane..................................4.0%

Inert Ingredients..75.0%

Arthrohistory[R] Insecticide (25WP)- A wettable powder insecticide for control of insects on corn, wheat, strawberries and greenhouse-grown roses.

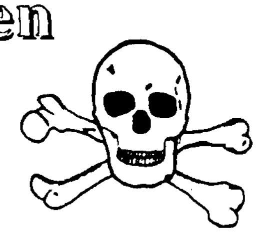
Always read and follow label directions
R=registered trademark of Arthohistory Co.

EPA Reg. No. XXXXXXX
EPA Est. No. YYYYYYY

Danger-Poison

Keep out of reach of children

¡ Peligro!



Precaucion al usario: Si usted no lee ingles, no use este producto hasta que la etiqueta le haya sido explicada ampliamente.

For PRODUCT use information call 1-800-555-3456
For EMERGENCY information ONLY call 24 hours a day
1-800-555-6789.

Sample front panel of a pesticide label

Precautionary Statements Hazards to Humans and Domestic Animals

Danger!

Fatal if swallowed, inhaled, or absorbed through the skin. Do not breathe. Do not get in eyes, on skin, or on clothing.

Signs and symptoms of exposure-Vomiting, headache, difficulty breathing, pinpoint eye pupils. IN ALL CASES OF SUSPECTED POISONING CONTACT A PHYSICIAN!

Note to Physician- Arthrohistory insecticide is a cholinesterase inhibitor. Atropine sulfate is an effective antidote. If ingested, induce vomiting promptly.

Wear freshly laundered, long-sleeved work clothing. While transfering from package to equipment, wear a clean cap, rubber gloves, and goggles. Rubber gloves should be washed with soap and water after each use. Do not wear the same gloves for other work.

Do Not Breathe Dust

Wear a face mask or other respiratory equipment while emptying bags of product into a hopper. While emptying bags into equipment, pour downwind and allow as little free fall as possible. Do not pour at face level and do not allow dust to reach the breathing zone.

Do Not Contaminate Food or Feed Products

Once a bag has been opened, use it completely. Make sure the hoppers are emptied completely while still in field.

WARRANTY

USE ONLY ACCORDING TO LABEL DIRECTIONS

Arthrohistory Co. guarantees this product conforms to the description on this label. It is suited for the purpose sold when used according to directions. The buyer agrees to assume all risks in the case of damage from the use of this product.

DO NOT EXPOSE TO MOISTURE!

Directions for Use: It is in violation of federal law to use this product in a manner that is inconsistant with its labeling.

How much to apply-

Crop	Pest	Lbs/100 gal	Days Between Last Application and Harvest
Corn	European Corn Borer Corn earworm	1 1/2-2	10 Do not make more than 3 applications per season
	Aphids Grasshoppers	1/2-1	
Wheat	Aphids	1-2	15 Do not graze treated fields
	Grasshoppers Cutworms	2-3	
Strawberries	Aphids Spider mites Plant bugs	1-2	3 Do not apply when temperatures are below 50 degrees (F) or injury may result
Roses	Aphids Thrips Spider mites	3-5	2 Do not apply to hybrid tea roses or injury may result

Arthohistory Insecticide Co.
P.O. Box 666
Yellow Jacket, Colorado USA

Sample side panels of a pesticide label

BRAND NAME The brand name is the product name given to the particular pesticide formulation by the manufacturer or the distributor. It is used for identification and advertising purposes. Several different brand name products may be identical or nearly identical in their formulation. The brand name does not necessarily describe the active ingredient(s) in the product. The active ingredient is listed on the label in the ingredient statement.

COMMON NAME The common name is a shortened generic name of the active ingredient(s) in a pesticide. For example, glyphosate is the common name of a herbicide sold under the brand names Roundup, Rodeo and Shackle. An insecticide disulfoton used in greenhouses is sold under the name Disyston. And, the fungicide benomyl used on turf and ornamentals in Colorado is sold as Benlate. Recommendations for use of a pesticide by an agricultural consultant or Extension office may give only the common names because there are so many registered brand name products with the same active ingredient.

CHEMICAL NAME The chemical name of a pesticide ingredient describes the chemical composition and structure of the active pesticide ingredient. Although they sound complicated, they are based on standard descriptions used by chemists. For example, the insecticide ingredient O-O-diethyl O-(3,5,6-trichloro-2-pyridyl)phosphorothioate, common name, Chlorpyrifos, is marketed as brand name Dursban for household products and Lorsban for agricultural products. The herbicide 2,4-dichloro-phenoxyacetic acid is commonly known as 2,4-D.

USE CLASSIFICATION The Use Classification statement is required on the front panel of all pesticides that are classified as RESTRICTED USE. This statement reads:

"RESTRICTED USE PESTICIDE"

For retail sale to and use by certified applicators or persons under their direct supervision. Certified commercial applicators may apply restricted use pesticides only within the use category in which they are certified.

There may also be a statement of why the pesticide is classified as restricted, such as "Acute Oral and Dermal Toxicity" or "Avian Hazard"

General Use pesticides do not contain label classification statements.

INGREDIENT STATEMENT The ingredient statement also appears on the front panel of each pesticide label. It tells the percentage of each active ingredient in the formulated product. This usually follows the chemical name. For pesticides in liquid formulations (emulsifiable concentrates, flowables, etc.), there is a statement giving the pounds of active ingredient in a gallon of the formulated product. The concentration of active ingredient is sometimes indicated in the brand name; for example, Benlate 50W is a wettable powder containing 50% of the active ingredient benomyl. Methyl Parathion 4E contains 4 pounds of methyl parathion per gallon of formulation. The other ingredients in the formulation (adjuvants) are described as "inert ingredients." The inert ingredients can be used to dilute or boost the effectiveness of the active ingredient. Adjuvants are emulsifiers, spreaders, stickers and buffering agents. Some can be more hazardous than the main ingredient; however, since 1987 EPA has required pesticide manufacturers to reformulate their products to eliminate most of the inerts that were of greatest toxic concern. Other inerts are being evaluated and new inerts are under more stringent regulations.

NET CONTENT The net contents statement indicates the amount of formulated pesticide product in the package. This information is useful in determining the amount to purchase.

REGISTERED USES The registered uses of a pesticide are listed in the "Directions for Use" on the label. This portion lists the specific crops, livestock applications, or other uses for the pesticide. The "directions for use" portion of the label also tells how much of the pesticide to use and when and where and how to apply it. Limitations on the use are found in this section or in a separate statement. It is illegal to use any pesticide in any way that is not stated on the label.

SIGNAL WORDS The pesticide label contains various warnings and precautions. On the front panel of each pesticide there are signal words that indicate the toxicity and/or hazards associated with its use. The pesticides with the greatest hazard are called Hazard Category I. Labels of these pesticides carry the signal words **DANGER-POISON** and have a red skull and crossbones on them. Moderately hazardous pesticides are Hazard Category II and carry the signal word **WARNING.** Slightly hazardous pesticides are Hazard Category III and carry the signal word **CAUTION.** All pesticide labels must also contain the statement **KEEP OUT OF THE REACH OF CHILDREN.** The approximate toxicity to humans of pesticides containing each of these signal words is:

Signal Word	Toxicity Category	Approximate oral* dose lethal to a human
DANGER-POISON (Skull/crossbones)	I-Highly toxic	Taste-teaspoon
WARNING	II-Moderately toxic	Teaspoon-2 table spoons
CAUTION	III-Slightly toxic	Ounce or greater

* Signal words may also be based on dermal toxicity or other hazards associated with the pesticide.

INCONSISTENT USE The use of a pesticide in a manner inconsistent with the label is a violation of FIFRA. The original prohibition of "use of any registered pesticide in a manner inconsistent with its labeling" was modified in 1978 [FIFRA Sec. 2 (ee)] to allow some deviations. Specifically there are four exceptions which allow applicators to vary applications from label instructions.

1. Application of a pesticide at dosages, concentrations, or frequencies **less than** those **specified on the label.**

2. Application of a pesticide **against a target** pest that is **not specified** on the label -- **if the crop, animal or site is specified on the label-- unless the label prohibits the use.**

3. Use **application methods not prohibited by the label** instructions. (Even more recent

regulations require that certain types of applications, such as chemigation, be specified on the label.)

4. Use **mixtures** of pesticides, or pesticides with fertilizers if they are **not prohibited** by label instructions.

WORKER PROTECTION

New rules for protecting agricultural workers from pesticide exposure were issued August 21, 1992. The new requirements for employers on farms, forests, nurseries and greenhouses are designed to reduce the risks of illness or injury resulting from pesticide handlers' and agricultural workers' occupational and accidental exposures during production operations.

The regulations apply to plant production and not to livestock, pasture/rangeland pesticide uses or control of vertebrate pests or post-harvest applications.

The agricultural enterprise's owner and immediate family are exempt from the required training, notification, decontamination, and emergency assistance provisions; however use of personal protective equipment and observation of restricted-entry intervals do apply.

Employers are responsible for protecting their workers; they are barred from preventing or discouraging any worker or handler from the benefits of the regulations.

An **agricultural employer** is one who hires or contracts for the services of agricultural workers OR who owns or is responsible for the management and condition of an agricultural establishment that uses such workers.

A **handler** is one who mixes, loads, transfers or applies, pesticides, disposes of pesticides or containers; flags; cleans, adjusts, handles or repairs contaminated equipment; assists with application, any worker who enters any enclosed area after use of airborne pesticide before Permissible Exposure Level or ventilation, who enters an area treated with a soil fumigant to adjust or remove tarps; or who performs tasks as a crop advisor during application or restricted entry interval.

A **worker** is one who performs other tasks related to production of agricultural plants in an agricultural establishment.

There are specific worker protection requirements for all employees and additional ones for "workers" and "handlers."

PROTECTION REQUIRED FOR ALL EMPLOYEES Centrally Located Information -- a poster containing information specified in the EPA Worker Protection Standards, the location of the nearest emergency medical facility, location of pesticide applications on the property and the product name, EPA registration number and active ingredient(s), time and date of application and restricted entry interval expires. The employer must inform all workers/handlers of the poster's location and allow access.

Emergency Assistance -- Prompt transportation to an appropriate medical facility if pesticide poisoning is suspected. Information from the pesticide label and how the exposure occurred must be provided to the employee and medical personnel who treat the exposed worker/handler.

Decontamination -- A decontamination site must be provided at the location during application, and during the restricted entry interval plus 30 days. Supplies for washing pesticides from the skin and eyes must be provided within 1/4 mile of all workers/handlers. This includes sufficient quantities of water, soap and single-use towels. Clean coveralls must be provided at the handler site. Eyeflush water must be made immediately available to handlers and early-entry workers if they are required to wear protective eyewear.

Information Exchange -- A commercial handler must provide an agricultural employer with the information that must be posted and deliver oral warnings as well as post treated areas, and provide other protection requirements on the label for workers or other people.

WORKER SPECIFIC REGULATIONS

Application Restrictions -- The employer must keep workers other than trained and protected pesticide handlers out of an area being treated. Under some application conditions, employers must keep nursery or greenhouse workers out of locations that are near an area being treated.

Entry Restrictions -- If contact with pesticides is possible, the employer must keep workers from entering a treated area until the Restricted Entry Interval expires. No entry for the first 4 hours after the application and until label-specified inhalation exposure level or the ventilation criteria have been met.

Workers must be informed of health effects and safety information from the pesticide labeling.

Personal Protective Equipment must be provided, cleaned, and maintained for the worker, the worker must be instructed in its proper use, maintenance and storage. Workers must be instructed that washing thoroughly after removing personal protective equipment is necessary. A clean place must be provided to put on and take off protective clothing and equipment, and to store personal clothing. Water, soap and towels must be provided. The employer is responsible for making sure no contaminated protective equipment or clothing is taken home. These provisions also apply to handlers.

Employers must make sure that **workers and handlers** are not subject to heat related illness while wearing personal protective equipment.

Unless the **worker** is a certified applicator or trained handler, any early-entry worker must be trained through written or audiovisual materials that the worker can understand. Training is to be administered by a certified applicator, a trainer of certified applicators, or other approved trainer. The training program must contain the general pesticide safety information specified in the Worker Protection Standards.

Notice of Applications - On farms, nurseries and forests, each worker who might enter a treated area or walk within 1/4 mile of a treated area either during application or a restricted entry interval must be warned orally or by posting warning signs at the treated area. At a greenhouse, each worker who might enter a greenhouse during an application or a restricted entry interval must be warned by posted warning signs at entrances to treated areas. Some pesticide labels require both methods of notice.

The posted warning sign must include the words "Pesticide/Pesticidas - Danger/Peligro - Keep Out/No Entre" and must contain the warning symbol (stern face and upraised hand), meet size and color requirements, and be visible at all usual entrances to the treated area.

The oral warning must give location and description of the treated area, the time span of restricted entry and instruct workers to not enter until the restricted entry interval is over.

HANDLER SPECIFIC REGULATIONS

Application Restrictions: The employer and the handler must make sure that no pesticide is applied so as to contact, either directly or through drift, any person other than a trained and protected handler. The employer must make sure that any handler who is working with a pesticide having a skull and crossbones symbol on the label is monitored visually or by voice contact at least every two hours. The employer must make sure that any handler who is working with a fumigant in a greenhouse maintains continuous visual or voice contact with another handler.

Knowledge of Pesticide Labeling: The employer must make sure that each handler has either read the pesticide labeling or been informed of its contents. The labeling must be accessible to the handler while working with the pesticide.

Safe Operation of Equipment: The employer must make sure that each handler is instructed in the safe operation of handling equipment and that all equipment is inspected and in good operating condition before each use.

Training: Unless already a certified applicator or trained to use restricted-use pesticides, handlers must be trained before performing handler tasks. The training must include written or audiovisual materials and be presented in a manner the handler can understand. The trainer must be a certified applicator, trainer of certified applicators, or other approved trainer. The training program must contain the general pesticide safety and correct handling practice information specified in the Worker Protection Standards.

Cleaning and Maintaining Personal Protective Equipment: The employer must make sure that anyone who cleans personal protective equipment is informed that the equipment may be contaminated with pesticides and the correct procedures for handling it, and that it is properly cleaned, dried and stored according to manufacturer's instructions. In addition, the employer must make sure that the equipment is inspected and repaired before each use and that filters, cartridges and canisters are replaced as required. The employer must make sure that equipment which cannot be cleaned or is severely contaminated is disposed of.

SUBSTITUTIONS AND EXCEPTIONS

Pilots in open cockpits are exempted from any chemical-resistant footwear requirement; a helmet may be substituted for chemical-resistant headgear and a visor may be substituted for protective eyewear.

Pilots in closed cockpits are exempted from all personal protective equipment requirements, but long-sleeved shirt, long pants, shoes and socks are required.

Handlers using closed systems for mixing and loading are exempted from all personal protective equipment requirements except chemical resistant gloves and apron; long sleeved shirt, long pants, shoes and socks. If the closed system is pressurized, protective eyewear is also required.

Handlers using enclosed cabs are exempted from all personal protective equipment requirements except respirator requirement; long sleeved shirt, long pants, shoes and socks. Respirators are waived if the enclosed cab offers respiratory protection equal to or greater than the type of respirator specified.

Handlers or early entry workers who are working with plants that have sharp thorns may wear leather gloves over chemical-resistant glove liners.

Handlers or early entry workers who are working in rough terrain may wear leather boots instead of chemical resistant footwear.

REQUESTS FOR EXCEPTION

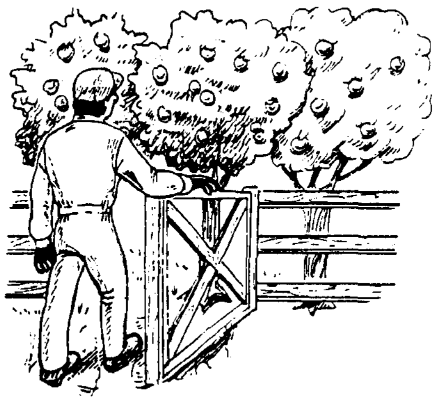
Affected parties may request an exception to the restricted entry interval; however the process takes approximately one year from the time of application.

PESTICIDE RECORDKEEPING

A 1993 U.S. Department of Agriculture regulation requires certified private pesticide applicators to keep records of Federal restricted-use pesticide applications. This recordkeeping is administered by the USDA's Agricultural Marketing Service. Where such records were already required by State law, applicators may continue to follow the State regulations. In other areas, applicators must begin keeping records that comply with the USDA requirements. You should be able to get details about the recordkeeping requirements from the Extension agricultural agent in your area or from your State agency in charge of pesticide regulation. In general, the records you keep must contain:

- o The brand or product name of the Federal restricted-use pesticide and its EPA registration number.
- o The size of the area treated.
- o The total amount of product applied.
- o The crop, commodity, stored product, or site to which the pesticide was applied.
- o The location of the application.
- o The month, day, and year of the application.
- o The certified applicator's name and certification number (if numbers are assigned in your State).

There is no required form that you must use for this recordkeeping. Any form is acceptable as long as the required information is included. You must keep the records for 2 years from the date of the pesticide application. If a commercial applicator performs work for you, that applicator must provide you with a written copy of the necessary information about the application. If you do not comply with the recordkeeping requirements, you may be fined up to $500 for a first offense and not less than $1,000 for any later offense (unless it is determined that you have made a good-faith effort to comply).



TRANSPORTATION

Shipment of pesticides and other dangerous substances across State lines is regulated by the U.S. Department of Transportation (DOT). The DOT issues the rules for hauling these materials. If you ever haul pesticides between States, you should know that:

- The pesticides must be in their original packages. Each package must meet DOT standards.
- The vehicle must have a DOT-approved sign.
- The pesticides may not be hauled in the same vehicle with food or feed products or with packaging material intended for use with such products.
- You must contact DOT immediately after each accident:
  (a) when someone is killed,
  (b) when someone is injured badly enough to go to a hospital, or
  (c) when damage is more than $50,000.
- You must tell DOT about all spills during shipment.

Contact the State, tribal, or territorial DOT office for detailed information on which pesticides are listed as hazardous substances and what rules apply to them during transportation.

AERIAL APPLICATION

Application of pesticides from airplanes is regulated by the Federal Aviation Administration (FAA) and may be regulated by your State. FAA judges both the flying ability of pilots and the safety of their aircraft. FAA rules say, as FIFRA does, that an aerial applicator may not apply any pesticide except as the labeling directs.

FIELD SANITATION

The Field Sanitation Standard is a 1987 Occupational Safety and Health Administration (OSHA) regulation. In general, it applies to agricultural employers who employ more than 10 field workers or who maintain a labor camp. The Field Sanitation standard requires these employers to provide three things to their employees who are exposed to agricultural chemicals: toilet facilities, hand-washing facilities, and clean drinking water. The Standard also requires the employers to inform each employee about the following good hygiene practices:

- Use the water and facilities provided for drinking, handwashing, and elimination.
- Drink water frequently, especially on hot days.
- Urinate as often as necessary. Wash hands both before and after using the toilet.
- Wash hands before eating and smoking.

Summary Chapter I

FIFRA is the basic law that regulates the use of pesticides.

Restricted Use Pesticides can only be applied by Certified applicators or under the direct supervision of a certified applicator

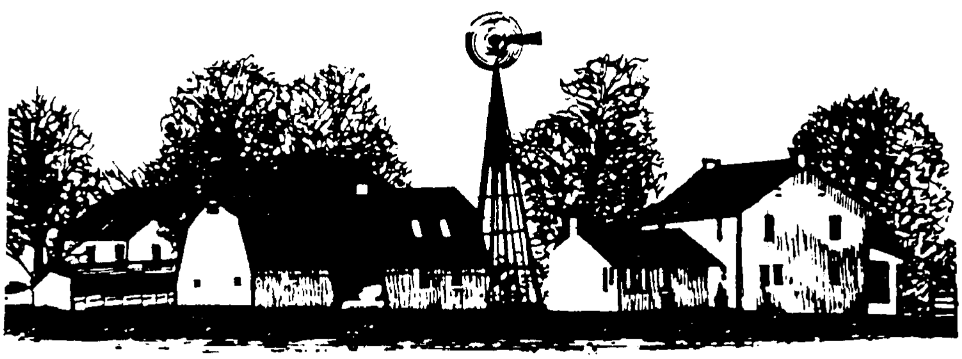
Pesticide labels contain all the information needed for determining use of the pesticides. THE LABEL IS THE LAW. Read and follow it exactly.

The Superfund Amendments and Reauthorization Act and Endangered Species Act have provisions that affect the use and handling of pesticides.

Be sure that each person who applies pesticides understands how to use them and follows the label precautions. A supervisor is responsible for everyone under his/her direction.

Observe Restricted Entry Intervals required by the product label. Never enter a treated field unless trained to do so using required protective equipment.

A CERTIFIED PRIVATE APPLICATOR IS AUTHORIZED TO PURCHASE AND USE RESTRICTED USE PESTICIDES ON PROPERTY HE/SHE OWNS OR RENTS OR FOR NEIGHBORS IF NO COMPENSATION OTHER THAN TRADING OF PERSONAL SERVICES IS EXCHANGED.



Chapter II

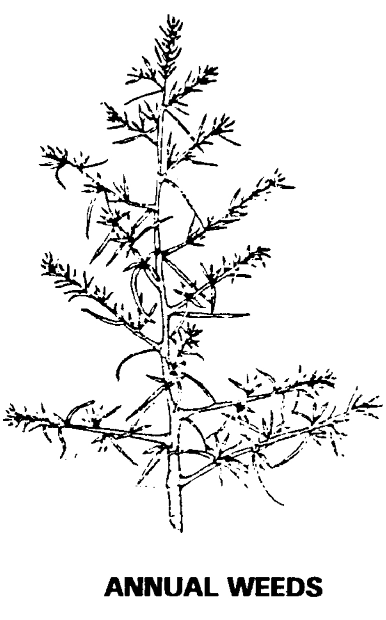
PESTS

In agriculture, various plants, animals and other life forms may impede the raising of crops and livestock. They are called "pests" in situations where they are not wanted, but a "pest" may be a desirable plant, animal, or other organism when it exists in a nonthreatening environment.

It is important to identify any pest that conflicts with production, affects human health or comfort, or destroys property. Knowledge of the life stages (growth), behavior and potential for damage to agricultural production is necessary so a pest can be managed effectively. Common agricultural pests in Colorado can be classified into five main groups:

1. Weeds
2. Plant disease agents (fungi, bacteria, viruses, etc.)
3. Arthropods (insects, mites, ticks, etc.)
4. Slugs and snails
5. Vertebrates (birds, rodents and other animals)

WEEDS



Weeds are defined as "plants out of place"; therefore, it may be difficult to distinguish between a weed and a desirable plant. Even a widely recognized agricultural weed such as quackgrass is beneficial when it is growing on a steep road bank and prevents erosion. Also, a corn plant may be a weed if it grows as a "volunteer" in a field planted with a different crop.

Unwanted plants assume the role of weeds when they compete for water, nutrients and light with an agricultural crop. Some "weeds" even secrete chemical inhibitors from their roots and damage nearby growing plants. They may also foul harvest machinery or contaminate produce. On rangeland, weeds crowd out needed forage plants and may be poisonous to livestock. Weeds also may harbor plant disease agents, insects or mites.

Weeds are commonly classified by their life cycles -- either annuals (one year), biennials (two years), or perennials (multi-year).

ANNUAL WEEDS

Annual weeds are plants that germinate from seed, grow, flower, and produce new seed in less than 12 months. However, among the annual weeds, a variety of life cycles can occur. ***Summer annuals*** are plants that germinate in spring, flower and produce seed during the summer, then die the same summer or fall. Common summer annual weeds are sunflower,

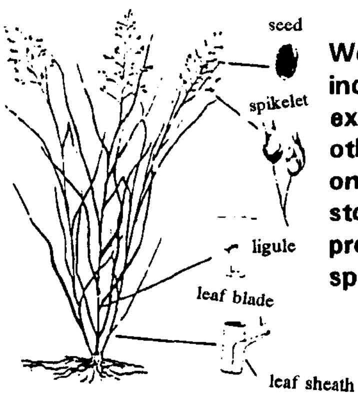
lambsquarter, nightshade, pigweed, wild oats, wild proso millet, and Russian thistle. Summer annual weeds are the greatest problem in crops that are planted in the spring.

Winter annuals germinate in the fall and overwinter as low growing plants, resume growth in the spring, bloom, and produce seeds shortly thereafter. Common winter annual weeds are tansy mustard, jointed goatgrass and shephardspurse. They tend to be the greatest problem in crops that are seeded in the fall and in semi-permanent crops such as alfalfa.

BIENNIAL WEEDS

Biennial weeds have a **two year life cycle**. They germinate in spring or early summer and overwinter as low growing plants (rosette) with a long taproot. The following year these plants resume growth and produce a flowering spike in late spring or summer. After producing seeds, the plants die. Biennial weeds in the region include musk thistle, burdock, and mullein. They pose the greatest problem in pastures.

PERENNIAL WEEDS



Weeds that live for several years are called perennials. They may persist indefinitely in an area unless they are controlled. Many perennials produce extensive root systems that prevent them from being destroyed by tillage or other above ground control practices. Perennials reproduce by seeds, but once established can spread by underground runners (spreading roots, stolons, rhizomes), bulbs, or tubers. Perennial weeds that are continual problems in agriculture are field bindweed, dandelion, Canada thistle, leafy spurge, and quackgrass.

PLANT DISEASE AGENTS

ABIOTIC DISEASES

An **abiotic plant disease** is any condition that disturbs the normal and optimal growth and function of a plant. These can result from adverse environmental conditions such as nutrient imbalance, excessive salinity, oxygen starvation of roots, air pollution, and extreme temperatures. Abiotic diseases are **not caused by living organisms**.

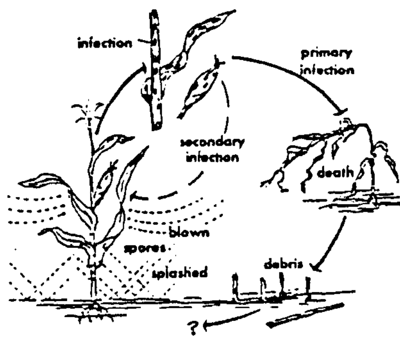
PARASITIC DISEASES

Parasitic diseases are caused by infection of a plant by any of a variety of microorganisms such as fungi, bacteria, mycoplasmas, viruses, and nematodes. **Organisms** that produce plant diseases are known as **plant pathogens**.

Sometimes plant disease agents are **spread by other organisms**, such as insects, mites or nematodes. These organisms are called **vectors**.

FUNGI

Fungi are the most important single group of plant pathogens in Colorado. Fungi are a highly diverse group of organisms with many different types of life cycles. Some feed on living plant tissues, others primarily on dead plants. Fungi cause rotting/decay, mold, powdery mildew, vascular wilts, and leaf spotting. In Colorado, fungi cause stalk rot of corn, rusts, Fusarium wilt, Phythophthora root rot, botyrtis neck rot, early blight, damping off diseases, blue stain diseases of conifers, wood decay fungi, and storage molds.



Fungi reproduce by spores, and an actively growing and fruiting fungus can release millions of spores. The familiar mushroom is the spore producing structure of many fungi, while other organisms produce very small, often microscopic, fruiting bodies. Many fungi also produce hardened protective structures, known as sclerotia, that allow the fungus to live for several years in the soil.

Most spores are dispersed by the wind, but zoospores can move in water. Spores have specialized structures that help them penetrate plant tissues.
When they land on a susceptible plant where warm moist conditions exist the spores germinate.

BACTERIA

Bacteria are very small one-celled organisms. They reproduce by budding and can multiply rapidly under high moisture conditions. Bacteria that affect plants dissolve plant tissues by secreting enzymes or by plugging the sap stream of the plant, causing it to wilt. Fire blight of apples and pears, bacterial ring rot, soft rots, crown gall, and halo blight of beans are examples of bacterial diseases found in Colorado.

Bacteria rarely are able to move by themselves; most are spread by splashing water, infected seed, farm equipment, or by insects.

MYCOPLASMAS

Mycoplasmas were recently discovered as plant disease organisms. They have many characteristics of bacteria but lack a cell wall. They develop in the sap stream of plants and are spread by insects, primarily leafhoppers. Aster yellows that affect vegetable and flower crops are caused by these organisms. Pear decline and X-disease of peach are serious mycoplasma diseases of orchard crops.

VIRUSES

Viruses are extremely small particles that are primarily recognized by the symptoms they produce in plants. Leaf streaking diseases, known as "mosaics," many "yellows" diseases, and ring spots are caused by viruses. Viruses multiply by causing the infected cells of their host plant to form virus particles. By changing the normal function of the plant cells, the plant is injured.

Many viruses are spread mechanically as plants rub together or by machinery. Others are spread by specific insects, usually aphids or leafhoppers. Some are spread by mites, nematodes, or fungi.

Potato leafroll, beet curly top, barley yellow dwarf, tomato spotted wilt, and wheat streak mosaic are viral disease problems in Colorado agriculture.

NEMATODES

Nematodes, also called roundworms or eelworms, are microscopic organisms of which thousands of different types occur in healthy soils and water. A few types attack plants and cause disease. Nematodes can move short distances on water films, but human movement of infested soil or plant materials is the most common method of movement. This is particularly true with nematodes that produce resistant structures, allowing them to survive for several years. In Colorado, sugarbeet cyst nematodes, alfalfa stem nematodes and various "cyst" and "sting" nematodes are the most common problems. Nematodes are fairly rare in the arid West because of dry and heavy soils.

PARASITIC PLANTS

Some plants live and develop by invading other plants and robbing them of water and nutrients. These "parasitic" plants include dwarf mistletoe which feeds on evergreen trees and dodder which feeds on alfalfa and other non-woody plants, both of which occur in Colorado.

These parasitic diseases spread by producing small seeds, or in the case of dodder, by movement of plant fragments. Infected plants can be seriously damaged or killed by the parasites and have to be destroyed to prevent further development of the problem.

ARTHROPODS

Arthropods, or the "jointed foot" animals, are the most common form of life on earth, with endless numbers of species.

One group of arthropods -- insects -- contains more than a million species. Other arthropod groups are mites, ticks, spiders, millipedes, and centipedes. All arthropods have a unique set of features that distinguishes them from other animals. These features are:

1. Segmented body
2. Jointed appendages (legs, antennae, feet)
3. External skeleton (exoskeleton)
4. Growth involving periodic shedding and replacement of the exoskeleton (molting)

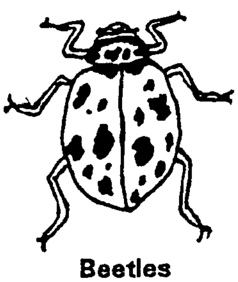
Arthropods also have characteristic internal structures -- a tube-like "heart" that runs down the back and a nerve cord that runs along the lower body.

Insects -- This is the largest group of arthropods. Characteristics that separate them from other arthropods are:

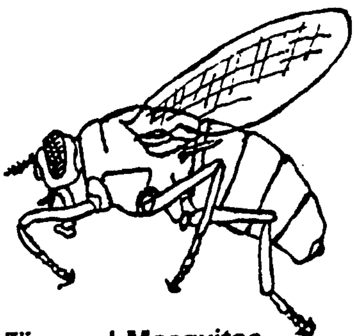
1. 3 body regions (head, thorax, abdomen)
2. 3 pairs of legs
3. Adult stage is often winged.

The various groups of insects are recognized by type of wings and mouthparts and the developmental changes they undergo.

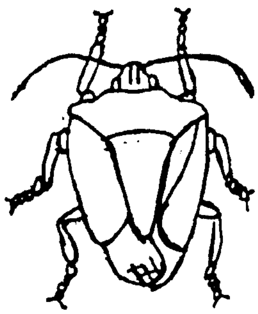
Wing types vary greatly among adult insects. Beetles have a hardened pair of front wings, while moths and butterflies have wings covered with scales. Flies and mosquitoes have only one pair of wings, while most insects have two. Some groups of insects never produce wings.



Beetles



Flies and Mosquitos

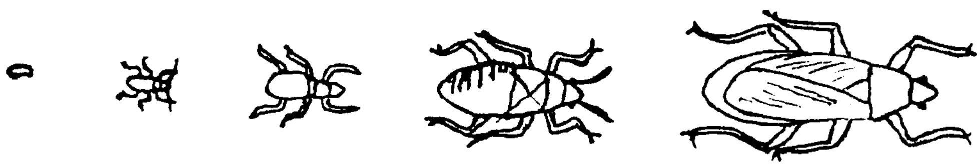


True Bugs

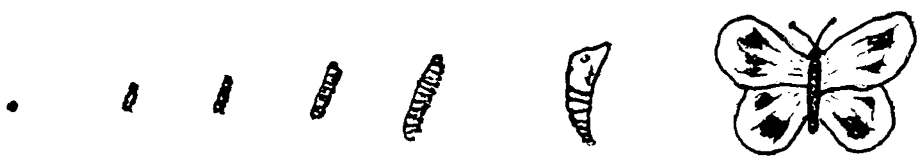
Mouthparts of insects are generally designed to either cut and chew or suck fluids. Grasshoppers, beetles, caterpillars, bees, and wasps are typical insects with chewing mouthparts. Insects with sucking mouthparts are aphids, leafhoppers, "true bugs," mosquitoes and moths. The mouthparts form a tube to penetrate plants or animals and suck fluids through a channel. The thrips have a special type of mouthpart that enables puncturing tissues and sucking fluids with a separate cone-like structure. Insects with sucking mouthparts can transmit disease organisms to plants or inject toxic substances while feeding.

Metamorphosis is the term for the changes in form that all arthropods undergo during development. Among the **insects**, two patterns of metamorphosis predominate -- simple (or gradual) and complete. The stages are:

Simple Metamorphosis: Egg -> Nymph (3-7 molts) -> Adult



Complete Metamorphosis: Egg -> Larva (several molts) -> pupa -> adult



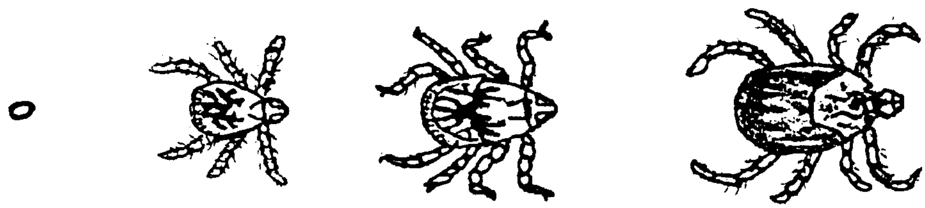
Aphids, leafhoppers, earwigs, grasshoppers, and true bugs are among the insects that undergo **simple metamorphosis**. The immature insects which emerge from eggs are called nymphs. As the nymphs feed and grow, they periodically shed their skins and transform to the next stage, a process known as molting. They go through 3-7 molts, emerging from the final molt as adults. Both the nymphs and adults of insects with simple metamorphosis feed in the same manner, are often found together, and may look somewhat alike. The adult insects, however, may be winged and are sexually mature.

Moths, butterflies, beetles, flies, ants and lacewings are examples of the many insects that undergo **complete metamorphosis**. The eggs hatch into the immature larval stage. This stage often causes the most injury to plants and animals since the larvae feed heavily in order to develop. As they grow, the larvae molt and shed their skin repeatedly. After reaching full development, they are transformed into a unique developmental stage called the pupa, during which they appear to be inactive but dramatic internal changes are taking place. The insects emerge from the pupa stage as adults, which look very different from the larvae and often have completely different feeding habits and behavior.

A separate group of arthropods called arachnids include the mites and ticks, spiders and scorpions. The key identifying feature is that they have four pairs of legs. Also, most have two distinctive body regions (cepahlothorax and abdomen) although in mites and ticks the separate regions may be hard to distinguish because they have rounded bodies.

Mite and tick eggs hatch into larvae which are tiny and have only three pairs of legs. After the first molt, they acquire the fourth pair of legs and are called nymphs. There can be several nymphal stages before transformation to the adult tick or mite.

Arachnids (mites and ticks), stages of metamorphosis:



Arthropods as Pests

Insects, mites and ticks are pests in crops, livestock and stored products. They transmit plant an animal diseases and cause human discomfort. Annually, arthropods do damage in the billions o dollars in the United States and cause greater losses worldwide.

Many insects, however, are beneficial since they assist in pollination of crops, recycle nutrients, serve as food for wildlife and other desirable species, and prey upon other pest species. It is important to distinguish between the pest and beneficial species and those that are neither.

SLUGS AND SNAILS

Slugs and snails are mollusks and are more closely related to clams or mussels than to insects and other arthropods. Pesticides used to control arthropods have little effect on slugs and snails.

Slugs and snails depend on moist conditions to survive and develop. For this reason, they are relatively infrequent problems in Colorado, except in greenhouses or lush growing garden areas.

VERTEBRATE PESTS

Mammals and birds can be pests when they interfere with agricultural production but may be considered "wildlife" in other situations. Examples include deer and elk which damage vegetables and haystacks in the mountain areas; coyotes which prey on lambs; blackbirds which damage ripening cherries; voles which injure trees, rodents that infest stored grain, or prairie dogs that damage pasture land and fields.

Summary Chapter II

Pests include plants, animals, and disease agents.

Plant and animal life that are pests in one place may not be pests in another.

The number of an unwanted plant or animal species determines the need to use pest control measures.

Chapter III

PEST CONTROLS

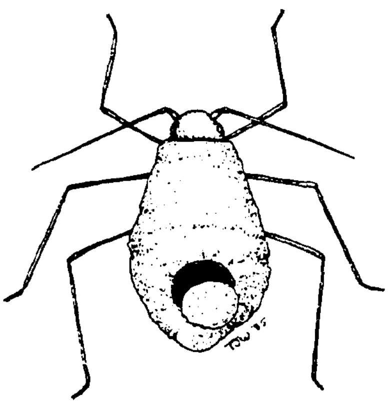
Pest control management can be achieved most effectively through a combination of techniques, including biological, cultural, mechanical, chemical, and regulatory/legal methods.

NATURAL CONTROLS All animal and plant species are subject to some degree of natural control, which is commonly known as the "balance of nature." Important natural controls are temperature, moisture, and wind. In Colorado, cold winter temperatures are significant in limiting the overwinter survival of many insects and mites. The germination of weed seeds depends on adequate soil moisture and temperature. Movement of bacteria, germination of fungus spores, and nematode survival all depend on the existence of water films. Wind movement of soil particles and water droplets reduces insect populations. These physical controls are also called **abiotic** controls.

Other natural controls are animal predators or disease agents that feed on or infect pest species. These natural enemies -- predators, parasites or pathogens -- are called **biotic** controls.

BIOLOGICAL CONTROLS

Predators are organisms that live and feed on other organisms. Common predators of insects in Colorado are ladybird beetles, lacewings, ground beetles and damsel bugs. Insects and mites can be predators of weeds and plants. Coyotes are predators of rodents. Nearly all animal and plant life can be both predator and prey.



Parasites are also natural enemies. Parasite often means an organism that is harmful to desirable plants, animals, and humans, but when it attacks a pest species, a parasite can be beneficial. Insect parasites consist of other insects which develop internally (rarely externally) on a host insect. Only a single host insect is killed by a developing parasite, but often several parasites develop in a single host insect. Parasitic insects can be highly specific as to the organism on which they develop and many attack only a single species of insect or a small group of closely related insects. Parasitic wasps and tachinid flies are common insect parasites. Colorado potato beetle, forest tent caterpillar, and greenhouse whitefly are examples of local pests which can be largely controlled by parasites.

Pathogens are various kinds of microorganisms that provide natural controls of pest species. They can be fungi, bacteria, viruses, and nematodes which attack weeds, insects, mites and even other pathogens. They are usually specific in the organisms they attack, and very few attack both plants and animals. For example, none of the numerous fungus diseases that affect pest insects also attack mammals or birds. Similarly, fungi which attack plant pathogenic fungi do not attack desirable species of plants.

BIOLOGICAL CONTROL is manipulation of biotic controls in managing pests, including:

- introduction of natural enemies of pests;
- conserving existing natural enemies of pests;
- creating favorable environmental conditions for the natural enemies.

Several natural enemies have been introduced into Colorado to control new pest species that have become established in the State. For example, several wasps that attack alfalfa weevil are now widely established and help reduce losses from weevils. Similarly, weevils (Rhynocyllus) that attack the seeds of musk thistle have been established. New natural enemies of insect pests and weeds in Colorado are continually being introduced through Colorado Department of Agriculture programs.

Some natural enemies of pests are used as "biological pesticides." The bacterial disease Bacillus thuringiensis is effective in controlling most leaf and needle feeding caterpillars such as the European corn borer. Other strains of the same disease control mosquito larvae in water or fungus gnats in potting mixes. Several species of predatory mites are used to control mites and thrips on greenhouse crops. Microorganisms are also used to control crown gall bacteria in woody plants. Disease agents are also being developed to attack specific weeds.

The conservation of natural controls can be accomplished by using chemical and cultural controls in ways that will not damage the natural controls. One method is to use "selective" insecticides that only kill the insects that are the pests, or timing the application to kill only the target pest species. For example, use of dormant oils on fruit trees will not harm predators that do not overwinter on trees. Reducing dusty conditions during planting helps insect parasites and predators of spider mites.

Improving the performance of natural enemies of pests may require changes in crop environments. When an insect predator requires nectar, planting suitable nectar producing plants or applying artificial nectar sprays may improve the predator population.

CULTURAL CONTROLS

Cultural control includes the use of clean planting stocks, resistant varieties, crop siting techniques, tillage, sanitation, and certain harvesting practices. These may be the most important means of pest control.

Clean Planting Stock: Using high quality seed and other materials that are free of weed seeds and plant disease agents can prevent serious pest problems.

Resistant Varieties: Development and use of plant varieties that are resistant to crop diseases is essential to production of many crops. The pea-aphid-resistant alfalfa is one example.

Plant Vigor: Conditions that favor rapid crop establishment and vigorous plant growth help reduce pest problems. Weeds can be smothered by a crop that has formed a thick canopy. Fungus diseases can prosper in crops that are stressed from inadequate water, poor fertility or other condition.

Crop Siting: Properly locating a crop can be extremely important in preventing pest problems. *Plantings should be not be done in fields where there have been infestations of* weeds or diseases that could adversely affect the crop. Fields can also be isolated from sources of overwintering insects and diseases, such as in seed potato production.

Crop Rotation: Crop rotation is fundamental to controlling plant diseases. Since many plant disease organisms survive in crop debris, planting non-susceptible crops can

can prevent further development of a disease organism and ultimately cause it to die out. For many pathogenic organisms, such as soft rots and Botrytis, a single year of crop rotation can sufficiently reduce the numbers of a plant disease agent so that it will not be a problem. Other plant disease agents, such as white mold and sugar beet cyst nematodes, may require multi-year rotations out of susceptible crops in order to reduce the organism to non-damaging levels.

Crop rotations are also important in controlling difficult weeds. Densely growing crops, such as small grains, may be used to help smother developing weeds in a field. Suitable crop rotations also allow control of weeds with herbicides that are not suitable in other crop systems. For example, wild proso millet may be controlled with post-emergence herbicides in bean plantings; available pre-emergent herbicides in corn may not achieve adequate control.

Crop rotation is an effective method for controlling insects that overwinter in immobile (egg, larva) stages. These insects die if the crop planted the following year does not support the later life stages of the insect. For example, corn rootworms lay eggs around the base of corn plants in late summer. If corn is not planted within a few feet of the eggs the following year, the larvae which hatch in June die from starvation. Rotation of greenhouse crops to allow for "host-free" periods can be effective in managing greenhouse whitefly.

Sanitation: Proper sanitation practices are important to the overall management of many pests. For example, pest species of flies that breed in livestock manure can be reduced by proper manure handling. Culled vegetables provide reservoirs for disease agents unless they are properly disposed. Pruning and disposal of diseased wood is necessary for management of fire blight. Flower cuttings and plant debris under benches promote the growth of leafminers and fungus gnats in greenhouses. Disinfection is a means of controlling bacterial ring rot of potatoes, and clean equipment controls the spread of disease agents and weeds between fields.

Harvest Practices: Harvest practices are also effective tools for managing pest problems. Wounds to potatoes or onions during harvest allow plant disease agents to enter and destroy the crop in storage. Blister beetles in alfalfa hay increase when the hay is crimped during cutting, trapping the beetles.

Tillage: The main purpose of tillage (cultivation) is weed control. During cultivation, roots of weeds are cut, and young seedlings are buried. Weed seeds, also buried during plowing, can survive for several years and return to the surface with subsequent plowing. Eliminating surface debris is necessary before using preemergence herbicides that are sprayed as a soil barrier.

Tillage also helps speed up the decomposition of crop residues, which can limit the survival of some plant disease agents. Many fungus disease organisms can overwinter on intact crop debris but die when decomposition occurs. For example, tan spot of wheat increases when tillage is reduced.

The effects of plowing on insects are mixed. Many insects which overwinter in crop debris, such as European corn borer, can be killed during plowing; grasshopper eggs can be exposed and killed. Highly mobile species, such as potato psyllid and corn earworm, are not directly affected by tillage. On the other hand, greenbug aphids are less attracted to wheat that has a lighter surface background created by crop debris.

MECHANICAL CONTROLS

Mechanical control means physically removing, trapping, or excluding pests from a field, crop or other site. These controls are usually labor intensive or expensive but can be useful on small acreages, in crops of high value, or where alternative controls do not exist.

There are various mechanical devices and means for excluding insects. **Screening** dairy barns is useful in reducing fly problems. Screens also prevent insects, such as cutworms and thrips, from entering greenhouses. Slugs can be excluded from a planting by using copper barriers. Insects may be **trapped** by attraction to lights and colors. Also hand picking insect pests off a crop would be a simple mechanical control.

Mechanical controls of weeds include **hand pulling, hoeing, or mowing.** Artificial mulches are mechanical weed controls, as are ditchbank burning and selective flaming.

REGULATORY CONTROLS

Legal controls involve the lawful regulation of areas to eradicate, prevent or control infestations of pest species.

Quarantines are laws that regulate the movement of plants or animals in commerce to help prevent the spread of pests. For products to be moved out of areas known to be infested by certain pests into protected areas, they must be inspected and certified as being pest-free. Quarantines are critical to preventing many animal diseases, such as foot and mouth disease and brucellosis. Quarantines have also prevented the movement of uninspected apples into California from Colorado's Western Slope orchard areas where apple maggot infestations were suspected. Quarantines also restrict the movement of white fleshed peaches and nectarines into Mesa County to prevent the introduction of peach mosaic disease.

Eradication programs are occasionally undertaken to eliminate pest species that have entered a new area. In Colorado, an attempt has been made to eradicate the gypsy moth, a serious pest of shade trees. Such efforts are more likely to be successful if initiated shortly after a pest is found in a region so that its distribution is limited.

Pest control districts are organizations embracing several political jurisdictions, formed to enable control of pests over a wide area. One type of pest control district is the Weed Control District empowered by noxious weed laws. In many parts of Colorado, these organizations are focussing on weed species that are particularly injurious and difficult to control once established, such as Canada thistle and leafy spurge. The districts can treat infested areas with herbicides and often have powers to require landowners to control noxious weeds on their properties. During periods of grasshopper outbreaks, grasshopper control districts can be formed to coordinate area-wide activities.

CHEMICAL CONTROL

Chemical control typically means use of pesticides. These controls have been used for **Centuries**, but it is only in the last 40 years that highly effec tive formulations have been produced and widely used to protect crops and livestock. Although chemical pesticides have been central to the control of many pests during these years, there are risks and hazards that dictate they be used with particular care. This is discussed more completely in the next chapter.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is a system for making the best Pest management decisions based on both ecological and economic considerations. It is not a 'particularly new idea since sound pest management practice has always involved IPM approaches.

Fundamental to Integrated Pest Management are a number of assumptions:

- Optimal pest management is achieved by using a combination of techniques;

- Use of the various pest management techniques should be integrated so their effects complement each other;

- Since eradication of pests is not often achievable nor desirable, controls should be applied only when pest populations are large enough to justify their control. Scouting or monitoring fields is used to determine the extent of the infestation.

- In deciding what pest management techniques to use, the long-term costs, including social and environmental costs, must be considered;

- The success of any pest management practice must be continually evaluated to determine whether the desired result is being achieved most effectively.

Often, a combination of control techniques is required to manage pest problems effectively. For example, control of flies in a dairy operation depends on proper manure handling (cultural control), screening of barns to exclude flies (mechanical control), and selective use of insecticides (chemical control). None of these techniques alone may be sufficiently effective.

Care must be taken to coordinate the various control techniques so their effects don't conflict in the overall pest management plan. For example, certain uses of insecticides against pest species can seriously reduce the effectiveness of biological insect controls. Mulching used for weed control can increase the prevalence of slugs, particularly in high moisture conditions. Some tillage and harvest practices may adversely affect beneficial biological control organisms as well as destroy pests.

Repeated use of a single pest control approach can diminish its value. This has been most common with the use of pesticides. Many insects, mites, fungi, and even a few weeds have become resistant to pesticides that had previously been effective. Pesticide use may also cause shifts in pest problems. For example, nightshade weed has increased in many fields after use of several commonly used herbicides that were ineffective against nightshade. Mite problems in fruit and field corn often are aggravated by early season insecticide use directed against other pests.

Finally, other serious "non-target" effects may result from pesticide uses:

1. Some pesticides may be highly toxic to the applicator or to wildlife around a treated area.
2. Pesticides may move into and pollute ground or surface waters.
3. Pesticide residues may contaminate food or feed.
4. Plants may be inadvertently damaged by pesticides.

These result in hidden costs that are not always considered when making pest control decisions.

ECONOMIC THRESHOLD A concept that is basic to the Integrated Pest Management approach is the economic threshold. This concept recognizes that almost any pest can occur in numbers that do not cause crop loss or where the cost of control exceeds the damage. The economic injury level means the lowest number of insect pests that will cause economic damage. **The economic threshold is the density at which control measures should be used to prevent the pest population from causing economic injury.** Use of economic thresholds require that fields be scouted regularly to determine the number of pests. Economic thresholds change with the growth stage of the crop and the crop value.

Several economic thresholds have been calculated for Colorado pests, particularly insect pests. For example, control of Banks grass mite on corn is recommended when visible damage occurs on the lower third of the plant and the mites have begun to make colonies on the middle third of the plant. Treatments for control of greenbug aphids on small grains are recommended when populations reach 5-15 aphids/stem on seedlings. The threshold increases to 25 per stem during the boot to heading stages. Greenbug control is not recommended for small grains that are heading since it is unlikely there would be a net economic return from an insecticide application at that stage.

Summary Chapter III

Natural pest control factors such as predators, parasites and pathogens keep many potential pests under control.

Cultural control consists of "housekeeping" measures that keep pests from multiplying in agricultural crops.

Mechanical control means physically excluding pests from areas where they are not wanted.

Chemical control means using pesticides to kill unwanted plant or animal life that interferes with agricultural production.

Integrated Pest Management is the coordinated use of all available control methods to keep pests from reaching the level that is economically harmful to agricultural producers.

Chapter IV

PESTICIDES: TYPE, CLASSIFICATION AND FORMULATION

A **pesticide** is a chemical or other substance produced and sold for the control of a pest species. A pesticide may kill the pest or merely inhibit its development. All substances sold to kill, retard, repel or attract pest species are regulated as pesticides. In the current version of the Federal Insecticide, Fungicide and Rodenticide Act, the legal definition of a pesticide has further been expanded to include defoliants, plant growth regulators, and desiccants.

TYPES OF PESTICIDES

Various types of pesticides are recognized by the types of pests they are used to control. Although most are chemical substances, some are either natural substances or synthetic versions of natural substances. Common pesticides include:

Herbicide - a chemical or other substance used to kill undesirable plants.

Insecticide - a chemical or other substance used to kill undesirable insects.

Fungicide - a chemical or other substance used to kill undesirable fungi.

Miticide (also called **acaricide**) - a chemical or other substance used to kill mites and ticks.

Bactericide - a chemical or other substance used to kill bacteria (sometimes referred to as sanitizers or disinfectants).

Molluscicide - a chemical or other substance used to kill pest mollusks such as slugs and snails.

Nematicide - a chemical or other substance used to kill nematodes.

Rodenticide - a chemical or other substance used to kill rodents.

Plant growth regulator - a chemical or other substance used to desirably alter the growth processes of crop plants.

Wood preservative - a chemical substance used to protect wood from decay and stain fungi, insects, and other wood destroying organisms.

Defoliant - a chemical or other substance used to produce leaf drop.

Desiccant - a chemical or other substance used to promote drying as a harvest aid.

CLASSIFICATIONS OF PESTICIDES

Pesticides are grouped and classified in different ways based on their chemistry, origin, or mode of action and use.

CHEMISTRY Pesticides and other chemical compounds have either inorganic or organic chemistry. Organic means they contain carbon in their molecular structures. These are overwhelmingly the largest group of currently used pesticides. Inorganic pesticides, the oldest used pesticides, do not contain carbon. Copper fungicides, lime-sulfur used to control fungi and mites, boric acid used for cockroach control, and ammonium sulfamate herbicides are examples of inorganic pesticides.

SOURCE Pesticides, particularly insecticides, are also discussed in terms of their source. Natural organic pesticides are derived from natural sources. Various plant-derived insecticides, such as pyrethrum, rotenone, and nicotine are examples of natural organic pesticides. Synthetic organic pesticides are man-made. Almost all currently used pesticides are synthetically produced compounds, although some are based on naturally occurring chemicals.

SYSTEMIC/CONTACT Pesticides may classified as either systemic (translocated) or contact compounds.

Systemic or translocated pesticides can be picked up through the leaves or roots of a plant and move within the plant. Systemic pesticides vary in how readily they move in a plant, and movement depends on environmental factors, such as heat and moisture, as well. Some systemic herbicides move widely in plants. For example, glyphosate, the active ingredient in many herbicide products, when applied to leaves may move into and kill the plant roots. Alternatively, the insecticide, aldicarb, applied to roots moves upwards in the plant and concentrates in actively growing foliage. Some insecticides used for control of livestock pests are also systemic after being fed or injected into an animal. **Contact** pesticides kill simply by coming in contact with plants (herbicides) or insects (insecticides).

MODE OF ENTRY Insecticides are also described in terms of how they enter the insect. Stomach poisons, such as Bacillus thuringiensis, must be ingested by the insect to be effective. Contact insecticides penetrate through the external skeleton (cuticle) of the insect. Insecticides which primarily enter through the breathing openings (spiracles) are called fumigants.

HERBICIDE TERMS Herbicides can be selective or non-selective, pre-plant, pre-emergence, or post emergence in their mode of action.

Selective herbicides can kill one type of plant but cause little or no injury to another. For example, 2,4,D is considered to be selective since it is more active against broadleaved weeds than against grasses. However, if it is used at an excessive rate or at the improper time,selectivity is reduced and injury can occur to normally tolerant crops. Selective herbicides applied to actively growing weeds may act as either contact or translocated herbicides.

Non-selective herbicides are toxic to both crop and weed plants. Desiccant herbicides such as paraquat and diquat are examples of non-selective herbicides.

Soil sterilants are non-selective herbicides used as soil treatment and which can kill actively growing plants and prevent growth of new plants for as long as the compound remains active, often several years. Soil sterilants are used in maintaining rights-of-way or in other areas where no vegetation is desired. **Serious damage can be done to desirable plants, such as trees and shrubs, if soil sterilants are applied near landscape plantings.**

Pre-plant herbicides are applied to the soil before planting a crop. **Pre-emergence** herbicides are applied after planting but before weeds or the crop emerges. **Post-emergence** applications are made after weeds and the crop have emerged.

FUNGICIDE TERMS Fungicides are often classified as being either protectants or eradicants. Protectants, such as maneb and chlorothalonil, must be applied to the surface of the plant before the fungus attacks the plant in order to protect the plant against infection. On the other hand, eradicants such as benomyl can move within the plant and kill developing fungi.

CHEMICAL FAMILIES

Among the various kinds of pesticides, chemical families are recognized based upon similarities in chemical structure and pesticidal activity. Some of the common families of pesticides are discussed below:

FAMILIES OF HERBICIDES

Triazine The triazine herbicides are used to kill weed seedlings. Atrazine, simazine, and cyanazine are commonly used members of this herbicide family. Plants are killed by triazine herbicides through interference with photosynthesis used by the plants to produce food. Broadleaf weeds are particularly susceptible to these herbicides. Some triazine herbicides may persist for several months or even years and injure susceptible plants in following growing seasons. Some triazine herbicides leach into groundwater or move laterally through the soil, injuring desirable plants.

Phenoxy The phenoxy herbicides are widely used in agriculture to control broadleaf weeds. 2,4-D, MCPA and MCPB are examples of phenoxy herbicides. This group of herbicides acts like many plant hormones and primarily affects the actively growing tissue of the plants. Most often these herbicides are sprayed onto plants, although they can also be picked up by plant roots. Phenoxy herbicides can cause unwanted plant injuries if applied when conditions allow drift onto susceptible plants.

Acid Amine Acid amide herbicides are usually used to control seedling weeds prior to, or immediately following, emergence. Alachlor and propachlor are examples. Acid amide herbicides are absorbed into the shoots or roots of plants and affect various growth processes in susceptible plants. Many broadleaved and grass weeds are vulnerable to acid amide herbicides. Persistence of these herbicides is generally fairly short; however, many of them are susceptible to leaching and have been found as contaminants in groundwater.

Dinitroaniline Dinitroaniline herbicides are used to control germinating weeds. Trifluralin and oryz alin are examples of this family of herbicides. The dinitroaniline herbicides prevent cells in roots and shoots from dividing and developing. Many annual grass and broadleaf weeds are susceptible to these herbicides. Dinitroaniline herbicides are yellow in color and must be incorporated into the soil to provide weed control.

Thiocarbamate Thiocarbamate herbicides are used to control germinating seedlings and young weeds, primarily grasses. EPTC, cycloate, and butylate are examples. The thiocarbamate herbicides change to a gaseous form (volatilize) readily when exposed to moisture, and they often must be incorporated into the soil to maintain their effectiveness. Thiocarbamate herbicides degrade rapidly in warm moist soils.

Sulfonyl Urea Sulfonyl urea herbicides are a fairly new group of herbicides, having very diverse characteristics, that are being used to control weeds in dry-land wheat. New compounds are being developed continually, some of which can be used after weeds have germinated (post-emergence). The sulfonyl ureas are used at extremely low rates, sometimes less than an ounce per acre. A drawback is they can be highly persistent in alkaline soils.

FAMILIES OF INSECTICIDES AND MITICIDES

Chlorinated Hydrocarbons Chlorinated hydrocarbon insecticides, such as DDT, toxaphene, and dieldrin were Hydrocarbons the main family of insecticides used following their introduction after World War II. However, environmental and health related concerns have caused most of the chlorinated hydrocarbon insecticides to be discontinued or banned in recent years. Some were extremely persistent in the environment. Problems with many chlorinated hydrocarbons also involved their tendency to concentrate in the fatty tissues of humans, livestock, and wildlife. This latter phenomena, called bio-accumulation, had severe adverse effects on many forms of wildlife. Chlorinated hydrocarbon insecticides still being used include methoxychlor, dicofol, and endosulfan. Chlorinated hydrocarbons tend to be more active at cool temperatures.

Organophosphates The organophosphate family has replaced most chlorinated hydrocarbon insecticides. Parathion, disulfoton, phorate, and chlorpyrifos are examples. Some of these insecticides are systemic when applied to foliage or roots of plants; others are not. Organophosphate insecticides do not persist in the environment as long as the chlorinated hydrocarbon products but tend to be more toxic to applicators and wildlife. The organophosphate insecticides are nerve poisons which inhibit cholinesterase vital to transmission of nerve impulses. These effects are cumulative, so repeated exposures result in increased poisoning. Most of the serious human pesticide poisonings have involved organophosphate insecticides. Most uses of ethyl parathion were cancelled because of extreme hazard to applicators, mixers, loaders, and field workers.

Carbamates Carbamate (or n-methyl carbamate) insecticides are nerve poisons in insects and other animals, as are organophosphate insecticides. Carbaryl, methomyl, and aldicarb are examples of carbamate insecticides. The effects of carbamate poisoning are more readily reversible (are not cumulative) than organophosphate poisoning. Carbamates tend to be quite soluble in water and some are systemic in plants. Because of their water solubility, several carbamates are susceptible to leaching into groundwater.

Pyrethroids The pyrethroid insecticides are the fastest growing family of insecticides. Chemically, these are related to naturally occurring insecticides (pyrethrins) found in certain flowers. Examples include esfenvalerate, bifenthrin, and permethrin. The pyrethroid insecticides are highly effective against susceptible insects (for example, caterpillars and leaf beetles) and are typically used at rates of active ingredient that are several times lower than organophosphate and carbamate insecticides. Most pyrethroids exhibit low mammalian toxicity, although some formulations have been associated with human irritation and allergic reactions. Most pyrethroids are highly toxic to fish and other cold blooded organisms.

FAMILIES OF FUNGICIDES

Organic Sulfur The organic sulfur (carbamate) compounds, derived from dithiocarbamic acid, is the most important family of fungicides in current use. Ferbam, meteram, and thiram are examples of this fungicide family. The organic sulfur fungicides must be applied in a preventive manner and will not control existing infections in a plant.

Benzene The benzene fungicides, such as chlorothalonil and PCNB, are used as protectants.

Benzimidazole The benzimidazole fungicides have been the most important group of fungicides with systemic activity. Benomyl, thiabendazole, and thiophanate methyl are examples of this fungicide class. Because of their systemic activity, they can help to control some diseases after infection. Benzimidazole fungicides are also used to prevent post-harvest rots and as soil-drench treatments.

Sterol inhibitor Sterol inhibitor fungicides are one of the newer fungicide families. Bayleton and Banol are examples of sterol inhibitor fungicides. The sterol inhibitors are systemic in the plant and have eradicant activity.

WOOD PRESERVATIVES

Creosote Creosote and creosote solutions are oily byproducts of making coke from bituminous coal. They have been widely used as preservatives for such products as railroad ties, large timbers, fence posts, poles, and pilings. Creosote based preservatives are toxic to wood-destroying fungi, insects, and some marine borers. They are easy to apply and are insoluble in water. Creosote has low volatility and does not readily produce fumes. However, creosote treatment of wood results in a dark color and strong odor. Creosote tends to "bleed" and the wood surface remains oily and unpaintable. Creosote-treated wood cannot be used in homes or other living areas.

Pentachlorophenol Oil-borne preservatives include wood preservatives such as pentachlorophenol (penta). These chemicals are generally insoluble in water and must usually be dissolved in organic solvents in order to penetrate wood. The oil-borne preservatives are toxic to fungi (including mold) and insects as well as to plants, animals and humans. However, for some applications, these preservatives provide less physical protection than creosote. Wood treated with penta can have an unpaintable surface (depending on the carrier) and produces toxic fumes. It should not be used in homes or other living areas.

Metallic Salts Water-borne preservatives include various metallic salts and other compounds. The principal compounds are combinations of copper, zinc, chromium, arsenic, and fluoride. Waterborne preservatives have gained increasingly wider usage for lumber, plywood, fence posts, poles, pilings and timbers. The treated wood surface is clean, paintable, and free of objectionable odors. The waterborne preservatives also resist leaching and can be used in living areas or for playground equipment. The preservative copper-8-quinolinolate also has been approved for food contact uses such as for boxes, crates, and pallets used during harvesting, storage, and transportation of food. Water-borne preservatives, however, do not protect the wood from excessive weathering, and the wood must be redried after treatment to prevent warping and checking.

ANTIBIOTICS

Antibiotics are substances produced by one organism that are toxic to another organism. Most antibiotics in current use are products of bacteria-like soil organisms known as actinomycetes. Antibiotics are used in medicine as well as in pest management. Examples include streptomycin, tetracyclines, and avermectins. Control of the bacterial fruit tree disease fire blight with streptomycin is one of the greatest non-veterinary uses of antibiotics in agriculture. Avermectins are also available for control of spider mites and leafminers on greenhouse crops, and for control of livestock parasites.

FUMIGANTS

Pesticides used primarily as toxic gases are known as fumigants. Methyl bromide, aluminum phosphide, and paradichlorobenzene are examples. Most fumigants kill susceptible pests that breathe the gases into lungs (mammals) or spiracles (insects, mites). Some fumigants may also enter through the skin and be corrosive to the eyes. Many fumigants, particularly those used to control insects in stored grain and for rodent control, are extremely toxic and hazardous to applicators.

Fumigants are also used to control nematodes, soil-borne fungus diseases, and weeds in crop land. Uses of fumigants in forestry have declined sharply since the banning of ethylene dibromide (EDB).

Some pesticides applied to soil or foliage may also have some fumigant activity. For example, some of the parathion applied to a crop will volatilize into a gaseous state and act in a fumigant manner. Several soil applied herbicides move through the soil in a gaseous state; however, these pesticides are not true fumigants since they are not designed for that use.

Special training is required in order to apply the more hazardous fumigants. Special protective equipment and supervision are required during application. In addition, use of fumigants for prairie dog control requires a pre-treatment survey to determine that the highly endangered black-footed ferret is not present. Fumigant properties and applications are covered in a separate chapter.

PESTICIDE FORMULATIONS

There are a variety of formulations for pesticides used in agriculture. Each formulation contains the active pesticide ingredient plus various "inert ingredients." Inerts are used to improve the performance of the pesticide by affecting such characteristics as handling, persistence on foliage, safety, ease of application, and ability to mix with water. Some of the more common formulations follow:

EMULSIFIABLE CONCENTRATES Emulsifiable concentrates (EC or E) are common liquid formulations with active ingredients that are insoluble in water. The addition of an "emulsifier" allows the pesticide to mix with water. This mixture is called an emulsion. Emulsifiable concentrates penetrate skin more readily than other formulations, and many of the inert ingredients are harmful to the eyes, so special handling is necessary. Inadvertent injury to plants is also possible with emulsifiable concentrates. These formulations are easily damaged by exposure to extreme temperatures.

WETTABLE POWDERS Wettable powders are pesticides formulated on a dry particle and contain ingredients that allow the particles to mix with water. The resulting mixture is referred to as a suspension. Continuous agitation is required when using wettable powders to prevent them from settling in the spray tank. Wettable powders may also cause increased wear on spraying equipment. Because they occur as dust-like particles, they can be easily inhaled during mixing if protective equipment is not used. However, wettable powder formulations often are quite safe to use on plants. They are used extensively in greenhouse and fruit production where plant injury is of great concern.

FLOWABLES Dry flowables/water dispersible granules are the fastest growing new pesticide formulations and are replacing many wettable powders. Ease of handling and reducing the hazards from blowing dusts during mixing are two reasons for the adaptation of dry flowable formulations. They form a suspension when mixed with water and require less agitation than wettable powders. A further advantage of flowables over wettable powder formulations is that they cause less wear on equipment.

Flowables are formulations of pesticides which can only be produced in solid or semi-solid form. They are often ground into a fine powder and suspended into a liquid. Flowables are produced for uses where they are more easily handled and mixed than wettable powders.

SOLUBLE POWDERS Soluble powders are dry formulations of pesticides that go into true solution when mixed with water. Because of this characteristic, soluble powders do not require agitation after mixing. Relatively few pesticides are water soluble. These pesticides may also be formulated as liquids.

DUSTS Dusts are formulations of pesticides on dry particles that are applied dry. Formerly widely used, few dust formulations are currently being produced because of difficulties in application with current equipment, excessive drift, increased hazards to honeybees, and applicator inhalation hazard. Currently, dust formulations are most often found in gardening products and for applications to livestock, pets, and poultry. Dusts used as "tracking powders" are also used for rodent control.

GRANULES Granules are dry formulations mixed onto fairly large particles of clay, ground corn cob or walnut hulls, or manufactured granules. Until wetted, most of the pesticide remains attached to the granule, making this a less hazardous formulation to handle than a liquid. Due to their heavy weight, granules have the advantage of being able to sift down into plant parts such as corn whorls or grass and are minimally susceptible to drift.

MICROENCAPSULATION Microencapsulated pesticides are impregnated into tiny, slow release plastic beads and mixed into a liquid. Pesticides formulated in this manner are often much safer to humans than other liquids and may have somewhat longer residual life. However they are often somewhat more expensive and can increase hazards to honeybees.

Numerous other formulations can be found for specialized purposes, primarily for ease of application and effectiveness. Ultra-low volume (ULV), aerosol, smoke bomb, paints and bait formulations are among these other specialty products.

ADJUVANTS *Adjuvants* are added ingredients which increase the effectiveness of the active ingredient and make application easier. When added by the user, these products are exempt from the food crop tolerance requirements that apply to pesticides used on food crops. Some common types of adjuvants are:

- Wetting agents or surfactants are used to improve spread of a spray mixture on foliage. Surfactants are most commonly used to apply pesticides on plants that have waxy leaves; or hairy leaves.
- Stickers improve the weatherability of a spray deposit, particularly from washing by rainfall or irrigation;
- Synergists greatly increase the activity of insecticides by blocking the ability of the insect to break down the insecticide;
- Penetrants are used to increase uptake of herbicides into a plant;
- Buffers are used in spray tanks to decrease breakdown of a pesticide caused by exposure to alkaline water conditions.

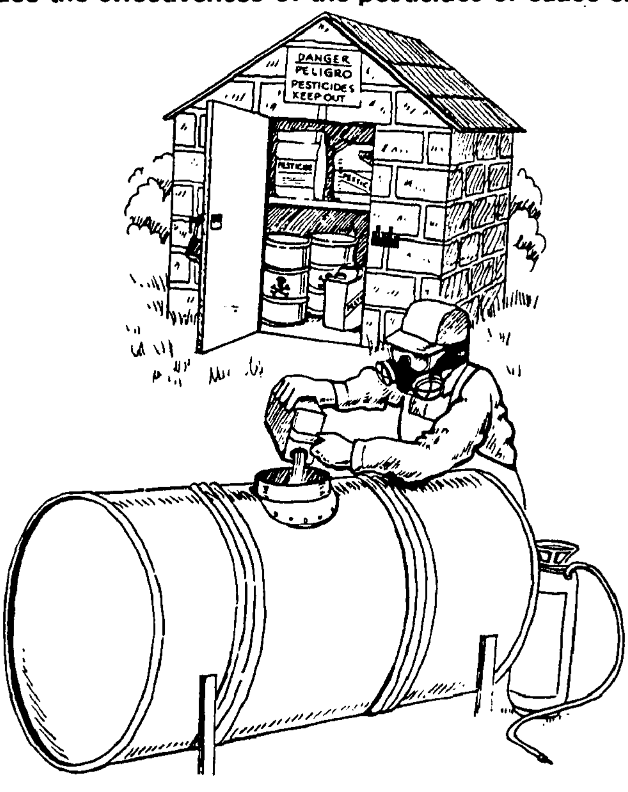
INERT INGREDIENTS

Essentially no pesticides offered for sale to growers contain 100% active ingredient. Instead pesticides are "formulated" by the manufacturer. During this process, various diluents or adjuvants are added. The resulting formulation may greatly change the active ingredient's performance and use; therefore, each formulated pesticide is individually registered by the U.S. Environmental Protection Agency under the FIFRA law. The percentage of adjuvants is given on the pesticide label as inert ingredients.

Despite the implied meaning of the term inert, these adjuvants can have some biological activity, and certain inert ingredients are associated with increased pesticide hazards. As with the active ingredients, many inert ingredients are being reviewed by the Environmental Protection Agency.

MIXTURES OF PESTICIDES

It is often desirable to mix two or more pesticides during application or to mix pesticides with fertilizers. When a mixture can be made without reducing safety or effectiveness, the mixture is said to be compatible. Otherwise it is incompatible. Incompatible mixtures can increase the toxicity or hazard of the pesticides to the applicator or the environment. Also incompatible mixtures may greatly reduce the effectiveness of the pesticides or cause crop injury.



Physical Incompatibility Incompatibility can involve undesirable physical changes in the mixture. For example, a mixture may cause material to precipitate as a solid and deposit on the bottom of the spray tank. Physical incompatibility may also cause the components to form separate layers following agitation. Large aggregates may form, or curdling of the mixture may occur. These types of physical incompatibilities may result in an unsprayable mixture or cause fluctuations in the amount of pesticide being applied. Physical incompatibility can be seen.

Chemical Incompatibility Chemical changes may occur when pesticides are mixed together or when pesticides and fertilizers are mixed. This is particularly common where highly acidic or alkaline materials are used. Reactions in the tank may form compounds that increase environmental hazards, reduce the amounts of active ingredients, or cause plant injury. You cannot see chemical incompatibility.

Increasingly, **tank mixes** of two or more compounds are specified on pesticide labels. Compatibility problems should be minimal with these previously tested and registered combinations. Where combinations are not specifically labeled, private pesticide applicators may make tank mixtures unless the label prohibits them. However, where specific tank mixes have not been extensively tested, caution is advised. Often testing procedures for determining incompatibility are given on the product label.

Summary Chapter IV

Pesticides are classified according to the type of pests they are used to control. They include herbicides, insecticides, fungicides, and others.

Pesticides are classified by their chemistry, origin, mode of action and use. They are organic or inorganic; systemic or contact; selective or nonselective, pre-plant, pre-emer-gence, post-emergence. These all determine how they are to be used.

Pesticides are classified by their chemical families, such as chlorinated hydrocarbons, organophosphates, carbamates, etc. This classification may indicate how toxic they are.

Pesticides are classified according to how they are formulated, whether liquid, dry, dust, granules, etc. This affects how they are applied.

Chapter V

PESTICIDES TOXICITY & ENVIRONMENTAL HAZARDS

Since pesticides are poisons designed to destroy pest species, there are many hazards associated with their use. Pesticides can be poisonous to the applicator or other people in the area. They can harm beneficial species such as bees that pollinate crops. They can injure crops and wildlife and contaminate surface or ground water.

TOXICITY TO HUMANS

Pesticides vary in their toxicity (potential for harm) to humans. During application, or other exposure, pesticides can be taken into the body through the skin, mouth, eyes or lungs.

DERMAL EXPOSURE Dermal exposure occurs when pesticides touch the skin. The skin can absorb pesticides, particularly the liquid formulations such as emulsifiable concentrates. Contact with the skin is a hazard during mixing of concentrated pesticides when they can be spilled or splashed. Also, during spraying operations pesticide drift may settle on exposed skin or clothing. The degree to which pesticides are absorbed by the skin depends on the type and formulation of the pesticide and the location on the body. Areas around the genitals and the thinner areas of skin, such as the forehead, absorb the pesticides faster. Also wounded areas such as burns, abrasions and rashes are more susceptible to pesticide penetration.

Pesticides splashed into the eyes can be extremely damaging, particularly the more corrosive ones such as lime sulfur, or formulations containing corrosive solvents such as xylene.

ORAL EXPOSURE Oral exposure is when pesticides enter through the mouth. This may occur from splashing, from drift or dust, or when an applicator smokes or eats with pesticides on the hands. Oral exposure is a hazard when a person cleans nozzles by blowing into them. Accidental poisonings often occur when children drink pesticides from containers that are not kept out of their reach.

INHALATION EXPOSURE Inhalation exposure (through the lungs) occurs from breathing dusts, spray mists or fumigant gases. Fine particles from pressure spraying and aerosols are particularly hazardous to lungs. Pesticide exposure to the lungs is highly dangerous because of the thin lining of air sacs in the lungs which are easily damaged and which allow rapid movement into the blood stream.

Measuring Toxicity/LD50 The toxicity of a pesticide is determined by laboratory testing on animals such as rats, mice and rabbits. The measuring method, LD50 (Lethal dose, 50%), describes the dose of a pesticide that will kill half of a group of test animals from a single exposure by either the dermal (skin) or inhalation (breathing) route. A lower LD50 number means the pesticide is more toxic than a higher number since it takes less of the pesticide to kill half of the animals.

LC50 The toxicity of fumigant pesticides is described in terms of the concentration of the pesticide in the air -- LC50. A similar system is used to test the potential effects of chemicals against aquatic organisms in water.

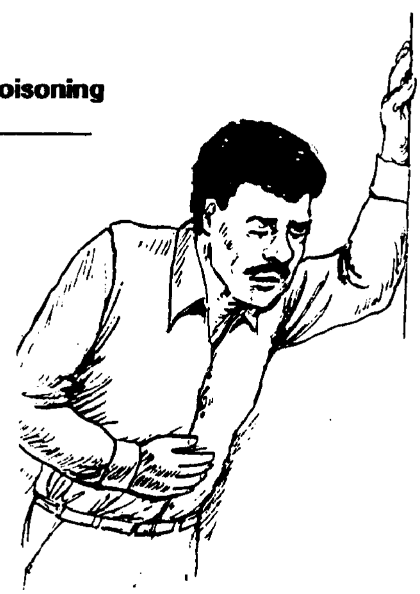
These methods for measuring toxicity give only approximate indications of how poisonous a pesticide is because the tests are conducted on animals other than humans. Also, they give indications of effects on the average animal and not the most resistant or most susceptible individuals. The numbers, however, can be used to assess the relative risks when comparing different chemicals.

Acute Toxicity Acute Toxicity of a pesticide means the poisoning that occurs after a single exposure such as an accident during mixing or applying pesticides. There are various signs and symptoms associated with acute poisonings. Symptoms (feelings noticed by the person who has been exposed) may include nausea, headache, weakness, dizziness, etc. A sign of poisoning is a result which can be seen by others, such as vomiting. Anyone who works with pesticides should learn what these signs and symptoms are to prevent serious injury and allow prompt treatment.

Poisoning Symptoms Pesticides in the same related chemical family tend to cause the same kinds of poisoning sickness, and follow the same illness pattern, which helps in diagnosis. **Organophosphate and carbamate insecticides** depress the levels of the enzyme cholinesterase which affects nerve transmission. Signs and symptoms of poisoning by these insecticides are:

Symptoms Associated with Organophosphate and Carbamate Poisoning

Mild poisoning	Moderate poisoning	Severe poisoning
Fatique Headache Dizziness Excessive sweating Salivation Nausea, vomiting Stomach cramps Diarrhea	Inability to walk Weakness Chest discomfort	Unconsciousness Severe constriction of the eye pupil
	Muscle twitching Constriction of the eye pupil	Muscle twitching Secretions from mouth and nose
	Increase in earlier symptoms, signs	Breathing difficulty Death, if untreated



NOTE: There is extensive overlap of symptoms between various described stages of poisoning. **If poisoning symptoms are suspected seek medical attention.**

Chlorinated hydrocarbon and pyrethroid insecticides are less likely to cause acute poisoning. Early signs and symptoms of poisoning are headache, nausea, vomiting, general discomfort and dizziness. Later symptoms can include excitability or irritability, convulsions, and occasionally coma and death.

Bipyridylium herbicides, such as paraquat and diquat are among the most hazardous pesticides since poisoning effects can be irreversible. Exposed cells can be killed so that permanent damage occurs, producing problems such as lung fibrosis. Skin contact can produce severe irritations.

Phenoxy herbicides, such as 2,4-D and MCPA, cause skin irritation or a local burning sensation when inhaled. Dizziness or chest pain may result from prolonged inhalation. When large quantitities of the pesticide are absorbed, muscle twitching, muscle tenderness, and muscle stiffness may occur.

Wood preservatives have been associated with a variety of acute and chronic hazards; therefore, they have been classified as Restricted Use pesticides. **Creosote** exposure can cause skin irritation, and prolonged exposure may lead to dermatitis. Vapors and fumes of creosote are irritating to the eyes and respiratory tract. **Pentachlorophenol** is also irritating to the eyes, skin, and respiratory tract, with prolonged exposure sometimes leading to an acne-like skin condition. Ingestion of penta solutions, excessive skin contact, or inhalation of concentrated vapors may cause fever, headache, weakness, dizziness, nausea, and profuse sweating. Extreme cases can induce loss of coordination and convulsions. Pentachlorophenol poisoning can be fatal. **Arsenical** wood preservatives can cause nausea, headache, diarrhea, and abdominal pain (if swallowed). Extreme symptoms can progress to dizziness, muscle spasms, delirium and convulsion. Prolonged exposure to arsenical wood preservatives can result in persistent headache, abdominal distress, salivation, low grade fever, and upper respiratory irritation.

Fumigant pesticides can be extremely hazardous to applicators. Methyl bromide and phosphine (released by the exposure of aluminum phosphide to water) damages the cells that line the air sacs in the lungs, causing fluids to accumulate. This is a major cause of deaths from fumigant exposure. Fumigants such as methyl bromide may also irritate heart muscles, leading to heart attack. Liver and kidney damage may also result from exposure to 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.

Among the botanical insecticides, nicotine, has a high degree of associated hazards when used as a spray or a fumigant to control greenhouse insect pests. Nicotine is very rapidly absorbed through the skin as well as through inhalation during these applications. Skin burning and irritation can occur from mild exposure. Stimulation and excitability, followed by extreme depression, are common advanced poisoning symptoms. Nicotine poisoning can be serious, and even fatal, causing death by paralysis of muscles used in breathing.

Chronic Toxicity

Chronic toxicity means the effects of long term or repeated low level exposures to a toxic substance. The effects of chronic exposure do not appear immediately after first exposure and may take years to produce signs and symptoms. Examples of chronic poisoning effects include:

Carcinogenicity - ability to produce cancer or to assist carcinogenic chemicals;

Mutagenicity - ability to cause genetic changes;

Teratogenicity - ability to cause birth defects;

Oncogenicity - ability to induce tumor growth (not necessarily cancers);

Liver damage;

Reproductive disorders (reduced sperm count, sterility, miscarriage);

Nerve damage (including accumulative effects on cholinesterase depression associated with organophosphate insecticides);

Allergenic sensitization (development of allergies to pesticides or chemicals used in formulation of pesticides).

The effects of chronic toxicity, as with acute toxicity, are dose-related. In other words, low-level exposure to chemicals that have potential to cause long term effects may not cause injury, but repeated exposures through careless handling or misuse (failure to follow label instructions) can greatly increase the risk of chronic effects.

Decisions by the Environmental Protection Agency (EPA) to continue registrations of pesticides with known or suspected risks of chronic effects are complicated. Among factors considered are:

- Weight of the evidence that the pesticide is capable of causing long-term injuries such as cancer, birth defects, or organ injuries;

- Amount of exposure possible during use of the pesticide, (hazard associated with its use);

- The number of people exposed to the pesticide at levels which may cause chronic effects.

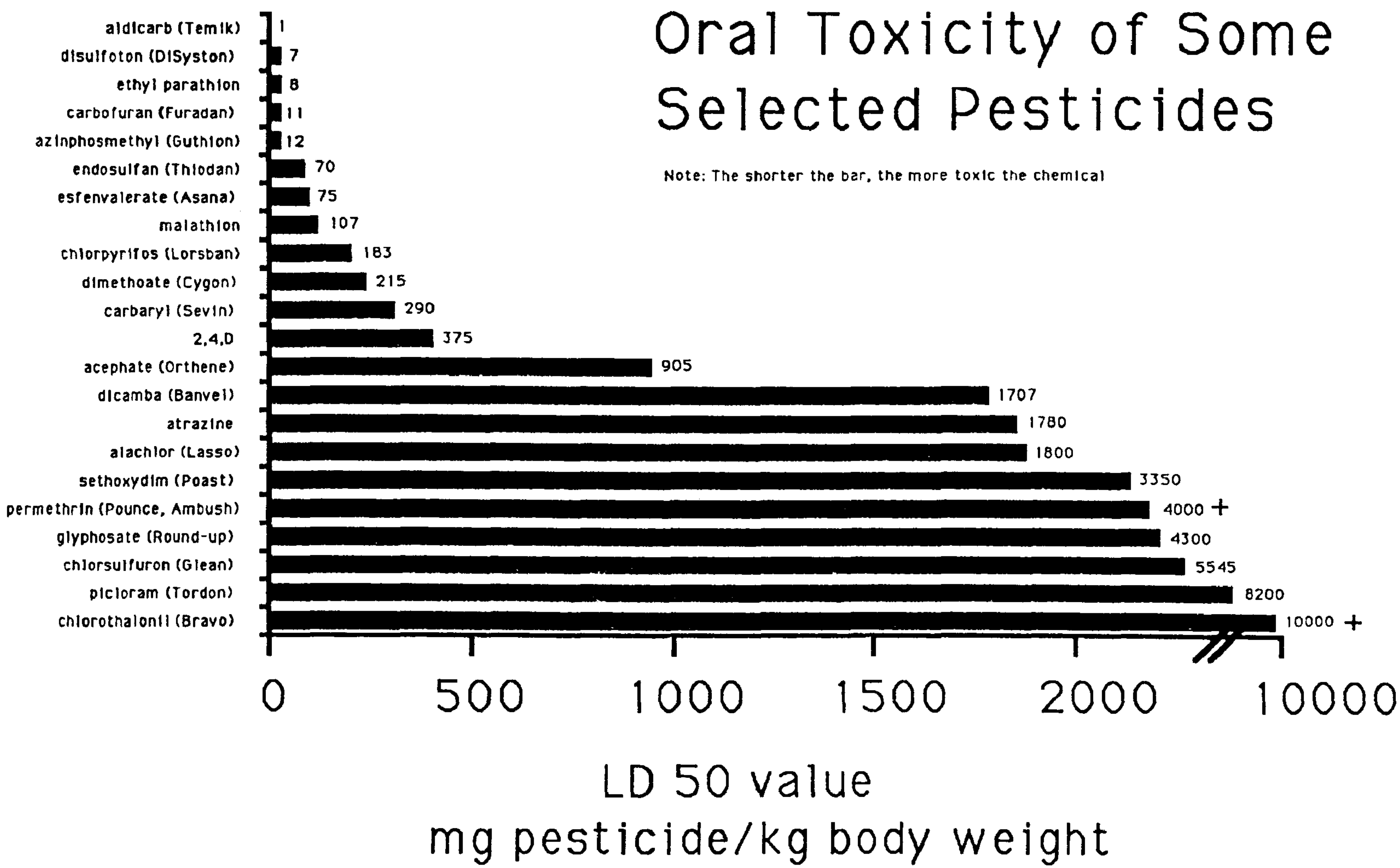
Label Restrictions The probability of exposure to a pesticide when it is used according to label directions is an important consideration. Methods of reducing this exposure by changing methods of using the pesticide (including protective clothing requirements, restricted entry intervals, etc.) are evaluated. Pesticides with hazards for chronic effects have warning statements on the labels to the effect that applicators, in using these pesticides, understand the hazards and agree to follow all label precautions to prevent injury **(A consent agreement).** Evidence of repeated applicator failure to use a pesticide in accordance with the label **(the label is the law)** can lead to the pesticide being banned or more strictly regulated.

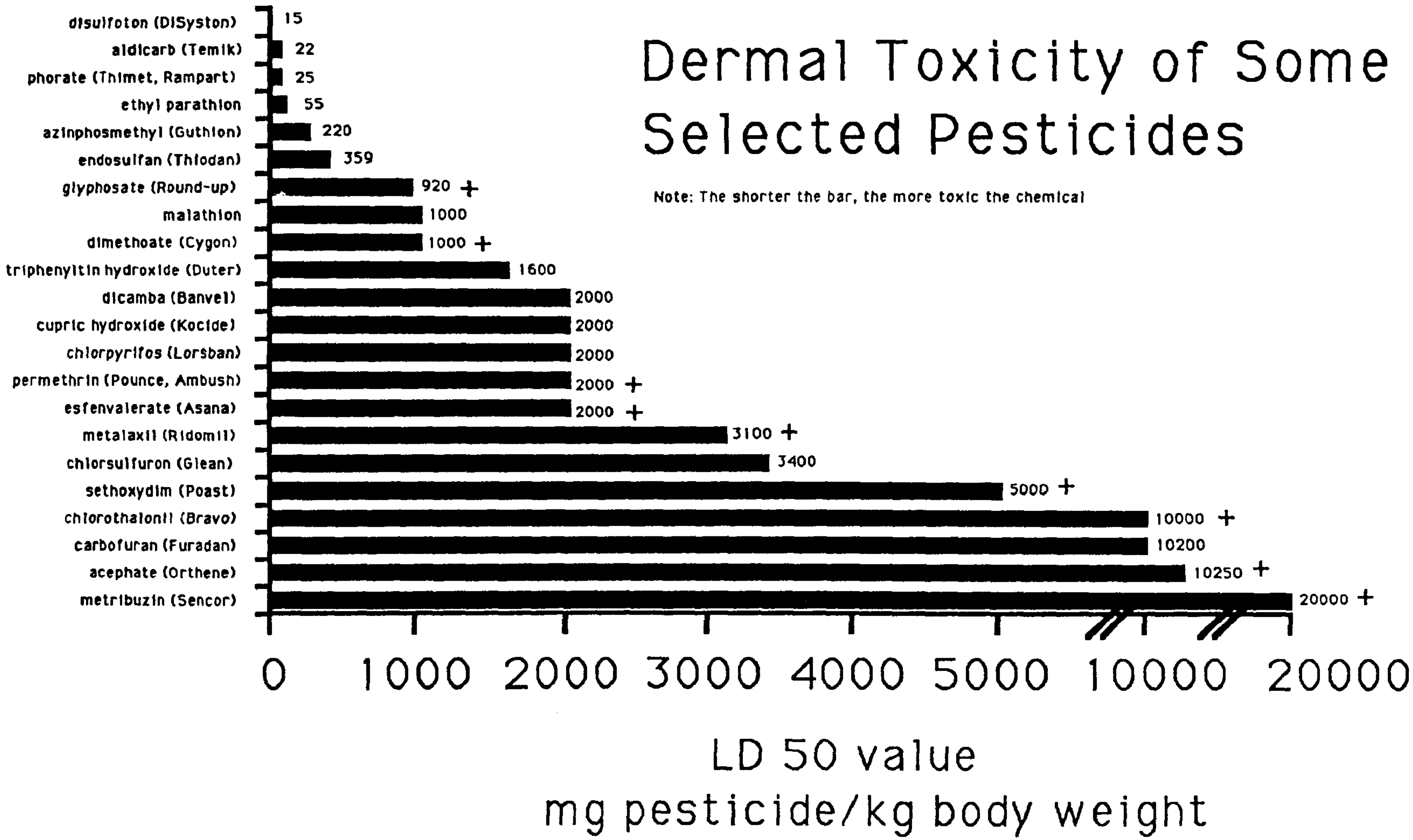
Hazard The hazard of a pesticide means the degree of danger from a pesticide considering the conditions of its use. Hazard can vary; whereas, toxicity is a constant. The hazard can be reduced by taking precautions that minimize exposure, such as using a less dangerous formulation or method of application, or using protective clothing and equipment that reduces the potential for exposure.

ENVIRONMENTAL HAZARDS

RESISTANCE *OF PESTS TO PESTICIDES* It is possible for pests to develop resistance to a pesticide, making the pesticide ineffective. Pesticide resistance develops from the survival of preadapted, genetically resistant individuals. When pesticides are applied, susceptible pests are killed and resistant ones survive. Subsequent generations carry on the resistance. Once established in a population, pesticide resistance is permanent. Pesticide resistance does not involve a single generation of the pest developing tolerance to the pesticide following repeated small exposure.

Resistance has led to the loss of use of many pesticides that formerly were effective for pest control in Colorado. This loss has been most severe in industries where pesticide use is most


Oral Toxicity of Some Selected Pesticides
Note: The shorter the bar, the more toxic the chemical
aldicarb (Temik) 1
disulfoton (DiSyston) 7
ethyl parathion 8
carbofuran (Furadan) 11
azinphosmethyl (Guthion) 12
endosulfan (Thiodan) 70
esfenvalerate (Asana) 75
malathion 107
chlorpyrifos (Lorsban) 183
dimethoate (Cygon) 215
carbaryl (Sevin) 290
2,4,D 375
acephate (Orthene) 905
dicamba (Banvel) 1707
atrazine 1780
alachlor (Lasso) 1800
sethoxydim (Poast) 3350
permethrin (Pounce, Ambush) 4000 +
glyphosate (Round-up) 4300
chlorsulfuron (Glean) 5545
picloram (Tordon) 8200
chlorothalonil (Bravo) 10000 +
0
500
1000
1500
2000
10000
LD 50 value
mg pesticide/kg body weight


Dermal Toxicity of Some Selected Pesticides
Note: The shorter the bar, the more toxic the chemical
disulfoton (DiSyston) 15
aldicarb (Temik) 22
phorate (Thimet, Rampart) 25
ethyl parathion 55
azinphosmethyl (Guthion) 220
endosulfan (Thiodan) 359
glyphosate (Round-up) 920 +
malathion 1000
dimethoate (Cygon) 1000 +
triphenyltin hydroxide (Duter) 1600
dicamba (Banvel) 2000
cupric hydroxide (Kocide) 2000
chlorpyrifos (Lorsban) 2000
permethrin (Pounce, Ambush) 2000 +
esfenvalerate (Asana) 2000 +
metalaxil (Ridomil) 3100 +
chlorsulfuron (Glean) 3400
sethoxydim (Poast) 5000 +
chlorothalonil (Bravo) 10000 +
carbofuran (Furadan) 10200
acephate (Orthene) 10250 +
metribuzin (Sencor) 20000 +
0
1000
2000
3000
4000
5000
10000
20000
LD 50 value
mg pesticide/kg body weight

intensive, such as greenhouse, tree fruits, livestock, and vegetables. In Colorado, resistance has been found in insect and mite pests such as pear psylla, two-spotted spider mite, green peach aphid, onion thrips, horn fly, and house fly. Resistance to fungicides has been developed in certain Fusarium diseases. Weeds such as lambsquarters and kochia have become resistant to herbicides.

ENHANCED DEGRADATION Enhanced degradation occurs when there is an increase in soil microorganisms that break down a pesticide, causing it to become ineffective. This happens after pesticide has been used too many times in the same location, and it has caused the loss of use for some pesticides. Once developed, the results are permanent.

Development of any new pesticide is a long and costly procedure. It is in the agricultural producer's own best interests to reduce the probability of pesticide resistance and enhanced degradation through proper pesticide management. The best practice is to use pesticides only when needed, thereby reducing the selective pressure that produces resistant pests. Also, it is desirable to switch between classes of pesticides to preserve their effectiveness.

DAMAGE TO *BIOLOGICAL CONTROL ORGANISMS* Use of pesticides can severely diminish the performance of biological control organisms such as natural predators and parasites. Specifically, the use of insecticides reduces organisms that prey on insect and mite pests. Fungicides are also known to kill certain predators of spider mites and inhibit naturally occurring fungus diseases of insect pests.

Secondary Pests One of the consequences of the disruption and destruction of biological control organisms is when pest species that are normally not economically harmful increase and reach a level of significance. These are called secondary pests. Many of the problems with spider mites in fruit and field corn are secondary pest problems; pea aphids in alfalfa have increased after alfalfa weevil treatment.

Pest Resurgence When a pest species is reduced by pesticide application, and their natural enemies are also reduced, the pest may increase rapidly after pesticide residues diminish. This is called pest resurgence or rebound.

DAMAGE TO POLLINATING INSECTS Pollinating insects, such as honeybees and leafcutter bees, are vital to the production of fruit and seed crops. Crop yields and quality depend on and are improved by the activities of these pollinators.

Industries surrounding the culture of honeybees are an important part of Colorado agriculture. Millions of dollars worth of honey, wax, and other honeybee products originate here. Income derived from these products is either a primary, or important secondary, source of farm income. Often, pesticide use conflicts with pollinating insects, especially when pesticides that are hazardous to honeybees are applied to areas where worker bees are gathering pollen or when harmful pesticides drift onto bees that are clustered on the outside of hives. Protection of honeybees must be an important consideration of pesticide applicators, since the success of their crops may depend on bees.

PHYTOTOXICITY Inadvertent crop injury can result from certain pesticide applications. This is known as phytotoxicity and is most likely when using "selective" herbicides that are selective only because they are less toxic to the crop than to the weed. Phytotoxicity can also occur when certain insecticides and fungicides are used on sensitive greenhouse crops. Many corn rootworm insecticides are phytotoxic if placed in contact with the seed. Occasionally, damage can be done when two pesticides are applied to a crop and there would have been no damage if only one pesticide had been used. Usually, phytotoxicity hazards are recognized when pesticides are being developed. Warning statements then are placed on the pesticide label giving directions on how to avoid such damage.

IMPACT ON WILDLIFE AND ENDANGERED SPECIES

Many pesticides have the potential to seriously damage wildlife. The use of pesticides has largely caused the elimination or sharp reduction in numbers of birds, certain mammals, and other species in areas of intensive agriculture in Colorado. In some cases, pesticide use has caused wildlife species to be in danger of extinction.

Damage to Wildlife

Pesticides can affect wildlife populations in a number of ways, including:

- pesticides directly applied to wildlife habitats can directly kill plants and animals.
- pesticides can run-off a site 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.

Endangered Species Among the species that have been most directly affected by pesticides in Colorado are the black-footed ferret and the peregrine falcon. The poisoning of prairie dogs eliminated the **black-footed ferret** from much of its original range, where its principal food source was the prairie dog. 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) in their bodies, which interfered with their ability to reproduce. Other endangered species have been greatly reduced through loss of habitat, water pollution, and hunting.

ENDANGERED SPECIES IN COLORADO

The following species of plants and animals found in Colorado are recognized nationally as being either endangered or threatened. Endangered species are in danger of extinction and are the subjects of the greatest measures of protection.

COUNTY	SPECIES
Boulder, Clear Creek, Custer	Greenback Cutthroat Trout
Delta	Mesa Verde Cactus
	Spineless Hedgehog Cactus
	Uinta Basin Hookless Cactus
	Clay-Loving Wild Buckwheat
	Colorado Squawfish
Douglas	Pawnee Montane Skipper (insect)
	Greenback Cutthroat Trout
El Paso	Greenback Cutthroat Trout
Garfield	Uinta Basin Hookless Cactus
	Colorado Squawfish
Grand	Penland Beardtongue (plant)
	Osterhout Milk-vetch (plant)
Huerfano	Greenback Cutthroat Trout
Jackson	North Park Phacelia (plant)
Jefferson	Pawnee Montane Skipper
La Plata	Knowlton Cactus
Lake	Greenback Cutthroat Trout
Larimer	Greenback Cutthroat Trout
Mesa	Spineless Hedgehog Cactus
	Uinta Basin Hookless Cactus
	Bonytail Chub
	Colorado Squawfish
Moffat	Bonytail Chub
	Humpback Chub
	Colorado Squawfish
Montezuma	Mesa Verde Cactus
	Mancos Milk-vetch (plant)
	Colorado Squawfish
Montrose	Mesa Verde Cactus
	Spineless Hedgehog Cactus
	Uinta Basin Hookless Cactus
	Clay-loving Wild Buckwheat
Park	Pawnee Montane Skipper
	Greenback Cutthroat Trout
Rio Blanco	Dudley Bluffs Bladderpod (plant)
	Dudley Bluffs Twinpod (plant)
	Colorado Squawfish
San Miguel	Spineless Hedgehog Cactus
	Clay-loving Wild Buckwheat
Teller	Pawnee Montane Skipper

The Bald Eagle has been identified in 46 of the 63 counties, the Whooping Crane in 17 counties, and the American Peregrine Falcon in 15 counties; however, their range is difficult to map.

In 1973, Congress passed the Endangered Species Act to protect America's endangered and threatened plants and wildlife. The Act requires all federal agencies to ensure that their actions, or actions they authorize, are not likely to "jeopardize the continued existence of any endangered species...or result in the destruction or adverse modification of habitat" critical to the species' survival. Through a cooperative effort with the U.S. Fish and Wildlife Service and the U.S. Department of Agriculture, EPA must ensure that registered uses of pesticides do not adversely effect endangered species. If the U.S. Fish and Wildlife Service determines that a pesticide jeopardizes a listed species, EPA will require generic labeling on affected pesticide products which will direct pesticide users to follow use limitations found in a "County Bulletin" developed for their county. County Bulletins contain maps and habitat descriptions of the currently occupied habitat of the listed species, and provide limitations on the use of specific pesticides to protect the species.

To find out if your county has a County Bulletin and how to obtain one, you may call 1-800-447-3813.

PESTICIDE DRIFT

Pesticide drift is the movement of a pesticide to areas other than the intended area of application. Some drift is expected during applications, and short-range drift can aid in crop coverage; however, small spray droplets or dust particles can be carried by air movement for great distances. Pesticides may also drift when they evaporate from the crop and travel as fumes. The effectiveness of pesticides at the application site can be reduced by drift, and damage can be done where it is not intended.

Sensitive crops, gardens, landscape and shelterbelt plantings may be damaged by pesticides that are not intentionally applied. Illegal residues can also occur on crops from these sources, and livestock, honeybees, and wildlife can be affected. Humans may also be exposed to pesticides because of drift.

Several factors influence the drift potential. Some important ones include the natural drift hazard of a pesticide, the formulation, droplet sizes produced during application, height at which the pesticide is released, temperature and air movements. Management of drift is critical to the successful use of pesticides. Failure to take proper precautions can cause damage to your own property and people there, as well as "chemical trespass" on neighboring properties.

POLLUTION OF WATER RESOURCES

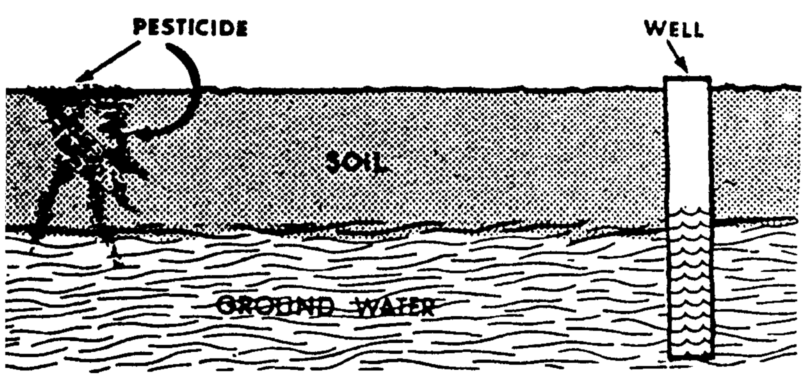
Contamination of surface waters is always a hazard of using pesticides, either directly from drift or by accidental application of pesticides into streams, rivers, or lakes. Extreme care must always be taken when applying pesticides near waterways.

Erosion Water may be contaminated by pesticides during runoff from irrigation or rainfall. Wind blown soil contaminated by pesticides may also enter surface waters. The potential for contamination from these sources is greater if there is rain or strong wind shortly after a pesticide application. Site conditions that promote erosion (steep slopes, exposed soil, etc.) greatly increase the probability of unwanted pesticide movement from erosion.

Groundwater Attention is now focused on groundwater contamination from pesticides and various industrial chemicals. Groundwater is the source of water for wells and springs which serve about half of the population of the United States for drinking water. In rural areas 90 percent of drinking water is from groundwater sources. Until recently, this resource was believed to be relatively free from pollution, but discoveries of contamination have raised serious concerns regarding pesticide use over major aquifers. In addition there is increased awareness that groundwater and surface water resources are often interconnected.

Groundwater is stored in an aquifer, a saturated zone of soil, sand, gravel, or fractured bedrock. The top of the aquifer is called the water table. These underground water reserves are supplied by water from the surface (recharge) that percolates downward through soil into the water table. The percolating water picks up chemicals from the soil, a process known as leaching. Leaching of soil salts can result from poor irrigation practices, and can be of great concern in areas of high salt content.

Groundwater becomes contaminated when recharge water carries pollutants, such as pesticides, with it to the water table. Once in the aquifer, water travels in a more horizontal direction. The pollutants move with the groundwater, forming a region of contaminated water known as a plume.



Once groundwater is contaminated, it may be too expensive or impossible to clean it up. Since pesticides degrade very slowly in groundwater, contamination may last for years. Clearly, the best solution is to keep pesticides and other chemicals out of groundwater through careful application, storage, and disposal.

A number of factors contribute to potential groundwater contamination. These include site conditions, characteristics of the pesticide, the method of application, and environmental conditions following application.

Site Conditions Site conditions associated with groundwater contamination potential include:

Soil texture: Texture is determined by the relative proportion of sand, silt, and clay. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer than soils with low clay and organic matter content. Soils that are more sandy allow contaminated water to move more readily into groundwater. Many Colorado agricultural areas, such as the northeast, have very sandy soils;

Soil permeability: Permeability is a measure of how rapidly water can percolate through a soil. Highly permeable soils allow greater downward movement of water-borne contaminants. Many Colorado areas (for example, the San Luis Valley) have highly permeable soils;

Soil organic matter: Organic matter, such as plant residue or manure, in a soil influences how much water it can hold and how well it can adsorb chemicals, including pesticides. Low organic matter soils are common in Colorado probably because of lack of moisture to degrade organic matter;

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: How deep the water table is below the surface influences the speed with which dissolved chemicals can reach the underlying aquifer. In areas of high water tables, such as parts of the San Luis Valley, the risk of groundwater contamination is greater. Areas along streams and rivers also pose a high risk for contaminating groundwater supplies when pesticides are applied there. Pesticides degrade slowly in groundwater since few microorganisms occur to break down the pesticide.

Pesticide Characteristics: Pesticide Characteristics of the pesticide that can influence hazards to groundwater include:

Water solubility: If a pesticide is easily dissolved in water, it will move more freely with the water. Among the highly soluble pesticides are many carbamate insecticides and triazine herbicides.

Environmental persistence: Persistence means a pesticide's ability to resist degradation. If a pesticide is persistent (lasts a long time without breaking down), it has a greater potential for entering groundwater.

Electrical charge: The charge, or speciation, of a chemical determines how readily it binds to soil particles (adsorbs). Since clay and organic matter tend to be negatively charged, chemicals with a positive charge will cling to the soil and resist leaching. Negatively charged pesticides, or soils with few negatively charged clay and organic matter particles, increase leaching potential.

***Application*:** The manner in which a pesticide is applied, and what it is used to control can increase or decrease the risk of groundwater contamination.

High use rates: If a high dose rate of a pesticide is applied to a crop or other location, the potential for leaching and contaminating groundwater is greater.

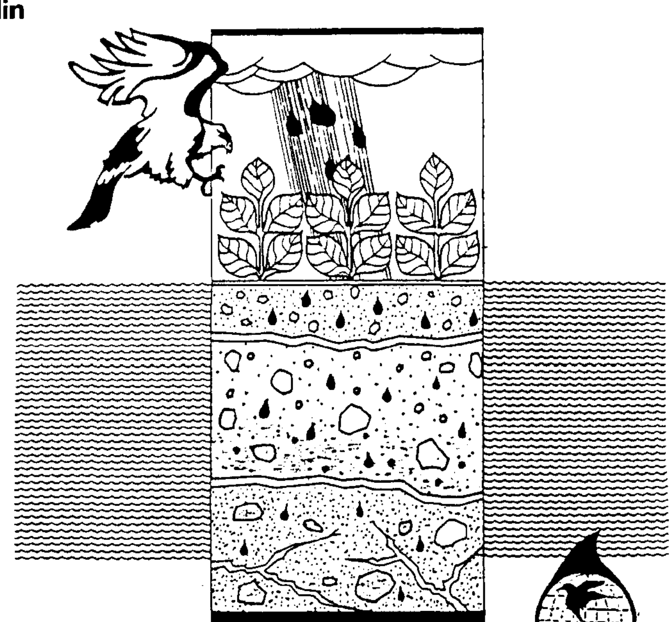
Over-irrigation: If too much water is applied to a crop, there is more likelihood of percolating water carrying pesticides into the groundwater.

Chemigation: The techniques for applying pesticides through irrigation systems present special hazards to groundwater. If a power failure occurs during application, there is a potential for back siphoning of chemicals, thereby drawing large amounts of pesticides directly into the well. Appropriate protective devices, such as check valves, are now required by law and pesticide labels carry instructions on how to prevent accidental back siphoning pollution of wells.

Leachers Several pesticides have been found as contaminants in groundwater supplies throughout the United States. These compounds, or those with similar chemical characteristics, are sometimes classified as "leachers" by the Environmental Protection Agency. Extra precautions should be used with these products to prevent groundwater contamination.

Pesticides that have been found in groundwater include:

acifluorfen	dicamba
alachlor	diuron
aldicarb	methomyl
ametryn	metolachlor
atrazine	oxamyl
bromacil	propachlor
carbofuran	propazine
cyanazine	simazine
2,4-D	terbacil
dalapon	trifluralin



Summary Chapter V

Pesticide exposure to humans can be by dermal, oral or inhalation routes.

Hazard to humans can be either acute (immediate) or chronic (long term) toxicity.

A pest can become resistant to a pesticide over time, making the pesticide useless for controlling that pest. Pests that have a built-in resistance to a pesticide survive its use and their offspring are resistant, eventually making a large part of the pest population resistant.

Pesticides can kill insects that are needed to pollinate crops.

A side effect of using pesticides is damage to wildlife or wildlife habitat.

A side effect of using pesticides is pollution of ground and surface water.

Chapter VI

REDUCING PESTICIDE EXPOSURE & ENVIRONMENTAL HAZARDS

Pesticides are designed to poison pests. Unfortunately, many pesticides are also toxic to people, desirable vegetation and/or other aspects of our environment. To reduce the risks associated with the use of pesticides, pesticide use restrictions, limitations and precautions such as those described in Chapter 1 to protect agricultural workers and other restrictions described in this chapter have become necessary.

WOOD PRESERVATIVES LIMITATIONS

A number of health-related concerns have been identified with pesticides used as wood preservatives. As a result, the Environmental Protection Agency has classified the three major wood preservatives (creosote, pentachlorophenol, inorganic arsenicals) as Restricted Use Pesticides. This restriction is based on studies that link creosote, arsenic, and a dioxin contaminant of pentachlorophenol to cancer in humans. In addition, these products have caused gene defects (mutagenicity) in laboratory animals. Continued use of these wood preservatives is currently based on regulations that limit how these materials can be applied, where treated wood can be used, and on new labeling directed at consumers.

APPLICATOR PROTECTION Special precautions for workers who apply pentachlorophenol require that a closed system be used for powdered, flaked, and prilled formulations. Spray applications of pentachlorophenol must be done in a manner to minimize overspray. Where visible mist occurs, workers are required to wear goggles and protective clothing through which the pesticide cannot penetrate. Pregnant women should avoid exposure to pentachlorophenol.

Workers who treat wood with arsenical wood preservatives are required to wear a respirator if the level of arsenic is unknown or exceeds a level of 10 micrograms/cubic meter of air during an 8 hour day (the Permissible Exposure Limit established by the Occupational Safety and Health Administration). Applications cannot leave visible surface deposits of the preservative on the wood.

USE RESTRICTIONS Wood treated with creosote and pentachlorophenol can no longer be used indoors or where there may be contamination of feed, food, drinking or irrigation water. In barns, stables, and similar sites, wood that is in contact with the soil can be treated with creosote or pentachlorophenol **if it is covered with a sealer** (at least 1 sealer coat for pentachlorophenol, 2 coats for creosote). Sealants must also be applied if wood is likely to be exposed to body contact. **Logs treated with pentachlorophenol can no longer be used for log homes.**

All uses of inorganic arsenical wood preservatives are Restricted Use except for brush-on treatment for commercial construction purposes (not household construction).

The treated wood industry agreed to develop and distribute Consumer Information Sheets to provide information to consumers about treated wood uses and restrictions. Consumer Information Sheets should be requested when purchasing treated wood products.

LIMITING PESTICIDE RESIDUES IN CROPS The public is greatly concerned about pesticide residues in crops; however, regulations limit these residues to what studies show to be safe levels. Preventing excessive residues in harvested crops is essential to keeping these pesticides on the market for use in agriculture. Pesticide residues can be limited by:

- following pre-harvest interval requirements;
- applying a pesticide only to crops listed on the label;
- applying a pesticide only by methods listed on the label;
- applying a pesticide only at the rate specified on the label.

PREHARVEST INTERVAL The **pre-harvest interval** is vital to reducing the hazards of pesticide use. It is the minimum amount of time that must elapse between the last pesticide application and harvest. Pre-harvest intervals are established for all pesticide uses on food and feed crops. Required intervals also exist for many ornamental crops. The length of the pre-harvest interval is determined after studies are done on the degradation of the pesticide under labeled use conditions.

The length of the pre-harvest interval varies with different pesticides. Also, intervals for any individual pesticide may vary on different crops on which it is used. Carbaryl (Sevin) applied to apples requires that 1 day elapse between application and harvest; a 14 day pre-harvest interval exists for carbaryl on head lettuce. **Pre-harvest interval requirements are listed on the pesticide label.** Failure to follow these requirements by harvesting prematurely can allow excessive pesticide residues to appear on the crop.

SITE RESTRICTIONS Pesticides can be applied to only those crops that are specifically listed on the label. Since pesticides degrade at different rates depending on how the crop is grown, use of a pesticide on a crop may depend on how the crop is produced as well as what is grown. For example, pesticide registrations for greenhouse grown tomatoes differ from field grown tomatoes since they are considered as separate crops. Pesticide uses for ornamental plants grown in greenhouses differ when the plants are moved to interior landscaping.

APPLICATION METHOD The methods that can be used to apply a pesticide are also specified on the label. Complying with these instructions helps reduce the possibility of excess residues on harvested produce. For example, a pesticide may be applied to the root system of the crop but not to the foliar portion (and vice versa). Aerial application may be allowed but not chemigation. Chemigation is typically allowed for overhead irrigation systems but not trickle irrigation.

APPLICATION RATES Use of a larger amount of a pesticide than the label specifies is a violation of FIFRA and can also cause harmful residues on a crop. Use only the amount equal to or less than that indicated on the label. With some pesticides, there are also restrictions on how many times they can be applied during a season and the frequency. Ensuring that excess residues do not occur in harvested crops is a major concern when pesticide labels are written. **It is violation of the law to use a pesticide in a manner that is inconsistent with its labeling.**

MANAGING PESTICIDE DRIFT AND VOLATILITY

Drift control is vital during every pesticide application. Several techniques can be used to reduce the possibility of drift:

- use pesticides that have low volatility;
- use formulations that resist drift and volatility;
- use low pressures during spraying;
- use nozzles which reduce formation of small spray particles;
- use high water volumes during application;
- apply pesticides close to the crop or soil surface;
- avoid applying pesticides when the temperature is high;
- avoid applying pesticides during windy conditions;
- use drift reducing adjuvants.

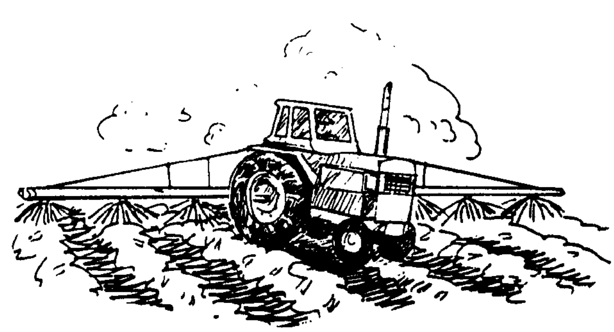
Certain formulations of pesticides can help reduce drift. For example, low-volatile acid and amine 2,4-D formulations have less potential for volatilization than ester formulations. Dust formulations drift much more readily than most sprays. Granular formulations are relatively less likely to drift.

Droplet size of pesticides during application is extremely important in determining the potential for drift. The ability of particles to drift increases greatly as the particle size decreases (below).

Distance water droplets drift while falling 10 feet in winds of 3 miles per hour.

Droplet diameter (microns)	Particle classification	Drift distance (ft)
30	Cloud	500
100	Mist	50
200	Drizzle	16
500	Light rain	7

The various spray nozzles and application equipment produce a wide range of droplet sizes. There are several techniques that will reduce the number of the smallest particles while still giving effective coverage.



Application pressures are important in determining the sizes of droplets that are formed. As pressure increases, the number of fine particles also increases. Drift can be reduced by reducing sprayer pressures during application.

Nozzle construction can also affect the number of small particles that are formed during spraying. Nozzle tips that produce larger droplet sizes help reduce drift. For example, larger nozzles can be used at lower pressures to get the same volume (Gallons per acre, or GPA) as smaller nozzles operated at higher pressures. Use of higher GPA applications are an alternate means of achieving adequate crop coverage with minimal pressures.

"Thickening" or "drift control" adjuvants can be added to the spray mixture to reduce drift. These compounds can increase the percentage of larger droplets which are formed but do not completely eliminate small droplets.

The weather conditions during application have a great effect on pesticide drift. Air movements, both horizontal and vertical, cause pesticides to move away from where you are spraying. The higher the wind speed, the larger the amount of pesticide that will be carried away. **Pesticides should never be applied during high wind conditions (greater than 10 mph).** This is particularly important when wind direction is likely to move drifted pesticides onto nearby sensitive crops or other sensitive areas. Drift to sensitive areas often can be avoided by spraying when the air is moving away from these areas.

Drift may also increase when warming air near the soil rises. **Applications should be done at times when air and soil temperatures are most similar, often during early morning and late evening.** At this time, vertical air movements are lowest.

If the air near the soil surface is cooler than the air above, an "inversion" exists. Small spray particles remain suspended in the cool air during temperature inversions, and the particles do not settle readily onto soil or plants. Later the suspended particles move out of the crop on winds and drift. **Pesticide applications should be avoided during inversions.**

Temperature and humidity can affect pesticide drift. When the temperature is high and humidity low, particles evaporate most rapidly. This evaporation causes droplet sizes to decrease and drift more readily. Volatile pesticides also evaporate more rapidly with high temperatures. Pesticides should be applied when the temperature is cool.

Height and orientation of sprayer nozzles can also affect drift. Distance and time for spray droplets to reach plants or soil is directly related to the height at which a pesticide is released. **Sprays should be released as near the target as will permit adequate coverage.** Sprays should also be directed so droplets are propelled downward to reduce the distance of droplet fall.

Vapor drift of soil-applied pesticides can be reduced by properly sealing the soil after application. This often involves proper soil incorporation of the pesticides during application.

AVOIDING POLLUTION OF GROUND AND SURFACE WATERS

Contamination of ground and surface waters is an imminent hazard of using pesticides in agriculture. This potential must be a major consideration in planning for pest control on cropland and other agricultural areas. Elements that enter into water pollution by pesticides are:

- proximity of the treated area to surface waters;
- proximity of the treated area to drinking water wells or aquifers;

- depth of the water table at the treated site;
- soil conditions that increase the potential for the pesticide to leach into groundwater; - the hazard of the pesticide as potential contaminant of groundwaters;
- conditions during application that affect pesticide drift into surface waters;
- crop management practices that minimize pesticide leaching;
- precautions during application to avoid leaching or direct groundwater contamination.

The potential for ground and surface water contamination should be evaluated whenever determining the need, method and frequency of pesticide use. Pesticides should only be used when and where necessary and only in amounts adequate to control the pests. When there are alternative pest controls available with less water pollution hazard, they should be considered.

Treatment of fields near rivers, streams, and other surface waters are most likely to result in contamination of surface waters. Treatment of fields where there are high water tables, or areas near drinking water wells may result in groundwater contamination. Pesticides should never be applied in a location or in a manner that could contaminate water resources.

In determining whether to use a pesticide or which one to use, the likelihood of leaching should be evaluated. Lighter soils and soils low in organic matter are most commonly associated with leaching of pesticides into groundwater. Soil pH (acidity or alkalinity) may also affect the breakdown and leaching potential of a pesticide. In fields where a high potential for leaching exists, pesticides should be avoided or use limited to chemicals that do not readily leach into groundwater. Some chemicals known to be "leachers" are highly water soluble and are weakly bound to soil particles. At sensitive sites where other conditions favor leaching, these pesticides should not be used.

Proper precautions should be taken during application to reduce potential contamination hazards. Application equipment should always be properly calibrated and maintained. Excessive application rates or spills due to poorly maintained equipment can result in high concentrations of pesticides on crops or land. Pesticides should always be applied in a manner that reduces drift. Application equipment should include safety devices to minimize problems with spills and back-siphoning. This includes the installation of backflow control equipment (check valves or air gaps) on filling pipes and in chemigation systems.

Irrigate in a manner that reduces pesticide movement. High rates of irrigation can increase the amount of pesticide leaching. Excessive irrigation can also cause run-off and erosion. Particular care should be given when irrigating shortly after a pesticide application, since the pesticide is in the highest concentration at this time.

Always follow directions on the pesticide label. Application safety instructions and any restrictions on the pesticide's use are on the label. It is the responsibility of the applicator to read and follow all the instructions. The pesticide label is a legal document, and the content of the label may change as manufacturers and the EPA evaluate uses and hazards. Don't take it for granted that once you have used a product that the directions for use will remain the same. There are criminal and civil penalties for using pesticides in a manner that conflict with the label instructions.

REDUCING HAZARDS TO WILDLIFE

Destruction of wildlife is an unfortunate offshoot of pesticide use. In some cases, such as DDT, the devastating effects have resulted in cancellation of the pesticide registration. Threats to endangered species have become important considerations in registering pesticides for use. Damage to wildlife from pesticide use can be reduced by:

- avoiding pesticides that are highly toxic to wildlife;
- using pesticide formulations that are less hazardous to wildlife;
- applying pesticides in a manner that minimizes damage to wildlife.

TOXICITY Pesticides vary widely in their toxicity to wildlife. For example, many organophosphate insecticides are quite toxic to birds and mammals. Fish tend to be more susceptible to synthetic pyrethroid insecticides. Often, several effective pesticides may be available and the less hazardous materials can be selected.

FORMULATIONS The formulation of a pesticide can make a chemical more or less hazardous to wildlife. Bait formulations for grasshopper control are less harmful to birds than broadcast sprays. Systemic insecticides applied to the soil can be less hazardous to wildlife than sprayed applications. Granules tend to be relatively safe to many types of wildlife; however, granules exposed on the soil surface, particularly colored granules, may be eaten by some animals. Surface exposed granular pesticides and pesticide treated seed have been involved in some serious bird kills. The pesticide, Diazinon, was banned for use on golf courses and sod farms because of its toxicity to birds.

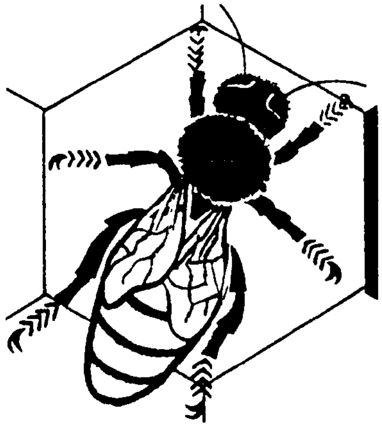
APPLICATION There are several application practices that can be used to protect wildlife. Pesticides should not be applied to known habitats of desirable wildlife. In some cases, such as prairie dog poisoning, pre-treatment surveys for wildlife are required. Also, there are restrictions under the Endangered Species Act on some pesticide uses in areas known to be frequented by threatened or endangered species.

Pesticide applications can be timed to reduce the hazards to wildlife. It may be possible to apply pesticides during periods when migrating wildlife is not present. Delays in treatments may also be considered to allow breeding birds to rear young and disperse from the area.

During application, care should be taken to reduce potential exposure of wildlife to pesticides. Pesticides applied to soil or pesticide-treated seed should always be covered with soil. When lifting equipment during field turns, it is possible for granules and seed to spill and pile. Spills or puddling of insecticide spray mixtures can be hazardous since water may attract birds and animals. Steps should also be taken to reduce pesticide drift into areas of wildlife habitat.

REDUCING LOSSES OF HONEYBEES

Honeybees visit fields and orchards to collect pollen, nectar, water and other materials needed to maintain their hives. For many fruit and seed crops, the pollination by bees is essential to crop production. In addition, the honeybee industry and honeybee byproducts provide a major source of income to full and part-time beekeepers, and contributes millions of dollars in value to Colorado agriculture.



Unfortunately, activities of pollinating insects such as honeybees often conflict with crop protection practices. Pesticides, particularly certain insecticides, kill large numbers of honeybees in Colorado annually, destroying or weakening colonies. For example, pesticides used to control alfalfa weevil and sweet corn insects can cause extensive honeybee losses. Steps to avoid these problems include:

- communication and coordination with area beekeepers;
- avoid treatments to crops in bloom;
- control flowering weeds in crops;
- avoid drift;
- use pesticides that are least hazardous to honeybees;
- treat fields during times when honeybees are not active.

COMMUNICATION Regular communication between pesticide applicators and beekeepers is a two-way process that can help protect honeybees. If applicators are aware of the location of bee colonies, they can warn beekeepers of planned applications so that colonies can be moved or temporarily covered. Also, beekeepers can block the main hive entrance and open a new entrance which disrupts honeybee foraging for several hours.

HAZARD There is a wide range of hazards to honeybees among the various pesticides. In general, relatively slow acting pesticides can be among the more hazardous since they may be carried to the hive and fed to many other bees. Pesticides which are readily collected by foraging bees, such as certain micro-encapsulated insecticides, are also most commonly associated with honeybee poisonings. However, formulation of pesticides can also reduce these hazards. For example, most carbaryl (Sevin) insecticides are considered highly hazardous to bees, but the Sevin XLR formulation is much less hazardous since bees do not easily pick up the insecticide during foraging.

Flowering crops in bloom should not be treated with pesticides that are toxic to honeybees. Indeed, some pesticide labels prohibit the use of the pesticide on crops in bloom. This is often relatively easy when bloom occurs over a limited time, such as with orchard crops; however, the presence of flowering weeds in nearby fields or orchards may attract bees for longer periods. Weed control can therefore be an important factor in reducing honeybee poisoning.

Sometimes crops must be treated when they are blooming because it is critical to crop protection. For example, the sunflower moth lays eggs during bloom and is most easily controlled by applying pesticides at that time. Less hazardous pesticides should be used 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.

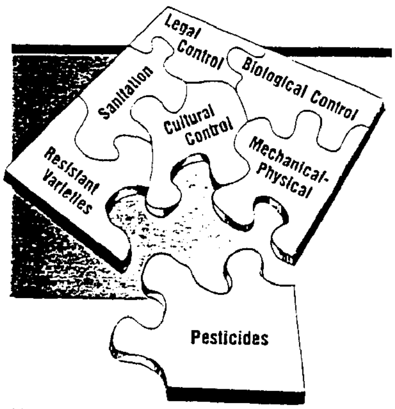
DRIFT Serious honeybee poisonings can be caused by pesticide drift. During warm periods, large numbers of honeybees may mass on the outside of the hive to help control hive temperatures. These exposed bees can be destroyed easily by drifting pesticides.

INTEGRATING CHEMICAL AND BIOLOGICAL CONTROLS

Biological controls are important to controlling insects, mites, weeds and diseases of crops. But, they can be eliminated by use of pesticides, causing an even greater dependency on chemicals. Whenever possible, it is wise to integrate chemical and biological controls by practices such as:

- recognition of existing biological controls and evaluating their value before applying any pesticides;
- using pesticides that are less harmful to beneficial organisms;
- timing pesticide applications so they are less harmful to beneficial organisms.

Scouting Biological control organisms may be effectively controlling pests even though they are not recognized. Even pests that occur regularly, such as spider mites on field corn or greenbugs on sorghum, may be effectively controlled under some conditions. Before applying pesticides, fields should be examined for the activity of natural enemies. If large numbers are present, pesticide use may be deferred or avoided.



Selective Pesticides When several different pesticides are available, selection of pesticides with less impact on natural enemies can be made. For example, "selective" insecticides (for example, Bacillus thuringiensis for first generation European corn borer or miticides such as Vendex for control of spider mites on fruit trees) can conserve most other biological control organisms.

Insecticides that are relatively short-lived may also be used selectively since resistant stages of the biological controls (eggs, pupae) may survive, allowing fields to be rapidly recolonized. The formulation may also be important in determining selectivity. Formulations of soil-applied systemic insecticides, such as Disyston 15G, can be more selective than the same insecticide used in a sprayed application, such as Disyston 8E.

Timing Pesticide use may also be timed so the effects on natural enemies will be low. For example, use of dormant sprays on fruit trees before flowering can control pest species on the plant at that time. Biological control organisms typically move to orchards later in the season so would not be affected by dormant applications.

MANAGING PHYTOTOXICITY HAZARDS

Plant damage resulting from a pesticide application to a desirable plant is known as phytotoxicity. Some burn of leaves, flowers, or growing tips will be seen. Yellowing, leaf distortions, abnormal growth and stunting are other signs of phytotoxicity. This is a particular concern where appearance is critical to marketing a crop (tree fruits, flowers, ornamentals).
Phytotoxicity is regularly associated with the use of specific pesticides or formulations on susceptible plants; however, phytotoxicity may be irregular. Problems can be reduced by:

- avoiding use of pesticides on plants known to be susceptible;
- using formulations that have reduced phytotoxcity hazard;
- applying pesticides under the best environmental conditions;
- following label directions on application rates or frequencies;
- avoiding pesticide mixtures;
- never using equipment that has been used for herbicides to apply insecticides or fungicides.

Careful reading of the pesticide label can help identify plants that are sensitive to the pesticide. Warnings may be in the label section that discusses crop uses or in a separate section. They may indicate that only certain varieties are susceptible to injury. Pesticides broadly labeled for use on flowers or ornamentals may not include warning statements for some susceptible plants.

Formulation **Wettable powder and other dry formulations tend to be safer to use on sensitive plants than emulsifiable concentrate liquids. This is because the various "inert" ingredients in some emulsifiable concentrates (xylene, for example) can be harmful to plants. Almost all aerosol formulations of pesticides for use on ornamental plants can cause injury if the spray nozzle is too close to the plant. It should be 18-20 inches or more from the plant.**

Weather **Avoid spraying plants during extremely hot sunny conditions. Temperatures above 90 degrees can increase plant injury by many insecticides. During sunny conditions, leaf and flower temperatures may be considerably higher than the air, allowing for injury at lower air temperatures. Cool temperatures increase the plant injury of other pesticides.**

Pesticides should not be applied when they will not dry. Plants sprayed when the weather is cool and humid will remain wet for long periods, and there will be increased likelihood of injury. Wet foliage is also more likely to be injured by aerosol formulations. Slow drying is one reason greenhouse grown plants are more sensitive to spray injuries.

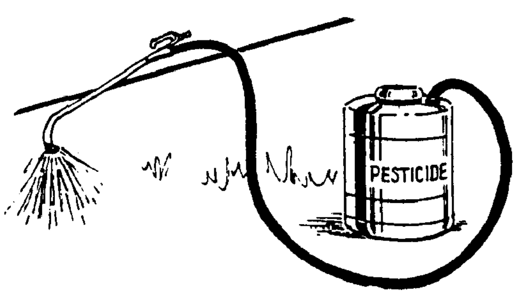
Never spray plants that need water. Wilted or dry plants are extremely sensitive to spray injury. Slow growing or diseased plants may also be injured more frequently than vigorously growing plants.

Mixtures/Rates **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. Compatibility charts that can help avoid many mixtures known to cause phytotoxicity.

Sprayer equipment used for applying herbicides should never be used for spraying insecticides and fungicides. Minute amounts of herbicide residues in such equipment can cause severe damage to desirable plants.

Testing **An important precaution for use of pesticides on flowers and ornamentals is to test the spray mixture on a few plants. Several (3-4) preliminary applications should be made, at short intervals (3-7 days) under normal growing and spraying conditions. Plant damage by some pesticides may appear within 18 hours; with others it may take 3 days. It is useful to compare sprayed plants with adjacent non-sprayed plants receiving identical cultural care.**



Summary Chapter VI

Be sure that each person who applies pesticides understands how to use them and follows the label precautions. A supervisor is responsible for everyone under his/her direction.

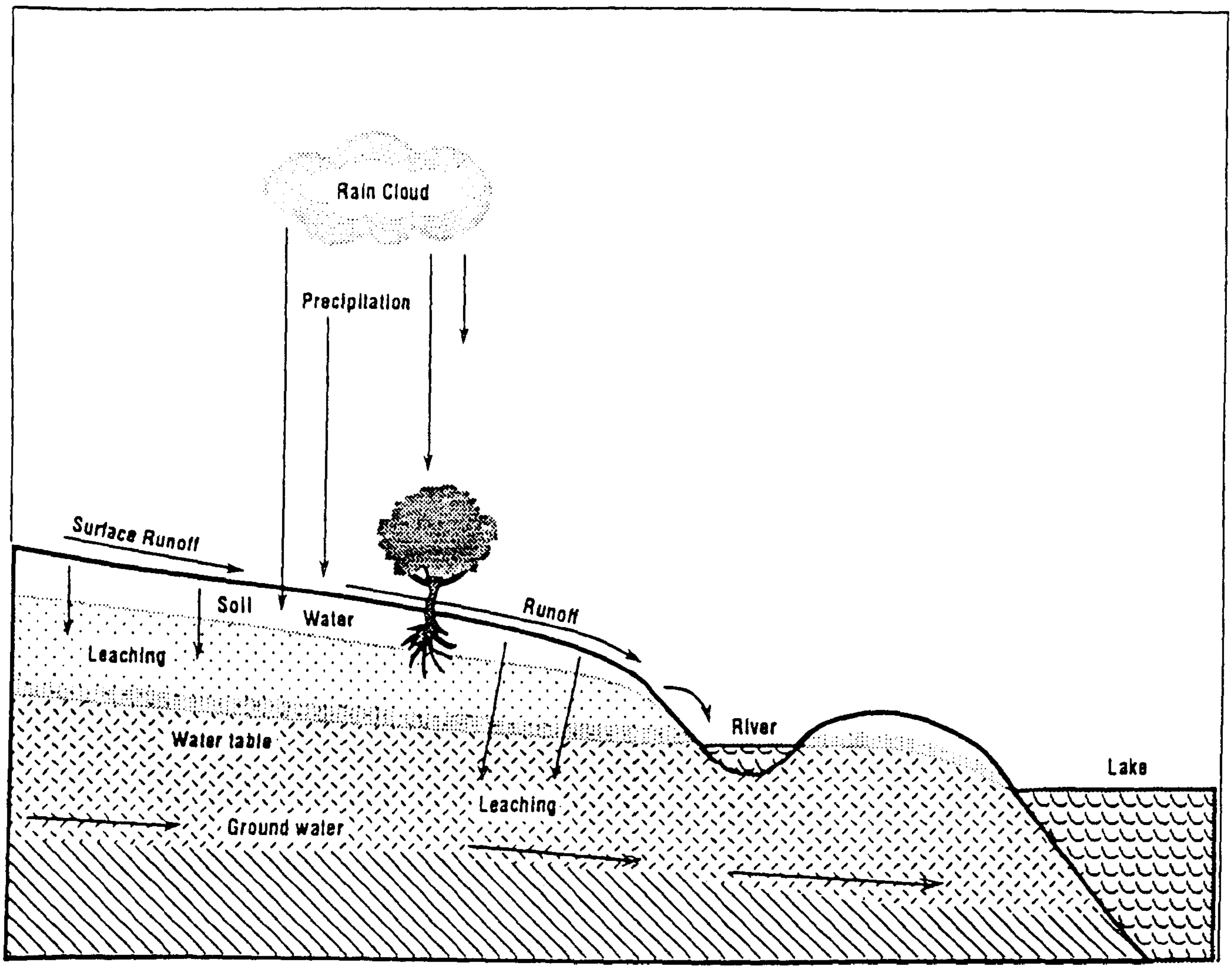
Observe Restricted Entry Intervals required by the product label. Never enter a treated field unless trained to do so using required protective equipment.

The Pre-harvest Interval is the length of time that must pass after a pesticide is applied before harvest of the crop can begin. If not observed, illegal residues may appear on commodities.

Make sure that pesticides do not drift into areas where other crops, animals, or people will be harmed. Never apply pesticides when there is a wind, or when it is too hot.

Some pesticides have greater potential for contaminating groundwater than others. Soil, the water table, irrigation practices, and the pesticide's characteristics all contribute to the likelihood of water pollution.

An undesirable side effect of using pesticides is damage to wildlife and its habitat. Use pesticides in a manner that is least likely to damage wildlife or the environment.



Chapter VII

PEST MANAGEMENT IN COLORADO

WEEDS

Essentially all crops grown in Colorado are subject to competition and attack by certain pest species. Information on the management of these pests is available from various sources, such as the Colorado State University Cooperative Extension Service, agricultural chemical dealers, and consultants. Some examples of pest management techniques follow.

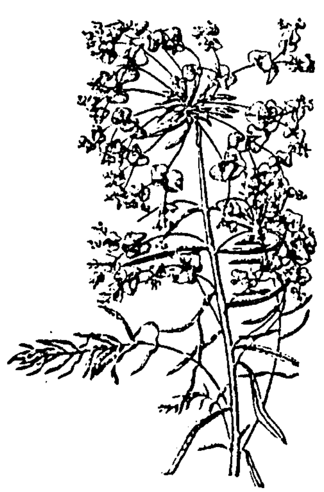
CANADA THISTLE

Canada thistle is a noxious weed under Colorado law. This aggressive and serious pest of pasture and cultivated crops usually starts in disturbed ground, such as overgrazed pastures, tilled fields and waste areas. Once established, Canada thistle spreads by means of underground rhizomes, creating circular patches. Root pieces cut by cultivation may regrow and spread the weed. In addition, large numbers of seeds which are produced during late spring and early summer are blown to new areas, spreading the weed.

In cropland, best control of the weed is achieved by persistent cultivation. Use of a duck-foot cultivator which cuts the plant no deeper than 4 inches below the surface is suggested for this operation. Plants are particularly susceptible to cultivation shortly before flowering, when root food reserves are lowest.

Planting cropland to highly competitive crops, such as small grains and alfalfa can help reduce Canada thistle infestations. In grain crops, rangeland, and pasture, a few selective herbicides can be used. Herbicides are more effective when applied in the fall, shortly before a killing frost when they are most likely to reach and kill the root system.

LEAFY SPURGE



Leafy spurge is the most damaging weed in Colorado's pasture lands. Cattle do not graze leafy spurge because it produces an irritating milky sap, and since it is highly aggressive, it can rapidly outcompete desirable forages. A relative newcomer to Colorado, leafy spurge has ruined large areas of rangeland in more northern states which spend millions of dollars to control it. Leafy spurge is recognized as a noxious weed.

The seed is spread primarily by birds, humans and water. It has taken hold along ditchbanks and streams in Colorado. Once established, an extensive creeping root system that produces numerous new plants enables it to reach into new areas. The rootsystem contains large nutrient reserves which help the plant survive control measures.

Intensive cultivation is an effective means to control leafy spurge. In rough terrain where this is not practical, specialized equipment can be used to lift and damage the roots and expose them to disease organisms. This is most effective if done at flowering. Herbicides applied at the proper time, depending on the product, can be effective in leafy spurge control.

JOINTED GOATGRASS Jointed goatgrass is a serious weed of winter wheat. It has a winter annual life cycle, similar to that of the crop, germinating primarily in fall. The plants resume growth in spring, usually flowering and setting seed shortly before the wheat. Occasionally, jointed goatgrass will hybridize with wheat. Jointed goatgrass has been classed as a noxious weed in Colorado since 1978.

The seeds are small cylinders which look like half inch pieces of wheat stem. Because of this similarity, many farmers have unknowingly planted the weed and contributed to its spread. Once established in a winter wheat field, jointed goatgrass is extremely difficult to control since it is so similar to the crop that selective herbicides are not available. Seeds may also remain viable for several years, particularly if buried deeply during plowing.

Farmers can prevent the spread of jointed goatgrass by learning to recognize the weed seeds and inspecting all seed for presence of the weed. Since infestations in fields can originate from roadsides, these areas should also be surveyed and treated for the weed. When jointed goatgrass has become a problem in a field, rotation to a spring crop should be considered as more effective herbicidal control is then possible.

MUSK THISTLE Musk thistle is a biennial weed found in pastures and rangeland. The musk thistle plant is usually large and has long spines; therefore, it is avoided by livestock.

Although musk thistle can become a problem even on good pastureland, it has more difficulty becoming established in vigorously growing grass. Herbicides are often used for controlling musk thistle. It is most sensitive to herbicide treatment while in the rosette stage, before it produces a seed spike.

A species of weevil which feeds on the developing seeds of musk thistle has been introduced into Colorado as a control technique.

LARKSPURS Larkspur is a major weed of Colorado ranges because it is poisonous to cattle, occasionally causing death. Horses are also susceptible to the effects of the weed but usually do not consume enough foliage to cause poisoning. Sheep are generally not poisoned by larkspur.

There are two groups of larkspurs. The tall variety is usually found in moist meadows or woodlands at high elevations; the low variety in the foothills at lower elevations and drier environments. Larkspurs are perennial and reproduce both by seeds and by tubers or rhizomes.

The plants produce a rosette of green growth early in the season, often before suitable forage plants have begun to grow. Animals then feed on the larkspur because other green plants are not present. Delaying use of the infested range or pasture until the grass begins to grow is a means of preventing animals from eating larkspur. Sheep may be run earlier to consume the larkspur, which also helps to save grass for cattle.

Broadleaf herbicides can be used to control larkspur in rangeland.

PLANT DISEASES: FUNGAL

BOTRYTIS NECK ROT OF ONIONS Botrytis neck rot and purple blotch are harmful fungus diseases of onions in storage. Under conditions favorable to the disease, near total losses from rotting are possible. Bulbs may become infected in the field or in storage since the spores are spread by wind, water, equipment, workers, or insects. Botrytis enters onions through wounds. Common sources of these wounds include hail, harvest injuries, foliage tip burns, topping, and inadequate curing of neck areas. Late planting and excessive use of nitrogen fertilizers contribute to problems by delaying maturity of the crop.

There are several ways to reduce losses from botrytis neck rot in onions. Cull piles should be covered with soil to prevent production of spores that can infect the crop. Fields should be rotated, preferably on a 3-4 year cycle, to allow elimination of infected crop debris. Neck areas should be allowed to cure properly before topping. Late season applications of fungicides may also help to protect the neck area from infections.

During harvest, bulbs should be carefully lifted and handled to avoid bruising, and only undamaged bulbs should be stored. Then stored onions should not be exposed to direct sunlight or freezing temperatures. Good air circulation can help prevent disease development in storage facilities.

PHYTOPHTHORA ROOT ROT Root rot caused by Phytophthora fungi can seriously damage vegetable crops such as tomatoes, peppers, squash and melons. Phytophthora fungi also cause root rot and crown rot in orchards. Most plant damage results when the fungus infects and girdles plants at or below the crown area. Vegetable plants may wilt and die. Infected fruit trees show symptoms of reduced vigor, such as poor growth and discoloration of leaves.

Phytophthora root rots are likely to develop when soils are poorly drained or when the soil is a heavy clay type. Growing vegetables in raised plant beds can help improve drainage and prevent infections. When irrigating fruit trees, avoid prolonged wetting of the crown area. Resistant varieties of vegetables and rootstocks help prevent root rots. In vegetables, crop rotations to non-susceptible crops, such as corn and grain, should be used to eliminate sources of the disease.

Some of the new systemic fungicides (metalaxyl) can effectively control Phytophthora; however, the County Cooperative Extension office should be consulted for information on the use of these products in Colorado.

CORN STALK ROT Corn stalk rots result from various types of fungi. Lodging is common with this disease or, infected plants may die. The fungi may also produce toxins that are injurious to livestock. Infection may occur through invasion of the roots or at nodes. Invasion of the roots is particularly common if there are cool, moist conditions after planting. Infection may also enter through insect wounds such as are produced by corn rootworm larvae.

Unfavorable growing conditions create stresses on the corn plant and promote corn stalk rot. By correcting fertility imbalances, maintaining optimal plant populations, and providing adequate moisture, the likelihood of corn stalk rot developing can be minimized. Favorable growing conditions are particularly important after pollination and during early grain fill when the plants are most susceptible to infection. Although no varieties are immune to the disease, some varieties are more resistant than others.

Crop rotations and plowing can help reduce the amount of infected plant debris in a field.

PLANT DISEASES: BACTERIAL

COMMON BACTERIAL BLIGHT OF BEANS Common bacterial blight and halo blight are two bacterial diseases of beans in Colorado. The amount of damage they do depends on what plant tissues are infected. Infections on leaves kill areas of plant tissues and if extensive can reduce yields. Infections on stems can form watersoaked cankers and cause plants to break. If pods are infected, seeds become shriveled, discolored or rot.

The disease organism overwinters on infected plant debris and in seeds. Use of certified, disease-free seed is important in minimizing the disease. Fields should also be rotated, preferably in a minimum 3-year rotation. (This practice also helps reduce other common bean problems such as white mold and root rots). Some varieties of beans have resistance to this organism.

Like most bacterial diseases, common bean blight is favored by warm moist conditions. Overhead irrigation, as opposed to furrow irrigation, promotes this plant disease. Use of certain copper fungicides can help manage the disease.

FIRE BLIGHT Fire blight is the most serious disease of pear, apple and other plants of the rose family. The disease organism kills the inner bark of trees, causing terminal shoots and foliage to suddenly wilt and die. As the disease progresses, extensive areas of the tree can be killed.

The bacteria enter the plant through wounds, flowers, and during pruning. Spread can be from splashing water, human activities and by pollinating insects. Once inside the tree, the bacteria can develop rapidly if warm, moist conditions exist. During active periods of disease development, the bacteria ooze from the damaged cankers that they produce on trunks and branches.

Pruning at least 15-18 inches below visible cankers is the only means to manage the disease in infected trees. Pruning should be done during the dormant season. Carefully sterilize pruning tools between cuts, and remove and destroy the infected wood. Preventive sprays of fixed copper or the antibiotic streptomycin can be used during periods when new infections can develop.

PLANT DISEASES: VIRUSES

BARLEY YELLOW DWARF Barley yellow dwarf is a virus disease of cereal crops in Colorado, including wheat and barley. Infected plants are stunted, generally discolored yellow, and yield poorly if at all. Young plants may die.

Barley yellow dwarf is spread by aphids. Greenbug, bird cherry oat aphid, English grain aphid, and corn leaf aphid are common species of aphids in Colorado which transmit the various strains of the disease organism. There is often an increase in the disease where Russian wheat aphid occurs. The disease occurs in corn, on perennial grasses, and other grassy weeds as well as in grain crops.

Barley yellow dwarf control can be difficult. Insecticides to control aphids that transmit the disease may be useful but are generally not economical. Planting crops far from infection sources and delaying fall planting can also help reduce disease incidence.

INSECTS

RUSSIAN WHEAT APHID The Russian wheat aphid was first identified in Colorado during 1986. It has spread extensively throughout the state and has caused severe losses to wheat and barley.

Unlike most other aphids found on small grains, the Russian wheat aphid produces saliva that is toxic to the plant, causing the chlorophyll to be destroyed, and producing symptoms of leaf streaking. Infected leaves often curl tightly, preventing normal seed heads from emerging. The leaf curling also protects the aphids from predatory insects such as ladybird beetles. Surveys of the insect are most easily made by watching for the symptoms.

The biology and habits of the Russian wheat aphid as a pest in Colorado are still poorly understood. Damage to winter wheat seems to be greatest on drought stressed plants. Dry winter conditions appear to favor overwintering of the insect. Among spring seeded small grains, barley is the plant that most favors development of the aphid.

Economic levels for treating the insect vary depending upon the growth stage of the crop. Because of continuous new research developments with this insect, grain growers should check with county Cooperative Extension offices regarding latest recommendations for control.

Insecticide treatment of the Russian wheat aphid is known to cause extensive bird kills.

POTATO PSYLLID The potato psyllid damages potato and tomato plants by injecting a toxic saliva during feeding. This toxin apparently moves systemically in the plant and has properties similar to plant growth regulators. Foliar symptoms in infested plants include stunting, erectness of new growth, and color changes. Potato tuber set can be disrupted causing the plant to produce numerous rough tubers that fail to grow. Alternatively, tubers may sprout prematurely. Tomatoes can be greatly reduced in size and quality. Following control of the insect there is some recovery of infested plants.

The potato psyllid does not overwinter in Colorado; infestations result from annual migrations. Once in a field the insect reproduces continuously, completing its life cycle in 3-4 weeks. Infestations are irregular but more common in eastern Colorado than other areas of the state. Fields should be surveyed regularly with a sweep net to detect adult insects as they first arrive.

ALFALFA WEEVIL Alfalfa weevil is the most serious insect pest of alfalfa in Colorado. Damage is caused by the immature "grubs" (or larvae) which chew on first cutting hay, reducing yields and quality. To a lesser extent, grubs may be present in sufficient numbers to damage second cutting hay.

Alfalfa weevils overwinter in the adult stage in protected areas around field edges. They return to the field in spring and deposit their eggs in developing shoots. The larvae feed for several weeks before becoming full-grown, at which time they drop from the plant and pupate. The emerging adults feed some but do not cause yield reductions. There is only one generation per year.

Pesticides used to control alfalfa weevils have caused extensive losses of honeybees. Also, pea aphids can increase after use of pesticides to control alfalfa weevils. The Colorado Department of Agriculture has released numerous parasites of the alfalfa weevil, several of which have become established, to control the pest naturally.

TWO-SPOTTED SPIDER MITE

The two spotted spider mite affects a wide variety of Colorado crops including greenhouse, fruit, bean and field corn. The mites damage the plants by sucking the cell contents from leaves causing areas of the leaf to die. During heavy infestations leaves can look scorched and die or drop prematurely.

Outdoors, two-spotted spider mites overwinter as full-grown females and often take on a red color. Populations indoors cycle continuously. During warm temperatures, particularly when dry conditions exist, mites can complete their growth cycle in as little as a week. Because of rapid growth and reproduction, mite populations can explode in a short time.

Two-spotted spider mites can be difficult to manage since they have developed resistance to most pesticides used to control them. Some natural controls can be effective on outdoor crops if they are not disrupted by pesticides used to control other pests such as codling moth and European corn borer. Indoors, some introduced predators of the two-spotted spider mite have been used successfully.

Water management can also be used in a mite control plan. Overhead watering can wash off and destroy many mites. Preventing drought stress on plants can also reduce development of the mites.

CODLING MOTH

Codling moth is generally the most critically damaging insect pest of apples and pears in Colorado. Damage is produced by the larval stage (common "apple worm") which tunnels into the fruit. The adult stage is a small, grey moth with a copper spot on the wing tips.

The insect overwinters in a cocoon on the bark of the tree or on debris in the vicinity of the trees. The adult moths emerge shortly after petal fall, mate, and the females lay eggs on leaves. The young larvae may feed upon leaves but then move to developing fruit, usually entering the calyx end. After feeding, they drop from the fruit and pupate.

Moths of the second generation fly in July and lay eggs directly on the fruit. The larvae tunnel into the fruit shortly after hatch. Most fruit damage is done by these second generation larvae. A third generation may occur in August.

Codling moth control is achieved primarily through the use of protective cover sprays of insecticides applied when moths are laying eggs and eggs are hatching. Pheromone traps, containing the sex attractant of the insect, can indicate timing for codling moth sprays.

GREENHOUSE WHITEFLY

Greenhouse whitefly damages many greenhouse crops and occasionally infests vegetables transplanted outdoors. Damage is caused when the insect removes sap during feeding and excretes a sticky honeydew onto lower leaves.

The greenhouse whitefly cannot overwinter outdoors in Colorado and the pest survives on indoor plants. Continuous, overlapping generations of the insect are completed in about a month, and egg laying adult insects can live for a month or more.

By scheduling greenhouse plantings to provide for host-free periods of 2-3 weeks, the life cycle of the insect can be broken. When new plants are introduced into clean greenhouses, they should be quarantine. The immature stages of this insect are particularly difficult to see, being pale colored and scale-like on lower leaf surfaces.

Insecticides, primarily those in the pyrethroid family, are used for managing the whitefly. Repeated applications are required since the egg and non-feeding "pupal" stages are resistant to control. Yellow sticky traps can be used to monitor and even control the greenhouse whitefly, which is attracted to yellow. In warm temperature greenhouses, exceeding average temperatures of 75 degrees, an introduced parasite (Encarsia formosa) may help control the insect.

COMMON CATTLE GRUB The common cattle grub, or "heel fly" is the most destructive insect pest of cattle in Colorado. Immature stages of the insect develop as parasites inside the animal, diminishing weight gains and milk production. In slaughtered animals, cattle grubs cause serious losses because carcasses must be trimmed and hides are damaged.

Adult flies lay eggs on the legs and lower areas of the animal in the spring. The buzzing of the "heel flies" is often disturbing to cattle and they may run wildly trying to escape. Disrupted feeding and disturbed behavior of the cattle is an indirect hazard of the common cattle grub.

Larvae of the grubs hatch from eggs in 3 to 5 days, migrate down the hair of cattle and penetrate the skin. Then they move through the animal and lodge underneath the skin on the back where they form a cyst. When full grown, they emerge through the skin, drop to the ground and pupate. There is one generation per year.

Cattle grubs can be controlled by using insecticides that can enter the animal systemically and kill the developing grubs. These treatments are sprayed, poured on the back of the animal, or used in dips. The timing of the treatments is critical since harm can be done if grubs die in sensitive areas such as the esophagus or spinal cord. Lactating dairy cows and animals that will be slaughtered before the required minimum post-treatment interval has elapsed cannot be treated with systemic insecticides.

STORED GRAIN INSECTS Insects that infest stored grain are both primary pests, which attack intact kernels, and secondary pests, which feed on broken or cracked grain. In addition, there are several insects that feed on fungi associated with grain molds. The most common primary pests include the lesser grain borer, granary weevil, and Indian meal moth. The sawtoothed grain beetle, flat grain beetle, and flour beetles are secondary pests.

Insects can damage stored grain in several ways. Direct feeding results in lower weight and nutritional value, and reduced germination. Insect feeding can help create conditions favorable for storage molds to develop. Sometimes the greatest injury is the mere presence of the insect, contamination of the grain, which can result in serious dockage. This latter issue has become increasingly important as strict standards for insect infestation have recently been enacted.
Fortunately, winters in Colorado are sufficiently cold to prevent serious losses during the first storage season. Further losses can be prevented if the proper precautions are taken when storing grain. These may include:

1. Keep storage bins and grain handling equipment clean;
2. Maintain the storage area in good repair;
3. Use residual sprays on bin surfaces after cleaning and before storing new grain;
4. Store clean, dry grain only;
5. Properly aerate the grain to maintain uniform temperatures and prevent condensation;
6. Use grain protectants as the grain is being moved into storage;
7. Inspect grain regularly to detect developing infestations.

When insect problems are detected, the following alternative methods may be considered:

1. Grain can be removed and retreated with a protectant insecticide.
2. When the grain is removed during very cold periods, some insects may also be killed by the handling and temperature.
3. Infested grain may also be fed to livestock.
4. A final option is to fumigate the grain.

Grain fumigation involves the use of highly toxic gases. Fumigation of stored grain requires the use of specialized equipment (discussed later) and special protective measures for the applicator. All entrances of grain storages being fumigated must be placarded. Furthermore, fumigated grain must be aerated and handled carefully to insure dispersal of residues. It is safer and often easier to allow fumigation professionals to do the job rather than attempting on-farm fumigation.

ANIMALS/RODENTS

RICHARDSON GROUND SQUIRRELS

Richardson ground squirrels occur over most of Colorado, including the higher elevations. They are usually seen close to their mounded burrow openings and tend to occur in small family or colony groups. When there is plentiful feed, ground squirrels may increase rapidly; they can produce annual litters of a dozen or more.

Planted or growing grain and forage crops are all food for Richardson ground squirrels. Where they are numerous, crops can be extensively damaged. Burrows may also be a hazard in irrigated areas such as pastures.

Populations of Richardson ground squirrels fluctuate rapidly and may be virtually wiped out by disease. Natural enemies also include hawks, weasels, badgers, and man. Four methods of control have been practiced successfully: poisoning, trapping, shooting and fumigation.

Poisoned grain is the most common and effective means of control on farms and ranches. On large areas with numerous animals, it is the only practical one. Poisoned oats or barley are cheap and effective; oats are favored. Grass seed and cracked wheat should not be used since seed-eating birds may feed on them. Timing is important; treatment should not be applied at the first sign of activity in spring nor in late summer when the squirrels start to disappear into burrows. Also there are periods when the squirrels may feed selectively on individual grains, eating kernels after removing the treated hull. The best time to use poisoned grain is when the entire colony is active and grain baits are being readily accepted, particularly when squirrels are "pouching" (gathering seeds for winter storage).

Poisoned grain should be scattered on the hard bare ground close to the cleared surface of squirrel runways, not piled or placed in the burrow. Bait stations can be built which make the bait inaccessible to other species of wildlife. *Poisoned grain should be handled and placed with care at all times to avoid poisoning seed-eating birds, pets, livestock, and young children.* **DO NOT REMOVE POISONED BAIT FROM ORIGINAL CONTAINERS WHEN STORING.**

PRAIRIE DOGS Prairie dog species found in Colorado include the black tailed prairie dog of the eastern plains, the Gunnison prairie dog in the southwest, and the white tailed prairie dog in the northwest. Prairie dogs are considered by many people to be pests since they reduce vegetation in the area around the colony. The holes and mounding produced by prairie dogs also can be a hazard to livestock and equipment. Prairie dogs, and many other rodents, may also harbor fleas that transmit bubonic plague.

Prairie dogs, however, are an important part of the short-grass prairie ecosystem, providing food for many wildlife species, including some which are threatened or endangered. Also, other animals sometimes use their burrows for protection. Colonies of prairie dogs range from 5-20 individuals per acre, increasing in April or May after the pups are born.

Prairie dog control is necessary in some situations, but precautions must be taken to protect threatened, endangered, and some non-target wildlife during control operations. Because of the hazards associated with poisons used for prairie dog control, to both the applicator and non-target wildlife, regulations have become increasingly restrictive. The Colorado Division of Wildlife, county Cooperative Extension offices, or the Colorado Department of Agriculture's Bureau of Rodent Control can provide information on regulations.

To protect the black-footed ferret, an important prairie dog predator and one of North America's most endangered mammals, special precautions must be taken. These may include surveys prior to controlling prairie dogs. The U.S. Fish and Wildlife Service has declared some areas as unlikely to support black-footed ferrets. Such "ferret free" areas no longer require ferret surveys before a fumigant (aluminum or magnesium phosphide or gas cartridges) or poison grain bait (zinc phosphide, effective 1993) is used to control prairie dogs. Follow label restrictions in areas not yet declared "ferret free."

To reduce harm and/or protect wildlife, read and follow all pesticide label directions. Fumigants will kill any wildlife in the burrows. Poison grain bait has to be eaten to cause death. It is used outside burrows, and any grain-eating wildlife can be killed by it. Carcasses found above ground should be properly disposed of to eliminate any risk of secondary poisoning. Proper control techniques and timing can prevent inadvertent death to non-target wildlife species.

Use of poison oat baits for prairie dog control is most effective when green food is not available. Late summer, fall or early winter are usually the best times for a poisoning program. Prebaiting the area with untreated oats 2-3 days before actual baiting will increase later acceptance of the poison bait by the prairie dogs. When doing the actual baiting, treat the entire colony at one time. Repeat the application 7-10 days later. **Poison baits (about 1 Tbsp/hole) should be thinly scattered at the edge of the mound where the soil and grass meet.** By scattering the grain, there is less likelihood that desirable wildlife or livestock will eat the grain. Whenever possible, livestock should be removed from the treatment area.

Fumigants may be used when additional control is required. Because fumigants are expensive and highly hazardous, their use should be limited to small acreages and only after use of poison baits. Swift/kit foxes, burrowing owls, badgers, rabbits, reptiles and amphibians inhabit the burrows of prairie dogs and will be killed by fumigants. Rabbits are at risk from zinc phosphide but zinc phosphide is less hazardous to foxes. Zinc phosphide is toxic to grain-eating birds.

Prairie dogs don't use burrows occupied by owls. Owl burrows often have white droppings, owl pellets, feathers or shredded cow and horse manure around the opening. Do not use fumigants in owl burrows between March 1 and October 31, especially during the critical May-June nesting period.

Summary Chapter VII

Troublesome weeds in Colorado crop and rangelands are Canada Thistle, Leafy Spurge, Jointed Goatgrass, Musk Thistle and Larkspurs.

Fungal and bacterial diseases do serious damage to corn, wheat, vegetable and fruit crops.

Russian Wheat Aphid, Potato Psyllid, Alfalfa Weevil, Two Spotted Spider Mite and Coddling Moth all can reduce agricultural production in Colorado.

Managing Colorado's most troublesome pests involves the use of mechanical, cultural and chemical controls, in a coordinated effort known as Integrated Pest Management.

The Colorado Division of Wildlife, County Cooperative Extension Offices or the Colorado Department of Agriculture's Bureau of Rodent Control can provide information of prairie dog control restrictions.

Chapter VIII

APPLICATION EQUIPMENT

The successful application of pesticides depends on use of appropriate equipment and its careful maintenance. The amount of pesticide applied, how efficiently it controls the pest species, and the safety of its use to both the environment and applicator all depend on the equipment. There is a wide variety of equipment available, each with advantages and limitations for the particular situation. It is important to choose the equipment best suited to the use.

SPRAYERS

Tanks Tanks used to apply pesticides should be constructed with materials that resist corrosion. Fiberglass and stainless steel resist corrosion caused by most chemicals, as do plastic coatings; however, durability of these materials is reduced if cracks or chips in the coating develop and expose the base metal to corrosive forces. Untreated metal can be used for applying non-corrosive pesticide solutions but precautions should be taken to prevent rust and scale. All tanks should be constructed to prevent leaking and rupture.

Regardless of their construction, sprayer tanks should be of a design that allows for ease in inspection, filling, and cleaning. A drain plug should be located at the bottom to permit complete drainage when cleaning.

Agitators Sprayer systems should include adequate agitation in the sprayer tank to provide uniform mixing of the pesticide during application. Proper agitation is particularly important when wettable powder formulations are used or they will settle to the bottom.

There are various agitation systems: **By-pass agitation** involves pumping excess spray material back into the tank under pressure. This system is good for stirring solutions and emulsions, but may not adequately mix wettable powders. **Mechanical agitation** uses paddles or other devices to mechanically agitate the spray solution. Mechanical agitators provide excellent mixing but are expensive and difficult to maintain. **Jet agitation** uses liquids from the sprayer's pressure system. The line to the agitator in this system should be connected between the pump and any cut-off valves so that agitation continues when spraying has stopped.

Pumps Any pump used to apply pesticides must supply the spray volumes at the pressures required for application. The selection of a pump is usually influenced by cost and durability for the intended use.

Piston pumps are among those most commonly used for applying agricultural chemicals. These are positive displacement pumps that can be used for both corrosive and abrasive materials. The two types of piston pumps are for different application purposes: high pressure-low volume-high speed, and low pressure-high volume-low speed applications.

Roller or **roller impeller pumps** are also used in many agricultural spray systems. These pumps are adaptable to a wide range of pressures, volumes, and materials. They are accurate in the amount of spray material applied because they maintain constant pressure and flow.

Centrifugal pumps are designed for use with abrasive and coarse materials. Pumping action is achieved by use of a high speed impeller that throws the material out of the pump. These pumps are used to spray high volumes, but the maximum spraying pressures are limited to 50-60 pounds per square inch (psi).

Gear pumps are semi-positive pumps that develop uniform, moderate pressures but output volume is limited. They cannot be used with abrasive materials.

Nozzles Nozzles should be chosen to give the proper particle size, spray pattern, and application rate for the pressures used during application. Each nozzle is rated as to the amount of fluid that will be applied at a specified pressure and ground speed. Nozzles also are rated by the angle at which the sprayed material is discharged.

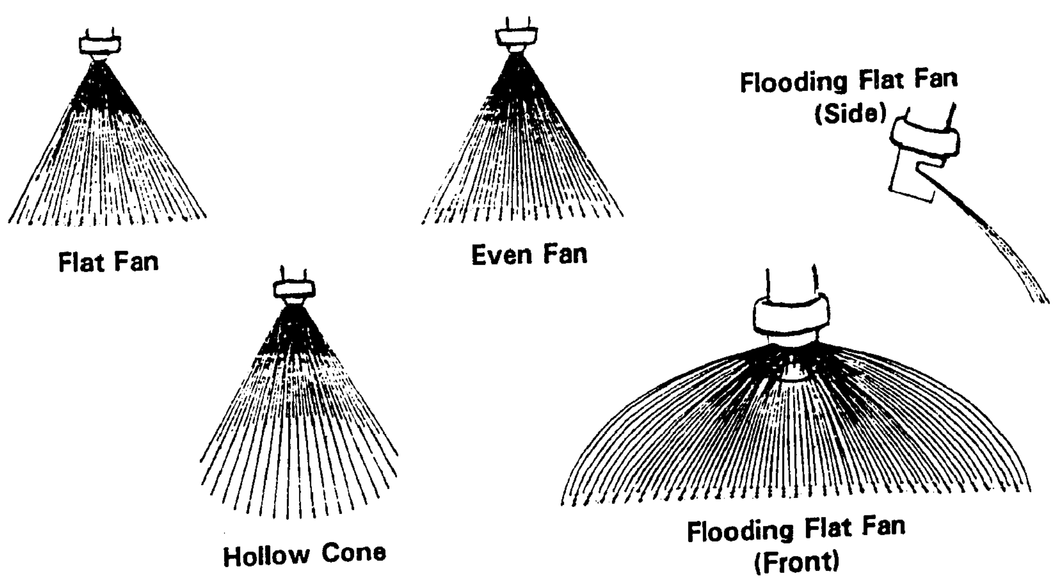
Nozzles are generally classified as to the pattern of spray they deliver. The more common types of nozzles are:

1. The **flat spray nozzle** produces a rather coarse spray in a fan-shaped pattern. Even coverage is achieved when spray areas overlap in boom sprayer applications. Flat-spray nozzles are suitable for most insect and weed control applications where penetration of the foliage is not necessary. A wide angle nozzle with a flat spray pattern can be operated close to the ground to minimize drift.

2. **Even spray nozzles** apply a more uniform spray than flat spray nozzles. Even spray nozzles are useful for band applications where there is no overlap of spray patterns from different nozzles.

3. **Solid and hollow cone nozzles** produce a sheet of spray in a cone shape. These nozzles are frequently used for insect or disease control because the spray pattern penetrates foliage well and from many directions.

4. The **flooding jet nozzle** is most commonly used to apply herbicides. It uses a fairly wide opening which can help reduce wear from abrasive materials such as wettable powder formulations. This type of nozzle also operates at a low pressure, reducing the amount of drift.



Nozzle Construction Nozzles are constructed from many different materials, each with different characteristics in terms of resistance to corrosion, abrasion, or reaction with spray mixtures. Selection of nozzle types should be made by balancing the characteristics of the construction materials against the cost of the different nozzles.

For example, brass nozzles are relatively inexpensive but wear quickly if exposed to abrasive materials. Aluminum nozzles resist corrosion by some pesticide spray mixtures but are readily corroded by some fertilizers. Stainless steel nozzles will not readily corrode and resist abrasion but cost substantially more than brass nozzles. Plastic nozzles may resist both corrosion and abrasion but may swell when exposed to certain solvents in pesticide formulations. Tungsten carbide and ceramic nozzles are most highly resistant to abrasion and corrosion but are usually the most expensive.

Strainers Strainers or screens are placed at various points in the sprayer system to exclude foreign material that would wear out precision parts or clog the system. Screens are normally placed at the entrance to the pump intake line, in the line from the pressure regulator to the boom, and in each nozzle. Usually 25- to 50- mesh screens are used in the intake hose, 50- to 100- mesh screens in the boom supply, and screens the size of the nozzle tip opening for the nozzle. For spraying wettable powders, all screens should be 50-mesh or coarser to prevent clogging.

Pressure Regulator The pressure regulator, or relief valve, maintains regulator required pressure in the system. This is a spring loaded valve that opens to prevent excess pressure in the line and allows some of the solution to return to the tank. Most pressure regulators are adjustable to permit changes in the working pressure of the system.

Types of Sprayers **Low-pressure sprayers** are normally designed to deliver low to moderate volumes at 15-80 pounds of pressure per square inch (psi). Application is usually made through a boom equipped with nozzles. Low-pressure sprayers are used primarily for weed and insect control on row crops, pasture, and forage lands where pressures of 80 psi or less provide sufficient crop coverage. Low-pressure sprayers are also used to apply liquid fertilizers or fertilizer-pesticide mixtures.

Low-pressure sprayers requiring low flow rates often are equipped with roller-impeller pumps. Centrifugal pumps are generally required where high flow rates are needed and when agitation of the spray mixture is required.

High-pressure sprayers are designed to deliver large volumes at high pressure. They are often similar to low-pressure sprayer systems but have a piston pump which can deliver high volume (up to 50 gallons/minute) at high pressure (up to 800 psi). Application rates of high-pressure systems are typically 200-600 gallons per acre. Sprays are usually applied with either a boom or a handgun. All components of a high pressure system must be designed and selected to withstand the high pressures. High pressure systems are used primarily on fruit crops, vegetables, and trees for insect and disease control. High pressure systems may also be designed for washing equipment.

Air-blast sprayers use a blast of air, instead of large volumes of water, to propel the spray mixture. Nozzles deliver the spray into a high-velocity airstream generated by a powerful fan which breaks the spray into fine droplets. Air-blast sprayers are typically used on fruit trees, shade trees and for fly or mosquito control.

Air-blast sprayers provide good coverage of foliage, are lighter weight, use lower pressures, and are easier to operate than high-pressure sprayers. However, they are often expensive and produce fine particle sprays which drift readily. Because of this drift potential, use of these sprayers is more limited by weather conditions. Since relatively low water volumes are used, calibration is particularly critical with air-blast sprayers.

Special air-blast sprayers which have higher air velocities (120-200 mph) and lower air volumes are known as **mist blowers**. These sprayers produce a very fine spray.

Small-capacity sprayers are designed for spot treatments, home and garden pest control, small tree and nursery spraying, and for restricted areas unsuitable for larger units. Most are hand sprayers which use compressed air to pressurize the supply tank, forcing the air through a nozzle. Several types of small power sprayers are available that deliver 1-3 gallons per minute at pressures up to 300 psi; adjustable handguns are usually used with these units, but spray booms are available on some models. Small-capacity sprayers are relatively inexpensive, simple to operate and maneuver, and easy to clean and store. Adequate agitation and screening for wettable powders, however, is necessary. Since there is a direct reliance on the operator for movement across the treated area, there can be substantial variability in application rates.

Maintaining Sprayer Equipment

Proper maintenance of sprayer equipment is essential to its proper performance. Several steps are involved in maintaining sprayers:

1. Use only clean water during application and cleaning.
2. Keep proper screens in place.
3. Never use a metal object for cleaning nozzles.
4. Do not lock a pump solidly to a tractor.
5. Lubricate the pump properly and fill with antifreeze or a light oil when not in use.
6. Flush a new sprayer before use.
7. Clean sprayers thoroughly after each use, when changing chemicals, or before storage. After using potent herbicides, such as 2,4-D, more extensive cleaning procedures are required to prevent possible crop injury from residue in the tank during subsequent applications of different pesticides. These are:
   a. Remove and clean all screens and nozzles with kerosene;
   b. Pump kerosene or fuel oil through the sprayer;
   c. Circulate a cleaning solution (1 lb detergent in 40 gal of water) through the bypass for 30 min. Flush part through the sprayer. Empty the remainder;
   d. Fill the tank with water and ammonia (1 quart ammonia per 25 gallons of water). Pump enough to fill the hoses and nozzles, then leave for 24 hours.
   e. Empty the sprayer and rinse with clean water.
8. For extended periods of storage, exposed metal parts should be coated with a light oil to prevent rusting.

GRANULAR APPLICATORS

Granular applicators are designed primarily for soil applications. They range from crank-operated, spinning disc backpack units which broadcast granules, to field equipment designed for broadcast, band or drill applications of granular pesticides. Granules are normally applied before or at planting and worked into the soil. Post-plant side dress applications made during cultivation through drop tubes and fertilizer shoes are another common method of granular application. Granules are also applied by air, such as for control of first generation European corn borer, which develops within whorl leaves of corn.

Construction Most granular applicators consist of a hopper for the pesticide, with a mechanical-type agitator at its base to provide efficient and continuous feeding. Some type of metering device, usually a slit-type gate, is used to regulate the flow of the granules. Metering devices typically consist of a dial with a set-screw, or an adjustable lever with a large dial. The granules flow out with gravity feed.

Spreader Drop-through spreaders attached to the ends of drop tubes are available in relatively narrow widths (1 1/2 - 3 feet). On band applicators, the height of the spreader also can be used to change the width of the band. Rotary spreaders, which distribute the granules to the front and sides of the spreader, can be used to cover a wider swath.

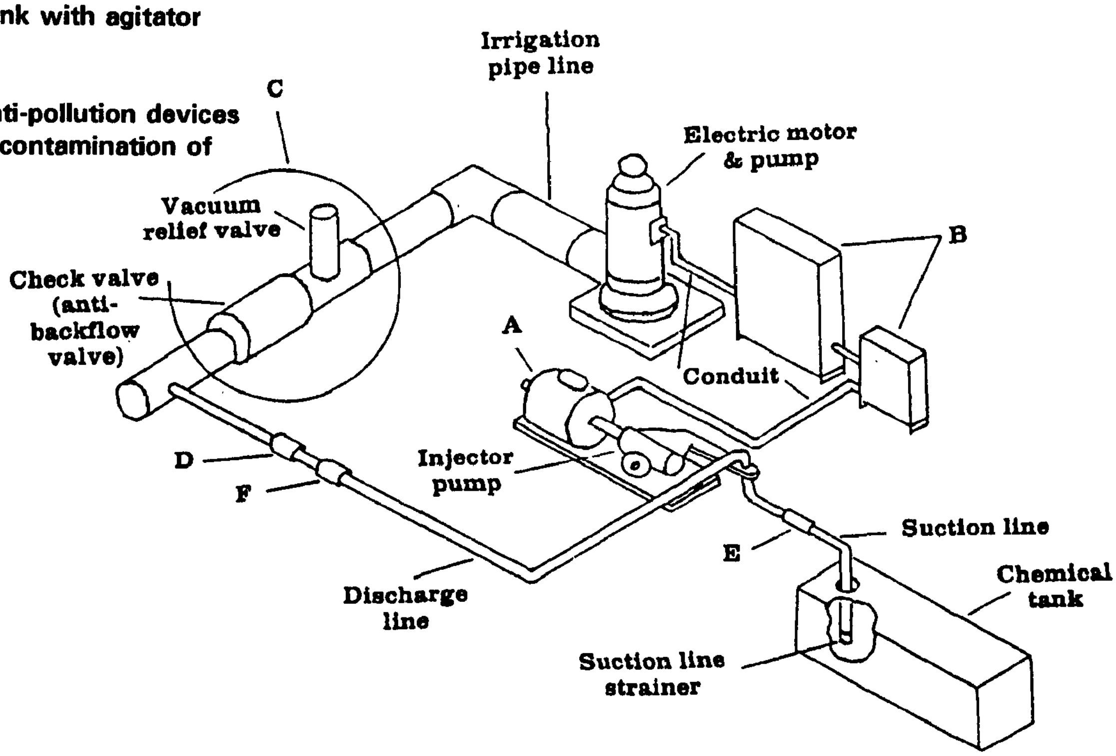
In selecting a granular applicator, choose a unit that is easy to clean and fill. Be certain that it has good agitation over the outlet holes. Banders should spread the granules uniformly, even on side slopes of 10-15%. Chain drives should have sprockets of eight or more teeth to keep drive speed uniform. Design should be so that granule flow stops when the drive stops, even if outlets are not closed.

Maintenance Granular applicators should be cleaned thoroughly after each job. Corrosion on feeder plates or the agitator can be removed with a wire brush. All fasteners should be checked regularly. Equipment should be lubricated in accordance with manufacturer specifications.

CHEMIGATION SYSTEMS

The application of both water and agricultural chemicals through irrigation systems is called chemigation. As with other methods of applying agricultural chemicals, there are both benefits and risks associated with chemigation. The most significant risk is potential contamination of the water supply; therefore, to minimize risks, an irrigation system used to apply agricultural chemicals must be properly equipped and operated. Equipment required to apply chemicals through an irrigation system includes:

- a chemical supply tank with agitator
- an injection pump
- a calibration tube
- proper safety and anti-pollution devices to prevent potential contamination of the water source.



Chemical Supply Tank The supply tank should be constructed of noncorrosive materials such as stainless steel, fiberglass, nylon, or polyethylene. Agitation should be provided to allow mixing of wett able powder, dry flowable, and flowable formulations and when tank mixes or other sus pended formulations are used. For hard-to-mix formulations, mechanical agitators are needed. Since some agricultural chemicals are flammable, the supply tank should be separated from any source of sparks or potential explosions. This includes use of explosion-proof electric motors and wiring, or placing electrical motors far from the supply tank. Wiring must conform with the National Electrical Code for hazardous area applications.

Pumps The proper functioning of the chemical injection pump is critical to performance of any chemigation system. Throughout the operating range of the pump, an accuracy of delivery plus or minus one percent is desirable. The pump should be easily adjustable for different injection rates. Mechanical design should be rugged and construction of non-corrosive materials.

The injection pump capacity should be consistent with pesticide/fertilizer application rates. This can range from 1 pint or less/acre for certain insecticides and herbicides to 30 gallon/acre for liquid fertilizer applications. With such a range, no single pump can be used for all jobs. The most efficient and consistent operation of a pump is in the broad middle capacities. Avoid operating a pump at or near the maximum output to avoid damage to the pump and inaccurate pumping rates. Several types of pumps are available for chemigation.

Diaphragm pumps, although often more expensive than other pumps, have some important advantages in use and maintenance. These include: 1) a small number of moving parts; 2) a limited area of exposure of pump components to the injected chemicals; and 3) design which allows for easy adjustment of injection rate.

Piston pumps were among the first used in chemigation systems. Calibration of these units requires that stroke length be adjusted mechanically, often while the pump is stopped. As such, calibration of equipment can take more time than with diaphragm pumps. Piston pump seals may also wear faster, increasing risks of leakage and requiring more maintenance. There are, however, various designs of piston pumps, some of which help limit these problems.

The relatively low cost **venturi** "pumps" draw the chemical by creating differential pressure or vacuum across a venturi device. It may be difficult to obtain accurate and consistent chemical injection rates with a venturi device. Variation in the flow rate of the chemical can cause pressures to vary, altering the rate of chemical injection.

Calibration Tube A calibration tube should be located in the line between the supply tank and the chemical injection pump. It is used to measure output of the injection unit during calibration. The calibration tube should be clear, resistant to breakage, and graduated in units of volume (pints, ounces, milliliters, etc.). To properly calibrate an injection system, it is necessary to monitor chemical injection for at least five minutes. Calibration tubes must be large enough to hold the amounts of chemical injected over that time.

Safety Devices Irrigation line check valves and vacuum relief valves are required in irrigation pipelines. They keep the chemical-water mixture from draining or siphoning back into the water supply. Both of these valves need to be located between the injection site and the discharge site.

The check valve must have a positive closing action and water-tight seal, and be easy to repair and maintain. The vacuum relief valve allows air into the pipeline when the water flow stops, preventing back-siphoning of the chemical-water mixture into the water source. **This back-flow prevention**

system must meet regulatory requirements. The valves should also be inspected before each chemigation operation. **Other safety equipment includes:**

an inspection port to permit visual inspection of the check valve for leaks;

a low-pressure drain located at the lowest point of the irrigation pipeline to allow the chemical solution to drain away from the water-source(well) in case the mainline check valve develops a leak;

one-way interlocking between the irrigation pump and injection pump to ensure that the injection pump will stop with the irrigation pump;

a chemical injection line check valve with a minimum opening (cracking) pressure of 10 psi to prevent flow of liquids into the supply tank, or from the supply tank into the irrigation line during unexpected shut-down;

a solenoid valve, normally closed, that provides a positive shutoff of chemical in the injection line if the chemical injection pump is stopped;

a chemical suction line strainer placed on the inlet end of the chemical suction line to prevent clogging of the injection pump, check valve, or other equipment.

FUMIGATION OF STORED GRAIN

Fumigation of stored grain is a highly specialized pest control practice. Because fumigants are extremely hazardous, special precautions must be taken for their application. Furthermore, a thorough understanding of fumigation is critical to effective pest control. It is usually safer and less expensive as well as more effective to hire a professional fumigator.

Safety **Two people should always work together when fumigating.** Never fumigate nor enter a fumigated storage alone.

Proper safety equipment is essential. A self-contained breathing apparatus must be used. These are expensive (typically $1500 or more) and require special training for use. Simpler chemical cartridge-type gas masks do not provide adequate protection when high concentrations of toxic gases exist.

Mark the treated area with warning signs at all entrances. The signs should be in place during the fumigation and remain there until the stored grain has been thoroughly aerated to reduce the fumigant to safe levels. Do not enter a fumigated storage until it has been aerated, and be sure aeration equipment is operating during any inspection of a fumigated grain storage facility.

Temperature Grain temperature is extremely important to the effectiveness of fumigation because it determines the speed with which a fumigant vaporizes and penetrates through the grain. Low grain temperatures (less than 50 degrees F.) greatly slow the vaporization rate and movement of lethal gas concentrations to the pest insects. Insect activity is also decreased during low temperatures, resulting in reduced kill. Longer time is required for fumigating when the temperature is cool.

Moisture Atmospheric moisture is used to release the phosgene gas from aluminum and magnesium phosphide tablets; however, high moisture grain retards the movement of the fumigant. High moisture grain also absorbs more fumigant than dry grain, reducing the concentrations in the air around the kernels. Non-uniform gas concentrations can cause reduced effectiveness.

Dockage Dockage (trash) in grain is very important in determining the effectiveness of fumigation. The ability of the grain mass to absorb the fumigant will increase with the amount of dockage. As grain is loaded into bins, the light dockage (chaff, dust, etc.) settles around the outside of the grain mass and the heavier dockage around the spoutline area. This uneven distribution causes fumigants to flow through areas of least resistance. In addition, insects often concentrate in areas of high dockage and therefore escape the effects of the fumigant.

Storage The shape and depth of the grain in a bin affects how well the fumigant works. Upright storages present a minimum of grain surface from which the fumigant can escape. Peaks in the top of the grain surface often have lower concentrations of gas allowing insects to escape; therefore, grain should be leveled before fumigation. Also, remove or break up any crust that has formed on the grain surface.

Fumigated storage bins must be tightly sealed to allow concentrations of the gas to build up and persist. Use of a gas-tight cover over the grain can improve fumigant performance, particularly when a bin is only partially filled.

Ventilation Fumigants are heavier than air and sink down through the grain. Penetration through the entire grain mass, especially in deep bins, can be improved by using aeration. However, during the actual fumigation, the aeration system should be sealed off. Aeration should also be used to remove the fumigant after the recommended exposure time.

Summary Chapter VIII

Equipment to apply pesticides includes sprayers of various kinds, granular applicators, chemigation equipment and fumigation equipment.

Equipment should be exclusive to the type of pesticides applied. Herbicides should not be applied using equipment previously used for insecticides, for example. Contamination of one by the other can do serious damage.

Meticulous maintenance of equipment is critical to effective use of pesticides.

Fumigation of stored grain is hazardous and should never be attempted by one person alone.

Chapter IX

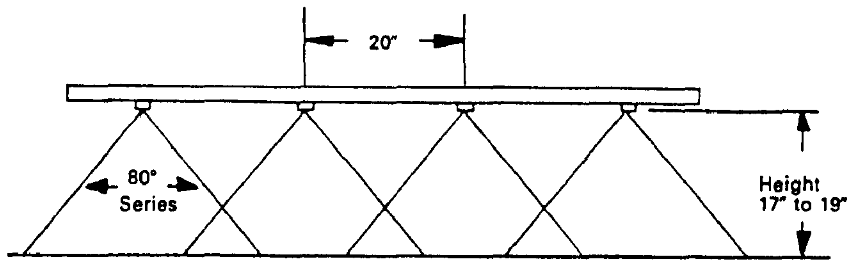
CALIBRATION

Proper calibration of application equipment is essential to proper pesticide performance. Inadequate amounts of a pesticide may not control the target pest; too much pesticide can cause plant injury or excessive residues on the crop, contribute to environmental contamination, and cost money.

The objective of calibration is to apply the correct amount of pesticide. Calibration is relatively simple but takes time, some equipment, and accurate calculations. Because conditions at worksites vary and application system performance changes as a result of use, calibration should be done regularly. It is also necessary to recalculate whenever any components of application equipment are replaced.

CALIBRATING FIELD SPRAYERS

The application rate of pesticide mixtures used in field sprayers (including air blast sprayers) is usually given in gallons per acre (GPA). The speed at which the sprayer moves over the ground is given in miles per hour (MPH), the output of nozzles is listed in gallons per minute (GPM), and the pressure is given in pounds per square inch (psi). Ground speed, pressure, and nozzle size can all be varied to change the application rate.



NOZZLE CAPACITY CHART

Tip no.	Press. in PSI	Cap. in GPM	Gallons per acre 2 mph	3 mph	4 mph	5 mph	7.5 mph	10 mph
	20	.28	43	28	21	16.8	11.2	8.4
8004	25	.32	47	31	24	18.7	12.5	9.4
(*26 GPA)	30	.35	51	34	*26	21	13.7	10.3
(50 Mesh)	40	.40	59	40	30	24	15.8	11.9
	50	.45	66	44	33	27	17.7	13.3
	60	.49	73	49	36	29	19.4	14.6

Method 1

The easiest method of calibrating the sprayer is to run it across a known area of the field or orchard to be sprayed and to measure the sprayer output. The steps are:

1. **Determine the distance the sprayer must travel to cover one acre. This is accomplished by dividing the spraying width (in feet) into 43,560 (the square feet in an acre). For example, a sprayer with a boom that is set to apply spray to a 20 foot swath would travel 2178 feet to cover an acre (43,560/20 = 2178).**

2. Mark off this distance in the field to be sprayed. (Note: a fraction of this distance may be used to equal a fractional part of an acre.)

3. Prepare the sprayer and set the pressure to the level that will be used during spraying.

4. Fill the tank with a measurable amount of water.

5. Select a ground speed that will be used during spraying and note the throttle setting so that it can be duplicated.

6. Spray over the marked course. Be precise in turning the sprayer on and off at the start and end of the course. Maintain a uniform speed.

7. Measure the amount of water that has been applied. This may be done by measuring the amount remaining in the tank or by determining the amount of water needed to refill the tank to the original level.

If a shorter (or longer) course was used representing a fraction (or multiple) of an acre, determine the refill amount in the same proportion.

If an oil solution is to be applied, and water was used during calibration, add 10% to the measured volume.

Method 2. Calibration of sprayers can also be determined by measuring the various factors involved in application rates. These include:

- gallons per minute (GPM) discharge from each nozzle;
- ground speed (MPH) of the sprayer during application;
- nozzle spacing on the boom (in inches).

With these factors, application rates can then be determined using the formula:

$$\text{Gallons per acre} = \frac{5940 \times \text{Gallons per minute}}{\text{Miles per hour} \times \text{Nozzle spacing (inches)}}$$

Where width of spray coverage by the boom is known this formula can be modified as:

$$\text{Gallons per acre} = \frac{495 \times \text{Gallons per minute}}{\text{Miles per hour} \times \text{Total width sprayed (feet)}}$$

<u>Discharge</u> from nozzles can be determined by measuring the amount of liquid sprayed from nozzles during a known period of time. Fill the sprayer with water and set the sprayer pressure at the level to be used in field application. Place a collection container under the nozzle. **The number of cupfuls of liquid collected in 3 3/4 minutes is equivalent to the gallons per hour (GPH) output of the nozzle.**

All nozzles should be checked during this calibration to make sure they are discharging the same rates of liquid. Where there are substantial deviations in nozzle output (greater than 5%), they should be checked for wear and replaced as needed. Inconsistent output will cause streaks in application pattern.

Ground speed (MPH) determinations can be made by running the sprayer along a course of known distance and using the formula:

$$\text{Miles per hour (MPH)} = \frac{\text{Distance traveled in feet}}{1.47 \times \text{Seconds required to travel distance}}$$

Changing sprayer pressure is not a good means of changing sprayer output because sprayer output only increases as the square root of the pressure increase. For example, doubling the sprayer pressure would only result in increasing output 1.4 times. Furthermore, increased sprayer pressures may cause increased drift.

CALIBRATING GRANULAR APPLICATORS

Several factors affect application rates of granular applicators. No applicator units are identical, and even seemingly minor differences can affect application rates. Wear of granular applicators can be substantial because many of the products are abrasive. Furthermore, each pesticide and each formulation of the pesticide has different flow characteristics which affect application rates. Although manufacturers may provide guidelines for typical applicator settings, it is important to check these settings by calibration.

Recommended granular application rates for formulated pesticides are expressed in pounds per acre or ounces per thousand row feet. Herbicide and insecticide calibrations may differ slightly. Herbicides are typically applied at a constant rate per unit area (acre), so band width is critical to proper calibration. Most granular insecticides used at planting in Colorado are applied at a constant rate per length of row (oz/1000 row-ft).

To calibrate a granular applicator:

1. Set each applicator at the setting suggested by the manufacturer or at the setting determined by previous calibrations;
2. Fill the hoppers at least 1/2 full and run them until they all begin to feed;
3. Remove the feed tubes and attach a container, calibration bag, or premarked calibration tube to each hopper output unit;
4. Travel a measured distance at planting speed. Since ground speed and field conditions can substantially affect granular application rates, it is recommended that calibration be conducted in a worked field over a considerable distance;
5. Weigh and record the amount of pesticide collected in each container using an accurate scale. (Remember to subtract empty container weight.);
6. Calculate the application rate for each row.

The application rate is determined by various formulae. Insecticides, applied at rates indicated by ounces per 1000 row-feet, are calculated by:

$$\frac{1000 \times \text{ounces collected}}{\text{distance traveled (feet)}} = \text{ounces/ 1000 row-feet}$$

Where labeled insecticide application rates are given as pounds per acre, this formula changes to:

$$\frac{43560 \times \text{pounds collected}}{\text{distance traveled (feet)} \times \text{row width (feet)}} = \text{pounds/Acre}$$

Granular herbicides are often applied as bands over the row. Where labelled application rates are expressed as ounces per 1000 row-ft the formula used is:

$$\frac{1000 \times \text{ounces collected}}{\text{distance traveled (feet)} \times \text{band width (feet)}} = \text{oz/1000 row-feet}$$

Herbicide application rates indicated by pounds of formulation per acre use the formula:

$$\frac{43560 \times \text{pounds collected}}{\text{distance traveled (feet)} \times \text{row width (feet)} \times \text{band width (feet)}} = \text{lbs/Acre}$$

If the application rate of any unit is not within 5% of the recommended rate, adjust the rate setting gauge and repeat the calibration.

To roughly check an application rate, place a vertical strip of tape in each hopper. Fill the hopper one pound at a time. After each pound is added, level the pesticide by shaking the hopper and mark the new level. Using this method, the application rate can be checked quickly by reading the level before and after treating a known acreage.

HANDGUN AND KNAPSACK SPRAYERS Handgun and knapsack spraying equipment, such as that used in green house operations, are difficult to calibrate because "ground speed" is difficult to judge. One method is to calculate the time it takes to cover a measured area. By timing the spray, gallons-per-hour (GPH) can be determined. As with other sprayers, gallons-per-hour can be determined by collecting the liquid from the nozzle for 3 3/4 minutes. The number of cupfuls collected in this time equals the gallons per hour (GPH) output of the sprayer.

With this information, the formula to determine

$$\text{minutes needed to cover 1,000 square feet} = \frac{1.38 \times \text{Gallons per Acre}}{\text{Gallons per Hour}}$$

CALIBRATING CHEMIGATION SYSTEMS:

Calibration of sprinkler chemigation equipment involves 5 basic steps:

1. determine the area (in acres) to be irrigated;
2. determine the amount of material desired per acre;
3. determine the total amount of material required for application (step 1 X step 2);
4. determine the time (in hours) that injection will require;
5. determine the injection rate in gallons per hour (step 3/step 4).

The calibration process is based on the measurements of the irrigation system (length, end gun wetting area, etc.), some common mathematical constants and conversions, and the desired rate of chemical injection. The following calculations must be made: a) area irrigated; b) amount of chemical required; c) travel speed; d) revolution time; and e) chemical application rate.

The **area irrigated** is calculated with one of several formulas, depending on the shape of the field. Where fields are square or rectangular in form the area is simply determined by:

$$\frac{\text{length (feet) X width (feet)}}{\text{43,560 (square feet/acre)}} = \text{area (acres)}$$

Where a complete circle is involved, as with center pivot irrigation systems, the calculation for determining area is:

$$\frac{\text{3.1416 (pi) X radius (feet) X radius (feet)}}{\text{43,560}} = \text{area (acres)}$$

Determining the area irrigated becomes increasingly more complex with partial circles, and other irregular areas. In many situations involving center pivot equipment, it may be wise to leave off the end gun during chemigation and when making calibration estimations. Water patterns from end guns are easily distorted by wind, and end guns may cause off-target applications.

The **amount of chemical** to use per acre is indicated on product labels. By multiplying this figure by the number of acres, the amount of chemical required for the chemigation operation is determined.

For moving systems, **travel speed** is critical to calibration. When calculating the irrigation system speed, the system should be running "wet" and at the speed and pressure that will be used while chemigating. Two measurements, **time** and **distance** are required to determine travel speed. These can be made in either of two ways:

a) record the time it takes for the outer pivot tower to travel a premeasured distance (minimum of 50 feet); or
b) measure the distance traveled by the outer pivot tower in a preselected time (minimum 10 minutes).

The result of either method is a **rotational travel speed** measurement in feet per minute. A measurement error of only a few feet or few minutes can create a significant error in the entire calibration process. If the terrain is rolling, check rotational travel speed at several locations and determine an average value.

Rotational speed should be checked periodically throughout the season to account for differences in wheel track resistance due to cover, soil compaction, track depth, etc. Always recalibrate when changing speed settings.

In center pivot systems, **revolution time** must be calculated. This is done by measuring rotational travel speed (above) and circumference of the last wheel track. Circumference is calculated by the formula:

Circumference (feet) = 2 X 3.1416 (pi) X radius (feet).

Revolution time is calculated by dividing the circumference (in feet) by the rate of travel (feet per minute).

The **chemical application rate (gallons per hour-GPH)**, is the amount of chemical to be applied per hour of chemigation. This amount is calculated by determining the total amount of pesticide to be applied to the field (amount of pesticide applied per acre X number of acres). Divide this figure by the number of hours required to complete a full revolution of a center pivot irrigation system.

Example of calibration measurement - center pivot chemigation

The field to be chemigated has a wetted radius (length of pivot) of 1300 feet. (Note: A decision must be made whether chemigation is going to include the end gun throw distance or to shut-off the end gun during application). The area would be equivalent to:

$$\frac{3.1416 \times 1300 \times 1300}{43{,}560} = 122 \text{ acres}$$

The pesticide is to be applied at the rate of 1 quart/acre. The total amount of chemical required for the chemigation will be:

122 (acres) X 1 quart (use rate/acre) = 122 quarts (30.5 gallons)

Measurements to determine the travel speed indicate that the outer pivot tower moved 130 feet during 20 minutes. The travel speed is:

$$\frac{130 \text{ feet}}{20 \text{ (minutes)}} = 6.5 \text{ feet/minute}$$

To determine revolution time, a calculation first has to be made to determine the circumference travelled by the last wheel track. Assuming the radius of the last wheel track to the tower is 1280 feet (does not include overhang), the circumference is:

2 X 3.1416 X 1280 = 8042 feet.

The revolution time is then determined by:

$$\frac{8042 \text{ (feet)}}{6.5 \text{ feet/minute}} = 1237 \text{ minutes per revolution (20.6 hours/revolution)}$$

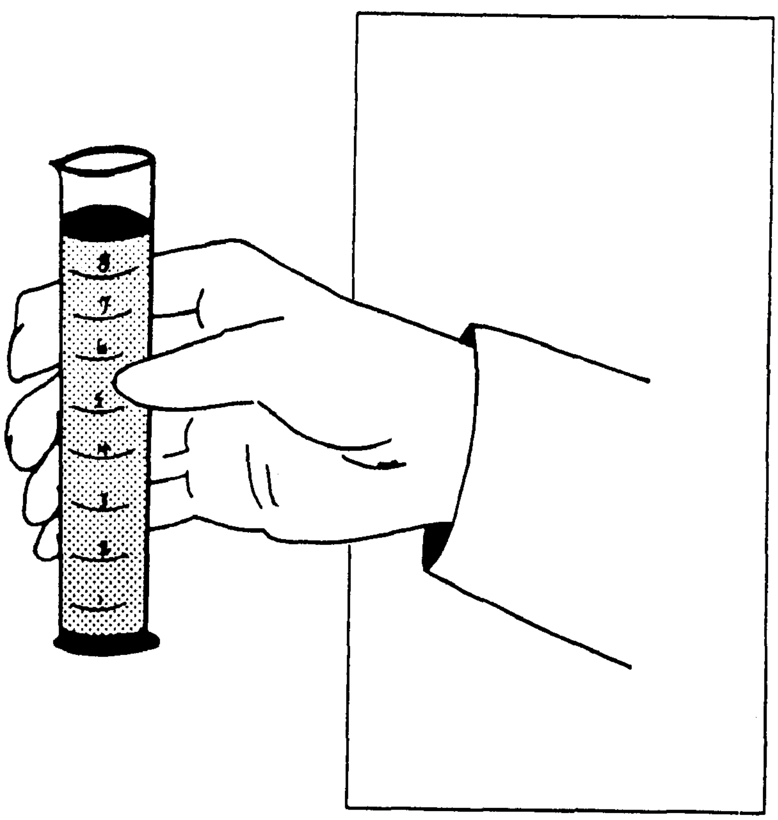
The chemical application rate would thus be:

$$\frac{\textbf{30.5 gallons (amount of pesticide for field application)}}{\textbf{20.6 hours (revolution time)}} = \textbf{1.48 gallons/hour}$$

The use of the calibration tube is now needed to determine at what injection pump setting this amount of chemical is being applied. By setting the pump at this setting, the calibration is completed.

Summary Chapter IX

Accurate calibration of application equipment is critical to economical and effective pest control.



Chapter X

PERSONAL PROTECTIVE EQUIPMENT (PPE)

TYPES OF PPE

Because pesticides can enter your body through various routes it is necessary to wear protective clothing and/or use protective equipment to prevent exposure. No safety recommendations cover all situations; use common sense and remember that more protective measures are called for as the hazard increases. **Always read and follow the pesticide label for directions on use of protective clothing or devices.**

Gloves The most common location on the body for pesticide exposure is the hands. Therefore, the single most important protective equipment for most pesticide applications is a pair of protective gloves. Use of liquidproof gloves (such as rubber or neoprene) when handling pesticides or contaminated equipment greatly reduces the likelihood of pesticide exposure. Do not use gloves with fabric linings because pesticides cannot easily be removed from fabrics. Never use cotton or leather gloves when handling liquid formulations or when working with pesticides diluted with water because these materials absorb pesticides and do not provide adequate protection. Some granular pesticides may be handled with cotton gloves, if the gloves are washed or discarded after every use. Always consult the pesticide label for directions on protective clothing.

Always wear your shirt sleeves outside the gloves to prevent pesticides from getting into the gloves. Gloves used to handle pesticides should never be used for other purposes.

Boots Wear lightweight **rubber boots** when handling or spraying pesticides. Do not use leather or canvas footgear since they absorb and retain pesticides. Do not tuck pants legs into boots since that may funnel pesticide sprays or chemicals into the boot.

Covering Shield yourself with some form of protective body covering. Wear a long sleeved shirt and long legged trousers or a coverall type garment of closely woven fabric. An outer layer of spunbonded olefin or fabric with a soil-repellent finish offers more protection than durable press or untreated fabrics. Soil-repellent finishes can be applied by clothing manufacturers or by consumers. Alternatively, use a disposable suit designed for protection when handling hazardous materials. A second layer of clothing, made with smooth T-shirt fabric, can further help to prevent pesticides from touching the skin. Wettable powder formulations of pesticides are easier to keep off the skin than liquid formulations. **Wear pants legs outside your boots to prevent pesticides from getting inside.** When handling pesticide concentrates or highly toxic chemicals, also wear a lightweight raincoat or rubber apron for added protection.

When applying pesticides **use a wide-brimmed, waterproof hat** to protect your neck as well as your eyes, mouth, and face. The hat should not have a cloth or leather sweatband, since these materials retain pesticide residues and are difficult to clean.

Eye Protection Many pesticides are highly corrosive to eyes, and eyes readily absorb pesticides into the body. Wear **goggles** or a **face shield** when there is risk of pesticides coming in contact with eyes during mixing or application. Goggles may be worn separately or in combination with a respirator.

Respirators Respiratory protection is essential in some pesticide handling situations since the lungs readily absorb pesticides, and inhalation risks are high when handling highly toxic pesticides with volatile fumes or fumigants. **Always follow the instructions on the pesticide label regarding use of respiratory protection equipment.** It is vital that the appropriate equipment be used for the particular product and its application. It is also essential that the respirator fit your face properly to insure a good seal. Long sideburns, a beard, or glasses may prevent an adequate seal.

Chemical cartridge respirators draw air through activated charcoal or a dust filter. Most harmful gases, vapors, and particulate matter are removed by the filter. This type of respirator is lightweight and easy to use but does not provide eye and face protection. Chemical cartridge respirators are not suitable protection where toxic fumigants are being used, such as in grain storages.

Gas mask respirators cover and protect the entire face. They contain larger filters with more absorbent material than do chemical cartridge respirators. Gas mask respirators should be used when mixing or applying pesticides in poorly ventilated areas. Neither gas mask nor chemical cartridge respirators give sufficient protection in low-oxygen environments.

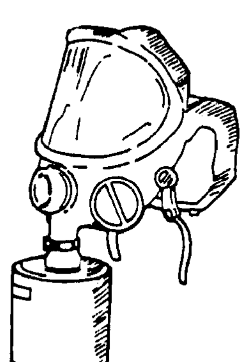
Gas mask respirators which have a **self-contained oxygen supply** should be used where the application **site is deficient in oxygen or where high concentrations of toxic gases** are present (such as fumigants).

Wearing a respirator does not eliminate the need for protecting other parts of the body!

Respirator Maintenance Respirators should be inspected regularly for defects, cleaned and disinfected, repaired and stored in a clean dry place away from pesticides or other contaminants. An inspection check includes: tightness of connections and condition of the face piece, head bands, valves, connecting tube, and canister. Clean all respiratory devices after each day's use. Prior to cleaning, remove any filter, cartridge, or canister. Wash the face piece and breathing tube with warm soapy water and rinse with fresh water to remove all traces of soap; sanitize if necessary, and air dry in a clean place away from possible pesticide contamination.

When using a respirator, change the cloth filter twice a day, or more often if breathing becomes difficult. Change the cartridges after eight hours of actual use, or more often if an odor of pesticide is detected.

Periodically, test the fit of a respirator by removing the cartridges and blocking the intake while wearing the respirator.



Several factors affect the service life of respiratory protective devices. These include: the type and amount of chemical fill in a cartridge or canister, the concentration of the contaminants in the air, the breathing rate of the wearer, and the temperature and humidity. **It is essential to read carefully the manufacturer's instructions on use and maintenance of any respirator and its parts before using it.** Use respirators approved by either the National Institute of Occupational Safety and Health, the U.S. Bureau of Mines, or the U.S. Department of Agriculture.

MAINTENANCE OF PPE

Handling Clothing If liquid concentrates of pesticides are spilled on clothing, other than rubber or neoprene gloves and unlined boots, discard the clothing. **Washing will not remove enough of the pesticide to make the clothing safe to wear.** Wear rubber gloves when handling highly contaminated clothes. (Research has shown that clothing contaminated by undiluted pesticides can still contain high amounts of pesticides after 10 washings; diluted pesticides were largely removed after 3 washings.)

Outdoors, empty any pesticide granules from cuffs and pockets. 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.

Keep clothing worn while applying pesticides separate from other clothing. Always wear rubber gloves when handling the contaminated clothing.

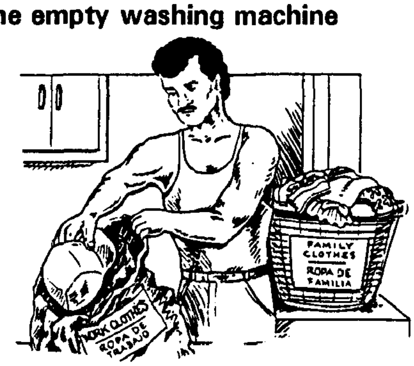
Wash pesticide contaminated clothing immediately after use. The longer the clothing is stored, the harder it is to remove pesticide residues.

Washing Procedures Prerinse or presoak the clothing in a bucket or tub or by agitating in a washer and spinning out before running them through the regular wash cycle. Prerinsing followed by a regular wash cycle has been found to be much more effective in removing pesticides, especially wettable powders, than washing without prerinsing.

Use hot water for washing, never cold. Cool water (86 degrees F) removes much less pesticide than does warm (120 degrees F) or hot (140 degrees F) water. Heavy duty liquid detergents should be used to wash pesticides from contaminated clothing. In hard water areas, use higher rates of detergent to get adequate cleaning action. Pre-wash cleaners help remove pesticides from clothing; however, ammonia and bleach do not. Wash a small number of items at a time, using the highest water level and longest wash time available.

Do not dry clean clothing contaminated with pesticides. Dry cleaning solutions are routinely recycled. Including pesticide contaminated clothing contaminates other clothes.

Laundry Equipment Care After washing clothes contaminated by pesticides, run the empty washing machine through a complete cycle using detergent. Line dry pesticide contaminated clothing to avoid contaminating the dryer.



Always wash clothing immediately after mixing and applying pesticides!

Summary Chapter X

Always read and follow the pesticide label regarding protective clothing. Preventing exposure can save your health and your life.

Keep protective clothing and equipment clean and in good repair, and easily accessible.

Chapter XI

PESTICIDE STORAGE AND DISPOSAL

STORAGE FACILITIES Storage facilities that protect the pesticides and keep them away from other materials, people and animals are essential. The effectiveness of pesticides may be lowered by freezing, extreme high or low temperatures, or exposure to moisture. Proper storage reduces the chance of pesticide-related accidents and allows for easier handling of accidents if they do occur.

The structure should have a concrete floor which is impermeable and easy to wash. The structure should be fire resistant and located away from other buildings. Adequate ventilation providing fresh air exchange is needed to prevent exposure of the pesticides to extreme heat and reduce the concentration of toxic or flammable vapors in the building. Insulation and a heating system to protect pesticides from freezing during cold temperatures are essential in Colorado. Many pesticides, particularly liquid emulsifiable concentrates, separate and degrade at low temperatures. Lighting in storage facilities must be sufficient to allow easy identification of stored materials.

Pesticide storage areas should not be used for other purposes. Pesticides should never be stored with food, feed, seed, planting stock, fertilizers, or veterinary supplies. 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, designated pesticide storages should not be planned for subsequent uses.

Running water and materials for safely handling small-scale pesticide accidents should be located near storage facilities.

Placement of pesticides in a storage area is important. Dry formulated pesticides should be stored on wooden pallets or metal shelves so they will not be in contact with damp floors. Dry materials should be stored above liquid formulations so they will not be contaminated from leaking containers.

If metal containers are to be stored for long periods, they should also be placed on pallets to prevent corrosion caused by dampness. If a container is corroded, it should be either repaired or the contents transferred to another container which has held exactly the same product and which has an intact label.

Pesticide storage areas should always be kept locked when unattended. They must be clearly marked as to contents with warning signs that conform with standards for marking hazardous storage areas. This will assist emergency response personnel in case of accidents or fires.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT

A federal law, the Emergency Planning and Community Right-to-Know Act (EPCRA), sets **regulations for pesticide storage**. Certain pesticides have been designated as "**Extremely Hazardous Substances.**" These include **most Restricted Use pesticides** and some materials considered hazardous, such as ammonia. If the amount of these chemicals in storage exceeds the "Threshold Planning Quantity" for that pesticide, this regulation applies. The amount varies from 10-10000 pounds of active ingredient, depending on the pesticide.

Notification must be given to both state and county agencies when pesticides more than the Threshold Planning Quantity are stored. State notification should be given to the Colorado Emergency Planning Commission, c/o Colorado Department of Health, 4210 E. 11th Ave., Denver CO 80220. (Phone number 303-331-4858). Local Fire and Police officials will have information on whom to contact within the county. Most County Cooperative Extension offices also have information on the Threshold Planning Quantities of various pesticides.

To notify the State and local authorities, send a letter such as the following:

"This is to notify you that I am/we are storing one or more of the Extremely Hazardous Substances at or exceeding the "Threshold Planning Quantity" at my/our (farm, ranch, or

greenhouse) which is located at ______(address)___.

The contact for my (farm/ranch/greenhouse) is ______(name)_________.

He/she can be contacted by calling ___(phone number)___ or by writing ____(address)________."

CONTAINER DISPOSAL Pesticide containers come in many shapes and sizes and are made of paper, glass, plastic, or metal. They must be disposed of in a manner to protect people, animals and the environment, in accordance with the Federal Insecticide, Fungicide and Rodenticide Act and appropriate label direction. Proper methods for disposal of pesticide containers include:

1. **Paper bags** must be completely emptied and either buried on your property in a safe location away from water, susceptible animals or plants, or placed with other trash destined for sanitary landfill disposal.

2. **Rigid containers** must be **triple rinsed or jet rinsed** and then either buried or placed with solid waste destined for a sanitary landfill. Do not let "empty" pesticide containers set for more than 12 hours before triple rinsing. Pesticide residues may solidify and stick to the inside of the container and not be rinsed away adequately. Mark "triple rinsed" on containers destined for landfills to identify them as non-hazardous waste.

The Triple Rinse Procedure

- Empty your pesticide container into the spray tank and allow the container to drain for 30 seconds;
- Add rinse water to the container until it is 1/4 full;
- Rinse the container thoroughly. Pour the rinse water into the spray tank and drain for 30 seconds. Repeat 3 times.
- Recycle, or puncture and dispose of the triple rinsed container properly.

3. **Plastic containers** (bottles and jugs) should be triple-rinsed, punctured, and then either buried or added to other solid waste for sanitary landfilling.

4. **Metal containers**, other than pressurized containers, must be triple-rinsed, punctured, and either buried, recycled, or added to other solid waste for sanitary landfilling. Flattening metal containers after they have been triple rinsed reduces landfill space requirements and

facilitates recycling as well. Properly rinsed metal drum containers may be accepted by some reconditioners and manufacturers.

Promptly store used pesticide containers in proper pesticide storage facilities pending disposal. Improperly stored containers are a potential poisoning hazard to children, pets, and wildlife.

DO NOT send pesticide containers that have not been triple rinsed to sanitary landfills, reconditioners, or recyclers.

DO NOT discard pesticide containers in unapproved locations.

DO NOT reuse pesticide containers for other purposes.

DO NOT dispose of any pesticide container in a manner that is inconsistent with its label directions.

PESTICIDE WASTE When pesticides are used there may be some excess pesticide or waste. Proper disposal of these wastes can be difficult and expensive; however,improper disposal can result in serious pollution or poisoning hazards. Improper disposal also subjects the applicator to substantial fines, clean-up and disposal costs. Good planning for pesticide needs can keep waste to a minimum and reduce disposal needs. **The best way to avoid the need for pesticide waste disposal is to avoid creating pesticide waste.** Some ways to reduce your wastes are:

1. Purchase only the amount of pesticide needed for the intended pest control task or for a season's use.

2. Prepare only the amount of the pesticide needed for the application after calculating how much is needed to cover the intended site.

3. Protect pesticides from damage and contamination so they remain useful and have legible labels. Store pesticides in a cool place out of the sun in locked storages. In the winter, protect liquid formulations from freezing. Protect dry formulations from moisture.

4. Always try to use pesticides while they are still effective for the intended purpose, using older products first.

Even planning may not eliminate all the needs for pesticide disposal. When disposal is necessary, methods include:

1. Use as much of the pesticide according to label directions as possible. This will not always be feasible, especially when use is on a food crop or animal or when the label limits the frequency of application to a site. Read the label to be sure that this method of disposal is appropriate for the pesticide in question.

2. Acutely hazardous wastes (Toxicity Category I, LD_{50} of 50 mg/kg or less) in quantities greater than 222 pounds must be disposed of **in an approved hazardous waste site.** Failure to properly dispose of these highly hazardous materials is considered a pesticide spill and is subject to regulations covering spilled pesticides.

3. Smaller quantities of hazardous pesticide waste (or pesticides not classified as being highly hazardous) generated by an agricultural producer can be disposed of on the property of the producer. **Such disposal must be done in a manner that prevents potential environmental**

damage, away from waterways, wells, wildlife habitats and sites that may erode or allow leaching.

PESTICIDE SPILLS Pesticide spills can threaten human health and cause significant environmental contamination. Knowing what to do in the event of a spill will help you minimize adverse effects and save you expensive clean-up costs. Always be prepared to handle spills before they occur. Contamination can be much more serious if response to a pesticide spill is delayed. Keep a spill cleanup kit immediately available any time pesticides or their containers are handled, so you or others can quickly and correctly respond to a spill.

A Spill Kit should consist of:

- sturdy gloves, footwear, and apron that are chemical resistant to most pesticides, such as foil-laminate gear,
- protective eyewear,
- an appropriate respirator, if any of the pesticides require the use of one during handling activities or for spill cleanup,
- containment "snakes" to confine the leak or spill to a small area,
- absorbent materials, such as "spill pigs," absorbent clay, sawdust, pet litter, activated charcoal, vermiculite, or paper to soak up liquid spills,
- sweeping compound to keep dry spills from drifting or wafting during cleanup,
- a shovel, broom, and dustpan (foldable brooms and shovels are handy),
- heavy-duty detergent
- a sturdy plastic container that will hold the quantity of pesticide from the largest pesticide container being handled and that can be tightly closed, and
- a fire extinguisher rated for ABC fires.

Spills may be relatively minor, involving one or a few leaking containers. However major spills, such as when a truck or sprayer overturns and the contents are spilled, can occur. Regardless of the magnitude of the spill, the proper response is the same. **First, control** the spill; **second, contain** the spill; **third, clean it up**. These three steps are called the **"Three C" program of spill management.**

Control Immediately after a spill has occurred, control the flow of leaking pesticide. Do everything possible to stop the leak or spill immediately at its source! Leaking containers can be repacked. Leaking sprayers should be turned off immediately. Stopping large leaks or spills often is very difficult. When trying to control the flow of the chemical, **do not expose yourself unnecessarily**. Always carry protective clothing and equipment when transporting pesticides and use it whenever there is a pesticide emergency.

Contain After the leak has been stopped as much as the possible, **contain** the spilled material in as small an area as possible. If the spill is liquid, build a dam to prevent the chemical from spreading. It is particularly important to prevent any chemical from getting into any body of water, or storm sewer. **Do not hose down the area**; this will cause further spread of the chemical.

Liquid spills can be further contained by spreading absorbent materials such as fine sand, vermiculite, sawdust, or clay over the entire spill. For absorbing small spills and minor leaks, kitty litter is particularly useful. (Note: Do not use sawdust or sweeping compounds if the pesticide is a strong oxidizer. Such a combination is a fire hazard).

Reporting Spills on public property and all spills involving pesticides that are considered to be highly hazardous **must be reported immediately to the local and state emergency planning agencies.** Police or fire officials are the usual local contacts for reporting such spills. Contact the State Emergency Planning Commission at 303-331-4858 or 303-331-4830. These agencies will advise as to proper procedures for cleaning and disposing of spilled pesticides. Failure to report such spills is a violation of the Emergency Planning and Community Right-to-Know Act (EPCRA), and can result in fines of up to $25,000 for each day the violation continues.

Accidents involving some pesticides and hazardous materials are also regulated by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (1980). Spills involving CERCLA-regulated materials (see below) require that the National Response Center also be notified (1-800-424-8802). If you are not sure whether a spill is covered by this law, report it.

During a major spill, someone must remain at the site at all times until it has been effectively contained and cleaned up. The contaminated area should be isolated, preferably by roping it off. Keep people (and animals) at least 30 feet from the spill. Avoid coming into contact with drift or fumes from the spill. Depending on the circumstances, it may be necessary to evacuate people downwind from the spill. **Do not use road flares if you suspect the material to be flammable.**

Clean-up When **cleaning up** the spill, spread absorbent material over the contaminated area, if not already done. Sweep up the saturated material and put it in a heavy duty plastic bag. Continue to add absorbent and pick up the saturated material until all the liquid has been soaked up. It may then be necessary to decontaminate and neutralize the area, particularly if highly hazardous pesticides are involved. Use a mixture of full-strength bleach and hydrated lime. Work the solution into the spill area with a coarse broom, then add absorbent material to soak up the cleaning solution. Sweep and place the contaminated material in a heavy duty plastic bag. Repeat the procedure until the area is thoroughly decontaminated.

When large amounts of pesticides are spilled on soils, effective decontamination is often not possible. In these instances, the top 2-3 inches of soil should be removed. Cover the contaminated soil with at least 2 inches of lime, then cover with fresh topsoil.

Where there are minor spills on soil, activated charcoal can be used in clean up. The charcoal may absorb and tie-up enough chemical to avoid significant long-term injury.

STORAGE FIRES Pesticides (also fertilizers) should be stored in separate, locked buildings, away from other structures on the farm or ranch. Such things as ammonium nitrate fertilizers can become highly flammable when contaminated by fats, oils, acids, finely divided metals, or sulfur.

Should the storage facility be involved in a fire, the local fire authorities should be allowed the clear option of allowing the facility to burn. In many cases, extensive contaminated run-off would result from fire-fighting activities or incomplete combustion would produce toxic compounds in the air. Allowing the pesticide facility to burn completely may be the best option in these instances.

Pesticide storage facilities must be marked with appropriate warning signs showing the contents. This is an essential safety regulation designed to protect individuals who respond to fires, spills, and other emergencies at a pesticide storage facility. Growers are also required to pre-notify local fire authorities of pesticide storage contents as regulated by the Emergency Planning and Community Right-to-Know Act, discussed before. Should fires occur in pesticide storage facilities, persons involved in the firefighting and cleanup should follow personal precautions:

1. Wear rubber footgear during clean-up operations. Leather or cloth footwear will absorb and retain pesticides;
2. Wash and shower using large amounts of soap and water to remove any trace of toxic chemicals;
3. Put on clean clothes;
4. Wash all personal clothing, protective clothing, and respirators. Wash separately from clothing that is not contaminated with pesticides.
5. **Watch for pesticide poisoning symptoms.**

Decontamination and disposal of fire damaged pesticide storage facilities is complex. This task should be undertaken in conjunction with state and local emergency response personnel.

Summary Chapter XI

Store pesticides in a dry building with heat source for winter and ventilation for summer, separate from other buildings on the farm or ranch. Keep it locked and marked as to contents.

Running water is needed in or adjacent to the storage facility in case of accident.

State and local authorities must be advised if certain hazardous chemicals are in a storage.

Plan the needed amount of pesticide for each use or season to reduce the need to dispose of waste.

Dispose of wastes in an approved manner: Triple rinse rigid containers before disposal.

In case of spills, CONTROL, CONTAIN, CLEAN UP, REPORT.

CHAPTER XII

FIRST AID AND EMERGENCY ASSISTANCE

Pesticide poisoning can result from exposure during handling or applying pesticides, from spills, from accidental spraying, ingestion or inhalation, from misuse, or illegal residues on commodities. Pesticide poisoning can also be the result of inadequate safety precautions. The rapid and appropriate administration of first aid may save the life of a person exposed to pesticides.

Symptom It is important to recognize symptoms of pesticide poisoning so that prompt medical treatment can be administered before more serious injury occurs. Although symptoms of pesticide poisoning vary, some typical symptoms of mild poisoning, or early symptoms of acute poisoning, can include: headache, fatigue, weakness, dizziness, restlessness, nervousness, perspiration, nausea, diarrhea, loss of appetite, thirst, soreness in joints, skin irritation, eye irritation, or irritation of the nose and throat. More advanced poisoning symptoms can involve: stomach cramps, nausea, diarrhea, trembling, reduced muscle coordination, extreme weakness, mental confusion, blurred vision, difficulty in breathing, rapid pulse, flushed or yellow skin, excessive perspiration, and weeping. **WHEN PESTICIDE POISONING IS SUSPECTED, SEEK IMMEDIATE MEDICAL ATTENTION!**

First aid procedures may be followed while waiting for a physician or while transporting a victim to medical facilities. **The first action to take with any poisoning is to remove the victim from the source of exposure.** Then administer basic first aid procedures.

Inhalation Exposure If a pesticide has been inhaled, immediately move the victim 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. Not using the proper equipment may result in the rescuers being poisoned also. Loosen all the victim's tight clothing and keep the victim as quiet as possible. Apply artificial respiration if breathing has stopped or is irregular. If the patient is convulsing, watch the breathing and keep the chin up to keep the air passage free. Prevent the victim from chilling by using blankets, but do not overheat.

Skin Exposure Where **dermal (skin) exposure of pesticides** occurs, immediately remove all contaminated clothing. The victim should be drenched with water (shower, hose, faucet, pond, etc.) and washed thoroughly with detergent or soap, then dried with a towel and wrapped in a blanket for warmth while being transported to a doctor or medical facility.

Eye Exposure Damage to the eyes from exposure to pesticides can be very serious, especially if corrosive pesticides are involved. It is critical to **flush the eye out as quickly as possible** with a gentle stream of running water. Continue washing the eye for 15 minutes or more. Do not use chemicals or drugs in the rinse water since that may increase the damage.

Ingestion If a person has swallowed pesticides, a decision has to be made whether to induce vomiting. Where highly toxic pesticides are involved, vomiting is almost always the better course of action. However, vomiting should never be induced in a person who is unconscious or in convulsions. When corrosive poisons (strong acid or alkali) or petroleum products (kerosene, emulsified pesticides, oil, etc.) are involved in the poisoning, first aid decisions are more complex. Highly corrosive materials severely burn the mouth, throat, and esophagus and vomiting will cause additional injury. These poisons should be treated by attempting to neutralize the poison. Petroleum products also can cause burns.

Ingested pesticides should be diluted or absorbed as quickly as possible. If the patient is conscious, administer milk or water. Activated charcoal is very effective in absorbing many poisons and can be mixed with water as a thick soup. A mixture of 4 tablespoons of toast (burned black), two tablespoons of strong tea (instant ice tea will do), and two tablespoons of milk of magnesia is a good home remedy. This mixture will not only absorb but also help neutralize most poisons.

First-aid Kit A well equipped first-aid kit which is always readily available is important in handling emergencies. One can be made easily and maintained in a lunch pail, tool box, or sturdy wooden box. It should contain such items as:

1. a small plastic bottle of **detergent** to help wash pesticides off skin;
2. a small plastic container of **salt** to help induce vomiting;
3. a container of **baking soda** or a bottle of **milk of magnesia** to neutralize acidic chemicals that have been swallowed;
4. a plastic bottle of **lemon juice** or **vinegar** to neutralize alkaline chemicals that have been swallowed;
5. a small package of **activated charcoal** to act as a pesticide absorber;
6. a bottle (at least one pint) of **clean water**;
7. **bandages and tape** to cover cuts and scrapes to keep pesticides out of the body;
8. a **blanket**;
9. a **quarter** to help place an emergency phone call;
10. a **plastic jar** to use as a drinking glass to induce vomiting or feed activated charcoal;
11. a card with **emergency phone numbers** including doctor, hospital, and Poison Control Center.

After administering first-aid to a poisoning victim, **immediately seek medical attention**. Take the label of the pesticide to the doctor or medical facility to assist in treatment. When the poison is unknown, a sample of the vomit can help medical personnel determine the type of poison.

SUMMARY CHAPTER XII

Always read and follow the label regarding protective clothing. Preventing exposure can save your health and your life.

Keep protective clothing and equipment clean and in good repair, and easily accessible.

In the event of accidental exposure, remove the exposed person immediately from the source of exposure.

In case of accident, always have a first aid kit immediately available with the essential elements listed in this chapter.

Dispose of clothing that has been saturated with pesticides.

Always wash pesticide contaminated clothing separately with hot water and heavy detergent and hang to dry outdoors.

COMPARATIVE WEIGHTS, MEASURES, ABBREVIATIONS AND DILUTION TABLES

FLUID MEASURE

1/6 fluid ounce	=	1 teaspoon (tsp.)		
1/2 fluid ounce	=	1 tablespoon (tbs.)	=	3 teaspoons
1 fluid ounce	=	2 tablespoons	=	1/8 cup
8 fluid ounce	=	1 cup	=	1/2 pint
16 fluid ounce	=	2 cups	=	1 pint
32 fluid ounce	=	4 cups	=	1 quart
128 fluid ounce	=	16 cups	=	1 gallon

AREA MEASURE

144 square inches = 1 square foot
9 square feet = 1 square yard
30 1/4 square yards = 1 square rod = 272 1/4 square feet
43,560 square feet = 160 square rods = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

LINEAR MEASURE

1 inch = 2 1/2 centimeters = 25 1/2 millimeters
1 foot = 12 inches
1 yard = 3 feet
1 rod = 5 1/2 yards = 16 1/2 feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

WEIGHTS

1 ounce = 28 1/3 grams
1 pound = 16 ounces = 453 1/2 grams
2 1/5 pounds = 1 kilogram = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms
1 gallon of water = 8.34 pounds

SPEED

1,466 feet per second = 88 feet per minute = 1 mph

PEST CONTROL TERMINOLOGY

Some of these terms have several meanings. Those given here are ones that relate to pest control.

Abrasion: The process of wearing away by rubbing
Abscission: The separation of fruit, leaves, or stems from a plant.
Absorption: The process by which a chemical is taken into plants, animals, or minerals. Compare **with adsorption.**
Activator: A chemical added to a pesticide to increase its activity.
Active ingredients: The chemicals in a pesticide product that control the target pest.
Adherence: Sticking to a surface
Adsorption: The process by which chemicals are held on the surface of a mineral or soil particle. Compare with Absorption.
Adulterated: Any pesticide whose strength or purity falls below the quantity states on its label. Also, a food, feed, or product that contains illegal pesticide residues.
Aerobic: Living, active or occurring only in the presence of oxygen. The opposite of anaerobic.
Aerosol: An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulations used to produce a fine mist or smoke.
Agitation: The process of stirring or mixing in a sprayer.
Agricultural Employer: (Worker protection) One who hires or contracts for the services of agricultural workers OR who owns or is responsible for the management and condition of an agricultural establishment that uses such workers.
Alkaloids: Chemicals present in some plants. Some are used as pesticides.
Anaerobic: Living without oxygen (air). The opposite of aerobic.
Animal Sign: The evidence of an animal's presence in an area.
Antagonism: The loss of activity of a chemical when exposed to another chemical.
Antibiotic: A substance which is used to control pest microorganisms.
Antidote: A practical treatment for poisoning , including first aid.
Aqueous: A term used to indicate the presence of water in a solution.
Arsenicals: Pesticides containing arsenic.
Aseptic: Free of disease-causing organisms.
Bait shyness: The tendency for rodents, birds, or other pests to avoid a poisoned bait.
Band spraying: Application of a pesticide to a strip over or along a crop row.
Bipyridyliums: A group of synthetic organic pesticides which includes the herbicides diquat and paraquat.
Botanical Pesticides: A pesticide made from plants. Also called plant-derived pesticides.
Broadcast spraying: Uniform application of a pesticide over an entire area.
Broadleaf Weeds: Plants with broad, rounded, or flattened leaves.
Brush control: Control of woody plants.
Calibration: The process of measuring and adjusting the amount of pesticide that a particular piece of equipment will apply to a target site.
Carbamate: A synthetic organic pesticide containing carbon, hydrogen, nitrogen and sulfur.
Carcinogenic: Can cause cancer.
Carrier: The inert liquid or solid material added to an active ingredient to prepare a pesticide formulation.
Causal organism: The organism (pathogen) that produces a specific disease.
Chemigation: Application of a pesticide through an irrigation system.
Chemosterilant: A chemical that can prevent reproduction.
Chlorinated Hydrocarbon: A synthetic organic pesticide that contains chlorine, carbon, and hydrogen. Same as organochlorine. {Examples: DDT, Chlordane, Dieldrin}
Chlorosis: The yellowing of a plant's green tissue.

Cholinesterase: A chemical catalyst (enzyme) found in animals that helps regulate the activity of nerve impulses. {Activity is affected by organophosphate and carbamate pesticides}
Concentration: The amount of active ingredient in a given volume or weight of formulation.
Contact pesticide: A pesticide that kills pests simply by contacting them.
Contaminate: To make impure or to pollute.
Corrosion: The process of wearing away by chemical means.
Crucifers: Plants belonging to the mustard family, such as mustard, cabbage, turnip and radish.
Cucurbits: Plants belonging to the gourd family, such as pumpkin, cucumber, and squash.
Deciduous plants: Perennial plants that lose their leaves during the winter.
Deflocculating agent: A material added to a suspension to prevent settling.
Degradation: The process by which a chemical is reduced to a less complex form.
Dermal: Of the skin; through or by the skin.
Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.
Diluent: Any liquid or solid material used to dilute or carry an active ingredient.
Dilute: To make thinner (weaker) by adding water, another liquid or solid.
Dispersing Agent: A material that reduces the attraction between particles.
DOT: U.S. Department of Transportation
Dormant: State in which growth of seeds or other plant organs stop temporarily.
Dose, Dosage: Quantity of a pesticide applied.
Drift: Pesticide movement in the air away from the release site.
Emulsifier: A chemical which aids in suspending one liquid in another.
Emulsifiable concentrate: A pesticide formulation that usually contains a liquid active ingredient, one or more petroleum-based solvents, and an agent that allows the formulations to be mixed with water to form an emulsion (droplets of one liquid dispersed in another liquid).
Emulsion: A mixture in which one liquid is suspended as tiny drops in another liquid, such as oil in water.
EPA: Environmental Protection Agency
Eradication: Destroying an entire pest population in an area.
FAA: Federal Aviation Administration
FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act, as amended
Foliage: Primarily the leaves; may include stems of a plant
Fungicide: A pesticide used to control fungi.
Fungistat: A chemical that keeps fungi from growing.
GPA: Gallons per acre.
GPM: Gallons per minute.
Growth Stages of Cereal crops: (1) Tillering--when additional shoots are developing from the flower buds. (2) Jointing--when stem internodes begin elongating rapidly. (3) Booting--when upper leaf sheath swells due to the growth of developing spike or panicle. (4) Heading--when seed head is emerging from the upper leaf sheath.
Habitat: The places where plant or animal lives, feeds and breeds.
Handler: (See Pesticide Handler)
Hard (water): Water containing soluble salts of calcium and magnesium and sometimes iron.
Herbaceous plant: A plant that does not develop woody tissue.
Herbicide: A pesticide used to control undesirable plants.
Host: The living plant or animal a pest depends on for survival.
Hydrogen-Ion Concentration: A measure of acidity or alkalinity, expressed in terms of the pH of the solution. For example, a pH of 7 is neutral, from 1 to 7 is acid, and from 7 to 14 is alkaline.
Immune: Not susceptible to a disease or poison.
Impermeable: Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot.
Insecticide: A pesticide used to control insects.

IPM (Integrated Pest Management): 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.

Lactation: The production of milk by an animal, or period during which an animal is producing milk.

label: The written, printed or graphic matter on, or attached to, the pesticide or device or any of its containers or wrappers.

Labeling: All labels and all other written, printed, or graphic material (1) accompanying the pesticide or devise at any time; or, to which reference is made on the label or in literature accompanying the pesticide or device, except to current official publications of the EPA, the USDA (or other Federal or State Agency)

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

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

Leaching: Movement of a substance downward or out of the soil as the result of water movement.

Life cycle: The series of stages an organism passes through during its lifetime.

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

Mechanical agitation: Stirring or mixing done by rotating paddles or propellers in the spray tank.

Metamorphosis: The series of changes through which insects and insect-like organisms pass in their growth from egg to adult.

MPH: Miles per hour.

Mutagenic: Can produce genetic change.

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

Nitrophenols: Synthetic organic pesticides containing carbon, hydrogen, nitrogen and oxygen.

Nonpersistent pesticide: A pesticide that breaks down quickly after it is applied.

Nonselective pesticide: A pesticide that is toxic to most plants (herbicide) or animals.

Noxious weed: A plant defined as being especially undesirable or troublesome.

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

Oral Toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic Compounds: Chemicals that contain carbon.

Organochlorine: (See Chlorinated Hydrocarbon)

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen, and phosphorus. {Examples: parathion and malathion}

OSHA: Occupational Safety and Health Administration, part of the U.S. Department of Labor.

Ovicide: A chemical that destroys eggs.

Nontarget: Any sit or organism other than the site or pest at which the pesticide is being directed.

Parasite: An organism that lives and feeds on or in an organism of another species, which it usually injures.

Pathogen: Any disease-producing organism.

Penetration: The act of entering or ability to enter.

Persistent pesticide: A pesticide that remains active for a period of time after application, giving continued protection against the pest.

Personal protective equipment: Devices and clothing worn to protect the human body from contact with pesticides or pesticide residues.

Pesticide: Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or intended for use as a plant regulator, defoliant, or desiccant.

Pesticide Handler: (Worker Protection) A person who mixes, loads, applies or does other tasks that bring them into direct contact with pesticides.

Pesticide Workers: (Worker Protection) A person who does (1) hand labor tasks, such as weeding, planting, cultivating, and harvesting, or (2) other tasks involved in the production of agricultural plants, such as operating or moving irrigation equipment.

Phytotoxic: Harmful to plants.

Plant disease: Any harmful condition that makes a plant different from a normal plant in its appearance or function.

Pollutant: An agent or chemical that makes something impure or dirty.

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

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

psi: Pounds per square inch.

Predator: Any animal that destroys or eats other animals.

Private Applicator: A certified applicator who uses or supervises the use of any pesticide which is classified for restricted use for purposes of producing any agricultural commodity on property owned or rented by him or his employer or (if applied without compensation other than trading of personal services between producers of agricultural commodities) on the property of another person.

Propellant: Liquid in self-pressurized pesticide products that forces the active ingredient from the container.

PSI: Pounds per square inch.

Pubescent: Having hairy leaves or stems.

RCRA: Resource Conservation and Recovery Act.

Restricted-entry Interval: (Worker Protection) The time after the end of a pesticide application during which entry into the treated area is limited.

Restricted Use Pesticide: A pesticide that can be sold to or used by only certified applicators.

Rodenticide: A pesticide used to control rodents.

RPM: Revolutions per minute

Safener: A chemical added to a pesticide to keep it from injuring plants.

SARA: Superfund Amendments and Reauthorization Act - amendments to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Seed Protectant: A chemical applied to seed before planting to protect seeds and new seedlings from disease and insects.

Selective pesticide: A pesticide that is more toxic to some kinds of plants and animals than to others.

Soil Sterilant: A chemical that prevents the growth of all plants and animals in the soil. Soil sterilization may be temporary or permanent, depending on the chemical used.

Soluble: Will dissolve in a liquid.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid which will dissolve a substance to form a solution.

Spreader: A chemical which increases the area that a given volume of liquid will cover on a solid or on another liquid.

Sticker: A material added to a pesticide to increase it adherence.

Stomach poison: A pesticide that kills when it is eaten by the pest.

Supervision: (Under the direct supervision of a certified applicator) Unless otherwise prescribed by its labeling, a pesticide shall be considered to be applied under the direct supervision of a certified applicator if it is applied by a competent person acting under the instructions and control of a certified applicator who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied.

Surfactant: A chemical which increases the emulsifying, dispersing, spreading and wetting properties of a pesticide product.

Susceptible: Capable of being diseased or poisoned; not immune.

Susceptible Species: A plant or animal that is poisoned by moderate amounts of a pesticide.

Suspension: A substance that consists of undissolved particles mixed throughout a liquid.

Swath width: Side-to-side measurement of the band or strip of pesticide released by the application equipment

Synergism: The joint action of two or more pesticides that is greater than the sum of their activity when used alone.

Systemic pesticide: A pesticide that is taken into the blood of an animal or sap of a plant. It kills the pest without harming the host.

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

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

Toxicant: A poisonous chemical.

Toxicity: The capacity of a chemical to do harm to an organism by other than mechanical means.

- **Acute Toxicity:** The poisoning that occurs after a single exposure (effects shortly after exposure).
- **Chronic Toxicity:** The effects of long term or repeated low level exposures to a toxic substance (cancer, liver damage, reproductive disorders, etc.)

Trade name: Same as brand name.

Translocated herbicide: A pesticide that kills plants by being absorbed by leaves, stems, or roots and moving throughout the plant.

Treated Area: (Worker Protection) Any area to which a pesticide is being directed or has been directed.

USDA: U.S. Department of Agriculture

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

Vector: A carrier, such as an insect, that transmits a pathogen.

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

Volatile: Evaporates at ordinary temperatures when exposed to air.

Wettable powder: A dry pesticide formulation, usually mixed with water for application. Does not dissolve in water, but forms a suspension.

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

Worker: (See Pesticide Worker)

WPS: Worker Protection Standard for agricultural pesticides.

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