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NEVADA PESTICIDE APPLICATOR'S CERTIFICATION WORKBOOK

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Material presented in this workbook is designed to help the reader prepare for the various pesticide certification examinations. General information shall be supplemented by reading the Applying Pesticides Correctly handbook.

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PESTICIDES AND THE LAW

Both federal and state laws govern the use and application of restricted-use pesticides. The federal law serves as an umbrella and the state law may be more restrictive, but not less. The following is an explanation of the federal law. The state law is in the appendix.

I. Federal Law

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) passed in 1972, and amended in 1974, 1978, 1988, and in 1996, Congress passed and President Clinton signed into law the Food Quality Protection Act.

A. Regulates the registration, manufacturing, transportation, distribution and use of pesticides.

B. FIFRA Section 1 – The United States Environmental Protection Agency (EPA) administers FIFRA.

C. FIFRA Section 2 – Definitions

1. Certified Applicator – any individual who is authorized (trained and/or tested for competency in the safe and effective handling and use of these pesticides) to use or supervise the use of any pesticide, that is classified for restricted use.
   a. Private Applicator – a certified applicator who uses or supervises the use of any restricted-use pesticide for purposes of producing any agricultural commodity on property owned or rented by him or his employer, (if applied without compensation) on another person's property. (EXAMPLES: farmers, ranchers, floriculturists, orchardists).
   b. Commercial Applicator – a certified applicator who uses restricted-use pesticides for purposes other than producing an agricultural commodity. (Government workers, forest service, licensed pest control personnel, highway department, public works, etc.).
2. "Under the Direct Supervision of a Certified Applicator" – unless otherwise prescribed by its labeling, is a restricted-use pesticide 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.
3. Person – any individual, partnership, association, corporation, or any organized group of persons whether incorporated or not.
4. Pest –
   a. any insect, rodent, nematode, fungus, weed or
   b. any other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other micro-organism (except viruses, bacteria, or other micro-organisms on or in living man or other living animals) that are considered pests.
5. Pesticide –
   a. any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest,
   b. or any substance or mixture of substances used as a plant regulator, defoliant, or desiccant; does not include "new animal drugs."
6. Label and Labeling –
   a. Label – the written, printed, or graphic matter on, or attached to, the pesticide, container, device or wrapper.

b. Labeling – all labels and all other printed or graphic matter accompanying the pesticide or device.

7. To Use Any Registered Pesticide in a Manner Inconsistent with its Labeling – means to use any pesticide in a manner not permitted by the labeling, provided that the term shall not include:
   a. Applying a pesticide at any dosage, concentration or frequency less than that listed on the labeling.
   b. Applying a pesticide against any target pest not on the labeling if the application is to a crop, animal, or site that is listed.
   c. Use any equipment or method of application that is not prohibited by the labeling.
   d. Mix a pesticide or pesticides with a fertilizer, if the labeling does not prohibit the mixture.

D. FIFRA Section 3 – Registration of Pesticides

1. Requirement – No person in any state may distribute, sell, offer for sale, hold for sale, ship, deliver for shipment, or receive and deliver to any person any pesticide that is not registered with the EPA.
   a. All states must accept all EPA registered restricted-use pesticides.
   b. A state may restrict any EPA registered general use pesticide.
2. General Use Pesticide – One (or some of its uses) that is less likely to harm humans or the environment when it is used according to label directions. (Appears immediately below the heading of "Directions for Use").
3. Restricted-Use Pesticide – (or some of its uses) that could cause human injury or environmental damage, unless it is applied by competent "certified applicator" persons who have shown their ability to use these pesticides safely and effectively, (in a box on a prominent part of the front panel).

Refer to the most current list of Federally Restricted-Use Pesticides available from Nevada Department of Agriculture.

4. Classification of pesticides and their uses by the EPA is based upon "risk assessment":
   a. potential for poisoning humans
   b. type of formulation
   c. the way the pesticide is used
   d. site of application
   e. potential for environmental harm
5. EPA will assign each registered pesticide a registration number. (EXAMPLE: Reg. No. 012S001).

E. FIFRA Section 5 – Experimental Use Permits

1. Issued to accumulate the necessary information and data required to register a new pesticide.
2. Permit period shall not exceed one (1) year, and is not required for areas less than one acre.
3. A tolerance of exemption under the Federal Food, Drug and Cosmetic Act does not need to exist. EPA may establish a temporary tolerance level if the use of a pesticide may reasonably be expected to result in any residue on or in food or feed.

F. FIFRA Section 7 – Registration of Establishments

1. Requirement: No person shall "produce" any pesticide or active ingredient used in the production of a pesticide unless the establishment in that it is produced is registered with the EPA.

2. "Produce" means:
   a. to manufacture, prepare, compound, propagate, or process any pesticide or
   b. to repackage or otherwise change the container of any pesticide.
3. EPA shall assign each registered establishment an establishment number. (EXAMPLE: EPA Est. No. 0123-NV-01).

G. FIFRA Section 11 – Certification of Restricted Use Pesticide Applicators
   1. EPA requires each state to maintain a program for certification of restricted use pesticide applicators. The Nevada Department of Agriculture, in cooperation with the University of Nevada Cooperative Extension, conducts training and testing sessions for certification.
   2. Certification requires training and/or testing for competency in the safe and effective handling and use of these pesticides. Persons who are not certified pesticide applicators may not use restricted-use pesticides unless they are directly supervised by a certified applicator.

H. FIFRA Section 12 – Unlawful Acts
   1. It shall be **unlawful** for any person in any state to distribute, sell, offer for sale, deliver, etc., to any person:
      a. any pesticide not registered by the EPA.
      b. any registered pesticide whose composition or claims differ from those made in connection with its registration.
      c. any pesticide that is "adulterated" or "misbranded" or any device that is misbranded.
         1) "Adulterated" – meaning any pesticide whose strength or purity falls below the standard expressed on its labeling, or any substance that has been wholly or partly substituted for the pesticide, or any valuable constituent of the pesticide that has been wholly or partially left out.
         2) "Misbranded" – a pesticide is misbranded if:
            a) labeling bears any statement, design, graphics, etc., relative thereto or to its ingredients that is false or misleading.
            b) the package, container, or wrapper does not conform to specific EPA standards.
            c) it imitates or is offered for sale under the name of another pesticide.
            d) its label does not bear an EPA Establishment Registration Number.
            e) any word, statement, or other information required to appear on the labeling, is not conspicuously or prominently placed, as to render it unlikely to be read and understood by the ordinary individual.
            f) the label does not contain a cautionary statement that adequately protects health and the environment.
   2. It shall also be **unlawful** for any person:
      a. to detach, alter, deface, or destroy, in whole or in part, any labeling.
      b. to refuse to keep required records, or to refuse to allow the inspection of any records or establishment, or refuse to allow a designated employee of the EPA to take a sample pursuant to Sections 8 and 9.
      c. to advertise a restricted-use pesticide without giving the product's classification.
      d. to make available for use, or to use, any restricted-use pesticide for purposes other than those registered except that it shall not be unlawful to sell a restricted-use pesticide to an uncertified person for application by a certified applicator.
      e. to use any registered pesticide in a manner inconsistent with its labeling, or any experimental use permit contrary to the provisions of such permit.
      f. to knowingly falsify any required application for registration, record, information, or report; or failure to file reports required by this Act.
      g. to add, or take, any substance from any pesticide to defeat the purpose of this Act.

h. to use any pesticide in tests on human beings unless they:
   1) are fully informed of the consequences and
   2) freely volunteer to participate.

I. FIFRA Section 14 – Penalties
   1. Civil Penalties –
      a. Any registrant, commercial applicator, wholesaler, dealer, retailer, or other distributor who violates any provision of this Act may be assessed a civil penalty of not more than $5,000 for each offense.
      b. Any private applicator or other person not included in Paragraph (a), who violates any provision of this Act subsequent to receiving a written warning or a citation for a prior violation may be assessed a civil penalty of not more than $1,000 for each offense.
      c. Any applicator not included under Paragraph (a), who holds or applies registered pesticides, or uses dilutions of registered pesticides, only to provide a service of controlling pests without delivering any unapplied pesticide to any person, and who violates any provision of this Act may be assessed a civil penalty of not more than $500 for the first offense nor more than $1,000 for each subsequent offense.
   2. Criminal Penalties –
      a. Any registrant or producer who knowingly violates any provision of this Act shall be guilty of a misdemeanor and shall, on conviction, be fined not more than $50,000, or imprisoned for not more than one (1) year, or both.
      b. Any commercial applicator of a restricted use pesticide or any other person not described in paragraph (a) who distributes or sells pesticides or devices who knowingly violates any provision of this act shall be fined not more than $25,000 or imprisoned for not more than one (1) year, or both.
      c. Any private applicator or other person not included in Paragraph (a), who knowingly violates any provision of this Act, shall be guilty of a misdemeanor and shall, on conviction, be fined not more than $1,000 or imprisoned for not more than thirty (30) days, or both.

J. FIFRA Section 18 – Exemptions of Federal Agencies
   1. EPA may exempt any Federal or State agency from any provision of this Act, if it is determined that emergency conditions exist that require such exemption.
   2. This provision allows the sale and use of a product for a non-registered purpose for a specified period of time, when an emergency situation occurs.

K. FIFRA Section 19 – Storage, Disposal and Transportation
   1. The labeling of a pesticide contains requirements and procedures for the transportation, storage and disposal of pesticides. The EPA may also issue requirements for the design and disposal of pesticide containers, and the disposal of pesticide rinsate.
   2. Section 19f establishes standards for removal of pesticides from containers and container rinsing, establishes standards for container design, labeling, and refilling and establishes requirements for containment of stationary bulk containers and pesticide dispensing areas.
   3. EPA will provide advice and assistance to the Department of Transportation (DOT), in functions relating to the transportation of pesticides and hazardous wastes.
      a. DOT regulates shipments of pesticides between states and within states. DOT regulations also require that for transportation of small quantities of many commonly used pesticides, training, markings on vehicles, and shipping documents are required. Contact the DOT regarding their specific laws and regulations.

L. FIFRA Section 24(c) – Authority of States (Special Local Need – SLN).
1. Allows a state, under certain conditions, to register additional uses for a federally registered pesticide.
2. These registrations may involve adding (a) application sites; (b) pests; or (c) alternate control techniques to those listed on the federally registered label.
3. Provisions:
   a. Registrant must provide supplemental labeling for each SLN registration.
   b. Applicator must have a copy of the SLN label in his possession in order to apply the pesticide for that purpose. (EXAMPLE: SLN-NV) registration only legal in the State or locale specified in the labeling.
   c. A tolerance or exemption under the Federal Food, Drug, and Cosmetic Act must exist that permits residues of the pesticide on the food or feed, before the SLN will be approved.

M. FIFRA Section 26 – State Primary Enforcement Responsibility
1. For the purposes of this act, a state shall have primary enforcement responsibility for pesticide use violations.

II. OTHER LAWS AND REGULATIONS:

A. Food Quality Protection Act of 1996 (FQPA) – EPA regulates pesticides under two major federal statutes; 1) Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA registers pesticides for use in the United States and prescribes labeling and other regulatory requirements to prevent unreasonable adverse effects on health or the environment. 2) Under the Federal Food, Drug and Cosmetic Act (FFDCA), EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food. Tolerances are enforced by the Department of Health and Human Services/Food and Drug Administration (HHS/FDA) for most foods, U.S. Department of Agriculture/Food Safety and Inspection Service (USDA/FSIS) for meat, poultry, and some egg products and the U.S. Department of Agriculture/Office of Pest Management Policy.

For over two decades, there have been efforts to update and resolve inconsistencies in these two major pesticide statutes, but consensus on necessary reforms remained elusive. The 1996 FQPA law represents a major breakthrough, amending both major pesticide laws to establish a more consistent, protective regulatory scheme, grounded in sound science. It mandates a single, health-based standard for all pesticides in all foods; provides special protections for infants and children; expedites approval of safer pesticides; creates incentives for the development and maintenance of effective crop protection tools for American farmers; and requires periodic re-evaluations of pesticide registrations and tolerances to ensure that the scientific data supporting pesticide registrations will remain up-to-date in the future.

For more information about FQPA, EPA's implementation of the law, and opportunities for public involvement, go to http://www.epa.gov/oppfead1/fqpa/backgrnd.htm.

B. Aerial Application – regulated by the Federal Aviation Administration (FAA).
1. FAA – judges the flying ability of pilots and the safety of their aircraft.

C. Title III of the Superfund and Reauthorization Act of 1986 (SARA): Emergency and Community Right-to-Know Act
1. Subtitle A – stipulates procedures for emergency planning in states and localities.

2. Subtitle B – builds a framework for community awareness concerning potential chemical hazards and outlines requirements for submission of material safety data sheets, chemical inventory forms, and toxic release forms.
3. Subtitle C –trade secret protection, citizen petitions, and information availability.

D. Endangered Species Act (ESA)
1. Sets up pesticide restrictions, beginning in 1991, for growers, applicators, and dealers designed to protect endangered plant and animal species.
2. Developed to bring FIFRA into compliance with the Endangered Species Act.
3. U.S. Fish and Wildlife Service (FWS) is the final authority for the interpretation of the ESA.
4. The label on a pesticide product that affects an endangered species will identify the state and the counties in the state where endangered species prohibitions on the use may occur.
   a. The label will also direct the pesticide user to contact either the Department of Agriculture, U.S. Fish and Wildlife Service, or the Cooperative Extension Service to determine where pesticide use restrictions exist and to obtain a county range bulletin.
      1) Bulletins will include:
         a) County map with identifiable boundaries
         b) Affected pesticides listed by active ingredient
         c) List of endangered species with ranges in that county
   b. Users will be obligated to obtain and comply with bulletins for the county in which they operate.

E. Chemical Hazard Communication Standard part of the Occupational Safety and Health Act (OSHA) – workers right-to-know
1. Employer must inform employees of chemical hazards,
2. MSDS must be available,
3. Written training program must be implemented, and
4. Labeling must be attached to all chemical and service containers (not application devices).

F. EPA's Office of Pesticide Programs –
1. Groundwater protection program
   a. EPA review the registrations of some 600 pesticide active ingredients first registered before 1978, as well as all new pesticides coming onto the market to be used outdoors.
   b. Each one is being carefully examined for its potential to leach to groundwater, and is regulated accordingly. Reviews may result in:
      1) Continued registration with up-to-date data requirements.
      2) Newly required labeling through strict Registration Standards includes:
         a) restricted-use classification
         b) advisory label statement
         c) geographical restrictions
         d) required monitoring or other environmental fate data
   c. New labeling will contain the following EPA groundwater advisory statement: "_____ is a chemical that can travel (seep or leach) through soil and can contaminate groundwater that may be used as drinking water. _____ has been found in groundwater as a result of agricultural use. Users are advised not to apply _____ where the water table (groundwater) is close to the surface and where the soils are very permeable; i.e., well drained soils such as loamy sands.
      Your agricultural agencies can provide further information on the type of soil in your area and the location of groundwater."

d. EPA will require each state to develop a groundwater management plan to regulate use and protect groundwater aquifers from pesticide contamination.

2. Worker Protection Program

a. EPA has revised its regulations governing worker protection from agricultural pesticides. The scope of standards includes agricultural, forest, nursery and greenhouse workers. This proposal expands requirements for training, warnings about applications, personal protective equipment and reentry restrictions and adds new provisions for decontamination, emergency medical duties, and training.

b. In 1992, EPA revised the worker protection standard (WPS) for agricultural pesticides. The WPS governs the use of pesticides used in the production of agricultural plants on farms, forests, nurseries, and in greenhouses. With few exceptions, if you are an employer of agricultural workers or pesticide handlers, the WPS requires you to take steps to reduce the risk of pesticide related illnesses.

An agricultural worker is anyone who is employed doing tasks such as harvesting, weeding, or watering, related to the production of agricultural plants. An agricultural handler is defined as anyone who is employed by an agricultural establishment to apply, mix, load, transfer, handle open containers of pesticide, act as a flagger, or assist in the maintenance of application equipment.

Not all pesticides are covered by the WPS. Only pesticide products that are used in the production of agricultural crops will reference the WPS. You will know that the product is covered by the WPS if you see the following statement under the "Directions for Use" section of the pesticide labeling:

AGRICULTURAL USE REQUIREMENTS

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

There are two types of WPS provisions that you must comply with that appear on the label, those that are fully spelled out and those that are referred to but not thoroughly described on the label. Those requirements that are fully spelled out on the container include required personnel protective equipment (PPE), a statement permitting only protected pesticide handlers to be in the area during application, a product specific restricted entry interval (REI), and whether double notification (giving agricultural workers oral warnings and by posting entrances to treated areas) is required.

In addition to this, the WPS reference statement will appear on agricultural pesticide products that require employers to provide pesticide handlers and agricultural workers with all WPS protections. These protections include: pesticide safety training for agricultural workers and handlers;

- providing a decontamination site for workers and handlers
- notification of handlers and workers about pesticide applications
- display and exchange of information; emergency assistance
- and PPE (handlers only)

If it is necessary for you to meet the requirements of the WPS, you will need to obtain a copy of the WPS "How to Comply" Manual from the Nevada Department of Agriculture. The manual outlines specific information about the regulation and what you need to know to comply with the WPS.

III. NEVADA REVISED STATUTES (NRS) CHAPTER 555

A. Purpose: regulate, in the public interest, the application of pesticides that, although valuable for the control of pests, may seriously injure man, animals and crops over wide areas, if not properly applied.

B. Licenses and certificates issued.

Table 1. Types of licenses and certificates issued

	CUSTOM	CERTIFIED
DEFINITION	Licensed to apply pesticides for hire	Certified to apply restricted-use pesticides (RUPs)
APPLICATOR TYPES	Principal, Operator, Agent	Commercial, Private
EDUCATION/ EXPERIENCE	Principal: 2 years experience or 6 months experience plus 16 college credits in category	None
EXAMS		
Retest Period	Principal: 10 working days Operator: 7 working days Agent: 10 working days	5 working days
Questions	100 Operator General, 50 Principal	50 General, 20 Category
Passing	70%	60%
Fees	$25.00 per exam	$25.00 per exam session
LICENSE/CERTIFICATE		
Fees	$250.00 Business	None
Period	$50.00 Each license	None
Renewal	$300.00 Minimum, Annual	Every 4 years
CONTINUING EDUCATION	6 total hours each year, with one hour in laws and one in safety	None
INSURANCE		
Ground	$10,000 each occurrence; $20,000 aggregate (bodily injury), property damage and drift	None
Aerial	$100,000 each occurrence; $300,000 aggregate (bodily injury), property damage and drift	None
Report	Monthly pesticide usage by the 15th of each month for RUP* and agricultural applications. Use summary submitted annually.	None
Records	Keep and maintain for 2 years	Keep and maintain for 2 years

*RUP = Restricted Use Pesticide

C. Penalties: suspension, modification, or revocation of license; grounds for automatic suspension.
   1. The Department of Agriculture may suspend, pending inquiry, for not longer than ten (10) days, and after opportunity for a hearing, may revoke, suspend, or modify any license or certificate if it is found that the applicator:
      a. is no longer qualified,
      b. applied known ineffective or improper materials or made any application in a faulty, careless or negligent manner,
      c. aided or abetted a person to evade the provisions of NRS 555,
      d. was intentionally guilty of fraud or deception in the procurement of a license or certificate,
      e. deliberately falsified any record or report, or
      f. violated any provisions of NRS 555 or regulations made there under.
   2. The Department of Agriculture may assess monetary penalties for any violation of the provisions outlined in NRS 555 or the regulation made there under.

IV. Nevada Revised Statute (NRS) Chapter 555 (See Appendix A)

A. Every pesticide that is distributed, sold, or offered for sale within this State, or delivered for transportation, or transported in intrastate commerce, shall be registered with the Department of Agriculture.
   1. annual renewal
   2. $60.00 per pesticide

B. It shall be unlawful for any person to distribute, sell, or offer for sale in this State any pesticide:
   1. not registered in the State
   2. unless it is in the registrants or manufacturers unbroken immediate container and there is affixed to such container the required information.

C. It shall be unlawful for any person to sell or offer to sell at the retail level, or distribute or deliver for transportation for delivery to the consumer or user, a restricted-use pesticide that is not registered with the Department of Agriculture.
   1. Restricted-use pesticide Dealer registrations expire on December 31, and are renewable annually at a fee of $25.00.
   2. All restricted-use pesticide dealers must keep and maintain for two (2) years a record of all sales of restricted-use pesticides showing:
      a. date of sale or delivery
      b. name and address of person to whom the product is sold
      c. brand name of the pesticide
      d. amount of pesticide sold
      e. other information as may be required (e.g., Certification Number)

V. Nevada Administrative Code (NAC) Chapter 555 – Certified Applicator Regulations (See Appendix B)

A. Provisions do not apply to any person applying or supervising the application of any pesticide classified for general use.

B. Establishes categories for the certification of applicators who apply restricted use pesticides.
   1. NON PRIMARY PRINCIPAL COMMERCIAL APPLICATORS – Standards for competency for non primary principal commercial applicators are:

a. Agricultural Pest Control
   1) Animal – Applicators who apply a pesticide directly to animals must demonstrate practical knowledge of such animals and their associated pests. A practical knowledge is also required concerning specific pesticide toxicity and residue potential when host animals will be used for food. Further, applicators must know the relative hazards associated with such factors as formulation, application techniques, age of animals, stress, and extent of treatment.
   2) Plant – Applicators must demonstrate a practical knowledge of crops grown and the specific pests of those crops on which they may be using restricted-use pesticides. The importance of such competency is amplified by the extensive areas involved, the quantities of pesticides needed, and the ultimate use of many commodities as food and feed. Practical knowledge is required concerning soil and water problems, pre-harvest intervals, phytotoxicity and potential for environmental contamination, non target injury and community problems resulting from the use of restricted-use pesticides in agricultural areas.

b. Aquatic Pest Control – Applicators must demonstrate practical knowledge of the secondary effects which can be caused by improper application rates, incorrect formulations and faulty application of restricted-use pesticides used in this category. They must demonstrate practical knowledge of various water-use situations and the potential of downstream effects. Further, they must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects, and other organisms which may be present in aquatic environments. Applicators must demonstrate practical knowledge of the principles of limited-area application.

c. Chemigation – Applicators must demonstrate practical knowledge of pesticides, safety procedures, environmental concerns, and methods and equipment for the application of pesticides through chemigation systems.

d. Forest Pest Control – Applicators must demonstrate practical knowledge of the type of rangeland, forests, forest nurseries, and seed production in the State and the pests involved. They must possess a practical knowledge of the cyclic occurrence of certain pests and specific population dynamics as a basis for programming pesticide applications. A practical knowledge of the relative biotic agents and their vulnerability to pesticides to be applied is required. Applicators must demonstrate practical knowledge of control methods which minimize the possibility of secondary problems, such as unintended effects on wildlife and natural aquatic habitat. Proper use of specialized equipment must be demonstrated, especially as it may relate to meteorological factors and adjacent land use.

e. Fumigation Pest Control – Applicators must demonstrate practical knowledge of pesticide problems associated with the use of poisonous and lethal gases, including cognizance of potential phytotoxicity to animate host and residual accumulation of fumigants, practical knowledge of fumigant confinement and circulation procedures, injection procedures, dosage calculations, leakage and concentration testing procedures, and ventilation.

f. Greenhouse and Nursery Pest Control – Applicators must demonstrate practical knowledge of pesticides, plants, plant pests and the adverse effects associated with pesticide use in a greenhouse and nursery.

g. Industrial, Institutional, Structural and Health-Related Pest Control – Applicators must demonstrate a practical knowledge of the wide variety of pests encountered in this category, including their life cycles, types of formulations appropriate for their control, and methods of application that avoid contamination of food, damage contamination of habitat, and exposure of people and pets. Since human exposure, including babies, children, pregnant women, and elderly people is frequently a potential problem, an

applicator must demonstrate a practical knowledge of the specific factors which may lead to a hazardous condition including continuous exposure of human beings in the various situations encountered in this category. Applicators must also demonstrate practical knowledge of the environmental conditions particularly related to this activity.

h. Mosquito Pest Control – Applicators must demonstrate practical knowledge of mosquito pests, including identification and life cycle, reproducing habitats and vector capabilities. Further, they must have practical knowledge concerning the potential effects of pesticides on plants, birds, fish, and other organisms in aquatic environments, and methods of application that avoid unacceptable contamination of the habitat and exposure to people and animal life.
i. Ornamental and Turf Pest Control – Applicators must demonstrate practical knowledge of pesticide problems associated with the production and maintenance of ornamental trees, shrubs, plantings, and turf, including cognizance of potential phytotoxicity due to a wide variety of plant material, drift and persistence beyond the intended period of pest control. Applicators in this category must demonstrate practical knowledge of application methods which minimize or prevent hazards to human beings, pets, and other domestic animals.
j. Predatory Pest Control/M-44 – Applicators must demonstrate a practical knowledge of animal damage and control procedures, including identification of predatory mammals, conditions conducive to animal damage, secondary poisoning and protection of non target species, and knowledge of special laws and regulations governing the use of poisons to control predators on private and public lands.
k. Public Health Pest Control – Applicators must demonstrate practical knowledge of vector diseases transmission as it relates to and influences application programs. The wide variety of pests involved must be known and recognized, and their appropriate life cycles and habitats must be understood as a basis for control strategy. An applicator must have practical knowledge of the various pest environments ranging from streams to those conditions found in buildings. They must also have practical knowledge of the importance and employment of such non chemical control methods as sanitation, waste disposal, and drainage.
l. Right-of-Way Pest Control – Applicators must demonstrate practical knowledge of the wide variety of environments which rights-of-way may traverse, including waterways. They must demonstrate practical knowledge of problems on runoff, drift and excessive foliage destruction, and the ability to recognize target organisms. They must also demonstrate practical knowledge of the nature of herbicides and the need for containment of these pesticides within the right-of-way area, and the result of their application activities in the adjacent areas and communities.
m. Seed Treatment – Applicators must demonstrate practical knowledge of types of seeds that require chemical protection against pests and factors such as seed coloration, carriers and surface active agents which influence pesticide binding and may affect germination. They must demonstrate practical knowledge of hazards associated with handling, sorting, and mixing and misuse of treated seed such as introduction of treated seed into food and feed channels, as well as proper disposal of unused treated seeds.
n. Sewer Line Root Control – Applicators must demonstrate a practical knowledge of the characteristics of herbicides and the environmental effects, precautions and concerns associated with sewer line root control.
o. Wood Preservatives – Applicators must demonstrate a practical knowledge of the environments in which chemical preservatives are used, the concerns associated with the use of chemical preservatives and characteristics of various wood preservatives.

2. PRIVATE APPLICATORS – The categories of private applicators are:

a. Agricultural Pest Control
   1) Animal
      a) Dairy animal pest control – The control of any pest in, on, or around dairy animals, including, but not limited to, goats and dairy cattle, and also including places on or in which dairy animals are confined, including, but not limited to, barns and corrals.
      b) Meat animal pest control – The control of insects, including ectoparasites, in, on, or around meat animals, including, but not limited to, horses, beef cattle, swine and, sheep and also including places on or in which meat animals are confined, including, but not limited to, barns and corrals.
   2) Plant
      a) Forage, grain, pasture and range pest control. The control of any pest in, on, or around the production of forage, grain, pasture and range.
      b) Row crop pest control. The control of any pest in, on, or around row crops.
      c) Seed crop pest control. The control of any pest in, on, or around seed crops.
   3) Specialty Crops
      a) Aquatic pest control. The control of any pest, excluding predators, in standing or running water involved in aquaculture, including, but not limited to, catfish farms.
      b) Greenhouse and nursery pest control. The control of any pest, excluding predators, in, on, or around greenhouses and nurseries and the control of any pest, excluding predators, in, on, or around green house or nursery operational sites, including, but not limited to, equipment storage areas.
      c) Industrial farm pest control. The control of any pest, excluding predators, in, on, or around apiaries and industrial farmsteads, including, but not limited to, grain silos, equipment buildings, barns, warehouses and any other building associated with a farm operation.
      d) Ornamental and turf pest control. The control of any pest, excluding predators, in the production of turf and the control of any pest, excluding predators, in, on, or around turf production operational sites, including, but not limited to, equipment storage areas.

b. Chemigation – The control of any pest through the application of pesticides by injection of the pesticides into irrigation water.

c. Forest and Rangeland Pest Control – The control of any pest, excluding predators, in or on forests and rangelands, and the control of any pest, excluding predators, in, on, or around forest or rangeland operational sites, including but not limited to, equipment storage areas.

d. Fumigation – The control of any pest by fumigation with poisonous and lethal gases in any habitat, including, but not limited to, structures and soil.

NEVADA LAW MUST BE AS RESTRICTIVE OR MORE SO THAN THE FEDERAL LAW

GUIDELINES FOR THE SAFE USE OF PESTICIDES

No one really knows what would happen if farmers were denied the use of pesticides, however agricultural experts and some scientists believe that without pesticides the production of crops would decrease about 35 percent almost immediately and livestock production would drop at least 25 percent. Even with currently available pesticides, losses in agricultural production and marketing caused by all kinds of pests are estimated at $30 billion annually in the United States and much more worldwide.

Without pesticides, we could not produce commercially the high-quality fruits and vegetables that we now enjoy in abundance. Pests not only adversely affect agricultural productivity, but they impair the health of humans, domestic and wild animals, and damage the environment.

Pesticides efficiently control most public health pests. Scientists estimate that about thirty major human diseases have been reduced or eliminated altogether through the use of insecticides to control pests that carry or transmit disease-causing organisms. Among the diseases suppressed in control campaigns are malaria, equine encephalitis, yellow fever, bubonic plague, Rocky Mountain spotted fever, African sleeping sickness, Lyme disease, West Nile virus, and dengue fever. Mosquitoes, biting flies, fleas or ticks spread these major diseases.

Quite obviously, pesticides aid in the production commercially of food, feed, and fiber. Pesticides are equally important in the control of home garden and landscape pests. In the home, they protect against termites, cockroaches, fleas, bed bugs, lice, mice and rats. We even use pesticides to control fleas, ticks, and other pests that attack our pets.

The correct use of pesticides is critical; too much of a chemical may damage or kill the plants or animals it was intended to protect; too little may not provide adequate pest control. Many desirable animals, fish, insects, birds, and ourselves can be harmed by the incorrect or careless use of pesticides. Pesticides are here to stay, but we must use them wisely, properly, and safely.

Pesticides must be used in strict accordance with the instructions on the product label (the printed material that is attached to the container). The pesticide label is a legal document according to federal and state laws. Any deviation from the label constitutes a misuse and subjects the user to either civil or criminal penalties. These laws also require that all pesticides be classified as either restricted-use or general-use products. **Restricted-use pesticides may be used only by certified applicators or by persons working under the direct supervision of a certified applicator.** These certified applicators have demonstrated, by written or oral examination, competence in using and handling pesticides. General-use materials are available to anyone without restrictions unless otherwise designated on the label.

The Federal Food, Drug, and Cosmetic Act, administered by the EPA, requires maximum permissible residue levels (tolerances) be established for each pesticide on each edible crop. These tolerances vary for different crops, even with the same pesticide. Safe residue tolerances are determined through extensive residue analyses for every pesticide applied to a food or feed crop.

Strict pesticide laws and regulations allow the widespread use of synthetic chemicals to produce food and fiber, while protecting our health, preserving the structures we live in, and preventing damage to the environment. Pesticide laws and regulations are designed to protect the general public, crops (plants and animals), users, workers, and the environment from the negative side effects of pesticides.

WHAT IS A PEST?

Pests are living organisms that compete with people for food supply or fiber, damage structural or personal property, injure ornamental plants, damage livestock and pets, or transmit diseases to people or animals. Pests can be animals such as insects, spiders, ticks, mites, rats, birds, snails, slugs, and nematodes or plants such as weeds, or fungi like rusts and mildews. Microorganisms such as bacteria and viruses can be pests as well.

WHAT IS A PESTICIDE?

A pesticide is any substance or mixture of substances used to kill, destroy, repel, or prevent the growth and development of a living organism (pests). Pesticides can be classified according to their function:

Avicides – to control pest birds;
Bactericides – to destroy bacteria;
Fungicides – to destroy fungi;
Herbicides – to kill weeds and other undesirable plants;
Insecticides – to destroy insects and related arthropods, such as ticks, spiders or centipedes;
Miticides (acaricides) – to kill mites;
Molluscicides – to kill snails and slugs;
Nematocides – to kill nematodes;
Piscicides – to control pest fish;
Predacides – to control vertebrate pests;
Rodenticides – to destroy rodents.

Although not usually thought of as pesticides, the following three classes of chemicals are also regulated under both federal and state pesticide laws.

Defoliants – chemicals that cause leaves or foliage to drop from a plant;
Desiccants – chemicals that promote drying or loss of moisture in plant tissues;
Plant-growth regulators (PGRs) – substances (excluding fertilizers and other plant nutrients) that alter the normal or expected growth, flowering, or reproduction of plants and animals.

Some pesticides, such as fumigants (gases), give nonspecific control of a wide variety of pests. Others may kill a pest at a certain stage of its development. Ovicides, for example, kill only the eggs of insects and related arthropods.

Manufacturers of pesticides spend considerable time and money developing and testing new products before releasing them. Companies commonly test as many as 20,000 different compounds before finding a marketable product. Costs of developing a new pesticide and bringing it to market often exceed $80 million and more than ten years.

PESTICIDE TYPES

Antibiotics have been registered as pesticides to control plant bacterial and some fungal diseases, but their expense often precludes their use on only the most valuable crops and plants.

Botanicals (plant-derived compounds) are all contact or stomach poisons; some are skin irritants. Examples are rotenone, pyrethrin, nicotine and strychnine (no antidote for strychnine, a restricted use pesticide). Most persist in the environment for months or years.

Carbamates contain carbon, hydrogen, nitrogen and sulfur. They do not accumulate in the environment and are rapidly inactivated under alkaline conditions. They are slightly more persistent than the organophosphates. They affect control upon contact, ingestion, and skin penetration by inhibiting acetyl cholinesterase which harms the nervous system. Examples are Furadan, Sevin, Baygon. The antidote is Atropine Sulfate, never administer 2-PAM. They include some herbicides such as chloropropan and Eptam.

Dinitro Compounds include selective, pre-emergent herbicides such as trifluralin, oryzalin, pendimethalin. These compounds are generally considered to be low in toxicity; however, some may have a high leaching potential (metolachlor, alachlor).

Dintro Phenols are used as both insecticides and herbicides.

Farmamidines are a small group of chemicals classed as ovicides, insecticides and acaricides and have value as an alternate control of organophosphate – and carbamate – resistant pests.

Fumigants are generally biocides and because of their toxicity and gaseous or liquid application, may be difficult to manage. They include metam-sodium, chloropicrin, and methyl bromide (soon to lose most registered uses).

Inorganic Fungicides such as sulfur, cooper and mercury (registrations have been cancelled) have been used widely and for a long time in disease control.

Inorganic Pesticides contain arsenic, mercury, copper, or cyanide. Most are stomach poisons that are persistent in the environment and very toxic to mammals. Examples are Paris Green, lead and copper arsenate, mercuric chloride. All mercury and arsenic containing substances have been suspended.

Nicotinoids are a new class of insecticides mimicked after the natural nicotine with systemic root activity and notable contact and stomach action.

Organochlorines all contain hydrogen and chlorine. All are contact or ingestion poisons that persist in the environment for many years. They generally do not penetrate the skin, however, Endrin and Chlordane do. Examples are DDT, chlordane, heptachlor, aldrin, etc. Most have been cancelled and are not available.

Organophosphates contain carbon, hydrogen and phosphorus. They usually degrade within 72 hours. All will penetrate the skin, inhibit cholinesterase, and are toxic to mammals by affecting the nervous system. Systemic poisons are not readily stored in fat and most are degraded by alkaline solutions. Examples are parathion, Malathion, and chlorpyrifos. Antidote is Atropine Sulfate or 2-PAM.

Organosulfurs are compounds that have a central atom of sulfur surrounded by two phenyl rings. They are better miticides than sulfur itself, and they kill eggs as well as larvae and adults.

Phenoxy Compounds are mostly selective, translocated herbicides. Examples are 2,4-D, MCPP, and MCPA.

Plant Chemicals such as Limonene (d-limonene) from lemon peels, cinnamoldehyde (cinnamon derivative), eugenol (oil of cloves0, jojoba oil, rosemary oil, mint oil, azadiractin (oil from neem tree seeds), pyrethrum (from chrysanthemum) may be toxic, repelent or attractive to selected pests, mostly insects.

Pyrethroids are synthetic pyrethrum-like compounds (pyrethrum is costly and is not stable in sunlight) that are effective insecticides.

Pyridines herbicides (diquat and paraquat) are moderately to highly toxic, fast acting, non selective, post emergent herbicides.

Spinosyns are very new insecticides with both contact and stomach activity in a broad range of insects. It disrupts binding of acetylcholine in nicotinic acetylcholine receptors at the postsynaptic cell, which is a new mode of action.

Strobilurins are fungicides derived from mushrooms and wood decaying fungi with both systemic and curative properties.

Sulfonyurea compounds (sulfometuron, imazapyr) are non-selective post and pre-emergent herbicides that are active at very low rates.

Synthetic Pyrethroids are similar chemically to natural pyrethrins, but they are modified to increase their stability in the natural environment. Examples are allethrin, cypermethrin, and cyfluthrin.

Triazines include prometon, atrazine, simazine, metribuzin, hexazinone. These post and pre-emergent herbicides are considered to be highly leachable.

TOXICITY OF PESTICIDES

All pesticides must be toxic, or poisonous, to kill the pests they are intended to control and thus are potentially hazardous to people and animals as well as to pests. Since pesticide toxicity varies widely, it is very important for persons who use pesticides or those who regularly come in contact with pesticides to have a general knowledge of the relative toxicity of the products that are being used.

The toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits, and dogs) to different dosages of the active ingredient in a pesticide product. The active ingredient is that portion of a pesticide formulation that is toxic to the pest.

The toxicity of each active ingredient is determined by at least three methods: (1) oral toxicity, the chemical is fed to test animals; (2) dermal toxicity, the skin is exposed to the chemical and its absorption through the skin and its accumulation in the bloodstream is measured; and (3) inhalation toxicity, test animals breathe the chemical's vapors. In addition, the effect of the chemical as an irritant to the eyes and skin is examined under laboratory conditions.

Acute toxicity is usually expressed as LD 50 (lethal dose 50) and LC 50 (lethal concentration 50). This is the amount of concentration of a toxicant (the active ingredient) required to kill 50 percent of a test population of animals under a standard set of conditions. Acute toxicity values of pesticides, based on a single dosage, are recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm). LD 50 and LC 50 values are useful in comparing the toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD 50 or LC 50 of a pesticide product, the greater the toxicity of the material to people and animals. Pesticides with high LD 50s have the least acute toxicity to man when used according to the labeled directions.

Pesticide products are categorized on the basis of their LD 50 or LC 50 values. Those pesticides that are classified with highly acute toxicity on the basis of either oral, dermal, or inhalation toxicity must have

the signal words DANGER and POISON (in red letters) and a skull and crossbones prominently displayed on the package label. Effective December 31, 1984, the Spanish equivalent for DANGER, PELIGRO, must also appear on the labels of highly toxic chemicals. As little as a few drops of such a material taken orally could be fatal to a 150-pound person. Acute (single dosage) oral LD 50s for pesticide products in this group range from a trace to 50 mg/kg.

Pesticide products considered to have moderate acute toxicity must have the signal word WARNING (AVISO in Spanish) displayed on the product label. Acute oral LD 50s range from 50 to 500 mg/kg. From 1 teaspoon to 1 ounce of this material could be fatal to a 150-pound person.

Pesticide products classified with slight acute toxicity or that are relatively nontoxic are required to have the signal word CAUTION on the pesticide label. Acute oral LD 50 values are greater than 500 mg/kg.

Pesticides formulated in petroleum solvents or other combustible liquids must also include the precautionary word FLAMMABLE on the product label.

Despite the fact that some pesticide products are considered to be only slightly toxic or relatively nontoxic, all pesticides can be hazardous to man, non-target animals, and the environment if used inconsistently with the instructions on the product label. Use the pesticide only as recommended by the manufacturer. **As the applicator, you are legally responsible if a pesticide is misused in any way.**

ROUTES OF ENTRY

There are three principal ways a pesticide can enter the human body: (1) through the skin (dermal), (2) into the lungs (inhalation), and (3) by mouth (oral).

Dermal route. The skin is the most important entry route of most pesticides into the body. Approximately 97 percent of all exposure to pesticides during a spraying operation is dermal. Keep pesticides away from the underarms and groin (don't sit on pesticide containers or contaminated seats); these areas absorb pesticides through the skin very rapidly. A small amount of chemical allowed to remain on the skin can be absorbed into the body and cause pesticide poisoning. Wear protective clothing when handling pesticides. Follow application and equipment cleanup procedures, always wash thoroughly, immediately after an application, to remove all traces of a pesticide and prevent further absorption through the skin. It is also important to change into clean clothing.

Inhalation route. Protect the lungs from toxic dusts, vapors, gases (fumigants), and spray particles while handling and applying pesticides, especially in confined areas. Once breathed into the lungs, pesticides enter the bloodstream very rapidly and completely.

Cartridge or canister-type respirators provide respiratory protection for most types of outdoor applications. When fumigants or highly toxic pesticides are used in confined areas, it may be necessary to use a self-contained air supply for safety.

Oral route. The most serious oral exposure occurs when liquid concentrates splash into the mouth during mixing or someone unknowingly consumes a pesticide. A certain amount of chemical may be swallowed when eating, drinking, or smoking with contaminated hands, rubbing ones mouth on contaminated clothing, or even licking ones lips. Since the intestinal tract rapidly and completely absorbs many pesticides, it is sound advice to wash your hands and face thoroughly before eating, drinking or smoking.

There are several other routes of entry that are generally not as important as the dermal, inhalation, and oral routes. However, under certain conditions and with certain pesticides, absorption through the eyes or through skin abrasions can be significant and particularly hazardous. Eyes are very sensitive to many pesticides and are able to absorb a surprisingly large amount of pesticide, considering their size. The eyes and any open wounds should be protected when handling pesticides.

READING THE PESTICIDE LABEL

Pesticides are poisons designed to kill or repel animals or plants that are considered pests. Pesticides can have unintended effects on people, pets, wildlife, and the environment. Most pesticide accidents result from their careless use. Lack of knowledge about pesticides and improper handling of them are very serious. When using pesticides, do everything possible to limit your exposure, and that of other employees and the environment, to an absolute minimum.

All pesticides must bear labels that provide the pesticide user with information about the product. In fact, the label is the law. Read and make sure that you understand the information presented on a product before you use it. Explore alternatives to applying pesticides and use the least toxic methods available first. If pesticides are necessary, use the least toxic products available first.

The manufacturer of pesticides is required by law to put specific information on the label. The label must include the brand or trade name of the product, a common chemical name, if one has been approved, and the full chemical designation of the active ingredient. The percentage or amount of active ingredient in the formulation must also be included, as well as information on the pests to be controlled, the crops or areas to be treated, the rate or amount of material to be used, mixing and application instructions, safety information (including signal words, proper equipment and clothing, first aid instruction and antidotes), possible hazards to wildlife and the environment, storage and disposal instructions, reentry intervals following application, days to harvest if the pesticide will be used on an edible crop, a restricted-use statement if applicable, a statement of net contents, EPA registration and establishment numbers, and the name and address of the manufacturer. The label provides a wealth of information: **READ IT CAREFULLY!** The following gives an overview of the label requirements.

<u>Nine Required Parts of a Pesticide Label</u>

1. INGREDIENT STATEMENT
   The label of a pesticide must give the name and percentage by weight of each active ingredient and the percentage by weight of all inert ingredients. Ingredients must list chemical and/or common names of each active ingredient. The chemical name is a complex name that identifies the chemical components of the pesticide ingredients. Common names are shortened versions of the complex chemical names.
2. NAME, BRAND OR TRADEMARK
   The name, brand or trademark under which the product is sold must be on the front panel of the label. The brand or trade name is one used in advertising. The brand name does not give an indication of what active ingredient the product contains and, therefore, is not a good method for identifying a pesticide in case of a poisoning. Refer to the chemical name or common name in case of poisoning or when using a reference manual to seek additional information about the product, how to apply it, or about treatment for poisoning by the active ingredient.
3. PRECAUTIONARY STATEMENTS
   Precautionary statements inform the user of the proper precautions to take to protect self, others, domestic animals and the environment from harmful effects of pesticide exposure. Hazard statements help the user apply the pesticide correctly. Precautions must include signal words to reduce hazards to humans, child hazard warning, and may discuss additional precautions.

a. The **Human Hazard Signal Words** (DANGER, WARNING, CAUTION) indicate the level of acute toxicity of the pesticide:
   DANGER—A taste to a teaspoonful taken by mouth may kill an average-sized adult.
   WARNING—A teaspoonful to an ounce taken by mouth may kill an average-sized adult.
   CAUTION—An ounce to over a pint taken by mouth may kill an average-sized adult.
b. The **Child Hazard Warning** (KEEP OUT OF REACH OF CHILDREN) must be on the front panel of the pesticide product label.
c. The **Statements of Practical Treatment** can include information on: 1) signs and symptoms of poisoning, 2) first aid, 3) antidotes, and 4) a note to physicians in the event of a poisoning.
d. The **Hazards to Humans and Domestic Animals** statements provide information about routes of pesticide exposure to humans (i.e. mouth, skin, lungs) and specific actions to take to prevent pesticide exposure (i.e. protective clothing, facial masks).
e. The **Environmental Hazards** statement helps protect wildlife from a hazardous pesticide. The label must bear special toxicity statements such as "this product is highly toxic to birds, or to fish." General environmental precautions may include: "do not apply directly to water, or do not contaminate, water, food, or feed by storage and disposal of the pesticide."
f. The **Physical or Chemical Hazards** warning statements inform users about the flammability or explosive characteristics of the pesticide.

4. DIRECTIONS FOR USE

   Directions for use provide important information about the proper use, storage, and disposal of the pesticide product. The directions will indicate: 1) How much of the product to use and when to use it, (MORE IS NOT BETTER!), 2) the crop, animal or site the product claims to protect, 3) the proper equipment to be used for application, 4) mixing directions, if they apply, and 5) the proper methods of storage and disposal of the pesticide product that are necessary to follow in order to prevent contamination and accidental exposure.

5. NAME AND ADDRESS OF MANUFACTURER

   The name and address of the manufacturer or distributor must be on the label. This is the contact for additional information not provided on the label.

6. NET CONTENTS

   The net contents indicates how much of the product is in the container. This can be listed in pounds per gallon, gallons, quarts or pints for liquids or in pounds and ounces for dry formulations.

7. EPA REGISTRATION NUMBER

   Pesticide products must bear an EPA registration number which indicates that the federal government has approved the pesticide labeling information.

8. EPA ESTABLISHMENT NUMBER

   The establishment number identifies the facility that produced the product. If anything should go wrong, the facility that made the product can be traced and contacted.

9. USE CLASSIFICATION

   EPA classifies pesticides as either "General Use" or "Restricted Use" pesticides. Restricted use pesticides must only be sold to and used by certified pesticide applicators or persons under the direct supervision of a certified applicator. A statement indicating that a pesticide is a "Restricted Use" product must appear at the top of the front panel of the label. "General Use" pesticides do not require certification or special label designations.

IF YOU CHOOSE TO USE A PESTICIDE PRODUCT—REMEMBER:

- Read the label completely. The label is the law for use of the product.
- Heed the warnings by taking all precautions listed on the label.

- Use the pesticide only if it is really needed. Purchase and use only the amount of pesticide needed. Apply the pesticide at a lower rate if it is effective. It is against the law to exceed the application rate on the label.
- In the event of a pesticide poisoning, you can call the following hotlines to obtain further information:

NATIONAL POISON CENTER HOTLINE: 1-800-222-1222
NATIONAL PESTICIDE INFORMATION CENTER (NPIC): 1-800-858- 7378
TOLL FREE, 24 HOURS A DAY

It is essential that the applicator follow all instructions in the use of agricultural chemicals to avoid injury or damage to themselves, other persons, and the environment. Failure to follow the instructions on a pesticide label can result in a serious pesticide accident and constitutes a legal violation subject to civil or criminal prosecution. Remember, the label is a legal document. The user is liable for personal injury, crop damage, or pollution incurred through misuse of a pesticide.

If you do not understand the directions on the label, ask your pesticide dealer or salesman, vocational agricultural instructor, or University of Nevada Cooperative Extension Educator for assistance.

PESTICIDE FORMULATIONS AND PACKAGING

Pesticides are available in a wide variety of formulations. It is not uncommon to find some active ingredients formulated in several different ways. Formulation of a pesticide is the mixing of an active ingredient with some type of carrier or diluent, either a liquid or solid material. This is done to make the chemical suitable for application with modern equipment, more stable, or in some cases, more attractive to a pest (i.e., bait). Rarely are undiluted active ingredients used to control pests.

Pesticides are available as aerosols, baits, dusts, emulsifiable concentrates, flowables, fumigants, granules, soluble powders, solutions, water dispersible granules, and wettable powders.

Aerosols (A) are liquids that contain the active ingredient in solution, packaged in a pressurized container. "Bug bombs" contain a small amount of active ingredient mixed with a propellant that forces the contents from the can in a spray or mist. They are available for home garden and household use (12 to 16 ounce cans) and commercial use (4 to 10 pound cylinders). They are convenient to use since no measuring or mixing of ingredients is required. They are ready to use as purchased and are easy to store. Caution, never attempt to puncture or burn aerosol cans because they may explode and produce schrapnel.

Baits (B) are composed of an edible substance or some other attractant mixed with a poisonous active ingredient. The bait either attracts pests or is placed in a location where the pest animal will find it. The pest must eat the bait to be killed. They are used to control certain insects, snails and slugs, birds, rodents, and other pest mammals. Most bait formulations contain a low percentage of active ingredient and are often used in kitchens, gardens, granaries, other food-storage and food-processing facilities, and refuse disposal areas. A major advantage is that baits can be placed exactly where and only when needed, and can be removed after use. However, baits may be attractive to children and pets. Often domestic animals and wildlife are killed by these formulations. At times, poisonous baits do not control the target pest because other sources of food are available and more attractive.

Dusts (D) are ready to use as purchased without additional mixing. They contain an active ingredient plus a finely ground, inert substance such as talc, clay, nut hulls, or volcanic ash. The amount of active ingredient usually ranges from 0.5 to 10 percent. Dusts are easy to handle and low-cost application

equipment is available. However, dusts are generally not good buys. They are relatively expensive for the amount of active ingredient in the total formulation; there are often problems with drift; they may be more irritating to the applicator than sprays; often little active material reaches the target host; and rain and wind easily remove dust formulations from treated surfaces. Dusts are recommended mainly for use around the home and garden but not for large-scale use on the farm.

Emulsifiable concentrates (EC) are liquid formulations with the active ingredient dissolved in one or more petroleum solvents. An emulsifier is added so that the material will mix readily with water. Emulsifiable formulations usually contain between 2 and 8 pounds of active ingredient per gallon. EC formulations (ideal for the home gardener) are easy to measure and mix. They are not abrasive and will not plug screens and nozzles. There are, however, several shortcomings associated with the use of these materials. Because of the high concentration of active ingredient(s) in EC formulations, there may be considerable hazard to the applicant and other persons if the product is accidentally spilled on the skin or consumed. They should never be stored under excessively high temperatures or where the liquid can freeze. Most of these formulations are highly flammable because of the petroleum solvent. Compatibility with other products and phytotoxicity (toxicity to plants) of EC materials may occasionally be a problem. Most liquid concentrates of this type can cause rubber hoses, gaskets, and pump parts to deteriorate, and some formulations are detrimental to painted surfaces.

Flowables (F) consist of finely ground solid particles suspended in a liquid carrier. The solid in a flowable is similar to the active ingredient in a wettable powder, except that the solid is formulated to stay in suspension in the liquid. Normally, flowables contain four or more pounds of active ingredient per gallon. Flowables can be mixed readily with water and usually do not clog nozzles. They need only moderate agitation to remain in suspension. The principal disadvantage of flowables is the hazard associated with handling and storing undiluted concentrated materials. The same precautions should be observed with flowables as with emulsifiable concentrates.

Fumigants (LG) are poisonous gases. Many fumigants are formulated as liquids under pressure and become gases when released. They are used to control pests in soil, ship holds, and closed structures such as buildings, granaries, and greenhouses. A single fumigant may kill insects, weed seeds, nematodes, rodents, fungi, and other pests. Fumigants are nonselective and can penetrate into any area that is not airtight. They are the most hazardous of all pesticide formulations. Use extreme care and appropriate protective equipment, including respiratory protection when applying fumigants. Often fumigants are formulated with a foul-smelling or irritating warning gas, but this gas too is frequently highly toxic. Most fumigants can severely irritate or burn the skin, eyes, and lungs, so they are not recommended for use by the homeowner. Aerosols, smokes, mists, and fogs are finely dispersed particles and thus are not considered fumigants.

Granules and pellets (G) are dry, ready-to-use materials normally containing from 2 to 15 percent active ingredient. Most are prepared by applying the active ingredient as a liquid to a coarse, porous, solid material such as clay or ground corn cobs. Granules and pellets are ready to use as purchased and require no further mixing. Since the particles are relatively heavy, granules do not normally present a drift hazard and thus are safer to apply than most other formulations. They can be applied with relatively inexpensive equipment such as seeders and fertilizer spreaders. Granules are applied either directly to the soil, water, or over plants. Although granules are more expensive to use than many other formulations, the ease of application more than offsets the added cost. Granular formulations, with few exceptions, cannot be used for treating foliage because they will not stick to plant surfaces.

Solutions are designed to be used without further dilution or to be diluted with specially refined oil or other petroleum solvents. Some materials in this category can be mixed with water to form true solutions. High-concentrate formulations contain eight or more pounds of active ingredient per gallon,

while low concentrates usually contain less than two pounds active chemical per gallon. Many are formulated with chemicals that function as spreaders and stickers.

Water dispersible granules are dry, granular materials designed to be mixed with water. Upon contact with water, the granules disperse or break apart. The resulting preparation has all the characteristics of a flowable formulation or a finely dispersed wettable powder. The granules are easy to handle and are nearly dust free, which reduces their respiratory hazard. However, since many water dispersible granules have a fairly high percentage of active ingredient, the same precautions as observed with flowables should be taken.

Wettable powders and soluble powders (WP), (SP) are dry, powdered formulations usually containing from 25 to 80 percent active ingredient. Wettable powders are mixed with water to produce suspensions, whereas soluble powders dissolve in water to form solutions. A wetting agent is often added to keep suspended particles of wettable powders uniformly dispersed. As a rule, wettable powders are safer to use on foliage and usually are not absorbed through the skin as quickly as liquid formulations. They are generally easy to handle, transport, store, and mix and are relatively reasonable in cost. Since wettable and soluble powders are dust, they may be hazardous to workers who breathes the concentrated dust during mixing. Wettable powder suspensions need to be agitated constantly to avoid settling of the particles. Wettable powders will cause problems by clogging sprayer screens and nozzles. They are also very abrasive to spray nozzles and pumps. Very hard or alkaline water may cause some difficulty in mixing wettable powders.

Pesticides are packaged in a variety of containers, from pint containers for the home gardener to 55-gallon drums, and in bulk fiberglass containers holding upwards of 1,000 gallons. Dusts, wettable and soluble powders, granules, and other solid formulations are packaged in everything from small cellophane-wrapped bait packs and lined paper bags to cardboard and plastic containers and drums. Liquids are packaged in plastic or metal containers; the choice of container is often dictated by the reactivity or corrosiveness of the liquid materials. Aerosols usually come in reinforced metal containers and cylinders. The variety of packaging materials, shapes, and sizes is endless. Pesticide recognition by container packaging is helpful, but the final authority on the nature of the chemical is the product label itself. Glass containers have been replaced by plastic and corrosive chemicals are not put in metal containers.

PROTECTIVE CLOTHING AND PERSONAL PROTECTIVE EQUIPMENT.

The type of protective clothing and equipment needed depends on the job being done and the type of chemical being used. **READ THE LABEL** on the pesticide container carefully and follow all directions concerning necessary protective clothing and equipment. Many highly toxic pesticides require full protection, including a respirator, while mixing, applying, and disposing of the pesticide. In some cases, special equipment may be required, such as a self-contained air system when using fumigants. In most cases, the handler is required to wear a chemical resistant apron while mixing, loading, or disposing of a product in addition to the required personal protective equipment (PPE) designated for the applicator.

As a minimum, the following protective items should be available when using pesticides.

1) Clean clothing, including a long-sleeved shirt, long trousers, and/or coveralls or a spray suit made of a tightly woven fabric or a water-repellent material. A cotton T-shirt and shorts do not provide adequate protection when handling or applying pesticides.
2) Waterproof gloves, unlined and without a fabric wristband. Shirtsleeves should be worn over gloves in most instances, not tucked inside, unless you are spraying overhead, when sleeves should be tucked into the gloves.

3) Waterproof boots. Pants legs should be worn over boots, not tucked inside.
4) Wide brimmed, waterproof hat.
5) Safety glasses with brow and side protection, goggles or full-face shield.
6) Respirator with a clean cartridge or canister. Make sure you use the correct type of cartridge or canister for the chemical being applied; they differ among particular kinds or groups of toxicants. The cartridge or canister is that portion of the respirator that actually removes the harmful gases, mists, vapors, fumes, or dusts. It should be changed according to specifications, or anytime there is reason to believe noxious substances are not being removed from the air.
7) Handlers, those that mix, load, and dispose of concentrated product, are usually required to wear a chemical-resistant apron over other PPE.

Wash all your protective clothing and equipment after each day's use. Do not wash your clothing with the family wash; keep it separate to avoid any possibility of cross contamination. Keep all your protective equipment clean and in good operating condition. Replaced worn and cracked equipment.

AVOIDING HEAT STRESS

Heat stress is an illness that occurs when the body builds up more heat than it can cope with. Heat stress is not caused by exposure to pesticides, but may affect pesticide handlers and applicators who are working in hot conditions. Wearing personal protective equipment, clothing and devices that protect the body from contact with pesticides can increase the risk of heat stress by limiting the body's ability to cool down.

Several factors work together to cause heat stress. Before beginning a pesticide-handling task, think about whether any of these factors are likely to be a problem. Consider making adjustments in the task itself or in the workplace conditions to avoid heat stroke, including:

- heat factors – temperature, humidity, air movement, and sunlight,
- workload – the amount of effort a task takes,
- personal protective equipment (PPE),
- drinking water intake, and
- scheduling.

Heat and Workload

High temperatures, high humidity, and bright sunlight increase the likelihood of heat stress. Air movement, from wind or from fans, may provide cooling. Because hard work causes the body to produce heat, a person is more likely to develop heat stress when working on foot than when driving a vehicle or flying an aircraft. Lifting or carrying heavy containers or equipment also increases the likelihood of becoming overheated.

Use fans, air conditioning, ventilation systems (indoors), and shade whenever possible. A work area or vehicle sometimes can be shaded by a tarp or canopy or provided with fans, awnings, or air conditioners. Consider wearing cooling vests, garments with ice or frozen-gel inserts that help keep the body cool.

Allow time to adjust to the heat and workload. People who have become used to working in the heat are less likely to be affected by heat stress. To become adjusted to hot work environments, do about two hours of light work per day in the heat for several days in a row; then gradually increase the work period and the workload for the next several days. An adjustment period of at least seven days is recommended. If the warm weather occurs gradually, handlers may adjust naturally to working in hot conditions.

Personal Protective Equipment (PPE)
Pesticide handling tasks often require the use of extra layers of clothing and other PPE. These items keep pesticides from getting on the skin, but they also interfere with natural body cooling that occurs when sweat evaporates. A person can get overheated quickly when wearing PPE.

Select a level of PPE that is appropriate for the pesticide being used. The pesticide label will indicate the minimum PPE required. Use personal experience and PPE selection guides to help decide whether more protection is needed. Do not over-protect if heat stress is a concern, but wear whatever is necessary. Generally, the more protective the equipment is, the more it adds to the heat load.

Choose PPE that is designed to be as cool as possible or that provides a cooling effect, such as a powered air-purifying respirator or, when appropriate, back-vented coveralls. Whenever it is practical, choose coveralls that allow air to pass through, such as woven fabrics (cotton, or cotton-polyester blends). Rubber or plastic fabrics and fabric with chemical-resistant barrier layers allow almost no air to pass through. Non-woven polyolefin (Tyvek) fabrics allow little air to pass through. Non-woven polypropylene and polyester/wood pulp fabrics vary in their resistance to airflow, depending on how they are constructed.

Drinking Water Intake
Evaporation of sweat cools the body. Under the conditions that lead to heat stress, the body produces a large amount of sweat. Unless the water lost in sweat is replaced, body temperature will rise. Drink plenty of water before, during, and after work during heat stress conditions. Do not rely on thirst. A person can lose a dangerous amount of water before feeling thirsty, and the feeling of thirst may stop long before fluids are replaced. Be sure to keep body weight fairly constant. All weight lost because of sweating should be regained every day. People working in heat stress conditions should weigh themselves before work every day and keep their weight constant by drinking plenty of water.

Scheduling
When the combination of temperature, sunlight, humidity, workload, and PPE is likely to lead to overheating, use scheduling to avoid heat stress. Schedule tasks requiring the heaviest workload or the most PPE during the coolest part of the day, usually early morning. When heat stress is high, schedule frequent breaks to allow the body to cool. Consider using a work/rest cycle guide to decide how long to work before taking a break. Remember that people differ in their ability to work in hot conditions. Most work/rest cycle guides are based on an average of many people who are adjusted to the heat and the workload. Workers who have not had time to adjust should work less time than the guide indicates. When using recommended work/rest cycles, continue to be alert for possible heat stress problems. Anyone who gets dangerously hot should stop work immediately and cool down. If necessary, shorten the time between breaks. The above steps will prevent most heat stress problems. But under extremely hot conditions when cooling devices cannot be used, it may be necessary to stop work until conditions improve.

Signs and Symptoms of Heat Stress
Heat stress, even in mild forms, makes people feel ill, impairs their ability to think clearly, and do a good job. They may get tired quickly, feel weak, be less alert, and be less able to use good judgment. Severe heat stress (heat stroke) is a serious illness. Unless victims are cooled quickly, they can die. Severe heat stress is fatal to more than 10 percent of its victims, even young, healthy adults. Victims may remain sensitive to heat for months and be unable to return to the same work.

Learn the signs and symptoms of heat stress and take immediate action to cool down if they appear. Signs and symptoms may include:

- fatigue (exhaustion, muscle weakness)
- headache, nausea, and chills
- dizziness and fainting
- loss of coordination
- severe thirst and dry mouth
- altered behavior (confusion, slurred speech, quarrelsome or irrational attitude)

Heat cramps can be painful. These are muscle spasms in the legs, arms, or stomach caused by loss of body salts through heavy sweating. To relieve cramps, drink cool water or sports drinks. Stretching or kneading the muscles may temporarily relieve the cramps. If there is a chance that stomach cramps are being caused by pesticides rather than salt loss, get medical help right away.

First Aid for Heat Stress

It is not easy to tell the difference between heat stress illness and pesticide poisoning. The signs and symptoms are similar. **Don't waste time trying to decide what is causing the illness**. Get medical help right away.

First aid:

- Get the victim into a shaded or cool area.
- Cool the victim as rapidly as possible by sponging or splashing the skin, especially face, neck, hands, and forearms, with cool water or, when possible, immersing in cool water.
- Carefully remove all PPE and any other clothing that may be making the victim hot.
- Have the victim, if conscious, drink as much cool water as possible.
- Keep the victim quiet until help arrives.

Severe heat stress (heat stroke) is a medical emergency! Cool victim immediately. Brain damage and death may result if treatment is delayed.

MIXING PESTICIDES SAFELY

The concentrated form of many pesticides is relatively poisonous through skin absorption. Rubber gloves and eye protection always should be used for mixing the concentrated form of any pesticide. For very toxic materials, a chemical-resistant apron, a respirator, gloves, and face shield should be worn to prevent inhaling the material or splashing it into the face. Home gardeners should never use a pesticide that is so toxic that a respirator is required.

When mixing pesticides, put water in the spray tank until it is about half full before adding the chemical. Be sure to measure accurately the proper amount of chemical according to instructions on the label. All measuring utensils (spoons, cups, etc.) should be kept in the areas where pesticides are stored. These utensils should be thoroughly washed after each use and should never be used for other purposes.

Always keep your head well above the fill hole. Do not spill or splash when filling the tank. Carefully fill the spray tank with the correct amount of water. Make sure the water supply hose does not come in contact with the spray preparation. This prevents contamination of the hose and avoids the possibility of back-siphoning the pesticide into the water source.

In certain cases it is possible for applicators to mix two or more pesticides together and make a single application. Charts are available that show the compatibility of different pesticides. Only those materials, that are fully compatible, should be mixed together. Applicators should never mix herbicides with other types of pesticides.

APPLYING PESTICIDES SAFELY

First, **READ THE LABEL** carefully before applying any pesticide. Know something about the dangers of the product you intend to use. Be sure that you have properly identified the insect, weed, disease, or other pest that you want to control. It is unlawful to apply a pesticide to a site not specified on the label. Make sure that both the pest and the host plant or animal are included on the product label, and do not apply a pesticide unless it is actually needed.

Do not permit an irresponsible or careless person to handle, mix or apply any pesticide. They may cause harm to themselves or others. Some workers cannot read the instructions on labels; others may not care. *Ability and attitude are of equal importance in the safe, effective use of chemicals*. Applicators should work in pairs when applying highly toxic pesticides. Immediate assistance is then available if one of the applicators becomes ill.

If two or more products are equally effective, select the least toxic material if possible. Your University of Nevada Cooperative Extension Educator, or Specialist, can assist you in selecting the proper pesticide product for your particular pest problem.

Most importantly, use pesticides only on the crops for that they are registered. Spraying it with the wrong material can destroy an entire crop. You can avoid this type of crop damage by carefully following the instructions on the product label.

Be sure that you wear clean clothing and use protective equipment as needed. Never eat, drink, or smoke when applying pesticides; do not even carry food or smoking items with you. Carry fresh water, soap, and paper towels with you in a container protected from the pesticide spray in case you spill the chemical accidentally on your skin and clothing or are exposed to spray drift.

Guard against drift of sprays or dusts. Drift can be reduced or controlled by making the application when there is no wind. Some chemicals are capable of drifting for miles under certain conditions, the most important factors being wind velocity and direction.

Cover all feed and water containers when treating an area around livestock, and use the same precautions when spraying or dusting around your home. People and animals can be severely injured or killed if directions are not followed. Do not spray or dust close to farm ponds where the chemicals may harm fish or livestock that drink from the ponds. Where a farm pond is used for domestic water supply, you should be especially careful not to contaminate the water. Stay a safe distance away from any pond and be sure the wind will not carry drift to the water.
Consider wildlife as well as humans, domestic animals, and plants when applying pesticides. If properly handled, pesticides can control pests without endangering wildlife.

By keeping your application equipment in good condition and operating properly, you can avoid unnecessary hazards to yourself as well as possible damage to the crop. If, while spraying, you have to stop to fix and adjust equipment that is in poor condition, you may receive excessive exposure to the chemical. Also, be sure that you are using the recommended type of equipment. For example, a powder intended to be dissolved in water should never be used in a dust applicator. The label will explain what types of applications are permissible. *Use separate equipment for applying herbicides if at all possible*. It is not advisable, for instance, to use spray equipment that has contained the herbicide 2,4-D for spraying insecticides or fungicides. If you use the same equipment for applying other pesticides, accidental injury to plants is likely to occur unless the equipment has been very thoroughly cleaned with an approved material. The steps in cleaning spray equipment are:

1) Clean the sprayer thoroughly by draining the tank, pump, hoses, and nozzles and flushing with water.
2) Fill the tank with a mixture of water and household ammonia and allow to stand overnight. (Use two cups of ammonia for each ten gallons of water.)
3) Drain and flush with clean water.

Never reenter a recently sprayed field or greenhouse when the foliage is still wet unless you are wearing proper protective clothing and equipment. Pesticide labels list reentry interval times. These intervals should be strictly observed unless applicators or field personnel are properly protected against the residue. It is necessary to post fields or structures with appropriate warning signs to reduce the possibility of someone accidentally walking into a recently sprayed area. Make sure workers are aware of an application to a field and the length of the restricted reentry interval (REI).

Immediately following application and cleaning of equipment, applicators should wash thoroughly and change to all clean clothing. The spray residue must be removed from the skin. Applicators who delay bathing and changing to clean clothing can become extremely ill because of toxic residues on the skin and clothing. As many EC's use petroleum-based carriers, detergent soap is recommended when washing the hands or bathing. Otherwise, plain soap is satisfactory.

DISPOSING OF PESTICIDES SAFELY

Empty pesticide containers, discarded improperly, are potentially very hazardous. A number of deaths and illnesses, particularly among children, have resulted from contact with discarded pesticide containers. An empty can or drum readily entices curious children and animals and therefore should never be left where it can become an attractive nuisance.

First, avoid disposal problems associated with excess pesticides by purchasing only the amount you will need for an application or one growing season. DON'T STOCKPILE PESTICIDES; registrations change and new chemicals may be better than old ones. Mix only as much pesticide as you will need for a particular application. If you should happen to mix too much, it is best to apply the material in the recommended manner to another of the crops listed on the label.

If you must dispose of a surplus mixture, dispose only according to label directions. Commercial establishments and custom applicators should make sure that they are consistent with the hazardous waste guidelines established under the Federal Resource Conservation Recovery Act (FRCRA) as well as all comparable state statutes prior to disposing of pesticide wastes, and according to label directions. That is, follow disposal instructions on the pesticide label and use adequate safety equipment and proper clothing when disposing of pesticide wastes and empty containers.

Empty containers made of glass, metal, or plastic should be rinsed three times with water prior to disposal. Pour this rinsate back into the sprayer and spray out according to the label directions. After rinsing, containers should be punctured, broken, or crushed and then buried at least 18 inches deep in a properly designated burial site away from streams and other water supplies. Disposal of triple rinsed containers in a sanitary landfill is permissible, but it is a good policy to check with your local solid waste authority prior to discarding any pesticide containers. Many are classified as hazardous waste and must be disposed of accordingly. Combustible containers can be burned (if permitted by the instructions on the label and local ordinances) or disposed of in a sanitary landfill. Do not burn pesticide containers near residential areas or where persons can come in contact with the smoke. Always stand upwind when burning pesticide containers; the smoke may contain toxic vapors. This practice, along with burying containers, is being discontinued in most areas.

Large metal drums should be sent to a barrel-reconditioning company if possible or handled the same way as small noncombustible containers. Never reuse empty pesticide containers for any other purpose.

Homeowners may dispose of small quantities of pesticide waste through a municipal refuse collection service. Liquid formulations in quantities of less than 1 gallon should be left in the original container. Make sure the cap is closed securely and then wrap the container in several layers of newspaper (tie or tape the newspaper if needed) before placing in a trash receptacle. Dry formulations (up to 10 pounds) should also be wrapped securely with paper or placed in a carton prior to disposal in a trash container. Homeowners should handle empty pesticide containers in a similar way.

If a leak or spill occurs, clean it up immediately. Scatter sawdust, pet litter, or some other absorbent material over the spilled pesticide, then sweep this up, scatter lime over the contaminated area, and wash the area thoroughly with detergent and water. Dispose of the contaminated absorbent, lime, and wash water in a proper disposal site. Always be sure to clean up thoroughly and change to clean clothing after handling or disposing of pesticides.

If you have a serious accident or have problems during the cleanup phase, you should contact the Pesticide Accident Hotline (CHEMTREC), 1-800-424-9300 or the National Poison Center Hotline, 1-800-222-1222. Both offices are staffed 24 hours a day by trained personnel who are knowledgeable in emergencies involving handling pesticides, including spills and accidents.

STORING PESTICIDES SAFELY

Always store pesticides and other chemicals in their original containers with the label attached and the lid closed securely. Using soda pop bottles, fruit jars, or other types of non-pesticide containers can have serious consequences. Small children as well as most adults associate the shape of the container with its contents. Consequently, a child or an adult may be seriously poisoned or even killed.

Keep all pesticides out of the reach of children, pets, and irresponsible people. Do not store them in your home near food. This will help reduce the exposure hazard and also prevent possible contamination of food. LOCK all chemicals in a building or cabinet. The lock should keep everyone out of the chemicals except those who are qualified to use them. Also, be sure to identify the storage facility with a sign that clearly indicates that pesticides are stored in the structure.

Do not store pesticides near livestock and pet feeds to prevent possible contamination. Livestock and pets may be killed in this manner. Contamination of crop seeds by pesticides can reduce or prevent germination. Seed that is intentionally treated with a fungicide or an insecticide presents a potential hazard if not stored properly. Such seed is usually treated with a brightly colored dye that serves as a warning that the seed has been treated with pesticide. Unfortunately, the brightly colored seed may be attractive to children. Treated seed should never be used for food or livestock feed or mixed with untreated seed. It should be handled with the same care as the pesticide itself and stored in a locked storage facility away from feed, veterinary supplies, pesticides and other farm chemicals, and farm equipment.

Herbicides should be stored separately from other types of pesticides; the danger of cross-contamination is too great. Never store respirators, PPE, and other safety equipment in the same room with pesticides because of possible contamination. Maintain all safety equipment in top working condition.

Never leave a portion of a pesticide in an unmarked or unlabeled container. Other people may use the pesticide by mistake and injure themselves or others. Those who use the pesticide do not have the label with directions for its proper, safe use, and relying on verbal directions is a poor practice. Pesticides in

large containers, that are heavy to handle, should be stored on or near the floor to prevent their falling. Extremely heavy containers should always be placed on the floor or a pallet, never on shelves. Containers should not extend beyond the shelving or cabinets where they may be bumped, knocked off the shelf, broken open, and spilled.

Check containers frequently for leaks and breaks. Pesticides should be stored within a second container of equal or greater volume in order to contain the entire pesticide if a package or container breaks. If a leak or break does occur, transfer the contents to an empty container that originally held the same material. Otherwise, dispose of the contents in the prescribed manner. Clean up spilled pesticides promptly and thoroughly using proper PPE and safety equipment during the cleanup procedure. Dispose of the pesticide waste in a proper manner.

Be especially careful that corrosive materials are stored and handled in containers designed for such materials. A corrosive material in the wrong kind of container may corrode the container and cause serious damage.

Pesticides in glass bottles should not be stored near heat, where glass containers can break or explode, spreading the chemical over a large area. Materials in glass containers should be stored in dry, cool areas. However, it is necessary to protect some of them from freezing, so check the label carefully for proper storage information. Storage facilities with temperature regulations are recommended. Excessive heat and freezing often alters pesticides making them less effective or unusable.

To be sure that the label remains on the container in readable condition, protect it with transparent tape or lacquer if the pesticide is to be stored for a long period. Remember, the label is the most important safety factor in the use of pesticides. *Do not let it become damaged or destroyed*.

Keep an inventory of all pesticides and mark each container with the date of purchase. If a product has an effective shelf life recorded on the label, you will know exactly when expiration occurs if you have marked the purchase date on the label.

It is a good idea to inform your local fire department if you store large quantities of agricultural chemicals, including fertilizers. Chemical fires often cannot be extinguished by ordinary means and the smoke from the fire can be extremely hazardous to fire fighters. The fire department must be properly prepared in the event of an agricultural chemical fire.

The name of your physician, hospital, and nearest poison control center should be posted in a prominent location in the storage facility. Remember to consult the product label for specific storage information.

TRANSPORTING PESTICIDES SAFELY

Never transport pesticides inside the passenger compartment of any vehicle. No one should be permitted to ride near pesticides. In a vehicular accident, a pesticide spill might result in injury or even death to the occupants.

Secure pesticides in the trunk of a car or back of a truck so they cannot roll or slide around. Putting pesticide containers inside a cardboard box will keep them from tipping over. Never carry food, livestock feed, fertilizers, or seed together with pesticides. The danger of contamination is too great. It is a good policy to transport weed control chemicals separately from all other pesticides, since a spill could lead to cross-contamination.

Never leave your vehicle unattended when transporting pesticides in an open truck bed. You are legally responsible if curious children or careless adults are accidentally poisoned from pesticides left

unattended and exposed in your vehicle. Always haul pesticides in the trunk or in a secure compartment that can be locked to avoid their theft.

If a spill does occur, clean it up immediately. Always follow the instructions on the label regarding the use of protective clothing during the cleanup and proper disposal of the waste material.

IF A POISONING OCCURS

Above all, know how to recognize symptoms of pesticide poisoning. These may appear immediately after exposure or sometimes not for several hours or even days. Symptoms can include headache, giddiness, sweating, blurred vision, cramps, nausea, vomiting, diarrhea, numbness, changes in heart rate, general muscle weakness, difficulty in breathing, pinpoint pupils, rashes, and allergic reactions; in advanced poisoning cases there may be convulsions and coma that ultimately could lead to death. The symptoms could be mistaken for brain hemorrhage, heat exhaustion or heat stroke, pneumonia, asthma, respiratory and intestinal infections, and several other illnesses.

Know the general poisoning symptoms for the pesticides being used in your area. If at any time after exposure to a pesticide a person does not feel well, take them to a doctor or hospital at once. *Take the pesticide label or the container with you if at all possible*. The doctor needs to know what ingredients are in the pesticide. Often an antidote is listed right on the label.

If you use pesticides or reside near areas where pesticides are used, you should have the name and number of the nearest poison control center readily available or call 1-800-222-1222. There are times when you and the doctor may have to use the services of a center. The centers are staffed on a 24-hour basis. Contact your local hospital, physician, University of Nevada Cooperative Extension office, or Nevada Department of Agriculture to determine the nearest poison control center in your area.

There may be times when immediate action is necessary to prevent serious and often permanent injury to the victim of pesticide poisoning. It could indeed be a life-and-death matter in certain situations. It may be necessary for someone to administer first aid to the victim.

If the pesticide has been spilled on the skin or clothing, strip off all clothing immediately and thoroughly wash the skin with soap and water. Some pesticides are absorbed through the skin very rapidly. It may be best to dispose of the contaminated clothing, but if you decide to wash the clothing do not wash it with the family wash; keep it separate to avoid any possibility of cross-contaminating the family clothes.

If the pesticide has been inhaled. First, get the victim to fresh air. Have the person lie down and loosen all their clothing. Keep the victim warm and administer first aid if needed. Contact a physician or the nearest poison control center or call 1-800-222-1222 as soon as possible.

If the pesticide has been swallowed. The most important choice one must make when aiding a person who has swallowed a pesticide is whether or not to induce vomiting. The decision must be made quickly and accurately; the victim's life may depend on it. Usually it is best to void the swallowed poison fast, however:

> ***NEVER*** INDUCE VOMITING if the victim is unconscious or is in convulsions. The victim could choke to death on the vomitus.
> ***NEVER*** INDUCE VOMITING if the victim has swallowed petroleum products (kerosene, gasoline, oil, lighter fluid) unless so directed by the label or by a physician. Many pesticides that are formulated as emulsifiable concentrates are dissolved in petroleum products. The words "emulsifiable concentrate" on the pesticide label are signals NOT to induce vomiting without

first consulting the product label or a physician. Petroleum products aspirated into the lungs can cause serious respiratory disorders. If a person swallowed a dilute preparation, he should be forced to vomit immediately.
NEVER INDUCE VOMITING if the victim has swallowed a corrosive poison, a strong acid or alkali (base). Determine what the person has ingested. The victim may experience severe pain and have extensive mouth and throat burns. A corrosive poison will burn the throat and mouth as severely coming up as it did going down.

To neutralize acids – If you are sure the poison is an acid, give the victim milk of magnesia (1 tablespoon to 1 cup of water) or baking soda in water.

To neutralize alkali – If you are sure the poison is an alkali, give the victim lemon juice or vinegar.

How to induce vomiting. Do not waste a lot of time inducing vomiting. Use it only as first aid until you can get the victim to a hospital. Make sure the victim is lying face down or kneeling forward while retching or vomiting. Do not let him lie on his back because vomitus could enter the lungs and do additional damage.

First give the patient large amounts of water to dilute the poison. Give at least one to two glassfuls to victims. Do not use carbonated beverages.

If possible, use ipecac syrup to induce vomiting. This material is extremely effective in emptying the stomach contents and is available in small quantities on a nonprescription basis from most drugstores. If ipecac syrup is not available put your finger or the blunt end of a spoon at the back of the throat. Do not use anything sharp or pointed. Never use salt water to induce vomiting. Collect the vomitus for the doctor; he may need it for chemical tests.

Activated charcoal. After vomiting has occurred, give the patient two to four tablespoons of activated charcoal in water. Never administer activated charcoal at the same time as ipecac syrup, because the charcoal will absorb the ipecac. Activated charcoal absorbs many poisons at a high rate. It is available from most drug stores. In a poisoning emergency, "GroSafe", a commercial preparation of activated charcoal, may be substituted for a pharmaceutical grade of activated charcoal.

Only first aid has been discussed here. Be sure to take the victim to a doctor or hospital as soon as possible and take the pesticide label with you.

KEEPING RECORDS

Every person using pesticides should keep careful, written records of each application. He/she should write down:

1) date and time of application;
2) location of the application;
3) type of equipment used;
4) what pesticide was used;
5) the formulation;
6) rate of application (e.g., gallons per acre) and total area treated;
7) what crop or site was treated (e.g., corn, ornamentals, house foundation);
8) size of the area treated and its location;
9) what pest was controlled;
10) weather conditions at time of application;
11) name of applicator; and certification number if the pesticide is a restricted material;
12) miscellaneous comments.

Certified applicators that use restricted-use pesticides are required to keep records for two years, although all users of pesticides should keep records for their own protection. If a farmer's crop is seized for having an illegal residue, the application records may prove that the pesticides were not used illegally.

Your personal protection is not the only reason for keeping pesticide application records. Many herbicides can be used safely on certain crops, but may be fatal to others. Without written records it is difficult to know what pesticides have been used on a field during the previous few years.

More detailed information about record keeping requirements can be obtained from the Nevada Department of Agriculture.

SUMMARY

The best way to avoid the hazards of pesticides is to know what you are using and how to use it. The only way you can be sure of this is to **READ THE LABEL**. Most pesticides are safe when properly used.

The attitude of the user is of utmost importance. If a user mistakenly thinks he or she knows exactly how to use a pesticide, or does not care what precautions should be taken to prevent injury to persons, animals or plants, injury or crop damage is likely to occur. If such users realized the legal and moral obligations in using pesticides, they would be more apt to **READ THE LABEL** and follow the instructions closely.

Merely reading the label will not ensure safety; the instructions must be followed. By taking adequate precautions and practicing good management with safety in mind, there should be few accidents from the use of pesticides.

CALIBRATION AND EQUIPMENT

Pesticide Application

The skill and accuracy with that you apply a pesticide is just as important as choosing the correct pesticide. Once you select your equipment, you must learn to operate, service, and calibrate it.

Selecting Pesticide Application Equipment

Type and size of equipment depends on the use, where it will be used, what materials (formulations) will be used, the amount of use (size of area treated and number of times it will be treated), and the need for accessories (booms, drop nozzles, etc.).

If selected properly, your equipment can save you time and money in managing pests

Types of Equipment

Manually operated:

1. Aerosol – refers to particle size rather than the method used. Produces particles 0.1 to 50 microns in diameter. Generally contact poisons are applied as aerosols.
2. Trigger - pump, wash bottle – ideal for spot and individual plant treatment.
3. Handgun – flit gun, push-pull - produces a mist.
4. Compressed air – general home or business use. These are most common.
5. Bucket or trombone – small trees, applies pesticides farther than compressed air.
6. Garden hose – proportional venturi, the application rate and results may be variable.

Power-drive: [may be electrical, gas, or diesel driven, or power take-off (PTO)]

1. Low-pressure – with or without boom or handgun, 20 to100 psi: 300 gallon or larger tanks.
2. High-pressure – usually with gun, though a boom may be used 500 to 1000 psi: 300 gallon or larger tanks
3. Air blast – sprays, either one side or both sides of equipment, up to a 90 foot swath. Both sides can be used for ULV applications.
4. Aerial spraying – can apply pesticides conventionally or ULV over large acreages.

Types and sizes of pumps: in order to prevent unnecessary wear, match the pump and the spray material.

Manual pumps: (see manually operated sprayers)

Power pumps: (see Table 2.)

Types of drives:

1. Wheel drive – estate type equipment – use on less than five acres, small orchard, etc.
2. PTO drive – tractor power take off is adaptable to boom and gun applications
3. Separate engine – large high-pressure sprayers use, including boom, gun and airblast
4. Hydraulic motor drive – uses hydraulic system of tractor or other vehicle for boom sprayers
5. Electric motor drive – limited by access to electricity, is adapted to gun and boom sprayers

Table 2. Power pump specification

Pump Type	PSI[1]	GPM[2]	RPM	Comments
Piston	800	1-60	100-200	Abrasives OK; wears well; easy service
Gear	100	5-20	500-1800	Non-abrasives and non-corrosives only; either replace pump or kit
Flexible	50	1-30	500-1500	Mild abrasives OK; impeller, cannot use dry
Roller	300	1-35	600-1800	Non-abrasives only
Diaphragm	100	1-10	200-1200	Abrasives and corrosives OK; kit serviced
Centrifugal	50	1-150	600-4000	Abrasives OK

[1]PSI=pressure in Pounds per Square Inch
[2]GPM=Gallons of Spray per Minute

Types and sizes of tanks: vary in size, shape and material; durability is of prime consideration, then size and shape are next in importance.

Materials:

1. Mild steel – will flake unless it's lined.
2. Galvanized steel – often corrodes with time.
3. Fiberglass – visible liquid level, light-weight and fairly durable.
4. Stainless steel – this is best and most expensive.
5. Plastic – this is good, liquid level is visible and newer products are durable.

Types of agitators: power-operated sprayers, generally use 10 percent of the total power for agitation.

1. Mechanical: the best system, it typically uses rotating paddles in the tank, foam is possible if the paddle rpm is too high.
2. Jet action: robs the pump of power. Need to add an extra 10 percent to the pump capacity to be effective.
3. Return flow: not recommended. Use in small tanks only.

Types and sizes of nozzles: the success of your spraying operation depends to a large extent on the nozzles used. A spray nozzle is made up of:

1. A nozzle body
2. Strainer
3. Cap
4. Spray tip

They may be made of:

1. Stainless steel – very durable, but pricey.
2. Nylon – swells when exposed to some solvents; resists wear and corrosion well.
3. Aluminum – short thread life; subject to corrosion; not recommended.
4. Brass – abraded (worn) by wettable powders, tips may be easily damaged.
5. Ceramic – most durable, very expensive and easily chipped or broken.

Nozzle designs:

1. Flat fan – herbicides, some insecticides, 20 to 60 psi
2. Even fan – herbicides, 20 to 40 psi
3. Cone – insecticides and fungicide, 40 to 120 psi

4. Flooding flat fan – herbicides and fertilizers for maximum drift control
5. Boomless – weed and bush control, 10 to 30 psi
6. Air-injection – foam sprays, drift control, 15 to 40 psi
7. Adjustable – hand guns, 25 to 100+ psi

Nozzles should be mounted and adjusted on a boom sprayer to allow 20 percent overlap in the spray pattern. Therefore as you increase the height of the boom above the crop you must change the angle of the spray pattern. The following can be used as a guide.

Nozzle angle	Inches from target area
67 deg..	21-23
73 deg.	20-22
80 deg.	17-19

Spray output will vary with the number of nozzles you have on your boom.

Types of accessories:

1. Sight gauges – use if you have a non-see-through tank. Calibrated ones are available.
2. Pressure gauges – allow for changes in pressure during operation. It is best to have one at the pump and one on the boom.
3. Pressure regulators – allows for management of pressure during application.
4. Unloading valves – handy for quick unloading of chemicals.
5. Strainers – removes large pieces of debris. A strainer in the nozzle removes small stuff.
6. Control valves – must be quick acting and positive to allow precise on and off operation.
7. Booms – either steel pipe with nozzles or a bar that holds nozzles.
8. Hoses, pipes, and tubing – must be strong, corrosion proof, chemical and light resistant. With changes of hose sizes, the pressure will be affected.

DRIFT

Drift is no accident. It has clearly defined causes, and should be avoided at all costs.

Things that affect or cause drift.

1. Type of equipment, technique and operator skill influences droplet size.
   a. Select nozzles according to the droplet size of the spray.
   b. Adjust the pressure to minimize misting and increase droplet size.
   c. Nozzle fan angle affects drop size. The thinner the spray sheet, the finer the spray. Increasing nozzle output increases droplet size for all main nozzle types, and more so for flat fan and flooding types. Remember! Wind velocity decreases closer to the ground, lower your boom but keep the 20 percent spray overlap. Low relative humidity and wind cause drift from dust after the spray evaporates.
2. Microweather vs. microclimate: what's happening now?
3. Size of area to be treated.
4. Chemical formulation used
   a. Thickeners
   b. Additives
   c. Foaming agents
   d. Emulsifying agent

Understand to control or avoid problems.

1. Don't spray when it's windy.
2. 10-mph wind avoid drift injury.

3. Avoid drift at all costs.
4. Drift needs very precise monitoring.

As a rule, drift kills nothing. It only creates residues.

You get more drift with:

1. Smaller droplets.
2. Increased distance between nozzle and target.
3. Higher wind velocities.
4. Lower relative humidity.

Select nozzles and pressures carefully.

CALIBRATION OF YOUR FIELD SPRAYER

Modern pesticide formulations need to be applied at very specific rates to obtain desired results and to minimize potential health, safety, and environmental problems. Over or under application will result in less than desirable control of the target pest and increase the risk of causing problems. Both waste time and money. Especially with herbicides, this in NOT a case where "*if a little is good, a lot is better*". Therefore, accurate application rates are a must for best results. Accuracy should be within 5 percent of the recommended application rate for best results.

Calibration is often presented with many mathematical calculations, which tend to impress us only with the difficulty of the calibration process. In order to simplify the calibration process, the method described below has completed most of the math for you. This section is designed to be used with tractor or pickup mounted application equipment, when applying emulsifiable concentrates or other liquid pesticide formulations.

Because of various field conditions, different application equipment, and different speeds crossing a field, EACH person must calibrate their application equipment before using a sprayer for pesticide applications. This way, the pesticide mixture can be adjusted for individual and field differences and the appropriate pesticide application rate can be obtained.

FOLLOW THESE INSUCTIONS:

1. Clean your sprayer thoroughly with soap and water, sudsy ammonia, or a commercial tank cleaner. Dispose of the rinse material properly. Make sure all of the equipment is working properly. Fill sprayer with clean water.
2. Measure a specific distance such as 88, 100, 200, or 300 feet in a typical area of the field you will be spraying. If using a tractor, set your tractor RPM and select a gear, which will be used in that field. If using a truck decide upon a gear and speed or RPM. Record the time needed to cover the distance.
3. Place a measured container under each nozzle to collect the spray. Turn on the spray bar the same length of time it took to spray the distance in step 2. Because of variability between nozzles it is best if each nozzle is collected separately. Record the amount collected in each container for each nozzle, and add them together. Divided the total by the number of nozzles to get an average spray quantity per nozzle. If any nozzle sprays 10 percent over or under the average clean it, or replace it and repeat step 3.
4. The total amount collected in step 3 is converted to gallons per acre. Do this by multiplying the distance originally measure (traveled) by the width of the spray pattern to obtain the area of the plot sprayed. Divide the area of the plot sprayed by 43,560 (number of square feet in an acre) to obtain the fraction of an acre sprayed. Now you know the plot area sprayed and the liquid volume sprayed on the plot. Divide the area into the quantity of liquid to obtain the number of gallons of water applied per acre.

5. To determine the amount of pesticide you need to mix in a gallon of water, see Table 3 below. You only need to do additional math if the pesticide you are using is formulated at a rate different than 4 pounds active ingredient (a.i.) per gallon. For example: Controlling a certain weed requires 3 quarts per acre of a 2,4-D product with 4 pounds a.i. per gallon. Your spray volume calculated above is 40 gallons per acre. According to the chart, you would mix 2.3 fluid ounces of 2,4-D per gallon of water to apply the correct amount of herbicide per acre. If your tank holds 100 gallons of water, then you would add 1 gallon, 3 quarts and 6 fl ounces of 2,4-D to your 100-gallon sprayer tank. (2.3 fl. oz. X 100 + 230 fl. oz. Divide that by using the handy conversions.)

Table 3. Volume of pesticide (4 lbs. active ingredients per gallon) to mix in one gallon water*

Spray Water Volume	Desired application rate of pesticide per acre			
	1 qt	2 qt	3 qt	4 qt
10	3.3 fl oz	6.5 fl oz	9.5 fl oz	12.3 fl oz
15	2.0 fl oz	4.0 fl oz	6.2 fl oz	8.5 fl oz
20	10.0 tsp.	3.2 fl oz	4.8 fl oz	6.3 fl oz
30	6.0 tsp.	2.0 fl oz	3.2 fl oz	4.2 fl oz
40	4.8 tsp.	1.6 fl oz	2.3 fl oz	3.2 fl oz
50	3.8 tsp.	1.2 fl oz	2.0 fl oz	2.5 fl oz
60	3.2 tsp.	6.3 tsp.	1.6 fl oz	2.0 fl oz
70	2.8 tsp.	5.5 tsp.	1.3 fl oz	1.8 fl oz
80	2.3 tsp.	4.8 tsp.	7.2 tsp.	9.5 tsp.
100	2.0 tsp.	3.8 tsp.	5.8 tsp.	7.6 tsp.

*This table only applies to pesticides that have 4 pounds of active ingredients per gallon. **Read the label**. If the pesticide concentration you are using is different than 4 lb./gal a.i., then you will need to divide the pesticide mixture number (oz or tsp.) in the chart by 4 and then multiply that answer by the number of pounds of a.i. per gallon listed on your product label. That quantity would then be mixed per gallon of water in your sprayer.

Handy Conversions

3 teaspoons = 1 tablespoon	2 tablespoons = 1 fluid ounce
8 fluid ounces = 1 cup	1 cup = 16 tablespoons
2 cups = 1 pint	2 pints = 1 quart
4 quarts = 1 gallon	1 gallon = 128 fluid ounces

1 acre = 43,560 square feet

Refill Method Sprayer Calibration

A. Acre-Volume Method:
   1. Stake out 1 acre on same ground to be sprayed (210' X 210')
   2. Fill tank with water and mark level
   3. Start sprayer power unit
   4. Set desired pressure
   5. Select ground speed
   6. Spray test acre
   7. Add and measure water to fill the tank back to the original level, say ten gallons in this example
   8. Amount added equals application rate per acre

Calculate acres that can be sprayed with one tank (100 gallons)

$$\frac{\text{\#Gallons in Spray Tank}}{\text{Application Rate/Acre}} = \text{Acres per Full Tank}$$

$$\frac{\text{100 Gallons in Tank}}{\text{10 Gallons/Acre}} = \text{10 Acres per Tank}$$

B. Area-Volume Refill Method:

1. Stake out test area (1000' for boom broadcast)
2. Put water in tank and mark level
3. Start sprayer engine
4. Set pressure
5. Establish ground speed before entering course
6. Enter and spray test area, start and stop the spraying at the beginning and end of the test area while moving at the speed to be used when spraying
7. Return, fill and measure the amount of water to refill the tank sprayer to the original mark
8. Record amount of water used
9. Calculate rate of application

Find Area Sprayed

$$\frac{\text{Width of Swath X Length of Run}}{\text{Square Feet per Acre}} = \frac{\text{16' Boom X 1000'}}{\text{43,560}} = .37 \text{ Acres}$$

Find Application Rate (8 Gallons Used to Refill Tank)

$$\frac{\text{Gallons Used to Refill Tank}}{\text{Number of Acres Sprayed}} = \frac{\text{8 Gallons}}{\text{37 Acres}} = 22 \text{ Gallons/Acre}$$

Find Acres Per Full Spray Tank

$$\frac{\text{Gallons in Spray Tank}}{\text{Application Rate (GPA)}} = \frac{\text{100 Gallons in Tank}}{\text{22 Gallons Per Acre}} = 4.5 \text{ Acres per Spray Tank}$$

To Determine the Final Spray Mixture

Liquid Formulation

From the Label: 4 Quarts/100 Gallons
Sprayer Tank = 175 Gallons

175 Gallons/100 Gallons X 4 Quarts =

$\frac{175}{100} = 1.75$

1.75 X 4 = 7 Quarts/Tank

Dry Formulation

From the Label: 2 Pounds per Acre
Sprayer Tank = 100 Gallons
Rate of Application: 22 Gallons/Acre

$$\frac{\text{Gallons per Spray Tank X Lbs. Material/Acre}}{\text{Gallons per Acre Applied Desired (From Label)}}$$

= Pounds of Material to Add to Sprayer Tank

$$\frac{\text{100 Gallon Tank}}{\text{22 Gallons/Acre}} = \text{4.5 Acres Per Tank X 2 Lbs./Acre}$$

= 9 Pounds of Material Per Tank

To Vary the Output

1. Adjust pressure (minor correction)
2. Adjust speed (major correction)
3. Change nozzle or adjust nozzle spacing (major correction)

Hand Pesticide Application Calibration

Modern pesticide formulations need to be applied at very specific rates to obtain desired results and to minimize potential health or safety problems. Over or under application will result in less than desirable control of the target pest and increase the risk of causing problems. Especially with herbicides, this is NOT a case where "*if a little is good, a lot is better*". Therefore, accurate application rates are a must for best results. Accuracy should be within 5 percent for best results.

Calibration is often presented with many mathematical calculations, which tend to impress us only with the difficulty of the calibration process. In order to simplify the calibration process, this method has completed most of the math for you. This section is designed to be used with individual backpack or other hand carried application equipment, or nozzles, when applying emulsifiable concentrates or other liquid pesticide formulations.

Because each of us move at different speeds, have different application equipment, and we have a different idea of what full coverage is, EACH person must calibrate their application equipment before using hand sprayers for pesticide applications. This way, the pesticide mixture can be adjusted for individual differences and the correct pesticide application rate can be obtained.

FOLLOW THESE INSTRUCTIONS:

1. Clean your sprayer thoroughly with soap and water, sudsy ammonia, or a commercial tank cleaner. Dispose of the rinse material properly. Make sure your application equipment is working properly. Fill sprayer full with clean water.
2. Measure an 18.5-foot X 18.5-foot spot in a typical weedy area. Spray this area uniformly with water and record the number of seconds it takes to evenly cover the area. Remember that consistency is vital to uniform coverage. Develop a smooth sweeping motion with the spray wand while you walk at a comfortable pace. Keep the pressure constant.
3. Spray water into a large container for the same length of time it took you to spray the plot. 2. Be sure to maintain the same pressure used in step 2. Measure the fluid ounces you collect. If the product you are using is formulated at 4 pounds active ingredient (a.i.) per gallon, the ounces of water collected for that specific time converts directly to gallons per acre of pesticide mixture to be applied, i.e. 30 ounces of water sprayed is equal to a rate of 30 gallons per acre.
4. The first three steps should be repeated twice more and the results averaged for accuracy.
5. Determine the amount of herbicide needed to mix in a gallon of water, see Table 4. If the pesticide you are using is formulated at a rate different than 4 pounds a.i. per gallon you will need to do the additional math described at the bottom of the chart. For example: Controlling a certain weed requires 3 quarts per acre of a 2,4-D product with 4 pounds a.i. per gallon. Your spray volume calculated above is 40 gallons per acre. According to the chart, you would mix 2.3 fluid ounces of 2,4-D per gallon of water to apply the correct amount of herbicide per acre. If your backpack sprayer holds 4 gallons of water than you would add 9.2 fluid ounces of 2,4-D to your sprayer tank. (2.3 fl. oz. X 4 = 9.2 fl. oz. If needed, divide that out by using the handy conversions)

Table 4. Volume of pesticide (4 lbs. active ingredients per gallon) to mix in one gallon water*

Spray Water Volume (Gallons per Acre)	Desired application rate of pesticide per acre			
	1 qt	2 qt.	3 qt.	4 qt.
10	3.3 fl oz	6.5 fl oz	9.5 fl oz	12.3 fl oz
15	2.0 fl oz	4.0 fl oz	6.2 fl oz	8.5 fl oz
20	10.0 tsp.	3.2 fl oz	4.8 fl oz	6.3 fl oz
30	6.0 tsp.	2.0 fl oz	3.2 fl oz	4.2 fl oz
40	4.8 tsp.	1.6 fl oz	2.3 fl oz	3.2 fl oz
50	3.8 tsp.	1.2 fl oz	2.0 fl oz	2.5 fl oz
60	3.2 tsp.	6.3 tsp.	1.6 fl oz	2.0 fl oz
70	2.8 tsp.	5.5 tsp.	1.3 fl oz	1.8 fl oz
80	2.3 tsp.	4.8 tsp.	7.2 tsp.	9.5 tsp.
100	2.0 tsp.	3.8 tsp.	5.8 tsp.	7.6 tsp.

*This table only applies to pesticides that have 4 pounds of active ingredients per gallon. **Read the label**. If the pesticide concentration you are using is different than 4 lb./gal a.i., then you will need to divide the pesticide mixture number (oz or tsp.) in the chart by 4 and then multiply that answer by the number of pounds of a.i. per gallon listed on your product label. That quantity would then be mixed per gallon of water in your sprayer.

Handy Conversions

3 teaspoons = 1 tablespoon 2 tablespoons = 1 fluid ounce
8 fluid ounces = 1 cup 1 cup = 16 tablespoons
2 cups = 1 pint 2 pints = 1 quart
4 quarts = 1 gallon 1 gallon = 128 fluid ounces
1 acre = 43,560 square feet

HOW TO CALIBRATE YOUR GRANULAR APPLICATORS

For band application:
Where you have only a broadcast rate per acre in pounds, use this formula to calculate rate per acre for band treatment.

$$\frac{\text{Band Width in Inches}}{\text{Distance Between Rows in Inches}} \times \text{Rate/Acre for Broadcast Treatment} = \text{Amount Needed for Band Treatment}$$

For example, a broadcast rate per acre is 40 pounds. Your band width is 7 inches in 36 rows

$$\frac{7}{36} \times 40 = \frac{280}{36} = 7.77 \text{ or } 7\ \tfrac{3}{4} \text{ Pounds per Acre}$$

For band application at different row spacing:
Many granular insecticide recommendations are based on an acre of 40-inch rows, or 13,068 feet of row. Row widths fewer than 40 inches require more granular material per acres, but the calibration in the row stays the same. Narrow rows will take more granular material per acre than wide 40-inch rows. Use this Table 5 to calculate the actual amount used per acre.

Table 5. Band rates in pounds per acre for these row spacing

40 inch	38 inch	36 inch	30 inch	20 inch
2	2.1	2.2	2.7	4
3	3.2	3.4	4.0	6
4	4.3	4.5	5.3	8
5	5.3	5.6	6.7	10
6	6.4	6.8	8.0	12
7	7.5	7.9	9.3	14
8	8.5	9.0	10.7	16
9	9.6	10.1	12.0	18
10	10.7	11.2	13.3	20
12	12.7	13.5	16.0	24
14	14.9	15.8	18.7	28
16	17.0	18.0	21.3	32

Attach paper or plastic bags or granular calibration tubes over the bottom end of each row delivery tube.

While operating the applicators, drive a distance equal to 1/20 of an acre. Determine the distance by this formula:

$$\frac{\text{4,560 (Square Feet per Acre)}}{\text{Row Width in Feet X Number of Rows on Applicator X 20}} = \text{Distance to Drive in Feet}$$

For example, drive with a 4 row applicator set to a 36 inch (3 feet) row spacing:

$$\frac{43{,}560}{3 \text{ X } 4 \text{ X } 20} \quad \text{Or} \quad \frac{43{,}560}{240} = 181.5 \text{ Feet}$$

After driving the required distance, remove sacks or tubes and weigh or measure the contents of each. Contents of all should be equal. If not, adjust the output of the row applicator accordingly and repeat the run to check the calibration. Then combine contents of all sacks and weigh. Total weight should be 1/20 of the recommended amount of pesticide granules per acre.

For example, a granular insecticide is recommended for row application at 1 pound active ingredient per acre for 40-inch row spacing. The formulated product is a 20 percent granule. So 5 pounds (80 ounces) would equal 1 pound of active ingredient. Divide by 20, and the combined contents of the tubes should weigh 4 ounces and be close to 1 ounce per applicator tube.

Recalibrate when changing from one formulation to another, or with decided changes in humidity. When all applicator tubes are delivering equally, you can collect material from 1 tube and divide by 80 to get the 1-ounce reading.

For broadcast application, use a similar calculation using this formula:

$$\frac{43{,}560}{\text{Applicator Width in Feet X 20}} = \text{Distance to Drive in Feet}$$

For example, with a 10-foot wide application, you should drive:

$$\frac{43{,}560}{10 \text{ X } 20} = \frac{43{,}560}{200} = 217.8 \text{ Feet or } 218 \text{ Feet}$$

Weigh the contents of bags over all the applicator tubes. Weight should be 1/20 of the recommended amount of granules per acre.

For example, a granular herbicide is recommended at 4 pounds active ingredient per acre, or 40 pounds of 10 percent granules. On 1/20 acre, the combined granules collected should weigh 2 pounds or 32 ounces.

CALIBRATION OF CHEMIGATION EQUIPMENT

Chemigation is the process of applying pesticides through an irrigation system and proper equipment calibration is essential when using this method of pesticide application. Improper calibration can result in too little product being applied, which may result in inadequate pest control. If too much pesticide is applied the result may be crop or environmental damage. If more chemical is used than is necessary you will waste money, and if the recommended label rate is exceeded the applicator may be subject to a fine or other regulatory action, including the destruction of the crop.

Some simple equipment, time, and accurate calculations are necessary to calibrate chemigation equipment properly. Conditions at your work site will vary from those at the factory so it is essential that you calibrate on site and not rely on data provided by the equipment manufacturer. Manufacturer suggestions are a good starting point and will eliminate much trial and error, but it is necessary that you determine the exact irrigation water and injection pump settings.

Measuring Equipment:

Stopwatch
Steel measuring tape (at least 100 feet)
Pocket calculator
Flags

You will need a clear calibration tube that indicates units of volume (graduated cylinder). The calibration tube measures the output of the injection pump and should be large enough to hold a volume sufficient for a minimum of 5 minutes of injection.

The calibration tube is located in the injection line between the injection pump and the supply tank and should be attached by valves so it can be removed when not in use.

The steps below describe how to calibrate a center pivot; however, the principles apply to all pumped (sprinkler) chemigation applications:

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 (step 1 x step 2)
4. Determine the time (in hours) that injection will take
5. Determine the injection rate in gallons per hour (step 3 divided by step 4)

The calibration process is based on the given measurements of the irrigating 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:

1. Area irrigated
2. Amount of chemical required
3. Travel speed
4. Revolution time
5. Recommended chemical application rate

The following example will illustrate the procedure.

1. Area Irrigated:
   The area irrigated must be calculated with one of several possible formulas. The degree of difficulty in making this calculation depends on the configuration of the field. The simplest case would be a complete circle without intermittent end guns or corner watering systems. The calculation is:

$$\text{Area of the Circle in Acres} = \frac{\pi \text{ X } r^2}{43{,}560 \text{ sq. ft per Acre}}$$

   Where r = the wetted radius (length of pivot plus effective throw of end gun) and $\pi = 3.1416$.

   For this example, assume r = 1300 ft:

$$\text{Area} = \frac{3.1416 \text{ X } (1300 \text{ X } 1300)}{43{,}560} = 122 \text{ Acres}$$

   The area irrigated becomes increasingly more complex with partial circles, circles with intermittent end guns and other configurations. In many situations, it may be wise to leave the end gun off because the water pattern is easily distorted by wind. If an end gun shut off fails, it may result in an off-target application.

2. Amount of chemical required:

   Chemical Required = Acres Irrigated X Recommended Chemical Application Rate

   In this example, assume 1-quart of chemical is required per acre:

   122 Acres X 1 Quart Chemical per Acre = 122 Quarts (30.5 Gallons) Needed to Treat the Entire Field

3. Travel Speed:
   For moving systems, travel speed is one of the most important measurements. When calculating the irrigation system speed, the system should be running "wet" and at the speed and pressure that will be used while chemigating. Always recalibrate when changing speed settings or pressure. Avoid determining pivot speed at one percentage setting and mathematically calculating the pivot speeds for other settings, other than to obtain a "rough" figure. Using a stopwatch, the proportion of one minute that the end tower is actually moving can be checked against the percentage timer in the pivot control panel.

   Two measurements, time and distance, are required to calculate the rotational speed of the pivot. They can be taken in several ways:

   - Record the time necessary for the outer pivot tower to travel a pre-measured distance (usually a minimum of 50 ft.).
   - Measure the distance traveled by the outer pivot tower in a pre-selected time (usually a minimum of 10 minutes).

   The end result of either method is rotational speed in ft/minute. Be aware that a measurement error of only a few feet or a few minutes can create a significant error in the entire calibration process. If the percentage timer is set at less than 100 percent when determining pivot speed, make sure the start and stop measurements are taken at the same points in the move/stop cycle. (This is not a concern with some oil hydraulic pivots where the end tower moves continuously.) If the terrain is rolling or sloped, check rotational speed at several locations in the field and calculate the average value. It may also be wise to verify rotational speed several times throughout the season to account for differences in wheel track resistances due to cover, soil compaction, track depth, etc.

Assume the measured distance per 10 minutes = 65 ft:

$$\text{Travel Speed} = \frac{65 \text{ Feet}}{10 \text{ Minutes}} = 6.5 \text{ Feet per Minute}$$

4. Revolution Time:
   Circumference of the last wheel track and rotational speed of pivot are the two measurements needed to calculate revolution time. Circumference is calculated by the formula:

$$\text{Circumference} = 2 \times \pi \times r$$

Where r = the distance in feet from the pivot point to outer wheel track and where $\pi = 3.1416$.

Assume r = 1280 feet:

$$\text{Circumference} = 2 \times 3.1416 \times 1280 = 8042 \text{ Feet}$$

Even though the owner's manual accompanying the irrigation system might list the system length, the length required for this calculation is from the pivot point to last wheel track (it does not include the overhang). It is a good idea to correctly measure this distance once and permanently record it in the control panel.

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

$$\text{Revolution Time} = \frac{\text{Circumference (Feet)}}{\text{Travel Speed (ft/min)}}$$

Then:

$$\text{Revolution Time} = \frac{8042 \text{ Feet}}{6.5 \text{ ft/min}} = 1237 \text{ Minutes per Revolution}$$

To convert the revolution time to hours, divide the above answer by 60.

Example:

$$\frac{1237 \text{ Minutes}}{60 \text{ min/hr}} = 20.6 \text{ Hours per Revolution}$$

5. Chemical Application Rate:
   The application rate is the amount of formulated material needed to treat the field (step 2) divided by the revolution time in hours (step 4).

$$\text{Chemical Application Rate (Gallons per Hour or gph)} = \frac{\text{Total Material Needed (Gallons)}}{\text{Hours/Revolution}}$$

Example:

$$\text{Chemical Application Rate} = \frac{30.5 \text{ Gallons}}{20.6 \text{ Hours}} = 1.48 \text{ gph}$$

Determining these amounts in gph is necessary because most commercially available pumps are rated in gph. Knowing the injection pump capacity in relation to the delivery rate needed can help you

establish an initial pump setting. However, be aware that book output values of pumps are normally measured at the factory based on a drive shaft speed of 1725 rpm. Any variance in this shaft speed will alter the pump output. When the injection pump is belt driven from the engine drive shaft, a tachometer is helpful. Pump wear will also alter output. Fine-tuning should be accomplished using a calibration tube placed on the suction side of the injection pump. Chemicals vary in viscosity and density. Always make the final calibration with the material to be injected and at the operational pressure of the irrigation system. If the volume is small, as with an insecticide, and the calibration tube is measured in milliliters or ounces, gph can be converted to milliliters/minute by multiplying gph X 63.07 or can be converted to ounces/minute by multiplying gph X 2.133.

- If the calibration tube is in milliliters, 1.48 gph X 63.07 = 93 ml/minute.
- If the calibration tube is in ounces, 1.48 gph X 2.133 = 3 ozs/minute.

This amount of chemical, in ml/min or oz./min, is the working factor for calibrating the injection pump. Using the calibration tube, make coarse adjustments on one-minute time checks. Make a final check over an extended time period (at least 5 minutes).

For an initial injection pump setting, the desired injection rate is divided by the pump capacity to give a percent setting.

Example:
Required injection rate is 1.48 gph and pump is rated at 4 gph max.

$$\text{Injection Rate, \% of Capacity} = \frac{1.48 \text{ gph}}{4.00 \text{ gph}} \times 100 = 37\%$$

Thus 37 percent is the suggested first setting for the initial calibration attempt.

Calibrating a Stationary Sprinkler System
Solid set, hand lines, and wheel lines are examples of stationary irrigation systems that can be used for applying agricultural chemicals.

An advantage of the stationary system is being able to inject the chemical anytime during the irrigation process. An herbicide may be injected midway through the irrigation process to allow additional water to be applied for incorporation. A foliar insecticide, in contrast, will usually be applied near the end of the irrigation to limit the amount of water that is applied following the insecticide application to reduce wash off.

The following is one way to calibrate a stationary sprinkler system.

1. Determine the acres to be irrigated in one set. Multiply the lateral spacing along the main line by the length of the lateral and divide by 43,560 (square feet per acre). If more than one lateral is being operated simultaneously, also multiply by the number of laterals.

   Example: 10 laterals, 800 feet long, spaced 40 feet apart.

$$\text{Area Irrigated} = \frac{800 \times 40 \times 10}{43{,}560} = 7.3 \text{ Acres}$$

2. Determine the amount of formulated chemical needed per acre (consult product label).

   Example: 4 Pounds of Wettable Powder Herbicide per Acre

3. Determine the total amount of chemical needed (Step 1 X Step 2).

   Example: Total Chemicals = 7.3 Acres X 4 Pounds per Acre = 29.2 Pounds

4. Determine the amount of water to be applied during the application. Follow recommendations on chemical product label.

   Example: Herbicide Label Recommends that 1.0 Acre-Inch of Water be Applied and that the Herbicide be Injected During the First Half of the Irrigation Period

5. Determine the rate of water application by the irrigation system. Attach a short piece of hose to the nozzle outlet(s) of one sprinkler, start the irrigation system, and measure flow for 1 minute. Repeat this procedure at several sprinklers along the lateral and determine the average sprinkler flow rate. Given the sprinkler flow rate in gallons per minute and the sprinkler spacing, the water application rate in inches per hour can be determined from application rate tables or with the following equation:

$$\text{Water Application Rate, Inches/Hour} = \frac{96.3 \times \text{gpm}}{S_1 \times S_m}$$

   Where gpm = discharge from sprinkler in gallons per minute, S_1 = spacing of sprinklers on lateral in feet, S_m = spacing of lateral on main in feet.

   Example: Sprinkler flow = 4 gallons per minute. Sprinkler Spacing = 40 ft X 40 ft.

$$\text{Water Application Rate, Inches/Hour} = \frac{96.3 \times 4 \text{ gpm}}{40 \text{ ft} \times 40 \text{ ft}} = 0.24 \text{ in/hr}$$

   Another method to determine water application rate is to determine the sprinkler nozzle(s) size (usually stamped on the nozzle) and discharge pressures, and then consult the sprinkler manufacturer's application rate table. Adjust the length (time) of the irrigation to apply the amount of water necessary for proper chemical application.

6. Determine time to irrigate. Divide the gross amount of water to be applied by the rate of water application (Step 5).

$$\text{Gross Irrigation Amount} = \frac{\text{Net Irrigation Amount}}{\text{Irrigation Application Efficiency}}$$

$$\text{Irrigation Time} = \frac{\text{Gross Irrigation Amount}}{\text{Water Application Rate}}$$

   Example: Irrigation application efficiency = 80% (assumed), Net irrigation = 1.0 in.

$$\text{Gross Irrigation Amount} = \frac{1.0 \text{ in}}{0.8} = 1.25 \text{ in}$$

$$\text{Irrigation Time} = \frac{1.25 \text{ in}}{0.24 \text{ in/hr}} = 5.2 \text{ Hours}$$

7. Fill the solution tank with the chemical to be applied or chemical-water solution. Start the tank agitator if needed.

   Example: Add 30 gallons of water (approximately 1-gallon water for each pound of wettable powder) to solution tank, start agitator, and add 29.2 pounds of formulated herbicide. Add more water to bring total volume to 50 gallons.

8. Determine the injection rate by dividing the total gallons in the tank (Step 7) by the time (hours) required to apply the chemical.

   Assume that chemical will be applied for 2 hours during the mid portion of the irrigation time.

   Example: Injection Rate = $\frac{50 \text{ Gallons}}{2 \text{ Hours}}$ = 25 Gallons per Hour

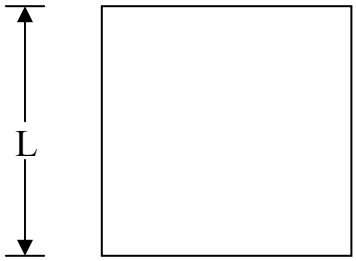
9. Calibrate the delivery rate of the injection pump to make certain the rate is correct.

10. If the chemical solution is to be applied throughout or during the last part of the irrigation, allow the irrigation system to operate for sufficient time after the injection to completely flush the chemical from the system. The time required will normally be a minimum of five minutes and may be as long as 15 to 20 minutes.

Determine Irrigated Acreage

Formulas for calculating acreage in fields and irregular portions of fields are shown below:

1. Area of a square.
   Area of a square = L^2
   "L" is the length, in feet, of one side of the square

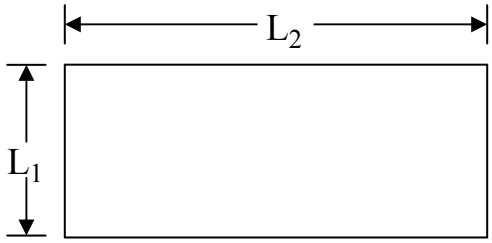


   If L = 2640'
   L^2 = 2640 X 2640 = 6,969,600
   Area = 6,969,600 sq. ft

   Acres = $\frac{\text{Area ft}^2}{*43{,}560}$
   Acres = $\frac{6{,}969{,}600 \text{ ft}^2}{*43{,}560}$ = 160 Acres

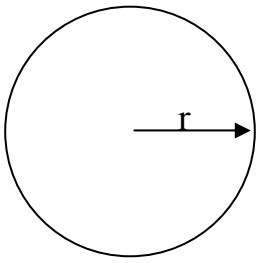
   *One (1) Acre = 43,580 Square Feet

2. Area of a rectangular field.
   Area = L_1 X L_2
   If L_1 = 2640 feet and L_2 = 5280 Feet
   Area = 2640' X 5280' = 13,939,200 sq. ft



   Acres = $\frac{13{,}939{,}200 \text{ sq. ft}}{43{,}560}$ = 320 Acres

3. Area of a circle.
   Area = r^2 X π*
   If r = 1300'
   Area = 1300^2 X 3.14 = 5,309,291



   Acres = $\frac{5{,}309{,}291 \text{ sq. ft}}{43{,}560 \text{ sq. ft}}$ = 121.88 Acres

   *π = 3.1416

4. Area of a part circle.

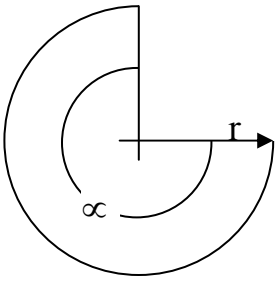
   $\text{Area} = (r^2 \times \pi) \times \frac{\propto}{(360)^\circ}$

   If r = 1300 and $\propto = 270^\circ$

   $\text{Area} = (1300^2 \times 3.14) \times \frac{270^\circ}{360^\circ} = 3{,}981{,}968 \text{ ft}^2$

   $\text{Acres} = \frac{3{,}981{,}968 \text{ ft}^2}{43{,}560 \text{ ft}^2} = 91.41 \text{ Acres}$

   $\propto$ = Number of Degrees, Measured with a Protractor



5. Area of a triangle.

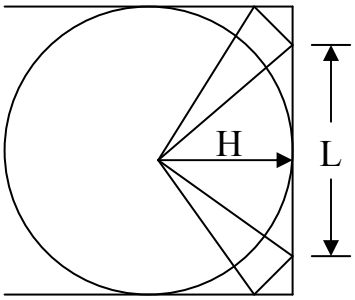
   $\text{Area} = \frac{H \times L}{2}$

   If H = 1300 ft and L = 1900 ft

   $\text{Area} = \frac{(1300)\ (1900)}{2} = 1{,}235{,}000 \text{ ft}^2$

   $\text{Acres} = \frac{1{,}235{,}000}{43{,}560} = 28.4$

   "H" is the same as system length and is equal to the "radius"
   "L" is length of the base in the triangle



NOTE: To calculate (estimate) the acreage included in a very irregularly shaped area irrigated by a corner system, draw a straight line or a circular arc that will most nearly provide an "average" boundary.

GENERAL PEST PROBLEMS

PLANT DISEASE

A plant is diseased when it has abnormal physiology (is not functioning normally) that is caused by the continuous interaction between a host (the plant) and a primary causal agent (the disease organism or damaging agent) that results in characteristic symptoms. Plant disease is the exception in nature as most plants are healthy, but there are many diseases that severely limit the economic production of crops or the aesthetic value and function of ornamentals.

Primary causal agents of plant disease occur in two major groups: biotic and abiotic.

A. Biotic Primary Causal Agents: plant pathogens
   1. Viruses (viroids and virons)
   2. Mycoplasma-like organisms
   3. Bacteria
   4. Fungi
   5. Nematodes
   6. Parasitic higher (seed producing) plants

B. Abiotic Primary Causal Agents: noninfectious agents
   1. Air pollutants
      a. O3 – ozone
      b. SO2 – sulfur dioxide
      c. PAN – peroxyacylnitrate compounds
   2. Temperature – too low or too high
   3. Water – too little or too much
   4. Nutrients – deficiencies or excesses
   5. Light – too little or too much
   6. Soil compaction – human activity

The more or less continuous interaction between the host (plant) and the primary causal agent is the determining factor that creates abnormal physiology (dysfunction) within the host and allows the distinction between disease and injury to be made.

A large portion of plant disease diagnosis is based upon recognizing the characteristic symptoms that plants express as a result of their abnormal physiology. There are three general types of plant disease symptoms:

1. Necrosis – necrotic symptoms are the most common and include as dead or dying cells or tissues. Both biotic and abiotic primary causal agents can cause necrotic symptoms to develop in diseased host plants.
2. Hypoplasia – hypoplastic symptoms are the reduction in some plant part or process. Hypoplasia may be an overall reduction in growth (stunting, shortness, smallness) or it may only be reflected in dwarfing of a specific plant part (little leaf, short internodes.)
3. Hyperplasia – hyperplastic symptoms are the over-development of some plant part or process. In many cases this over-development is caused by abnormal cellular division and/or enlargement that is detrimental to the host plant (galls, wrinkling.)

Specific requirements must be met before disease will develop significantly or warrant the application of control measures. The specific requirements are a host or susceptible plant, a primary causal agent, and an environment that supports disease development. In most instances, the elements of the environment, most often water and temperature and sometimes light, are the limiting factors of disease development. In many instances signs of disease are also important in disease diagnosis. Signs of disease are evidences of the pathogen (biotic primary causal agent) that include structures such as mushrooms, conks, bacterial ooze, etc.

Plant diseases occur in cyclic fashion depending upon the environment. The sequence of events that develop in plant disease is called the disease cycle. It is important to understand the disease cycle since effective control is dependent upon interrupting this cycle at some point. The disease cycle begins with the overwintering stage of the biotic primary causal agent. In this stage the pathogen usually has a low population and as such, often can be controlled at this point. Control measures, however, must be carefully selected since the pathogen produces survival structures that are often difficult to eradicate. Primary inoculation of the host occurs when innoculum, fungus spores, bacterial cells, etc., are produced from the overwintering stages and are disseminated by wind, water, insects, man, equipment, etc. to host surfaces or infection courts. Soil-borne diseases resume growth from an overwintering stage. The continued development of the host's root system affects the process of inoculation. Infection of the host follows unless some control measure is applied. At this point protective chemicals applied before infection actually occurs often give good levels of control. If infection occurs, the pathogen proceeds to colonize the host and reproduce itself in large numbers. This results in innoculum for secondary disease cycles and if the environment is supportive, the disease epidemic or epiphytotic is underway. Obtaining adequate control at this point is usually difficult. Eradicative, protective, and in some instances therapeutic chemicals are used to reverse epiphytotic development. As energy supplies for the pathogen dwindles and/or the environment no longer supports disease development, the pathogen produces over-wintering structures and the disease cycle is completed.

Plant disease management is based on several important principles. A basic understanding of these principles is essential to the application of existing control practices.

1. **Exclusion** – plant disease management by practices designed to keep pathogens, vectors, and infected plants out of disease-free areas. Establishing plants in areas where the pathogen does not occur.
2. **Eradication** – plant disease management designed to destroy the pathogen after it has become established. This includes destruction of infected plants, disinfestation of storage bins, containers, and equipment, soil disinfestation by fumigation, pasteurization, or drenching.
3. **Protection** – plant disease management that establish a chemical or physical barrier between the host and the primary causal agent.
4. **Resistance** – plant disease management achieved by altering the genetic system of the host to make it less susceptible to the pathogen. Vertical resistance is very high level (immunity) resistance to specific strains of pathogens. Horizontal resistance is a lower level (tolerance) resistance to many more strains of pathogens. Both types of resistance are employed in the development of crop plants.
5. **Therapy** – plant disease management that is achieved by incorporating a chemical control agent into the physiological processes of the plant to reverse the progress of disease development after infection has occurred. Use of this principle is limited by the relatively small number of systemic materials available.
6. **Avoidance** – Plant disease management practices such as planting date selection, seedbed preparation, water management, etc. to manage diseases culturally.

In most cases, successful plant disease management practices are a combination of two or more of these principles applied at carefully selected points in the disease cycle.
The basic steps involved in plant disease management are:

1. timely and accurate disease identification
2. consideration of all potential control methods:
   a. physical/mechanical
   b. cultural
   c. biological
   d. chemical
3. recognize and evaluate the potential benefit and risks associated with the disease and its management
4. choose the most effective, economical, safe method
5. ensure the proper use of materials or methods
6. know and follow the regulations

Most plant disease control chemicals can be broadly classified as eradicants or protectants. The fungicides, bactericides, and nematicides are then categorized according to their mode of action or activity.

INSECTS

As a group, insects are the most successful animals to have evolved. They are old, and they have been on earth more than 300 million years, and are much the same now as then. They have survived and sometimes thrived over a vast expanse of time in the face of cataclysmic, geological, climatic and biological changes that have wiped out more "advanced" creatures. They have survived this length of time by becoming extremely diverse as a group. This adaptability has lead to more species of insects than all other species of plants and animals combined. Current estimates place the number of insect species in the world at more than 11 million with up to 25,000 species in Nevada.

They survive on a wide variety of hosts (food) including each other (predators and parasites) and nearly every natural product man grows or uses. Part of their ability to survive and adapt is related to their reproductive capabilities, both in sheer number and rapid generation time.

Insects only become a problem when they interfere with man's activities. Insects otherwise are an essential part of any ecosystem. They are primary and secondary consumers (predator and parasite) and decomposers. Less than five percent of all the insect species are pests at one time or another.

When attempting to control insects, we normally only suppress the target population for a small period of time over a relatively small area of land. Insect populations are normally held in check by a variety of natural factors such as temperature, moisture, diseases, predators and parasites, and geographic separation by mountains, oceans and deserts. These natural controls are the primary way most insect populations are suppressed. When we see an outbreak of insects, we are observing an increase in survival from one to two percent of the individual of the previous generation to three or four percent. Causes of insect outbreaks can be divided into five general areas:

1. Introduction into an area with few natural suppression factors (Gypsy moth, invasive weeds).
2. Previous use of a chemical to control another pest and subsequent loss of predators and parasites.
3. Weather that favors a pest while suppressing its predators and parasites.
4. Planting of monocultures of host plants (typical U.S. agriculture).
5. Overuse of a chemistry (product) and developed resistance by the pest.

All pest populations must be regularly monitored. This can be done by a variety of means, including the use of traps both actively (baits, lures, pheromones, light, etc.) and passively (sweep nets and visual observations). Accurate records of pest observations can lead to prediction of future outbreaks. Monitoring may also indicate when a pest has reached an economic, aesthetic, or emotional threshold. An economic threshold is the point at which, if the insect outbreak continues, it will cause enough damage to pay for the cost of treatment. Aesthetic and emotional thresholds are subjective, for example, there may be a high tolerance for scale on a tree until the tree's leaves prematurely turn color and drop, then the landscape looks unthrifty. Emotionally, some people's tolerance for a cockroach or spider in their kitchen is zero.

Insect Identifications

Before any action is taken against a suspected pest, an accurate identification must be made. Pest control handbooks, field guides, and other references may be adequate for identification of common pests and beneficial insects. Remember that the scope of these references are extremely limited. For more accurate identification of the insect, help is available from both the University of Nevada Cooperative Extension and the Nevada Department of Agriculture.

The proportions of these species (pest to beneficial) allow pest managers to make accurate determination of whether or not to control a given insect.

Basic Insect Identification

Animal Kingdom (1 or 2 kingdoms) Phylum Arthropoda (12 phyla in animal kingdom) All animals in this phylum have the following characteristics:

1. Segmented bodies 2 or 3 distinct body regions
2. Paired and segmented appendages
3. External skeleton of chitin
4. Ventral nerve cord
5. Open circulatory system as opposed to a system with enclosed veins and arteries, e.g. mammals.

Class Insecta (all insects)

Differences between insects and other classes of Arthropods:

<u>Crustaceans</u>

Two body division (head, abdomen) no wings
Five or more legs
Two pairs of antennae
(Examples: crabs, crayfish, shrimp, and sow bugs (pill bugs)

<u>Millipedes (Diplopoda)</u>

Two body divisions no wings
Two pair of legs per body segment each animal with many segments
Zero or one pair of antennae

<u>Centipedes (Chilopoda)</u>

Two body divisions, no wings
One pair of legs per body segment; each animal with many segments
Zero or one pair of antennae

<u>Arachnids</u>

Araneae are spiders, Acari are mites, Scorpiones are scorpions, Solifugae are wind scorpions, Opiliones are harvestmen or daddy longlegs
Two body parts
Four pair of legs
Zero antennae
Zero wings

Insects

Three body regions composed of a head, thorax, and an abdomen
Three pair of legs
One pair antennae
Often wings in adult stage; usually two pair, a few, e.g. flies, have one pair
Classes are further divided into orders

The class Insecta is currently divided into 31 orders. The basis for this includes such things as types of mouthparts (chewing and sucking are the most common), presence, absence and number of wings, wing structure, type of life cycle, and presence of social forms.

Insect life cycles: it is important to know the life cycle of an insect so that control mechanisms, when necessary, may be incorporated at the most susceptible stage of the cycle.

complete life cycle	simple or incomplete life cycle
egg-larvae-pupa-adult	egg-nymph-adult

Many insects are only pests during certain stages of their life and often may only be effectively controlled in one or two stages of their life cycles. As well, how they feed may affect the control measure selected. Without this knowledge, much effort, time, and money may be wasted on control.

Table 6. Distinguishing characteristics of insects among orders

Order	Mouthparts	Life Cycle	Wings
Thysanura	chewing	simple	none
Collembola	chewing	simple	none
Dermaptera	chewing	simple	none, 2pr
Isoptera	chewing	simple	2 pr
Othoptera	chewing	simple	2pr
Mallophaga	chewing	simple	none
Anaplura	sucking	simple	none
Thysanoptera	rasping	simple	2pr,none
Hemiptera	sucking	simple	2pr
Blattodae (Blattaria)	chewing	simple	2 pr
Homoptera	sucking	simple	2 pr
Neuroptera	chewing	complete	2 pr
Lepidoptera	chewing	complete	2 pr
Coleoptara	chewing	complete	2 pr
Siphonaptera	sucking	complete	none
Hymenoptera	chewing	complete	2 pr
Diptera	lapping-chewing sucking-sponging	complete	1 pr

Thysanura: This order contains the silverfish and firebrats. They are very primitive, soft-bodied insects with chewing mouthparts that lack wings but have long cerci. These insects are nocturnal and can cause damage to stored books, paper products, wallpaper and other products containing starch.

Collembola: Springfoils make up this order. Small, wingless insects without compound eyes, these insects go through a simple life cycle. They get around using a tail-like structure that folds beneath their body and propels them. They habit moist areas and may be a nuisance in homes. Only one is known to feed on seedlings and mushrooms.

Dermaptera: The earwigs make up this order. They have long slender bodies with or without wings that end in pincer-like cerci. A nuisance pest in homes, they are a minor pest in vegetable and ornamental gardens.

Isoptera: Termites have a broad juncture at the abdomen and thoras, two pairs of similar-sized and -shaped, membranous wings and monikform antennae. They are pests of wood and require cellulose from wood or other plant tissue for food. They are social insects.

Orthoptera: This order contains the grasshoppers, crickets, praying mantis and walking sticks. Their life cycle is simple. They have strong chewing mouthparts. Their rear wings are membranous and are covered and protected by the front pair. Most are large insects and many are pests.

Mallophaga: Chewing lice. Small wingless, chewing insects, the chewing lice have a simple life cycle spent entirely on the host. The head is wider than the thorax. Most attack birds, domestic fowl and mammals as ectoparasites, but not humans.

Anaplura: Sucking lice. These small, ectoparasites suck blood from mammals, are wingless and their long, pointed heads are narrower than their thorax. The life cycle of sucking lice is simple. These insects irritate livestock reducing their vitality. They also transmit diseases to animals and humans.

Thysanoptera: Thrips are minute insects and may be winged or wingless. If winged, there are four narrow wings with long hairs. They have a simple life cycle and feed by rasping-sucking plant juices. Most feed on flowers, buds, and leaves. Some are predaceous species to other insects.

Hemiptera: This order contains the true bugs. They can be recognized by the X formed by the wings. This order includes both pests and beneficial insects. They have piercing-sucking mouthparts and a simple life cycle. These include box elder bugs, leaf footed bugs, stink bugs, assassin bugs, big-eyed bugs, minute pirate bugs, and bed bugs.

Blattodae: Cockroach Family. Cockroaches have an oval, brown to black body, two pairs of membranous wings, if present, and long antennae. Their head is bowed down and covered with a pronotum. They run rapidly and secrete themselves from light.

Homoptera: In this order we find the aphids, leafhoppers, cicadas, scales and mealy bugs. All are plant feeders and may be pests. They have piercing-sucking mouthparts, are winged or wingless and may have simple to near complete life cycles. Many are vectors of plant diseases-viruses and microplasma.

Neuroptera: Antlions and lacewings are placed in this order. Most of the members of this order are predacious. The adults in this order have wings that have numerous veins giving them a net-like appearance. Larvae can be destructive. They have chewing mouthparts. They have complete life cycles and many are important aquatic insects.

Lepidoptera: The major characteristic of the adults of this group are the scale-covered wings. They have a long tube mouthpart for sucking or siphoning, two pairs of wings and they go through complete metamorphosis. This order contains the moths and butterflies. Many serious pests occur in this order. Their larvae are caterpillars.

Coleoptara: This is the largest order of insects with over 300,000 species. Most can be easily identified by the hardened forewings, called elytra. This order contains both beneficial and injurious species of beetles. The larvae are grubs and are economically important. They have a complete life cycle.

Siphonaptera: These fleas are brown, flattened, wingless insects with jumping legs and reaching mouthparts. They have a complete life cycle and are vectors of diseases such as bubonic plague and typhus.

Hymenoptera: This order contains the ants, bees, wasps and sawflies. This order contains many beneficial insects, however the adult's ability to sting can cause problems. The sawflies are a group whose larvae are plant feeders and the adults lack the conspicuous constricted abdomen.

Diptera: This order contains the flies, mosquitoes, and leafminers. The members of this order feed on a variety of materials. They have only one pair of membranous or clear wings. They experience a complete life cycle.

WEEDS

I. Weeds – plants growing where they are not wanted.

II. Characteristics of weeds
   A. Competitive – grow in spite of interference from other plants.
   B. Persistent – occurs year after year.
   C. Pernicious (harmful) – can be economically undesirable as well as aesthetically unpleasing.
   D. Have same requirements as other plants, i.e., light, water, nutrients, and space.

III. Stages of development
   A. Seedling – small vulnerable plant. The water and nutrient requirements are small.
   B. Vegetative – plant is growing up. The uptake of water and nutrients is rapid. The plant develops vigorous roots, stems and leaves.
   C. Seed production – development of flowers and fruit. The plant energy is directed toward fruit and seed development.
   D. Maturity – little or no water and nutrient uptake and little energy produced. The plant "dries down".

IV. Life cycles of plants
   A. Annuals – one season for all stages of development.
      1. Summer annuals – spring to fall - lambsquarters, foxtail, pigweed, crabgrass
      2. Winter annuals – fall to spring - shepherds purse, mustards, cheatgrass, and annual bluegrass
   B. Biennials - two seasons for all stages of development
      1. First year – heavy root development, low growing leaves (rosette).
      2. Second year – go through vegetative, flowering and maturity stages.
      3. Cold winter period is necessary to complete life cycle.
      4. Examples – wild carrot, mullein, bull thistle.
   C. Perennials – live more than two years. They may go through all four stages the first year and then they will go through vegetative, seed set and maturity each year thereafter.
      1. Simple perennials – reproduce by seed and pieces of roots – dandelion, plantain, and trees.
      2. Bulbous perennials – produce seed, bulblets and bulbs –- wild onion, wild garlic.
      3. Creeping perennials – produce seeds, rhizomes or stolons or creeping roots – Johnsongrass, Bermuda grass, Canada thistle.

V. Classification of plants

A. Many – physiology, poisonous potential, life cycle, legal, habitat

B. Habitat – where they grow

1. Land plants
   a. Grasses – one seed leaf, upright and narrow leaves, parallel veins; fibrous roots; covered growing points early in life cycle; both annual and perennial species.
   b. Sedges – triangular stems; three rows of leaves; like wet places; usually perennials.
   c. Broadleaves – two seed leaves; broad leaves, netlike veins; coarse tap root; growing points at ends of stems and in leaf axils, growing points on roots and below ground stems; can be annuals, biennials or perennials.
2. Aquatic plants – live in water environments
   a. Vascular plants – roots, stems and leaves; mostly perennials.
      1) emersed – most of plant above water surface, cattails, reeds, rushes
      2) floating – all or part of plant is on water surface, water lilies, duckweeds
      3) submersed – all of plant is below water surface.
   b. Algae – no true leaves or vascular systems
      1) plankton type – cause blooms of growth in waters
      2) filamentous – long, thin strands or strings that attached to rocks or bottom sediments - *Cladophora* or *Spirogyra*
      3) macroscopic algae – attached to bottom – Chara, Nitella
3. Parasitic plants – live on other plants; reproduce from seed; can spread from plant to plant – Dodder

VI. Weed control strategies

A. May include more than one method

B. Sanitation – clean seed, eradication

C. Cultural weed control

1. Mechanical/Physical – tillage, mowing, mulches, flooding, burning and others.
2. Management – irrigation, fertilization, planting times and rates, companion crops.

D. Biological control – use of a living organism to control weeds.

1. Success depends upon selectivity, reproduction, adaptation, and ability of the organism to reach a high level of effectiveness.
2. Examples: Chrysolina beetle, cactus moth, cattle, sheep, etc.

E. Chemical control – many herbicides are available. How they are used and how they work should be known before they are applied.

1. Selective herbicides: chemicals that kill specific plant life.
2. Nonselective herbicides: chemicals that kill all plant life.
3. Contact herbicides: chemicals that kill the plant only where the chemical touches the plant. They require thorough coverage, are quick acting and are good for the control of annuals, biennials, and seedling perennials.
4. Systemic herbicides: chemicals that are absorbed through the leaves or roots and move freely throughout the plant; application to part of the plant will kill the entire plant. Systemics are effective against most plants and are recommended for perennials. They take time to be effective and may be soil or foliage applied.

5. Examples of these herbicides are:

MSMA	selective, contact herbicide
Paraquat	nonselective, contact herbicide
2,4-D	selective, systemic herbicide
Roundup	nonselective, systemic herbicide

6. Soil applied materials may be selective or nonselective, depending upon the rate of application.

VII. Factors affecting chemical weed control

A. Stage of growth.
1. Seedlings – very susceptible; all life cycles (annual, biennial, and perennial) can be controlled.
2. Vegetative – not as effective for annuals and biennials; chemical control of perennials is mediocre.
3. Flowering – nearly impossible to control annuals and biennials at this stage of growth, very effective on perennials, particularly at bud or early flowering.
4. Maturity – plant is in a dry down state; annuals and biennials are not affected by chemicals; perennials only partially controlled.
5. Stage of growth summary – ideal time to control all life cycles is at the seedling stage; with annuals and biennials a second chance is during the vegetative stage. After that has been passed, chemical control is ineffective. With perennials, if the seedling stage is missed, the next best time of control is the bud to early flowering stage. If this application is missed be sure to control the regrowth.

B. Time of year
1. Spring seeded crops – treat at seedbed preparation time or pre-emergence. Can treat after harvest if the following crop is to be a winter annual or fall seeded perennial.
2. Fall seeded crops – preplant cleanup with tillage or sprays is ecologically safe. Biennials and winter annuals partially or totally controlled.
3. Established crops – fall application is ideal and ecologically safe. There are broad spectrum selective materials available. Fall application of herbicides stress weeds and may be compounded for lack of winter tolerance due to the action of the herbicide or the lack of competitive ability with the crop.

C. Plant factors affecting chemical weed control
1. Growing points – protected in grasses until near flower, but exposed in broad-leaved species. Contact materials will not control creeping perennials because the herbicide does not contact the growing points on below-ground vegetative structures.
2. Leaf shape – narrow vertical leaves of grasses deflect chemical sprays; leaves of broad-leafed plants retain spray solution longer and are an easier target.
3. Leaf surface wax and cuticle – present on every leaf. The thickness of the wax may vary among species. The waxy cuticle is a barrier to herbicide absorption.
4. Leaf hairs – some plants are very hairy The hairs hold spray droplets above the leaf surface where it dries before it is absorbed into the plant. Fewer and shorter hairs occur on seedling plants.

D. Soil factors affecting chemical weed control
1. Magnetism – chemicals vary from highly magnetized to no magnetism. Magnetically charged herbicides become tied to soil particles and are not easily removed by plant roots. Herbicides with no magnetism leach easily through the soil, away from the roots, making them ineffective.

2. Solubility – herbicides vary from highly soluble to insoluble. Insoluble materials remain where they are placed and will kill weeds when plant roots come in contact with them. Soluble materials are effective weed killers but can be leached below the root zone.

3. Leaching – soil texture is important; sandy soils are coarse and have few magnetically charged sites. Consequently, herbicides may leach rapidly through sandy soils. Clay soils have many charge sites that may tie up herbicides and virtually no leaching occurs. Silt is intermediate between sand and clay. Organic matter has a very high number of charged sites that may be occupied by other materials. Higher application rates or herbicides are necessary for organic and clayey soils. Some herbicides are not to be used on sandy soils because they move into groundwaters too rapidly, polluting the aquifer..

E. Climatic factors
1. Rainfall or irrigation occurring immediately following foliar application may reduce the herbicide's effectiveness by washing it off the leaf. However, a half inch rainfall or irrigation is necessary to activate soil applied materials. Excess water can move herbicide below root zone of weeds or erode herbicide-laden soils off site, polluting the area.
2. Temperature – herbicide activity increases with temperature. Do not apply volatile materials during warm days or they may drift onto adjacent plants and cause damage..
3. Humidity – during periods of high relative humidity, absorption of pesticides is greater and evaporation is decreased. Leaves produce thinner wax and cuticle when humidity is continuously high.
4. Wind – causes spray drift. Aerial application should not occur if wind speeds are greater than 5 mph and ground application should not occur if wind speeds are greater than 10 mph.
5. Wind and temperature – hot, dry winds accelerate evaporation, cause wax layers to harden, and cuticle to thicken, close stomates (leaf pores) all while increasing drift.

F. How to reduce the drift problem:
1. Use lower spray pressures.
2. Leave an untreated border.
3. Angle nozzles of ground rigs toward the ground, slightly forward in direction of travel.
4. Use nozzles that produce larger spray droplets.
5. Use less volatile formulations, e.g. amine form of 2,4-D instead of the ester formulation.
6. Spray when wind speed is low – early a.m. or late p.m.
7. Do not spray during temperature inversions.
8. Spray when susceptible adjacent vegetation is mature or not present.
9. Spray only when it is calm.
10. Use directed, covered spray equipment.

VERTEBRATE PESTS

Vertebrate pests are those pest animals that have backbones.

Moles – Moles are insectivorous. They eat soil-dwelling insects, as well as other invertebrates like worms. Often found in urban areas, moles cause damage by building shallow surface tunnels that dislodge plants or push up turf. Trapping controls moles. They will not accept bait. Soil insecticides may be used to reduce the mole's food supply.

Ground Squirrels – Four species cause problems to crops and ornamentals: Richardsons, Belding, Townsend and California. The best time for control is after emergence from hibernation, and before young are on their own. Strychnine cabbage bait (restricted use pesticide) is well accepted, but it may be used underground only to protect non-target species! Acceptance of grain baits is inconsistent, check and pre bait first with untreated grain.

Pocket Gophers – Their activity is determined by fresh mounds. Strychnine grain bait (restricted use pesticide) is most effectively applied in fall, or early spring. Hand apply or use in a burrow builder for large areas. Synchronize application with neighbors for best results. Anticoagulant and zinc phosphide baits are available also. Trapping is most commonly used.

Norway Rats and House Mice – Exclusion is recommended. Seal opening over ¼ inch. Feces and urine damage stored products. Anticoagulant baits are most used. Baits for trapping include: peanut butter plus oatmeal, bacon, gumdrops (mice), nutmeats and dried fruit. Urine fluoresces under UV light and can be used to locate their trails and commonly frequented areas. Bait and trap in these areas.

Meadow Voles – They damage turf with shallow tunnels and holes and girdle plants when feeding. They have cyclic populations. Control with zinc phosphide baits. Snap traps work for small areas. Keep turf and weeds mowed to reduce cover.

Jackrabbits – They have cyclic populations. Exclusion fences are recommended around haystacks, small areas, ornamentals, and gardens. Strychnine (restricted use pesticide) is no longer registered for jackrabbit control.

Deermice – These mice can carry Hantavirus. Although the chance of infection is low, the mortality rate is high. Anticoagulant baits, snap traps, and excluding the mice from structures are recommended control measures. Clean up droppings and urine with disinfectant or dilute, five to ten percent, bleach solution. Do not sweep, vacuum or atomize these wastes. Use a micron-filtered dust mask and gloves during the cleanup. See Hantavirus information following this section. Close openings over ¼ inch in size.

Birds – The droppings, disease potential, and consumption of crops and livestock feeds all make birds pests.

> Pigeons. Avitrol used around feedlots and urban areas may cause a flock to leave. Modification of and exclusion from nesting and roosting sites in urban areas has reduced the nuisance.
>
> House Sparrows. These birds consume field crops and pollute livestock feed. Exclude them from buildings. Netting over high value crops may reduce bird damage.
>
> Starlings. These feedlot pests are urban pests, too. Use starlicide around feedlots. To be successful, pre bait first. Exclude and/or modify urban roosts and nesting sites.

Snakes – Rattlesnakes are the only poisonous snakes in Nevada. They have a triangular head with elliptical pupils and usually rattles on their tail. Physical removal is often necessary. Remove cover for snakes that exposes them to their prey. Exclude them from an area with snake proof fencing.

Trash Fish – For control of trash fish, use rotenone. You must contact the Nevada Department of Wildlife prior to any aquatic pest control operation.

Skunks – By and large, skunks are beneficial in that they eat insects. However, they can cause problems when they eat bees, chickens, or eggs. They are a serious problem to beekeepers. They also transmit rabies that is a serious disease. Skunks have one litter annually, but may have a second litter. A litter usually consists of five to eight kittens. Spread crushed naphthalene crystals (mothballs) around to get a skunk out from under structures. Seal openings to buildings to prevent their entrance. They are live trapped. Use a completely covered trap and the skunk will not spray; bait the trap with a piece of meat, cantaloupe, fruit or dog food.

Feral dogs – Domestic dogs that have gone wild are serious pests. They have been known to attack children, and can inflict heavy damage to livestock. Contact animal control or trap.

HANTAVIRUS – AN UPDATE

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In May 1993, a cluster of unexplained deaths in the Four Corners area of the southwestern United States led to the discovery of a previously unrecognized disease. This disease, Hantavirus Pulmonary Syndrome (HPS), is caused by a previously unknown Hantavirus, the Sin Nombre virus.

Though newly discovered in the southwest, Hantaviruses are not new. During the Korean War, over 3,000 United Nations troops contracted hemorrhagic fever with renal syndrome (HFRS), a disease caused by a strain of Hantavirus. There is evidence that HFRS was known as early as 960 A.D. in China.

Although it was discovered in 1993, the Sin Nombre virus is not new in the United States. As of November 3, 1994, 95 cases of HPS have been diagnosed. Some cases were diagnosed from the saved blood of people who died from unknown causes – two died in 1959. The virus has been present long enough to differentiate into subtypes. Using RNA analysis, the Center for Disease Control has determined for example, that an Arizona resident died from HPS that he contracted in Colorado. A closely related strain, the Black Creek Canal virus, causes HPS in the Southeast.

Prior to the discovery of the Sin Nombre virus, five strains of Hantavirus were recognized along with many subtypes (Table 7). The mortality rates from these diseases vary but generally are under 10 percent. One strain, Prospect Hill, which is known in the eastern United States, has not been shown to cause disease in humans.

The Hantaviruses are maintained in nature by a reservoir species (usually a rodent) that carries the virus but does not contract the disease (Table 1). Once infected the reservoir species probably carries the virus for the rest of its life and sheds the virus in feces, urine, and saliva. This appears to be the case for deermice (*Peromyscus maniculatus*), the reservoir species for the Sin Nombre Hantavirus. There have been thousands of deermice trapped and tested for Hantavirus in the U.S. since the 1993 outbreak and as the age of deermice (indicated by body weight) increases, the percent found Hantavirus positive increases. Non-reservoir species may carry the virus to a lesser extent and for shorter periods.

Table 7. Strains of Hantavirus

Strain	Reservoir Host	Location	Disease
Black Creek Canal	cotton ran (*Sigmodon hispidus)*	Southeastern United States	HPS[1]
Hantaan	field mouse (*Apodemus agrarius)*	N. Asia, Eastern Europe, Far East	HFRS[2] severe
Porogia	field mouse (*A. flavicollis)*	Balkans	HFRS severe
Prospect Hill	meadow vole (*Microtus pennsylvanicus)*	N.E. United States	none
Puumala	bank vole (*Cleithrionomys glareolus)*	Europe, Western Russia, Scandinavia, Balkans	HFRS
Sin Nombre	deermouse (*Peromyscus maniculatus)*	Central Western United States	HPS

1 Hantavirus Pulmonary Syndrome
2 Hemorrhagic fever with renal syndrome

While the Sin Nombre virus has the deermouse as its reservoir, the Black Creek Canal virus occurs outside of the range of the deermouse and is reservoired by the cotton rat (Sigmodon hispidus). The Navajo Indians, interestingly enough, through oral history say that deermice and people should not be together because deermice cause sickness. They further say that in 1918, 1933, and 1934 rain caused large piñon nut crops that caused high populations of deermice that resulted in deaths in young healthy Navajo Indians.

Since the 1993 outbreak, the Nevada Division of Health, along with other cooperating agencies, has conducted a state survey to gather information about Hantavirus in Nevada. About 12 percent of the sampled mice have tested positive for Hantavirus. In California, 11 percent of the deermice being tested are positive. Hantavirus can be found to some extent in deermice populations throughout most of Nevada, regardless of elevation.

Fortunately, HPS is very difficult to contract. Since the disease was discovered in 1993, the Center for Disease Control has collected blood from over 10,000 people who are at risk of coming in contact with infected deermice. These people include biologists, mammalogists, and animal handlers. About one percent carried antibodies to Hantavirus.

Unfortunately, the HPS fatality rate is currently about 55 percent.

Symptoms

The symptoms of HPS are not specific to HPS; however, there are some characteristic patterns to look for and be aware of: fever and muscle ache of large muscle groups occur in all cases; abdominal pain is present in about half of the cases, coughing, shortness of breath, dizziness, and chills may also occur. Earaches, rashes, and sore throat are VERY UNCOMMON in HPS.

Symptoms do not appear for 1 to 3 weeks, occasionally up to 6 weeks. Shortness of breath is a symptom that appears later due to the filling of the lungs with fluid. Pneumonia is the most frequent misdiagnosis of HPS. Abdominal pain and bilateral filling of the lungs in HPS serve to differentiate the two.

Transmission

Sin Nombre virus is passed in the feces, urine, and saliva of infected deermice. Breathing contaminated air is the major route of transmission to people. Being bitten by an infected deermouse is also a possible route of transmission; however, it is much less efficient and has not been demonstrated. Biting, along with grooming, probably helps perpetuate the virus in deermice. Person to person transmission has not been observed and health care workers who have cared for HPS patients have not become infected. Piñon nuts have been mentioned as a possible source of Sin Nombre virus. They are not. They do contribute to an increased deermouse population. They do not carry the HPS virus!

Risk Factors

There do not appear to be differences in susceptibility due to age or sex. Increased likelihood of exposure to deermice increases someone's chance of contracting the disease. Entering tightly closed areas that have deermouse infestations increases risk. Spring and summer are the seasons when most cases occur due to increased contact with rodents – i.e. deermice.

Prevention

Rodent proofing and sanitation are the best ways to eliminate deermice and minimize the chances of contracting Hantavirus. To keep deermice out of a building, seal all openings over ¼ inch in size. Locations where utility lines or pipes enter a building may be entrance routes. Remove trash, brush, and

debris from around the outside of structures. Use rodent proof containers for storing food and trash both inside and outside of the home. Keep pet food in sealed containers when not being used.
Deermice can be trapped using snap traps (mouse traps.) Peanut butter mixed with uncooked oatmeal makes a good bait. Trapped deermice can be buried or placed in a bag or container and then into the trash.

Safety Precautions
To reduce the risk of contracting HPS, wear rubber gloves when handling deermice. Clean up urine and feces by spraying with a disinfectant solution, wait ten minutes and then wipe up. Do not sweep or vacuum, stirring up dust increases the levels of airborne virus.

If dusty areas must be entered, wear a respirator or dust mask with a HEPA filter to remove viruses. It is probable that the virus only remains viable for three or four days in feces and urine. Because of this, trapping deermice from an area and waiting three or four days before cleaning will also reduce levels of the virus.

Treatment
There is no specific antidote or vaccine for HPS. Treatment consists of ventilation and early aggressive treatment of the symptoms. Transfer to an intensive care unit that provides detailed monitoring is extremely important. An experimental drug, "Ribarvirin", has been given to patients and is thought to provide some benefit.

Identification of Deermice
Deermice and house mice (*Mus musculus*) are similar looking but have characteristics that enable them to be differentiated. Deermice have white hair on their belly, legs, and feet. Their tail has short hair that is bicolored: dark on the top and white on the sides and bottom. The house mouse has a tail that is scaly with few hairs. The belly of a house mouse is lighter than its back and sides but a house mouse does <u>not</u> have a white belly, feet, and legs. Deermice have no odor, whereas house mice have a musty odor. Comparatively, deermice have larger ears and eyes than house mice.

PESTICIDE USE AND THE ENVIRONMENT

PESTICIDE DRIFT

Studies have shown that a significant percentage of pesticides never reach the intended site of application, because of drift, volatility, or misapplication. It is impossible to totally eliminate particle drift and chemical volatility, but it is possible to reduce them to acceptable levels.

Where significant drift does occur, it can damage sensitive crops, pose health hazards, contaminate soil and water in adjacent areas, and cause considerable friction among neighbors. Applicators are legally responsible for damages resulting from off-target pesticide movement.

Drift can be defined simply as the movement of pesticides through the air to non-target areas. There are two types of drift: Particle Drift and Vapor Drift (chemical volatility).

Particle Drift refers to the small spray droplets carried by air movement from the target area during application. Any pesticide applied with a sprayer is susceptible to particle drift.

Vapor Drift refers to the movement of pesticide vapors from the target area. Some pesticides are volatile and can change from a solid or liquid form into a gas. As a gas or vapor the pesticide may drift farther and over a longer time than spray droplets. Only volatile pesticides are susceptible to vapor drift.

Factors Affecting Particle Drift

Many factors influence the amount of spray drift. Of primary concern are **spray droplet size** and **wind velocity**; they cause most of the problems associated with spray drift. Droplet size produced by the sprayer, the droplet velocity, and direction of the wind all impact spray drift.

Spray Droplet Size

The size of the spray droplets dictates how fast they fall to the ground and how far they drift. Small, lightweight droplets fall very slowly and consequently drift farther away from the target site. The diameter of spray droplets is measured in microns; a micron is 1/1000 of a millimeter (the diameter of a human hair is approximately 50 microns). Drops smaller than 50 microns are highly susceptible to drift under normal conditions. The ideal range of spray droplet diameter for general ground spray application is 80 to 150 microns. The fall rate and lateral drift of different spray droplets is presented in Table 8. As droplet size increases, the potential for drift decreases. Because of this, it is desirable to operate a sprayer so that it produces the largest droplets that will provide adequate coverage of the target area. However, as droplet size increases, the volume of water required to give the same degree of coverage also increases. Most farmers apply pesticides in less than 25 gallons of water per acre in order to minimize the quantity of water that needs to be hauled to the field.

In order to achieve adequate coverage of the target area with these volumes, especially with post emergence chemicals, it is necessary to equip the sprayer with nozzles that produce fairly small droplet sizes. This is why there is always a potential for drift, and why it is critical to pay attention to the factors that influence the amount of off-target pesticide movement.

Table 8. Influence of droplet size on potential distance of drift

Type of Droplet	Diameter (in microns)	Time required for droplets to fall 10 ft.	Lateral distance traveled by droplets[1]
Fog	5	66 minutes	3 miles
Very fine spray	20	4.2 minutes	1,110feet
Fine spray	100	10 seconds	44 feet
Medium spray	240	6 seconds	28 feet
Coarse spray	400	2 seconds	8.5 feet
Fine rain	1,000	1 second	4.7 feet

1 Droplet falling 10 feet in a 3 mph wind

Vapor Drift

Pesticide formulations with high volatility have the ability to volatilize off treated areas and drift as vapors. The ester formulations of 2,4-D or MCPA may produce damaging vapors. The amine formulations are essentially nonvolatile. One study showed that three to four percent of both 2,4-D amine and high volatile ester drifted as spray droplets. However, an additional 25 to 30 percent of the ester drifted as vapor in the first 30 minutes after spraying while no additional movement of the amine was detected.

Temperature also influences the volatility of pesticides. Vapor formation from a highly volatile ester of 2,4-D approximately tripled with a temperature increase from 60 °F to 80 °F and there was a corresponding increase in the amount of plant damage at the higher temperature.

The commercial formulation of Banvel (dicamba) is not highly volatile. However, after application, some of the herbicide is converted to a volatile form and vapor drift can occur for some time after spraying. The higher the temperature, the more product will be converted to the volatile form. When temperatures exceed 85 °F any time within three days after spraying Banvel, vapor drift is possible.

Drift may occur as particle drift during application of pesticides or as vapor drift when a product evaporates from the soil and leaf surfaces. Some products must be applied as a soil-incorporated treatment in order to reduce the risk of vapor drift. Their label lists plant species that are sensitive to drift and how to prevent drift.

Areas adjacent to fields to be treated with volatile compounds should be checked for sensitive species, and they should not be sprayed within 100 feet of these plants.

Wind Velocity and Direction

Wind speed is the major weather condition affecting drift. The greater the wind speed, the greater the drift. Below five miles per hour (mph), wind poses very little drift hazard. Nearly all the spray particles will have a chance to deposit on the ground or in or on the plant canopy. When wind speed increases above 5 mph, it does become an important factor and must be considered. Wind over 10 mph will control and carry all of the small particles and will affect the drift of medium and large particles.

In general, wind speed is reduced just before sunrise and just after sunset. Air is usually the most turbulent during mid afternoon. Pesticides should not be applied when the wind is blowing toward an adjoining susceptible crop.

Other factors

Several other minor factors influence the potential for drift. These factors should be considered when operating under conditions favorable for drift.

Physical properties of liquids – The viscosity of a liquid is a measure of its resistance to flow. For example, mayonnaise is more viscous than water. As the viscosity of the liquid is increased, the droplet size of the spray increases. The addition of thickening agents to the spray increases the number of large droplets and reduces drift.

Drift control agents include foam additives, invert emulsions, and thickeners. Research with ground sprayers indicated that the addition of a spray thickener reduced spray drift by 66 to 90 percent. However, some post emergence herbicides require small droplets for optimum performance, so techniques that increase droplet size may reduce weed control. Always follow the label directions regarding the use of any spray additive.

Air stability – Air turbulence is influenced by the temperature at ground level and the temperature of the air above it. When the air near the soil surface is warmer than the air above it, the warm air rises and the cool air settles, resulting in a gentle mixing of the air. This condition occurs early in the morning and in the early evening and these are the best times to apply pesticides since any pesticide released into the atmosphere will disperse slowly.

As the temperature near the soil increases, the hot air rises faster and mixes rapidly with the cooler air above it causing windy conditions. These windy conditions occur during mid-day and the wind velocity can exceed 10 mph.

Temperature inversion is the abnormal situation where cool air is near the surface under a layer of warm air. Temperature inversions often occur early in the morning. A temperature inversion allows very little vertical mixing of air, even with wind. Damage from spray drift is most severe with temperature inversions since small spray droplets or vapors will be suspended in the cool air layer at crop height for long periods.

Humidity and Temperature – Low relative humidity and/or high temperature increases the evaporation rate of water-spray droplets. Evaporation reduces the droplet size that in turn increases the potential for droplet drift. Droplets greater than 150 microns are not significantly affected by evaporation.

Method of Application – Spray drift is usually greater from aerial applications than from ground applications. Low-pressure ground sprayers usually produce larger spray droplets that are released closer to the target than aerial sprays. Irregular air movements around the fixed wing of airplanes or the rotary blades of helicopters also increase the potential for spray drift.

Keep booms mounted as low as possible to diminish wind effects but allow the recommended spray overlap between nozzles. Do not adjust the boom lower than the recommended height for the nozzle type you are using. Flat fan tips are available in several nozzle angles. Using a wide-angle tip allows the boom to be placed closer to the ground, reducing the potential for drift.

The two major factors that influence spray droplet size are nozzle type and spray pressure.

Nozzle types vary in droplet sizes produced at various spray pressures. The flood nozzle tends to produce slightly larger droplets than the flat fan, while the flat fan produces slightly larger droplets than the hollow cone. In a given nozzle type, nozzles with smaller outputs will produce a large number of smaller droplets when operated at equivalent pressures. Drift potential can be decreased by using nozzles that produce larger droplets, but this will require higher spray volumes.

Spray pressure influences the size of droplets formed from the spray nozzle. Increasing nozzle pressure will increase the number of small droplets that are susceptible to drift. It is important to use pressures within the guidelines of the particular nozzle type. Operating outside of the suggested range may distort the pattern, resulting in non-uniform coverage, often increasing drift. Table 9 shows the effect of spray pressure on droplet size produced by several types of nozzles.

Table 9. Influence of nozzle type and spray pressure on droplet size (diameter in microns)

	Spray Pressure		
Nozzle type	15	30	40
Flat fan			
Flood	239	194	178
Hollow cone	289	219	185
Whirl chamber	195	185	170
Raindrop	506	358	310

PESTICIDE EFFECTS ON WILDLIFE

Since the 1800s, the landscape of Nevada has changed dramatically. Fish and wildlife have suffered as their natural habitats disappeared and the quality of their environment declined.

Nevada's wildlife finds shelter and food around the many lakes, streams, forests, ravines, and meadows across the state.

The fate of wildlife should concern everyone. As Chief Seattle stated in 1854: "What is man without the beasts? If all the beasts were gone, man would die from a great loneliness of the spirit. For whatever happens to the beasts, happens to man." In effect, wildlife are the environmental "barometer." Their presence or absence tells us about the quality of our environment.

Pesticides can affect wildlife in many ways. Some chemicals are toxic enough to directly kill wildlife. Others weaken animals so that they are more likely to die of disease, exposure to harsh weather, or predation. Herbicides can affect the available habitat by killing vegetation and insecticides and can reduce the amount of food by killing non-target insects.

Birds appear to be more sensitive to commonly used pesticides than mammals. The increased use of agricultural chemicals near wetlands has been blamed for some of the decline in the waterfowl population. Fish also are affected by agricultural chemicals. In Nevada, some of the most sensitive fish include Woundfin and Virgin River Chub.

Chemical Hazards

Insecticides are generally more toxic than herbicides to wildlife. Few acute or chronic effects on wildlife are currently known to be connected with herbicide use. The organophosphate, carbamate and synthetic pyrethroids are the most commonly applied insecticides. The organophosphate and carbamate kill insects by damaging their nervous system, and can kill wildlife in the same way. The synthetic pyrethroids also affect the nervous system. However, the pyrethroids have low to medium toxic effects on birds and mammals, but are highly toxic to fish.

Wildlife can be exposed to a chemical by eating contaminated food, by drinking contaminated water, by breathing the chemical, by absorbing the chemical through the skin, or by swallowing the chemical while grooming. Young birds can die from insecticides by eating or being fed insects that have been contaminated. These are called **lethal effects**.

Insecticides also can damage the central nervous system of wildlife in such a way that the animal does not die, but shows abnormal behavior affecting its ability to survive or reproduce. These are called **sub-lethal effects**.

Insecticides also can affect wildlife indirectly by killing insects other than crop pests. Insects are very high in protein that is necessary for growing birds. The growth of young birds, such as ducklings, is stunted in areas where insecticides are heavily used because they do not have enough insects to eat.

Fish also feed on insects, as well as very tiny water animals called zooplankton. Scientists say that fish also may show stunted growth in areas with heavy insecticide use because both the aquatic insects and the zooplankton are killed. This, in turn, affects fish reproduction because the number of eggs a fish can produce is directly related to its size and health.

Some persistent pesticides are of particular concern because they can accumulate in the bodies of animals in the fat tissue. This process is referred to as **bioaccumulation or bioconcentration**. Many of the chlorinated hydrocarbons (DDT, heptachlor, chlordane) are both persistent and accumulative; these combined properties account for most of the environmental problems associated with their use. As a result, EPA canceled the use of most chlorinated hydrocarbons.

Accumulative pesticides can build up in the food chain. A **food chain** describes the sequence whereby an animal feeds on a particular plant, animal, or microorganism and is in turn eaten by another animal and so forth until we reach the animal at the top of the chain. At each succeeding level, an animal normally eats a number of individuals from a "lower level." An accumulative pesticide can, therefore, become increasingly concentrated as it moves up the food chain; this process is referred to as **biomagnification**. For example, in a study where levels of DDT in the soil were 10 parts per million, it reached a concentration of 141 ppm in earthworms and 444 ppm in robins.

Application Hazards

Any application method or farming practice that allows considerable drift or runoff is potentially harmful to wildlife. Insecticides aerially applied near wetlands can contaminate these areas. In 1987, an aerial application of ethyl parathion, an organophosphate insecticide, to sunflower fields adjacent to wetlands in North Dakota led to the death of 96 percent of the mallard ducklings in the wetlands. When the pilot was instructed to avoid these areas, no deaths occurred.

Granular insecticides left on the surface of a treated area may be attractive to birds. Some birds can die from swallowing even a single granule of some of these insecticides.

By following the best management practices outlined in this study guide, you can minimize pesticide impact on wildlife. If you apply pesticides near wetland or other wildlife habitat, consider the following strategies:

- Avoid contaminating wetland areas when aerially spraying. Instruct applicators to avoid spraying wetlands or other natural areas.
- Use buffer zones of unsprayed crops or grass strips to protect the wetland or other natural area.
- Plant and protect grass Conservation Reserve Program (CRP) filter strips at least 66 to 99 feet around wetland areas.
- When applying pesticides, try to choose chemicals that are not as hazardous to wildlife. Near ponds and streams, avoid using pyrethroids where they may be run off into the water. Pyrethroids are a good alternative in upland areas because they have low toxicity in birds and mammals.
- Avoid draining wetlands for planting and avoid cultivating wetland borders and wetlands that are dry in drought years. Wetlands that are cultivated in dry years may be wet again the next year. Some chemicals may remain in the soil which is harmful to both wildlife and habitat.
- Use the RAATS (Reduced Agent and Area Treatments) program for applying insecticides to rangelands. The rate of insecticides applied is reduced by alternated untreated swaths with treated swaths.

PESTICIDE EFFECTS ON NONTARGET ORGANISMS

The effects of pesticides on non-target organisms may involve direct and immediate injury or may be due to the long-term consequences of environmental pollution. Valuable non-target plants, bees and other beneficial insects, livestock, and wildlife may be affected.

Effects on Non-target Plants

Nearly all pesticides can cause plant injury, particularly if they are applied at too high a rate, at the wrong time, or under unfavorable environmental conditions. **Phytotoxicity** is simply plant injury caused by exposure to a chemical; phytotoxic injury can occur on any part of a plant's roots, stems, leaves, flowers, or fruits.

Most phytotoxic injury is due to herbicides that are persistent at the site of application and may also injure succeeding crops. Damage to crops or other plants in adjacent areas is primarily due to drift, although it may sometimes be a consequence of surface runoff, particularly from sloping areas.

Effects on Bees

Bees pollinate many fruit, vegetable, and field crops. You should be aware of bee activity when applying pesticides. Prevention of bee loss is the joint responsibility of the spray operators, the farmer, and the beekeeper. Before applying pesticides that are toxic to bees, notify commercial beekeepers in the area so that they can protect or move their bee colonies. Applicators applying pesticides labeled as toxic to bees, must follow the Nevada Bee Rule. See the laws and regulations section for more information on the Bee Rule. Losses of bees to insecticide poisoning can be minimized by being aware of the following basic principles:

- Read the label and follow label recommendations.
- Apply chemicals in the evening or during early morning hours before bees forage. Evening applications are generally safer than morning applications. If unusually warm evening temperatures cause bees to forage later than usual, delay the insecticide application.
- Do not spray crops in bloom except when absolutely necessary.
- Do not treat an entire field or area if local spot treatments will control the pest.
- Use insecticides that are relatively non-hazardous to bees, whenever possible.
- Choose the least hazardous pesticide formulations. Emulsifiable concentrates are safer than wettable powders, and granules are the safest and least likely to harm bees.
- Determine if bees are foraging in the target area so that protective measures can be taken.
- Airplane applications are more hazardous to bees than ground applications.

Effects on Beneficial Insects

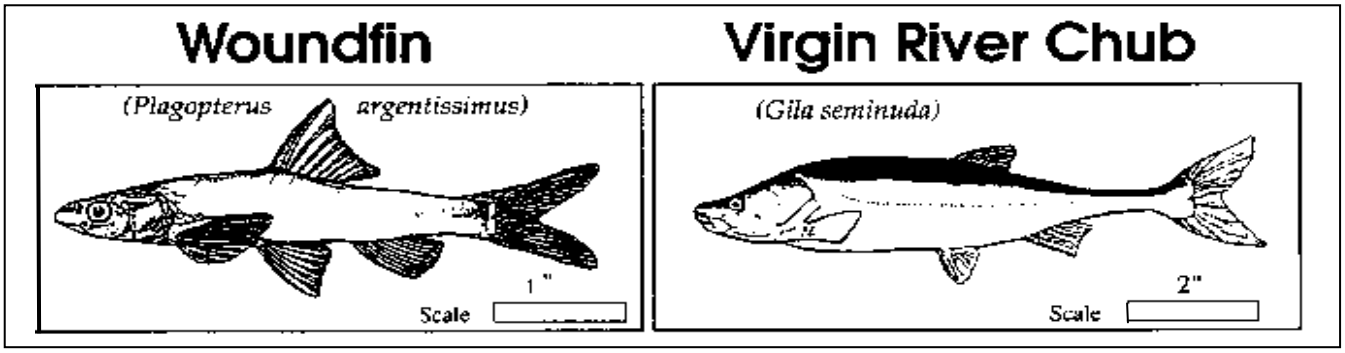
Beneficial insects, other than bees, can also be harmed by pesticides. Despite the fact that they are valuable allies in keeping pest populations below damaging levels, we often overlook them in our pest control efforts. When we apply pesticides, we frequently succeed in reducing their numbers as effectively as those of the pests themselves. In doing so, the resurgence of a pest population may be faster and greater because beneficial predators have been eliminated or are slower to rebound.

Effects on Livestock

Livestock poisoning by pesticides occurs by way of contaminated feed or forage and contaminated drinking water. This is often the result of simple carelessness. Examples are numerous and may result from improper transportation, storage, handling, application, or disposal of pesticides, or from a simple lack of attention.

PROTECTING ENDANGERED SPECIES

Some plants and animals listed by the U.S. Fish and Wildlife Service (Service) as endangered or threatened can be harmed by the use of certain pesticides. To help ensure the continued existence of these species, the U.S. Environmental Protection Agency (EPA) limits the use of certain pesticide products within the habitat of the species. This action reduces the exposure of endangered or threatened species to potentially harmful pesticides. The Woundfin and Virgin River Chub are two endangered fish in Nevada for which EPA has set pesticide use limitations. Check with the Nevada Department of Agriculture or local University of Nevada Cooperative Extension office for a current information pamphlet.



Habitat Requirements

Woundfin are most often found in runs of quiet water habitats with sand substrates (bottoms). Virgin River Chubs are most often found in deep runs or pools associated with instream cover.

Current Status

The Woundfin and Virgin River Chub are presently confined to the mainstream Virgin River in Utah, Arizona and Nevada. Historically, the Woundfin was also collected in the Salt River, Arizona; the mouth of the Gila River near Yuma, Arizona; the Colorado River near Yuma, Arizona; and the Moapa River, Nevada. Woundfin no longer occur in these rivers. Both the Woundfin and the Virgin River Chub have declined in the Virgin River, especially in the reaches below the Washington Diversion

What Threatens These Species?

Habitat Disturbance and Introduction of Exotics – Alteration of flow regimes from construction of dams and diversions, decreased water quality, and introduction of exotic species are the principal threats to these species. Introduction of non-native fish results in increased competition for food and space, as well as an increased threat of predation, disease, and parasitism.

Pesticides – Numerous pesticide uses occur within the vicinity of Woundfin habitat, including rangeland uses and corn and small grain production (wheat, barley, and oats). Less than approximately 500 acre of corn were grown in Washington County, Utah in 1987 while a total of 5,400 acres of wheat, barley, and oats were grown. Exactly how much of this was grown in close proximity to the Virgin River is unknown. However, an unquantified factor leading to the endangerment of the Woundfin may be pollution by chemicals such as pesticides and fertilizers added to the river from returning irrigation waters. Mosquito larvicides are also used in the area.

PROTECTING GROUNDWATER

Groundwater is the source of water for wells and springs. It is found underground, within cracks of bedrock or filling the spaces between particles of soil and rocks. The groundwater layer in which all available spaces are filled with water is called the saturated zone. The dividing line between the

saturated zone and overlying unsaturated rock or sediments is called the water table. The geologic formation through which groundwater flows is called an aquifer. This can be a layer of sand, gravel, or other soils, or a section of bedrock with fractures through which water can flow.

Why Groundwater is Important

Groundwater is widely used for household and irrigation water supplies. Approximately half of the population in the United States relies on groundwater for drinking water, and more than 90 percent of rural residents obtain their water from groundwater through wells or springs.

There are good economic reasons for this widespread dependence on groundwater. In its natural state, groundwater is usually of excellent quality and can be used with no costly treatment or purification. It can be inexpensively tapped adjacent to the point of use, thereby saving the costs of transporting water long distances. In addition, costly storage facilities such as water tanks or towers are not needed. Surface water, on the other hand, usually requires storage, treatment, and transport that are relatively expensive and difficult to manage without technical resources. For rural residents relying on individual wells, groundwater often is the only available water supply, and for many communities it is by far the least expensive option for municipal water. Consumption of groundwater is increasing at twice the rate of surface water, and this trend is expected to continue as the demand for water increases in the future. Protection of the quality of existing and potential future groundwater supplies is an issue of vital importance.

Traditionally, groundwater has been assumed to be a relatively pristine source of water, cleaner and better protected than surface water supplies. Although nitrate and bacterial contamination were known to occur in some locations, groundwater was thought to be immune from more serious forms of pollution such as industrial discharges, hazardous waste dumps, or leaching of pesticides from agricultural operations. Within the past two decades, however, a variety of pesticides and other synthetic organic compounds have been discovered in the nation's groundwater; often at concentrations far exceeding those in surface water supplies. Such discoveries have led to a new understanding of the link between what we do on the land surface and what we find in groundwater. Use, spillage, and disposal of hazardous chemicals, fertilization of lawns and crops, poorly constructed septic systems, and application of pesticides all are examples of activities that can affect the quality of our groundwater supplies.

Where Groundwater Comes From

Water entering the soil gradually percolates downward to become groundwater if it is not first taken up by plants, evaporated into the atmosphere, or held within soil pores. This percolating water, called recharge, passes downward through the root zone and unsaturated zone until it reaches the water table. Effective programs for protection of groundwater focus primarily on the recharge process since this controls both the quantity and the quality of water reaching the saturated zone. Water is far easier and less expensive to manage at the land surface than after it becomes less accessible and more dispersed underground.

The quantity of recharge in any particular location depends on the amount of precipitation or irrigation, the type of soil, and the topography, geology, and biology of the site. Seasonal fluctuations occur in the quantity of recharge, leading also to fluctuations in depth to the water table. In winter and early spring when plants are not yet taking up much water, the water table may be close to or at the ground surface in humid regions and low regions in a basin or hydrologic region. Evidence of this includes ephemeral streams and wetlands, wet basements and agricultural fields that are too wet for cultivation or planting. As the summer progresses, the water table commonly drops because evaporation and plant uptake exceed recharge. During dry periods this drop may cause water shortages in shallow wells, and drying up of springs, streams, and wetlands.

Both the quantity and the quality of groundwater supplies depend on the recharge water that continually filters down through the soil to the saturated zone. Any chemicals on the ground surface or introduced into the soil can become groundwater contaminants if they are carried downward by this recharge water.

How Groundwater Moves

Groundwater does not consist of large underground lakes or streams. Rather, it is water that moves slowly through irregular spaces within rock fractures or between particles of sand, gravel, or clay. Whereas water in a stream may move several feet per second, groundwater may move only a few feet per month or even per year. The major exception to this general rule is in limestone areas, where groundwater may flow rapidly through large underground channels and caverns.

The geologic formulation through which groundwater moves is called an aquifer. This can be a layer of sand, gravel, or other soils, or a section of bedrock with fractures through which water can flow. Randomly drilling a hole into the ground in many parts of the country will yield some water. Only major aquifers, though, will have sufficient flow to maintain community water systems or large irrigation wells. The quantity and quality of recharge received by aquifers depends on their depth from the ground surface, the geology of the overlying materials, the climate, land uses, plant type and distribution, and water and chemical management practices in these recharge areas.

Recharge water moves downward through the soil until it reaches the water table. Once in the aquifer, it then travels in a more horizontal direction. Eventually, groundwater resurfaces, producing springs or feeding water into wells, streams, wetlands, or other surface water bodies. Groundwater becomes contaminated when recharge water carries pollutants downward to the water table. Once in the saturated zone, these chemicals move with the groundwater, forming a region of contaminated water called a plume.

Consequences of Groundwater Contamination

Once groundwater is contaminated, fixing the problem is difficult and may be prohibitively expensive. In 1979, for example, the pesticide aldicarb was found in Long Island groundwater. Since then approximately $3 million has been spent measuring aldicarb concentrations in Long Island wells. Carbon filtration units have had to be installed in over 2500 affected households, and plans are being made to replace individual wells with expensive community water supply systems. These huge expenses are merely to define and treat the problem, without correcting the underlying groundwater contamination.

Another consequence of pesticide contamination of groundwater may be the imposition of restrictions on use of the pesticide. Aldicarb, for example, can no longer be used on Long Island or in parts of California, Florida, Massachusetts, New Jersey, and Wisconsin. Other compounds, such as DBCP and EDB, have been removed completely from agricultural use after their discovery in groundwater.

Cleaning up of groundwater contaminated by pesticides often is impossible, and the results may last for many years. Once in groundwater, degradation of pesticides tends to be quite slow because of the cold temperatures, low microbial activity, and absence of light. The slow movement of groundwater means that it may take many years for the contaminated plume to flow beyond the affected wells. Even determining what wells will be affected and for how long is a difficult problem, necessitating expensive long-range monitoring to ensure the safety of drinking water supplies. Clearly, the best solution is to keep pesticides and other contaminants out of groundwater, through careful planning of storage, use, and disposal practices.

Pesticide Contamination of Groundwater

Between 1950 and 1980, production of synthetic organic pesticides more than tripled in the United States, from about 400 million pounds in 1950 to over 1.4 billion pounds in 1980, some was exported. In 1999, it is estimated that 912 million pounds of pesticides were used in the U.S. in producing food,

clothing, and durable goods and for ambient pest control. This is down from the peak use in 1979 of 1.2 billion pounds. Although not much testing for pesticides in groundwater has been done, recent tests have shown a few to be significant contaminants. To date, 17 pesticides have been detected in groundwater (Table 10), and up to 80 are estimated to have the potential for movement to groundwater.

Most farm families rely on individual wells, untreated, unmonitored, and located close to fields on which pesticides are applied. Water feeding these wells is likely to contain whatever pesticides have been leached from the fields by recharge waters. But not all pesticides will leach, and certainly not all farm wells are contaminated. An understanding of what causes these differences is crucial in protecting the quality of rural groundwater supplies.

That pesticides will leach, and in what quantities, depends in part on the amount applied per acre per year, the solubility of the compound, how strongly it is held by the soil, and how quickly it breaks down in the root zone. Before the 1940s, most pesticides were compounds of arsenic, mercury, copper or lead. Although these compounds may have made their way into drinking water, they were not highly soluble, and the residues ingested in contaminated fruits and vegetables were of far greater concern. Synthetic organic pesticides were introduced during World War II and were thought to be far safer and more effective. These included chlorinated hydrocarbons such as DDT, aldrin, dieldrin, chlordane, heptachlor, lindane, endrin, and toxaphene. Because of their low solubility in water and their strong tendency to chemically attach to soil particles, these compounds have rarely contaminated groundwater. Although when introduced, they were thought to be safe to humans and the environment, they later were discovered to accumulate in the environment and build up to toxic concentrations in food chains. Use of most of the chlorinated hydrocarbon pesticides consequently have been canceled.

Table 10. Typical positive results of pesticide groundwater contamination in the U. S.

Pesticide	Use*	State(s)	Typical Positive, ppb**
alachlor	H	MC,IA,NE,PA	0.1-10
aldicarb	I,N	AR,AZ,CA,FL,MA,ME,NC,JN	1-50
(sulfoxide & sulfone)	H	NY,OR,RI,TX,VA,WA,WI	
atrazine	H	PA,IA,NE,WI,MD	0.3-3
Bromacil	H	FL	300
Carbofuran	I,N	NY,WI,MD	1-50
Cyanazine	H	IA,PA	0.1-1.0
DBCP	N	AZ,CA,HI,MD,SC	0.01-20
DCPA(and acid products)	H	NY	50-700
1,2 – Dichloropropane	N	CA,MD,NY,WA	1-50
Dinoseb	H	NY	1-5
Dyfonate	I	IA	0.1
EDB	N	CA,FL,GA,SC,WA,AZ,MA,CT	0.05-20
Metolachlor	H	IA,PA	0.1-0.4
Metribuzin	H	IA	1.0-4.3
Oxamyl	I,N	NY,RI	5-6.5
Simazine	H	CA,PA,MD	0.2-3.0
1,2,3 – trichloropropane	N	CA,HI	0.1-5.0

*H=herbicide, I=insecticide, N=nematicide

**parts per billion

One group replacing the chlorinated hydrocarbons has been the organophosphorus compounds such as malathion and diazinon. Although some organophosphorus compounds are highly toxic to humans, they generally break down rapidly in the environment and rarely have been found in groundwater. Another group replacing the chlorinated hydrocarbons are carbamate pesticides including aldicarb, carbofuran, and oxamyl. These compounds tend to be soluble in water and weakly absorbed to soil. Consequently, if not degraded in the upper soil layers, they have a tendency to migrate to groundwater. The most significant occurrences of groundwater contamination have been with the carbamate pesticides.

Sampling of shallow wells by U.S. Geological Survey personnel found pesticides contaminating groundwater in Nevada, Table11.

Table 11. Pesticide and maximum concentration (micrograms per liter) in urban and agricultural shallow groundwaters in Nevada. Sampled during 1993 to 1995.

Chemical	Urban/Agricultural Well (µg/l)[1]
acetochlor	CD – 0.023
atrazine	LV – 0.045 RS – 0.032 CV – 1.2
bromacil	CV – 0.020
deethyl atrazine	RS – 0.090 CV – 0.032 CD – 0.003
diazinon	RS – 0.010
diuron	RS – 0.010
oryzalin	LV –0.080
prometon	LV – 0.065 RS – 4.0
simazine	LV – 0.022 RS – 0.088 CV – 0.059 CD – 0.016
tebuthiuron	LV – 0.035
terbacil	RS – 0.034

1. The range of chemical concentration from the urban [Las Vegas (LV), Reno-Sparks (RS)] and agricultural [Carson Valley (CV), Carson Desert (CD)] wells are presented. Many wells were sampled, and many in each location were contaminated with more than one chemical.

After a pesticide is applied to a field, it may meet a variety of fates. Much is taken up by the plants, leaves and stems and harvested or converted to harmless by products. Some may be lost to the atmosphere through volatilization (evaporation), metabolized, carried away to surface waters by runoff, or broken down in the sunlight by photolysis. What enters the soil may be taken up by plants, degraded into other chemical forms, or leached downward, possibly to groundwater. The remainder is retained in the soil and continues to undergo these processes. How much meets each of these fates depends on many factors, including:

- the properties of the pesticide,
- the properties of the soil,
- the conditions of the site,
- the crop or plants involved, and
- the management practices employed.

PREVENTING GROUNDWATER CONTAMINATION IS THE APPLICATOR'S RESPONSIBILITY

Prevention is the best way to minimize groundwater contamination. Proper application practices when followed can make pesticide use more effective, efficient, and prevent groundwater contamination. The need, method, and frequency of chemical control should be evaluated in the context of potential groundwater contamination.

Pesticides should only be used when and where necessary and only in amounts adequate to control pests. Using pesticides only when necessary and using only the minimum amount consistent with effective pest management will minimize potential groundwater contamination.

Multiple applications of a single pesticide to the same site have caused groundwater contamination in several locations in the U.S. Growers who depend on continual applications of the same pesticide over long periods should evaluate their pest management practices carefully. Reducing the number of applications (and the total amount applied), changing to a pesticide that is less likely to move through the soil, or using alternative methods of pest control can help to minimize groundwater contamination. The susceptibility of the particular soil type to leaching should be determined prior to using pesticides with the potential to contaminate groundwater.

Pesticides can reach groundwater by moving through the soil. Some pesticides move readily through soils that are well-drained, sandy, or low in organic matter. Sandy soils have low water-holding capacity, support smaller populations of microorganisms that can break down pesticides, and lack clay and organic matter to bind the chemicals. Because of these factors, the possibility of groundwater contamination is greater when pesticides are applied to gravelly or sandy soils than to any other soil type.

Pesticides should not be applied where they can reach ground or surface water sources. The closer the water table is to the surface of the soil, the greater the possibility for contamination. As an example, land that is near a stream or a marsh most likely has a water table that is close to the surface.

In an effective pest management program, pesticides should be selected that are less likely to leach. The potential of an agricultural chemical to move in the soil varies according to the nature of the chemical, the properties of the soil, and the agricultural practices used.

The most significant cases of groundwater contamination have involved carbamate pesticides. These compounds tend to be soluble in water and are weakly absorbed to soil. Carbamates have a tendency to

migrate to groundwater if they are not degraded in the upper soil levels. Another pesticide group, the organophosphates, generally break down rapidly in the environment and rarely have been found in groundwater. Whenever possible, the pesticide applicator should select a non-carbamate pesticide that is less likely to leach and reach the groundwater.

Follow the direction on the pesticide label.
The pesticide label is designed to provide the applicator with useful and important information in order to use the pesticide efficiently, safely, and legally. There are four times when the pesticide label should be read: (1) before a pesticide is purchased, (2) before the pesticide is mixed and applied, (3) before the pesticide is stored, and (4) before disposing of the pesticide container.

Pesticide labels contain the following information: the brand name, common name, type of formulation, ingredient statement, net contents, name and address of manufacturer, EPA registration and establishment number, statement of use classification (general or restricted-use), signal words (danger, poison, warning, caution) and symbols (skull and cross bones), precautionary statement, statement of first aid, directions for use, misuse statement, re-entry information, storage and disposal directions, residues, and restrictive statement. An increasing number of pesticide labels also contain information on groundwater contamination.

There are both civil and criminal penalties for using a pesticide in a manner that conflicts with the label.

Pesticides should be measured carefully.
Pesticides should always be used at the rate specified on the label. Always read the label before you begin to mix the pesticide to make sure you have a measuring device that will accurately measure the correct amount of pesticide required. Measure pesticides carefully, accurately, and safely.

Applicators should direct pesticide applications to the target site.
Applicators should avoid over spraying the ground to prevent the possible introduction of the pesticide into the groundwater. Applications that are effectively directed to the target will reduce drift and are less likely to contaminate water sources.

Dispose of pesticides properly.
After the pesticide application is complete, the applicator should take care in disposing of the excess pesticide and the pesticide container. Follow the label for proper pesticide disposal to avoid groundwater contamination. Pesticide containers should be triple-rinsed or pressure-rinsed (to prepare them for disposal), with the rinse water poured back into the spray tank and used to treat the site or crop.

The best precaution against pesticide disposal problems is good planning. This begins with buying and mixing the right amount of pesticide.

PESTICIDES SHOULD BE STORED SAFELY

The law requires that pesticides be stored in a safe, secure, and well-identified place. Pesticides must always be stored in the original, labeled container with the label clearly visible. Pesticides should be stored in a cool, well-ventilated, secured (locked) location away from wells, pumps, or other water sources. Pesticide containers should be tightly sealed and periodically checked for leakage, corrosion breaks, tears, etc.

The pesticide applicator should maintain records of pesticides that were used.
Information from these records may help to prevent future contamination of the groundwater and help protect the applicator should questions about treatments arise in the future. Private applicators must keep records of pesticide applications and maintain them for possible inspections for two years.

ADDITIONAL GROUNDWATER PROTECTION METHODS

Additional protection methods, such as carefully timing irrigation, avoiding runoff, and inspecting wells, can be used to prevent groundwater contamination of pesticides.

Time irrigation

If it is practical, irrigation should be delayed for one or more days after a pesticide application. A delay in irrigation gives the plant and the soil more time to take up the pesticide. This reduces the amount of pesticide that is available for movement through the soil with irrigation. Thus, the chances of the pesticide reaching the groundwater are reduced.

Avoid irrigation run-off.

This will reduce soil erosion and decrease the chances of the pesticide entering into the surface and groundwater. Extra care should be taken when irrigating and applying pesticides on clay soils because they are especially susceptible to run-off.

Wells should be inspected to prevent groundwater contamination.

A well acts as a direct pipeline to groundwater. Groundwater can become contaminated if pesticides or other pollutants enter a well directly from the surface, through openings in or beneath a pump base, or through soil adjacent to the well. New wells, if properly constructed, can prevent groundwater contamination. For example, wells should be located away from pollution sources likely to contaminate the well. Proper seals between the pump and the pump base help prevent the entry of contaminants. Seals between the casing of the well and the wall of the hole can prevent water near the soil surface from entering the well and possibly contaminating the groundwater. In Nevada, a well must be sealed to 50 feet with neat cement.

Proper maintenance of existing wells helps prevent groundwater contamination. Wells and pumps should be inspected regularly for leaks and to ensure that the seal is adequate to prevent pesticides from entering the groundwater. Irrigation pipes should also be checked for leaks that could lead to contamination of the groundwater.

CHEMIGATION

Chemigation is the application of agricultural chemicals through a sprinkler system. Today over 40 percent of the sprinkler irrigated area in the U.S. involves chemigation. Particular care should be used when practicing chemigation. The irrigation may carry the pesticides downward through the soil to groundwater. Devices should be used to prevent possible back siphoning of the pesticides into the water supply system.

Chemigation has the advantage that the correct amount of chemical can be applied to the crop at the appropriate time, the application is inexpensive, convenient, and field access is unnecessary.

Apply chemicals only through the type of irrigation systems listed on the product label.

The system must contain a functional check valve, vacuum relief valve, and low-pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow.

The chemical injection pipeline must contain a functional, automatic, quick-closing check valve to prevent the flow of fluid back toward the injection pump. The chemical injection pipeline must contain a functional, normally closed, solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shut down.

The system must contain functional interlocking controls to automatically shut off the chemical injection pump when the water pump motor stops. The irrigation line or water pump must include a functional pressure switch that will stop the water pump motor when the water pressure decreases to the point where chemical distribution is adversely affected.
Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphragm pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock.
Crop injury, lack of effectiveness, or illegal chemical residues in the crop can result from non-uniform distribution of treated water. See the last section of this workbook for more details on chemigation.

See "Calibration of Chemigation Equipment" under the "Guidelines for the Safe Use of Pesticides" section for information on calibrating chemigation equipment.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is an alternative to pest control practices that rely exclusively on the use of pesticides. IPM integrates cultural, mechanical, physical, biological and chemical pest control techniques to prevent and suppress pests.

The goal of IPM is to reduce in an economical way the adverse impacts of pest control on human health, the environment and non-target organisms in an economic manner. Problems associated with widespread pesticide use such as pest resurgence, pest resistance, and secondary pest outbreaks are minimized by using IPM. IPM is based on and uses scientifically sound strategies. To be effective, there must be a thorough knowledge of the pest to be controlled, cultural requirements of the crop or plants to be protected, economic, aesthetic, or emotional thresholds for the pest and crop, landscape plant(s), or site and the availability and effectiveness of available control options. Field monitoring, using sweep nets, visual inspection or traps, can help determine if existing pest populations have the potential to cause enough economic, aesthetic, or, emotional harm to warrant implementation of a control program. Field monitoring will also indicate the level of beneficial organisms present. Controls are then selected that will impact them as little as possible while suppressing the pest.

The concept of Integrated Pest Management is nothing new and is widely implemented on field crops and orchards throughout the world. Implementation in the urban environment, in home gardens, landscapes, golf courses, and structural settings has special challenges. Urban IPM, or pest control programs with reduced use of pesticides in homes, private and commercial landscapes, golf courses, and structural settings is an expanding field with increased support from university and industry research.

ACTION THRESHOLDS

A fundamental concept of IPM is a certain number of individual pests can and should be tolerated. Crops are grown for profit, so control actions are largely based on economic criteria. Pest control measures are begun when the pest problem reaches the economic threshold: the point at which some form of control must be applied in order to prevent unacceptable economic damage to the crop. Pest control is undertaken to economically protect crop quality and yield; and of course, the cost of the control measure employed must not exceed expected returns. The cost benefit ratio must be in favor of the producer. The economic thresholds for most agricultural commodities, including production horticulture, are fairly well understood, and IPM programs have been developed for many agricultural crops around the world. This is because a single crop is grown over a large area with relatively uniform climate pattern. The number of pests associated with the crop is usually limited. Each pest has been studied in relation to the crop and the prevailing environment, and IPM strategies developed for its control.

Urban landscapes and structural settings are judged on their appearance, whether or not the presence of a pest presents a health or safety issue, and sometimes solely on the emotions of the property owner, their fear of pests. The aesthetics and healthful condition of an individual plant , a whole landscape or structure may be affected by pests. The presence of pests and their damage, though not serious, may be tolerable or annoying to some, yet readily accepted by others. Urban IPM strategies develop with less emphasis on the ideas of an economic threshold, unless of course, the soundness of the structure or the liability for a client is involved. It is often the appearance of a pest or the damage they cause that triggers control action. This is called the aesthetic threshold. The aesthetic threshold varies from person to person, making it difficult to establish control criteria for most landscape pest. An emotional threshold may also exist in that their may be strong feelings about the presence of certain pests—cockroaches, spiders, etc.

There is usually a variety of species in an urban landscape and within structures. Each is subject to variations in moisture availability, soil and environmental conditions, and multiple microenvironments. Because of this, the potential number of pests associated with the landscape and facilities is tremendous. Plant stress decreases the plant's ability to ward off a pest attack as does sanitation associated with and poor care of structures. Therefore, understanding species needs, the growing conditions in the landscape, and types of structural materials help eliminate factors that stress plants and encourage unhealthy and structural pests. This is of major importance in an effective urban IPM program. Consequently, urban IPM focuses on keeping plants in a landscape growing well so they can resist pest invasion naturally, and paramount to structural pest control, sanitation to reduce habitat and food sources, prevention through exclusion and control.

WHY UTILIZE IPM?

Effective IPM programs have successfully eliminated unnecessary pesticide applications and reduced the total number of applications in a season or to structures. This has resulted in reduced pest control costs, and may prevent some of the adverse effects of total reliance on pesticides, such as pest resurgence, secondary outbreaks, and pesticide resistance.

Pest Resistance: When a pesticide is effective against a pest or group of pests it may be over used. Under these circumstances pest become resistant to the pesticide or related pesticides. This happens because resistant individuals may pass the resistance on to their offspring; the others die. This eventually results in an entire population composed of resistant individuals. The pesticide is no longer effective, causing applicators to increase rates and application frequency, which in turn leads to increased resistance and an increased environmental hazard. Currently, hundreds of pest have developed resistance to one or more pesticides. Common pest species that have demonstrated resistance include houseflies, mites, aphids, cockroaches, and common mallow (a weed common in lawns and gardens.)

Resurgence: Pesticides, both synthetic and so-called "natural" materials, can do more harm than good because they often destroy the natural enemies of a pest. Although the natural enemies may be few in number, they are present and will continue to control a certain percentage of the pest population. If the existing natural enemies are destroyed through applications of pesticides, you will no longer be assisted by that small but effective force. Following a pesticide application, pest populations, particularly those with multiple generations per year, have the ability to rebound much more rapidly than their predators. Their numbers may quickly outdistance the ability of the predators to help control them. The pest population may resurge to greater numbers than before the pesticide application. This pest resurgence may result in a "pesticide treadmill." This occurs when applications of pesticides are followed by pest resurgence, followed by pesticide applications (at a stronger rate), followed by pest resurgence…and so on.

Secondary Pest Outbreak: An organism that usually does little damage if left alone may suddenly become a problem if pesticide applications destroy its natural enemies. A well-documented example of secondary pest outbreak can occur when broad-spectrum pesticides (carbaryl, organophosphates or acephate) are used for the control of aphids or coddling moth on apple trees. Recommendations on the labels of many orchard-spray products suggest mixing a miticide (a pesticide designed to kill mites) with the broad-spectrum insecticide, to help control the predicted surge in mites. Along with a decrease in the targeted pest population comes a decrease in natural enemies and a serious increase in the mite population. The mites existed before, but were being kept in check by natural enemies. The broad-spectrum pesticide releases the secondary pest from the control of their natural enemies and allows them to become a dominant pest themselves.

MANAGEMENT STRATEGIES

IPM incorporates a "holistic" view of pest management programs. Multiple management options are employed to reduce plant predisposition to pest problems and decrease or eliminate pesticide applications.

Selection and care of plants and structural materials: Plants that are adapted to and flourish in their growing environment are better able to resist insect and disease problems. This connection is one many pest managers fail to make. If a poorly adapted plant is selected for a landscape, or plant's cultural requirements are not fully met, it will be difficult to overcome the stresses imposed on the plant or control the pest problems that arise as a result. Properly choosing plants for existing site conditions can prevent pest problems.

Selecting structural materials and products that eliminate habitat or food for pests is very important. Many new materials (steel and plastic) are not eaten by pests nor can become a habitat for them.

Host plant resistance: Selecting plants based on their resistance to pests is critical for effective landscape IPM. Host plant resistance is the ability of the plant to tolerate pests without damage to the plant itself. For example, selecting a Norway Maple (*Acer platanoides*) instead of a Silver Maple (*Acer saccarinum*) or Box Elder tree (*Acer negundo*) will help avoid problems with box elder bugs. While the first is not favored by the box elder bug, the latter two are preferred hosts. The presence of the preferred hosts insures the presence of the box elder bug.

Cultural practices: Cultural practice, maintaining plants and the environment surrounding them, can influence how well plants will do under the prevailing conditions. Cultural practice such as proper fertilizer application, plant selection, appropriate watering, soil management, sanitation, and site selection can influence the health of plants, and therefore the frequency and severity of pest problems. Relatively small changes in cultural practices can have significant impact on pest populations. Removing disease or insect infested plant materials from the vicinity of susceptible plants will help prevent infestation of adjacent susceptible plants. For example, remove and destroy fruit "mummies" at the end of the season. Disease and/or insect pests may overwinter in them, leading to a reinfestation the following year. Regular cleaning and disinfecting of gardening equipment, particularly pruning tools, is also recommended to prevent the spread of some landscape diseases.

Good sanitation within and around structures is critical in controlling pests. It eliminates habitat and food sources of most pests.

Physical/mechanical practices: many times, reducing pests by mowing, cultivating hoeing, or trimming can provide and alternative to using pesticides in the landscape. Reducing direct competition from weeds through careful tillage or mulching around the base of plants can enhance the life and appearance of the plants. Avoiding mechanical damage can greatly improve a plant's survival and reduce potential pest problems. Wounds in trees caused by string trimmers, mowers or tillage equipment can induce stress and shorten the life of trees by making them susceptible to both insect and disease infestation. Pruning wounds created at the wrong time of year can make a tree more susceptible to insect and/or disease infestations. For example, pruning Black Locust trees when Locust Borers are active in late summer and early fall will create wounds that may attract egg-laying females.

Within structures, control of moisture, temperature, air circulation, etc. does much to reduce or eliminate pests.

Exclusion: The most effective way to prevent the development of a pest problem is not to allow the pest to become established. Exclusion is the most important tool of pest management. This is particularly important for weeds or pests that are introduced into an area (exotics). Exotic pests are much more difficult to eradicate after they become well established. Federal and state agencies often place quarantines on certain exotic pests to prevent their spread into other areas of the United States. Examples are the red imported fire ant, Mediterranean fruit fly, and gypsy moth. Much can be done by horticulturists, homeowners, or nursery personnel too. Inspect all new plants to make sure diseases, insects, weeds and other pests are not carried on them into the landscape. Refuse to accept plant material with obvious disease, insect or cultural problems. Remove weeds from nursery containers *before* you place them in a landscape.

Caulking around windows, doors, utility line access holes, and screening entrances, vents and access ports does much to keep structural pests out of a building. Do not bring pest-laden items (storage boxes, old furniture, plants and soil, stored products, etc.) into a structure without first inspecting it for pests and then eliminating them.

Biological Control: The importance of using biological control agents to control insect and disease pests is often overlooked. Biological agents of landscape pests include predators such as lacewings, predatory mites, minute pirate bugs, lady bird beetles, parasites such as parasitic wasps, parasitic nematodes, and microbiological organisms such as *Bacillus thuringiensis* or "Bt." Biological control programs may utilize existing beneficial organisms (conservation), supplement existing, beneficial organisms (augmentation), or introduce a new population of beneficial organisms (importation). The Nevada Department of Agriculture, in cooperation with USDA – Animal Plant Health Inspection Service (APHIS) and Plant Protection and Quarantine (PPQ) is utilizing biological control for a number of pests in Nevada. Russian wheat aphid (*Diuraphis noxia*), a recently introduced insect, is a serious pest of barley, wheat and other small grains. Parasitic wasps, syrphid flies and different species of lady bird beetles have been released experimentally with the hope that biological control will contribute to the control of this damaging aphid. Attempts to control leafy spurge (*Euphorbia esula*) employ beneficial insects to manage a noxious weed. Three species of flea beetle and a midge species have been released in Nevada in an attempt to decrease the population of this weed to manageable levels.

Few biological controls are available for structural and institutional pests.

Pesticides: Pesticides should be viewed as a last-resort treatment to prevent significant damage to plants in the landscape, or as a viable and possibly necessary treatment for agricultural commodities. Pesticides are an important tool but they should be used only when necessary and in conjunction with other management tools. In the urban environment, the tendency is to use pesticides on a preventative basis to ensure the prefect landscape because of a perceived threat from pests. For example, over-application of "weed and feed" products on lawns can have serious effects on adjacent ornamental plants, particularly trees planted in or adjacent to turf. The development of a pest problem is often a sign of poor management practices.

The use of pesticides for structural and institutional pest control must first take into account the exposure potential to the residents of the building and potential health effects to them. As well, being inside, the pesticide tends to breakdown more slowly so its residual must be considered. Consequently, limited pesticides are available for such applications and they are highly regulated.

PRINCIPLES OF INTEGRATED PEST MANAGEMENT

1. The pest problem and the associated plant species must be correctly identified. Is a living pest involved or are cultural problems to blame? If an insect, disease or other living pest is the problem, determine when the pest is most susceptible to control action.

2. Evaluate the necessity of implementing control. Will the pest cause unacceptable damage to the value or appearance of the plant or crop? How will it affect the structure and those who use the structure? *What will happen if no control action is taken*?
3. Determine that control options will produce long-term results with a minimum adverse impact to the plant or crop, the structure, the health of people or animals (pets), and the environment.
4. Employ the least harmful, most cost effective control tactics at the most effective time.
5. Evaluate the results and make adjustments in future pest control strategies.

CONCLUSION

Ideally, an IPM program considers all available pest control actions, including *no action*. Integrated Pest Management is not a substitute for good horticultural practices in agricultural fields or the landscape. Nor is it a substitute for selecting the most pest resistant or tolerant materials. IPM does not advocate the complete avoidance of pesticides. It recognizes that pesticides have a continuing role to play in conjunction with and in support of other pest control strategies. However, the applicator should consider the proper timing of applications and use spot spraying to promote the most effective control with the least amount of chemical. By reducing our reliance on pesticides in home gardens, agricultural fields, public health applications, structures, and parks and recreation areas, we lower the amount of pesticides introduced into the environment. We also reduce the potential for the applicator and others to be harmed by continued exposure to chemicals. In addition, with judicious use of pesticides, we can extend the useful life of some beneficial chemicals by reducing the buildup of pest resistance.

CATEGORY #1a
Agricultural Pest Control – Plants

PLANT (INSECTS)

Alfalfa weevil: This is the most serious state-wide pest on alfalfa. It overwinters as an adult along fence lines or in the surrounding native vegetation. The best time to control it is in the larval stage. Compounds previously used for controlling adults have been canceled. Therefore, treat only for larvae. In early spring, adults deposit eggs in stems of alfalfa; the eggs hatch, larvae make their way to the growing tips and upper leaves, where they feed. Once mature, they make their way to the base of the plant and pupate. On rare occasions, newly emerged adults may cause damage to the second crop. Timing for control can be very important with some compounds.

Mites: Mites often appear under dry conditions prior to first irrigation. Often the first irrigation will reduce their populations. They can be controlled with acaracides. Damage is caused by sucking plant juices. These are not insects.

Aphids: The typical aphid overwinters as a sexually produced egg or adult aphid. This may occur on a summer host or on an alternate winter host. In the spring, eggs hatch producing winged adults or the overwintering adults move to the summer host. Here the females mature and begin producing parthenogenic offspring. This may be repeated (adult to adult) in the summer time as often as once a week. Aphids, like mites, feed through sucking mouthparts. Almost every crop has its own type or types of pest aphids. Identification of which species is attacking the crop is extremely important since thresholds and the effectiveness of chemicals may vary from species to species. The Russian wheat aphid was first reported in the U.S. in 1986 from Texas and by 1987 had been reported in nearly all the Rocky Mountain states. It can cause severe damage to a number of small grains. Up until 1987, this aphid had not been found in Nevada. However, the aphid is now found throughout Nevada and can be a serious pest of small grains. Since 1990, the Nevada Department of Agriculture and the USDA-APHIS have been releasing predators and parasites of this aphid in several locations in Nevada. It is hoped that these beneficials will establish in the areas and help reduce Russian wheat aphid populations.

Lygus bugs: This is primarily a pest on alfalfa seed but can cause some damage on hay. It is usually a problem on other crops grown for seed. Control is difficult and the best success is achieved with pesticide applications aimed at the smaller nymphs.

Cutworms: Cutworms are an occasional problem in all agricultural crops. Early detection is very important. Symptoms often show up as "late spots" in alfalfa fields. In row crops young seedlings will be severed at ground level. If populations are high enough (about 1/square ft) controls are warranted. Baits can be applied but often bait acceptance is a major problem. It is important to know which cutworm or armyworm you are dealing with since many are nocturnal and for these species you must spray in the late afternoon or evening to get adequate control.

Grasshoppers and Mormon Crickets: Large grasshopper populations generally develop on non-cultivated land or on land that has been left fallow or abandoned. These populations or "bands" then move to agricultural lands and feed on crops. Controls must be aimed at the entire band of grasshoppers; treating only a portion of the band will often result in rapid re-infestation of the treated area. Treating must also occur before grasshoppers begin laying eggs. If properly treated, grasshoppers can be controlled in an area for up to five years. Control measures include ULV malathion (most effective and cheapest), carbaryl and oil, carbaryl baits, acephate (Orthene), Dimilin and *Nosema* (grasshopper spore) baits.

Nosema locustae is a disease of grasshoppers. This biological control can be used effectively against grasshoppers if the proper conditions exist. Success is most dependent on the grasshopper species present, stage of the grasshopper, and habitat conditions.

Thrips: These are important pests of onions and garlic. On these crops the economic threshold is considered to be about 10 per leaf. Thrips on other crops can cause cupped or silvered leaves, deformed flowers and problems in pollination from their rasping style of feeding. Thrips are very difficult to control. Consider crop rotation, sanitation near crops – removing alternate hosts, and chemical applications.

Pollinator Protection: When growing crops for seed or adjacent to areas of seed production it is vitally important to be aware of the effect that an application of pesticides will have on the pollinators of the crop. The three most important pollinators in Nevada are the alfalfa leafcutter bee, the alkali bee and the honey bee. If an application of pesticide is to be made near hives or domiciles, the owner of the bees should be notified so protective measures can be taken.

WEEDS

I. Introduction
   A. Prerequisites for effective herbicide use
      1. the herbicide must contact the plant
      2. it must remain on plant surface long enough to penetrate or be absorbed
      3. it must reach a living site to disrupt a vital process or structure
      4. it must be the product that will kill the target weed

   B. Items that impact the effectiveness of an herbicide
      1. herbicide uptake rate and quantity
      2. herbicide movement in the plant
      3. its mode of action
      4. fate of the material in the herbicide
      5. its selectivity
      6. its application in a timely manner

II. Herbicide uptake
   A. Soil applied materials
      1. move into the plant with the soil water solution
      2. absorbing parts of the plant will get the herbicide
      3. absorption of the herbicide takes place across cell walls of the root hairs
      4. non-germinating seed not affected
      5. do not disturb the soil and interrupt the herbicide barrier

   B. Foliar applied materials
      1. are difficult to get into the plant through the shoots and leaves
      2. the major barrier to herbicide uptake is the cuticle
      3. factors that affect movement of the herbicide into the leaf
         a. foliar retention
            1) herbicide carrier
               a) water "beads up" and runs off, therefore use a wetting agent
               b) oils spread out and adhere to the leaf, but are expensive to use
            2) spray volume
               a) excessive amounts can run-off
               b) adjust volume to get good coverage and penetrate the crop canopy

c) depends upon the nature of the herbicide – trend now is to lower volumes and increase pressures

3) amount of shoot growth
   a) must be enough to intercept spray
   b) freshly mowed areas or emerging shoots seldom have enough area
   c) wait until grasses are three to five leaves or perennial broadleaves are one-half to one inch in diameter and rapidly growing

4) rainfall probability
   a) retention time must be 6 to 12 hours for water soluble materials to be taken into the plant
   b) oil soluble materials must be retained for lesser periods, often as little as one hour
   c) rainfall soon after application may dilute, neutralize, or wash the herbicide off the plant

b. cuticular penetration
   1) oil soluble materials penetrate quickly
   2) water soluble materials require wetting agent which is often included in the product; if not included, label instructions will indicate need for addition of a wetting agent
   3) environmental conditions have greater impact on water solubles than oil soluble products

4. summary of foliar applied materials
   a. maximum kill will be obtained under warm, humid conditions with adequate soil moisture
   b. environment influences both the herbicide uptake and how the plant is growing

III. <u>Herbicide movement in the plant</u>

A. To be effective, the herbicide must reach a site to interrupt a growth process

B. Three groups of herbicides
   1. those with little or no movement, contact pesticide
      a. kill immediately after penetration, usually within hours
      b. complete coverage is necessary
      c. kills annuals but not biennials or perennials, may be used for burn back of these
      d. examples: foliar applied
         - nonselective, PARAQUAT
         - selective, MSMA
   2. those that are moved through the water stream (apoplastic movement)
      a. these are generally soil applied
      b. older leaves are affected first
      c. cannot move downward, so if foliar applied they act as contact herbicide
      d. examples:
         - selective, SIMAZINE or ATRAZINE at low rates
         - nonselective, SIMAZINE and ATRAZINE at high rates
   3. those that are moved in the food conducting tissue (symplastic movement)
      a. become distributed throughout the plant to points of active growth
      b. examples:
         - selective, 2,4-D
         - nonselective, ROUNDUP
      c. some are soil applied but movement is slow, PICLORAM (Tordon)
      d. must be used if foliar applied and the goal is to kill the roots
      e. all are used to control annuals, biennials or perennials

IV. Mode of Action

A. How the herbicide kills the plants

B. Several modes of action

1. synthetic auxins
   a. downward twisting and curving of stems
   b. puckered, twisted or epinastic leaves
   c. symptoms occur within hours
   d. plant dies slowly – usually three to four weeks
   e. acts unfavorable upon cell division and cell enlargement
   f. examples: 2,4-D, BANVEL, TORDON
2. inhibitors of photosynthesis
   a. cause food manufacturing to stop in leaves and stems
   b. causes plant to turn white
   c. examples: some TRIAZINES
3. disruptors of cell membranes
   a. most are contact herbicides
   b. cause cell contents to leak
   c. plants wilt and dry
   d. examples: TREFLAN, PARAQUAT
4. disruptors of cell division
   a. inhibit new cell formation
   b. examples: KERB, EPTAM
5. root and shoot inhibitors
   a. probably affect cell division and enlargement
   b. examples: EPTAM, CASORON, KERB
6. general metabolic inhibitors
   a. interfere with enzyme production, ROUNDUP
   b. interfere with enzyme activity
7. pigment inhibitors
   a. chlorophyll disappears
   b. plant death is slow
   c. examples: SONAR, SOLICAM

V. Fate of herbicides

A. Herbicides will be intercepted or retained or will come in contact with the ground

1. those that are INTERCEPTED
   a. absorbed into the plant
      1) may be combined with other plant components that can lead to selectivity: SIMAZINE OR ATRAZINE on corn
      2) after toxic reaction the metabolites are incorporated into plant constituents or may be degraded
      3) materials may be deposited on the soil as part of the crop residue
         a) tied up on soil particles
         b) degraded by soil microbes
   b. remain on the plant – dissipated by volatilization or photo decomposed (UV or red light)
   c. those that contact the ground - undergo the same degradation as soil applied materials
2. soil applied materials
   a. those portions that volatilize or leach away are covered in other sections of the manual
   b. degradation is both desirable and undesirable

1) desirable – do not build up in soil
2) undesirable – may not last long enough to be effective

c. degradation is measured as "half life"; how long it takes for the herbicide to break down to one-half the applied rate
   1) half life of majority of herbicides is six months
   2) most herbicides degrade to 1/3 or 1/4 or less in one season
   3) those that do not are short-term soil sterilants or used on non-cropland situations
   4) materials in or on the soil degrade by
      a) volatilization degradation is quick, therefore must be incorporated – TREFLAN; KERB
      b) photodegradation – broken down by light into less toxic or inactive compounds
      c) chemical degradation – combine with other materials in the soil or gain or lose water
      d) biological degradation – materials are decomposed as a result of microbes extracting carbon as an energy source

B. Our major concerns become residues on plants or contamination of soil and/or groundwater.
   1. crops grown for food or feed are expected to be free of harmful breakdown products
   2. COMPOUNDS THAT DO NOT DEGRADE TO HARMLESS PRODUCTS ARE EITHER DROPPED FROM CONSIDERATION AS HERBICIDES DURING DEVELOPMENT <u>OR</u> THEIR USE IS RESTRICTED TO NONCROP APPLICATIONS
   3. difficulties can be avoided by:
      a. using the right material on the right crop against the right pest
      b. application at the right time, using the right techniques, right dosage rates and being aware of the environmental conditions
      c. correct disposal of extra spray materials and containers
      d. always reading and following the directions on the label

PLANT DISEASES

There are <u>six</u> major principles of plant disease management:

1. eradication
2. exclusion
3. protection
4. plant resistance
5. therapy
6. avoidance

Most plant disease management methods are combinations of two or more of these principles. Plant disease management methods are generally classified as:

1. cultural
2. biological
3. chemical

Many of the common, approved agricultural practices that have been developed over the years are important in cultural and biological plant disease management. They include:

1. resistant varieties
2. isolines
3. crop rotation
4. plowing under residue
5. certified seed

6. general sanitation
7. planting depth management
8. proper fertility (including placement)
9. roguing out diseased plants
10. planting in areas climatically unsuited for a pathogen

These are only a few of the many non-chemical control methods. Growers should always consider these aspects of disease control in their management schemes.

Chemical plant disease control methods can be subdivided into three basic categories:

1. seed treatment (see appropriate sections in this booklet)
2. soil treatment
3. chemical treatment of growing plants

Nevada cropland, approximately 600,000 acres, can be divided into six major groups that account for 98 percent of the total acreage. The six major groups are:

1. alfalfa hay
2. potatoes
3. alfalfa seed
4. small grains
5. onions and garlic
6. fruits and vegetables

The major diseases of each group are as follows:

Alfalfa hay

Disease management in alfalfa hay production is largely based upon cultural practices to reduce loss. Variety selection and the use of certified seed are most important. Some seeds are treated by coating with fungicides to control damping off during germination and plant establishment. In most cases adapted resistant varieties are available for the most important alfalfa diseases.

Root Disease	Foliage Diseases
Phytophthora root rot	Common leafspot
Fusarium root and crown rot	Spring blackstem
Bacterial wilt	*Stemphylium* leafspot
Damping off of seedling blights	Downy mildew
Nematodes	Dodder – parasitic plant

Potatoes

This crop accounts for the largest single use of fungicides and fumigants (as nematicides) in the state. Varieties are usually selected for agronomic characteristics not disease resistance. Destroying cull piles as the final sanitation practice in the fall reduces the source of spring innoculum of late blight and early blight diseases.

Foliage Diseases of Potatoes

Late Blight – fungal disease that is most severe during cool, clear weather. Occurs in fields with sprinkler irrigation systems. Major fungicides that have been used to suppress spore production are: Dithane M-45, Bravo, Polyram, and Maneb.

Early Blight – similar to late blight, but the lesions are more prominent on lower, older leaves as target or bulls-eye lesions. Fungicides used for control are the same as for late blight. High rates of nitrogen fertilizer may help control the disease.

Black Leg – a bacterial disease that occurs on the stem and tuber. Mechanical injury of plants by cultivation increases incidence and severity. Certified seed is an absolute necessity. Seed treatment with Captan, Dithane M-45, or Polyram is good insurance.

Calico Virus – the name for alfalfa mosaic virus in potatoes. Control aphids in potato and alfalfa since they transmit the disease. Use certified seed, rogue all infected plants, control volunteers, and destroy cull piles.

Root and Tuber Diseases of Potatoes
Verticillium Wilt – a fungus disease that plugs the water-conducting tissues causing premature yellowing and death of the foliage. Invades through the root system. Long-term crop rotation and preplant soil fumigation with Vapam, Telone C-17, and Vortex have given good control.

Scab – a fungus disease that results in corky lesions on the tuber that may be superficial or deeply pitted. Certified seed, seed treatment, and cultural practices can control this problem.

Root Knot Nematode – stunted plants with roughened, pebbly-appearing tubers occur with this pathogen. Certified seed, soil fumigation, preplant Temik application, crop rotation, and general sanitation help to control this disease.

Alfalfa Seed
Controlling dodder is the major chemical disease control application, because the seed of this parasitic plant is similar to that of alfalfa. Materials used include pre-emergent herbicides: Kerb, Casoron, and Chloro IPC. An early forage harvest reduces the incidence of major foliage diseases in seed fields.

Small Grains (wheat, barley, oats, sorghum)
Smuts are the major biological disease problem. Primary control consists of using seed treatment (see appropriate section). Water application mismanagement is a major abiotic disease problem.

Onions and Garlic
Botrytis neck rot (onions) – This fungus causes considerable loss in the field curing period and in storage. White globe varieties are very susceptible to this disease. The most common cause for severe losses are: (1) use of excessive amounts of nitrogen that delays maturity, (2) irrigation and/or rainfall late in the season, (3) inadequate or improper curing, and (4) improper storage.

Pink Root (onions) – the fungus that causes this disease survives in the soil for long periods (ten years or more). Crop rotation will reduce severity. El Capitan, Fiesta, and Yellow Globe Danvers are resistant. Preplant soil fumigation with Telone II, Telone C-17, or Vorlex is effective for control.

White Rot (garlic and onions) – the leaves of the plants decay at the base, turn yellow, wilt, and topple over when infected by this fungus. The roots rot and white mycelium may be present on remaining roots when removed from the soil. Soil fumigation has given good control.

Fruits and Vegetables
Powdery Mildew (grapes) – white powdery mycelium and spores on all foliage. The fungus disease best controlled with various copper and/or sulfur formulations.

Fireblight (apples and pears) – bacterial disease spread by pollinators that causes typical firing appearance in fruit spurs and leaves. Brownish, sticky exudate is produced from diseased tissue. Remove cankers and prune to healthy wood. Use streptomycin or copper formulations during bloom.

Fusarium Wilt (cantaloupe) – causes root rot and wilting as the plant develops. Resistant varieties and seed treatment can be effective for control.

Curly top virus (tomatoes) – This virus is transmitted by leaf-hoppers. Dusting transplants as soon as they are set out and as new foliage appears until fruit set will discourage leaf-hoppers from feeding. Talc, diatomaceous earth or finely ground pumice are equally effective.

Specific Disease Types

1. Seed and seedling diseases
   a. damping off
   b. blights
2. Wilts
   a. fungal
   b. bacterial
   c. physiological
3. Root rots and cankers
   a. fungal rots
   b. bacterial cankers
   c. nematode cankers
4. Stem rots and cankers
   a. fungal rots
   b. bacterial cankers
   c. fungal cankers
   d. vascular rot
5. Leaf diseases
   a. spots
   b. blotches
   c. mosaics
   d. deformities
   e. yellowing
   f. necrosis
6. Blights
7. Rusts and smuts
8. Mildews
9. Storage
   a. rot
   b. mycotoxins in grains and hay

Almost every plant disease can be grouped according to one or more of the disease types listed above. Using this grouping can be highly beneficial to your University of Nevada Cooperative Extension educator when discussing disease problems.

VERTEBRATE PESTS

Vertebrate pests are those pests that have backbones.

Rodents

Squirrels – Four common types; Richardson, California Ground Squirrel, Townsend and Belding. Best time for control is mid-February through March. Strychnine grain baits (restricted use pesticide) on private property only. None on public lands! Grain baits are good, and by request to U.S. Fish and Wildlife Service, may be applied on public land if the situation warrants.

Pocket Gopher – Activity determined by fresh mounds. Burrows are 4-10" underground. For control, use Burrow Builder, make burrow bores 25' apart. Burrow Builder deposits 27-30 kernels of bait every 17". Compound used is strychnine grain (restricted use pesticide). Other compounds used are Fumitoxin and gas. Must synchronize your program with that of your neighbors to be effective. Bait acceptance changes with time so some bait does not work at all times.

Rats and Mice – The main problem is from defecation and urination on the product. Field mice eat alfalfa crowns; damage forage, seed and ornamentals by girdling. Baits and traps may be used for mice, and best baits are sardines, peanut butter, bacon, and salami. Use baits for best control of rats. Compounds used are zinc phosphide, anticoagulants. Baiting stations must be labeled "POISON". Damage from urine will fluoresce using a fluorescent light.

Rabbits – Damage alfalfa, particularly following season of drought. For best control, use strychnine (restricted use pesticide) on dry forage. Remember, private lands only.

Moles – Found in urban areas, damage caused by digging after insects and worms. You cannot poison moles directly. Soak an insecticide into soil to control insects and worms, and you will control moles as they will have no food source. Moles are insectivores. Trapping is best method.

Birds – Birds in feed yards eat large quantities of grain and their droppings carry disease.

Pigeons – pest at feed yards and urban settings. Control by finding the roosting area and physically eliminate at this point. Live trapping is best in urban settings.

Sparrows – may control by using toxicants on very small grains placed in bait boxes out of reach of animals and people.

Starlings – control method is to pre-bait for several days in area of control, then mix Starlicide at 1-10 with the bait. Bait should be the size of a large pea. You will only get one crack at starlings as those that survive will never eat the same bait again.

Snakes – Only control method is physical elimination (trapping, shooting, etc.).

Fish – For control of trash fish, use Rotenone. Contact the Nevada Division of Wildlife before making any aquatic pesticide application.

CATEGORY #1b
Agricultural Pest Control - Animal

LIVESTOCK AND DAIRY

Ectoparasites are the most important pests of livestock. They attach themselves to the outside of the animal and spend all or part of their lives there. Examples are flies, ticks, mites and lice.

Endoparasites are those that spend their lives inside the animal's organs or organ systems such as the gut, heart, lungs, etc. Examples are flukes, ascarid worms, heartworms, etc. Grubs are not endoparasites, horse bots are.

Lice – most livestock lice have mouthparts that are of the piercing sucking type. Four species are found on cattle: long nosed louse, short nose louse, blue louse, and one biting louse (*Bovicola bovis*, the cattle biting louse). All lice are species specific. Feeding lice cause skin irritation making animals rub; this causes skin abrasions, leathery skin, and sets up a source for secondary infection. Also, the animal's excess activity decreases food utilization.

Treat in the fall (the first time) at the same time as for grubs. Dipping is best, spraying is second best (remember use at least 250# of pressure when spraying). Other methods used are pour-ons, dusting, dust bags, and the newest methods are spot-ons and ear tags. Louse populations are greatest in the winter months, and should be treated with non-systemics in December or January (for the second time). Ectiban is a good compound at this time. The first treatment should be with a systemic (Co-Ral, Ruelene, Fenthion, Neguvon). Lice are the most common ectoparasite of hogs.

Two of the most common ectoparasitic pests of beef cattle are the horn fly (the most common) and lice (second most common). However, the most annoying pests of farm animals are the flies.

Horn Fly – has piercing, sucking-type mouth parts for sucking blood; this is the number one pest of cattle in the world. It is easy to control as it spends all of its time on the host; it leaves only to lay eggs. Methods consist of spraying, dust bags, feed additives, growth hormones, and ear tags. Some control is afforded by dipping. The fly lays eggs in fresh cow manure, and progresses from egg to adult in only 96 hours. By breaking up manure pats by dragging every 48 hours in pastures and corrals, you can reduce the populations by 50 percent. This works only in small operations. Large operations must depend on other methods. When hanging dust bags hang them so animal will touch them in passing. The horn fly has developed resistance to the synthetic pyrethroids in areas where the compounds have been used continuously for over three years. Integrated management practices should be used for control.

Heel Fly or Grub Fly – there are two species, the northern grub fly (or bomb fly) and the common grub fly (heel fly). The adults do not feed, and no control is available for them, so you must treat the animal in the fly's larval stage, that are the grubs.

Treat the cattle in the fall as close to the end of the fly season as possible, using a systemic dip for best results, or spray, pour-on, or spot-on. Ivomec 1 Percent Injectable is a valuable tool. Dust bags do not work very well. Eggs are laid on the hair where they hatch. The larvae travel down the hair, penetrate the animal's skin, then for six weeks make their way through the animal's body (this is the time to control them). They then accumulate in the throat (heel fly) and spinal canal (bomb fly). Those in the throat, if killed, cause chronic bloat; while those in the spinal canal, if killed, cause paralysis of the hindquarters. Do not treat during the months of November and December. The grubs leave the throat

and migrate to the back of the animal, arriving in January and February, causing eruptions on back and cutting holes in the hide. You can pop these out in dairy cattle, but if in beef cattle they must be chemically controlled.

House Fly – the number one pest of dairy operations. Very hard to control as they lay eggs in any kind of decaying organic matter. Sanitation is the primary prerequisite for house fly control. Dry up all areas where egg laying could take place. Chemical treatment for adult flies consists of ultra low volume sprays drifted into gathered cattle. Residual compounds sprayed on buildings, corrals, etc. give some control. In dairy operations, dust bags as animals leave the milking parlor give passable control. Dust bags should contain a compound that leaves little or no residue at the next milking, i.e. Malathion, Co-Ral, Ciovap.

Horse or Deer Fly – no control

Ticks – hardback ticks such as the Rocky Mountain wood tick, cause diseases such as Rocky Mountain spotted fever and back paralysis. Hardback ticks attach to the animal and feed for about ten days, then drop off, lay their eggs and die. No control for ticks exists except when they are attached to the animal. The best method of control, then, is dipping with a systemic. Spraying is the next best control method.

Spinose ear ticks – spend all of their life cycle in the ear canal of livestock leaving only to lay eggs. Approximately 67 percent of all livestock in Nevada are infested with this organism. Control is achieved with any of our recommended livestock insecticides. Squirt the compound in the ears of the animals when working them in a squeeze chute.

Psoroptic Mange Mite – a quarantinable organism. It causes mange in all farm animals and is responsible for scaly legs of chickens. Control for this organism requires dipping two times within a 12 day period with Co-Ral or utilizing Ivomec 1 Percent Injectable.

NOTE: No pesticides should be administered to animals that are sick or less than three months of age. **READ THE LABEL**. Remember, it's your best guide.

CATEGORY #2
Forest Pest Control

One out of every three acres in the United States is forested. Products from forestlands are a result of specific management plans for each forest. In turn, pest control practices are designed to meet the goals of each unique management plan.

MAJOR FOREST LAND USES

Soil and Water Management. In areas managed for soil and watershed protection, pest control activities may 1) contaminate water sources and 2) add an unnecessary expense. Fortunately, pest outbreaks are usually host specific and even though one host species may die, enough vegetation is usually left to protect the watershed.

Wildlife Habitat. Pest control measures in areas managed for wildlife could cause pollution of water and disturb or affect sensitive wildlife species. However, lack of a control may alter the habitat for a significant period of time.

Timber Management. Most control practices in forests target timber management for production of quality wood products. The high value of the end products dictates a high level of pest control.

Outdoor Recreation and Preservation of Natural Features. Pest control for these purposes are always unique to the site. Pollution effects on non-target species, natural succession, and human involvement play important roles in the decision of whether or not to control an outbreak of a pest.

Forage Production for Livestock and Wildlife Grazing. Although not directly affecting the forest; pest control practices for grazing animals in forests could also affect insect populations that feed on trees. As well, outbreaks might be controlled or exacerbated (enhanced) by control of pests by insecticides.

Christmas Tree and Forest Nursery. Plantations and nurseries require intense pest management. Christmas trees, with their emphasis on appearance, are very susceptible to a number of pests that also attack forest species. Again, due to the high value of the final product, there is a considerable amount of pesticide used in this type of management.

Suburban and Urban Forest. More pesticides can be used in the urban forest than in any other forests. Urban trees have an extremely high value and are often viewed individually with a great intolerance for any pest damage. Pest management at the suburban or urban interface with wild lands is most important and requires cooperative participation and coordination by all land managers involved.

FOREST INSECT PESTS

Most pest species are only occasionally important in forests. The damage resulting from chronic outbreaks is often dependent on the management history and environmental conditions when the outbreak occurs. Also, insect species that attack abundantly planted younger trees in already established areas are usually of less concern than those attacking the more valuable and less numerous mature trees. Native and exotic species present unique threats to forests and wild lands.

Forest insect pests are usually grouped according to the type of feeding they do and the location on the tree where they feed. Pest control is logically targeted accordingly.

Defoliators
Chewing insects that attack foliage, defoliate trees. Defoliation of evergreens is much more serious than the defoliation of hardwoods. Evergreens often die from one year of attack whereas some hardwood trees can withstand one or even two defoliations in a single year or even defoliation over two or three consecutive years.

Outbreaks of defoliators usually develop slowly and are often recognized by land managers late or near the peak of the outbreak.

Native defoliators include Douglas-fir tussock moth (occurring in eastern Nevada, Pioche area), various sawflies, tent caterpillars, and chafers and various leaf beetles. In North America the primary introduced defoliator of forests is the gypsy moth. This moth was intentionally brought into the U.S. It then escaped and became a major pest of deciduous trees in the eastern U.S. In recent years, established populations have been found in Oregon and California. Individual male gypsy moths have been trapped in many western states including Nevada.

Control of Defoliators Outbreaks of defoliators may cover wide expanses, up to one million acres or more, and may be recurrent and progressive. It is against this group of insects that most of the chemicals are applied in forest areas. Due to their exposure, these leaf-feeding insects can be easily controlled in the forest habitat with aerially applied chemicals. Many can also be controlled with various biological materials including bacteria and viruses.

Cambium and Phloem Feeders
This group is the most destructive group of forest pests. These insects feed on the water and food conducting tissue of trees. Most are secondary insects that attack stressed and dying trees although a few, especially the bark beetles and some flatheaded borers, may attack and kill healthy trees. Death of trees usually results from the girdling of the cambial tissue, but the introduction of disease may also kill trees (e.g. Dutch elm disease). Other insect pests in this group include pitchmoths and round headed woodborers.

Control of Cambium and Phloem Feeders Chemical sprays applied to individual trees prior to infestation or while infestation is not advanced can afford protection to highly valued trees, especially in the urban environments. The chemical should be applied as high as possible on the trunk and coverage should include the lowest branches if possible. Trap trees and selective thinning or salvaging of infested trees can be used on larger infestations in forested areas. The latter method is the primary method of controlling bark beetle infestations. Bark beetle populations can also be effectively monitored with the use of pheromones for the specific beetle. Pheromones can also be used to enhance the effect of trap trees in control.

Shoot and Root Feeders
These insects are the most important in the nursery and Christmas tree industries. They seldom kill trees (except small seedlings) but can cause deformity in tree growth that is important both to the lumber and Christmas tree industries. Severe damage can cause a reduction in growth. Insects that are common pests in this group include tip moths, pine sheath and needle miners, white grubs, and a variety of weevils. Control of these pests is difficult. Few, if any, effective controls exist for the root feeding insects and timing of chemical application to coincide with the vulnerable life stages of the shoot feeding insects is very critical. Mechanical control (removing tips) on small areas may be effective but is expensive and time consuming. Cultural controls such as site selection and delayed planting can help control some of these pests. One newly introduced shoot feeder is the Nantucket pine tip moth. It was first found in the Las Vegas area on pines from California. This insect has the potential of becoming a very serious pest of pines. It commonly prefers the smaller trees and can cause severe tip damage if not controlled.

Sap Sucking Insects
This group includes mites (not insects), aphids, scales, mealy bugs, spittlebugs, and plant bugs. These insects extract food from the plants through sucking mouthparts. This often results in the infested tree having a dry appearance and often dripping honeydew (from the insects). If infestations continue, defoliation can occur. With evergreens, this is usually seen as a loss of the two- to four-year old needles and the trees start taking on a sparse appearance. Deciduous trees generally lose their leaves and if the infestation continues, the new leaves will be much smaller than normal. Death of all trees usually results only from continuous infestations. Outbreaks of many of these pests are often directly correlated with man's activities in the infested area. Biological control agents offer some control, but more detailed studies are required to develop improved methods in this area.

FOREST DISEASE PESTS

Disease control in the forest environment is generally based upon management decisions designed to reduce loss. Cultural practices that produce the most vigorous stands of forest species also tend to reduce incidence of disease. There are several disease control practices that apply to forest nursery production. There are a limited number of recommended disease management practices involving chemicals that apply to the urban environment.

Seed-producing parasitic plants commonly called dwarf mistletoe cause one of the most important diseases of western forest conifers. Most of the dwarf mistletoes are host specific; that is, each species of mistletoe has its own host or group of host conifers. They live only as parasites on living conifers from which they absorb water, dissolved minerals and photosynthates from the phloem and xylem.

Dwarf mistletoes suppress tree vigor and growth. This results from a gradual reduction of the effective needle surface of the tree and a disturbance of the trees normal physiological processes. Damage by dwarf mistletoe is recognized in four general categories:

1. Reduced incremental growth – This may be 75 percent in some species.
2. Increased mortality – This is often very high in young trees.
3. Lower timber quality – increased cull of logs or degrade of lumber.
4. Indirect losses – predisposition to other diseases in the tree.

Dwarf mistletoes spread by seeds that are forcibly ejected from a capsule. This ejection system is a very efficient means of seed dispersal; 50 to 75 feet of dispersal is common. In addition, seeds have a very sticky surface and remain where they hit. If they land on a susceptible host, a new disease cycle is initiated. Mistletoe plants are perennial and will produce seed for many years. Mammals and birds also move seeds to new areas.

Management of stands infected with dwarf mistletoe is difficult. It is important to remove infected overstory trees, keep stands as even in height as possible, and in some cases clear-cut the stand. In individual high value trees pruning out infections is an effective control practice. Replanting species considered exotic to the area is a viable alternative where mistletoe infestations are severe.

***Cytospora* canker** of poplars, cottonwoods, and willows is a very serious disease at the present time throughout Nevada. Pruning out infected branches and destroying them will help control this disease. It is important that these species not be stressed for water in the establishment phase as this increases their susceptibility to infection.
Disease problems common in the forest nursery environment can be summarized as follows:

Root and soil borne diseases – *Fusarium* root rot, damping-off, black root rot of pine, *phytophthora* root rot, crown gall, and some nematodes are examples of this group. Seed treatment with Captan and Thiram has given some control. Soil fumigation with various methyl bromides and chloropicrin

formulations have been relatively effective. Disease incidence is dramatically increased by over watering or improper drainage.

Foliage, stem, and branch diseases – *Phomopsis* canker, white pine blister rust, *Lophodermium* needle cast, *Cercospora* blight of juniper, and *Cytospora* leafspot, and canker of poplar are examples of this group. Various protective fungicides including Bravo, Dithane M-45, and Captan have given control for some of these problems. Cultural practices can reduce disease incidence: avoid wetting foliage, promote a dry microclimate between nursery stock, isolate or destroy diseased nursery stock, and practice conscientious sanitation.

Disease management of forest tree species in the urban environment presents a distinct challenge. In this case cultural practices, including tree selection, site selection, planting procedures, and tree health maintenance all contribute to successful disease management.

Root rot and crown rot problems are very common on shade trees and on many conifers used as ornamentals. In most cases these problems occur because of mismanagement. The fungus *Phytophthora* that has many species and is widely distributed is often involved if over watered, if soils are poorly drained, or if any other factors reduce soil aeration. If good aeration can be restored, these plants often recover. Tree roots require moisture and oxygen to be healthy and grow.

Vascular wilts are devastating diseases of individual high value trees. Often the fungi that cause these diseases are brought into the area on bedding plants or other stock and then infect the tree species. In some cases (e.g. Dutch elm disease), the fungi are vectored by insects. Some good success in controlling these diseases has been achieved using high-pressure injection of systemic fungicides such as Lignasan BLP. It is important to get an accurate diagnosis of the pathogen before attempting this control measure.

FOREST AND RANGE WEED PESTS

Forest and Range Weed Management

Forest weed management in Nevada is nominal because of the limited acres of forested land in the state. However, rangeland weed management is very important given Nevada's vast amount of rangeland.

Undesirable native woody and herbaceous vegetation as well as noxious weeds, which are usually non-native, invasive plants may infest grazing lands and recreational areas. State law defines a noxious weed as any plant that is detrimental or destructive and difficult to control or eradicate. Landowners and managers are required to control noxious weeds on their lands; therefore ranchers, farmers, and resource managers should be familiar with weeds that are considered noxious. A current listing of state designated noxious weeds and laws regarding their control may be obtained from the Nevada Department of Agriculture.

Proper identification is critical when managing weeds. Contact the University of Nevada Cooperative Extension or Nevada Department of Agriculture for help with weed identification.

Plants such as leafy spurge, perennial pepper weed (tall white top) and Scotch thistle are found in forest and range lands throughout the state. Salt cedar, also known as tamarisk, is well adapted to alkaline soils commonly found in Nevada invading riparian areas. Because of their unpalatability and invasive nature, all noxious weeds have an adverse effect on wildlife and domestic range animals.

The objectives of weed management on forest or rangelands are to:

- Improve carrying capacity and productivity of range and forestlands.
- Reduce competition from weeds, thus improving growth of desirable vegetation and overall health of the range or forest.
- Improving reforestation success by reducing competition from weeds.
- Reduce the presence of ladder fuels and the potential for wildfire in the forest.
- Improve and protect habitat for wildlife and domestic range animals.
- Improve sites subject to erosion through weed removal and re-vegetation.
- Protect riparian areas and improve water quality.
- Enhance and maintain recreational access to forest and range lands by preventing the spread of invasive weeds.
- Enhance species diversity and the beauty of Nevada's forests, and range lands.

Integrated Weed Management (IWM)

Relying on only one practice usually does not provide long-term weed control. An IWM program successfully uses a variety of strategies in managing weeds.

Integrated weed management (IWM) utilizes a number of management strategies including prevention, cultural, physical, mechanical, chemical, and biological control methods. Successful weed management programs do not rely on one control technique, but they use a combination strategy.

Prevention

Prevention of weed infestations is a major component in effective, long-term range and forest weed management programs. When planting in forests or rangeland use certified weed free seed. Many weed species including the noxious weeds are transported to uninfested areas in contaminated hay and straw, therefore, it is important to restrict the movement of contaminated hay, straw or other commodities into an area. Each product should be certified weed free before it is transported to the area as feed, for erosion control or any purpose.

To prevent new weed infestations:

- Plant certified weed free seed
- Restrict movement of contaminated hay, straw and other products
- Clean vehicles and equipment
- Avoid grazing heavily infested areas
- Do not move weed infested soil, sand or gravel
- Hold and feed grazing animals for three days with weed free forage before moving them from an infested area to one that is not infested

Equipment, recreational vehicles, livestock, and wildlife are capable of moving weeds. Cleaning equipment after working or traveling in an infested area is a basic means to prevent weed spread. Preventing wildlife from spreading weeds may be impossible, but controlled rotational grazing to avoid heavily infested areas during weed seed production can help reduce the spread of noxious weed species by livestock. Keep a close watch and control new infestations around loading areas, such as corrals and loading ramps, these are sites where noxious weeds often are introduced when horses or cattle are transported to range or forest lands. Do not move grazing animals from an infested area to a weed free site without holding them for three days and feeding them clean feed. Do not move soil, sand or gravel infested with noxious weeds or use it in constructing roads, dams, ramps, etc.

Cultural

In the forest, selecting and planting adapted tree species is wise. Adapted tree species grow best at the site, are competitive and require the least number of inputs per acre. Most have fewer pests associated

with them for better vigor. Planting trees close together reduces weeds but increases competition among the trees. High tree densities at planting reduces weed establishment and can be followed up with tree thinning as the trees grow to reduce tree to tree competition and develop larger trees.

Physical and Mechanical

In Nevada, bulldozers with a brush blade or a chain dragged between two dozers are used to remove brush and prepare a site for planting. Unfortunately, wheeled and tracked vehicles are limited to gentle terrain. Brush control before planting can be accomplished by prescribed burning, however this method is usually not effective on the long-lived, perennial noxious weeds and some native shrubs that re-sprout.

In the forest, planting liners through three-foot by three-foot squares of fiber-reinforced, laminated Kraft paper mulch with an asphalt core for durability has been successful as a weed barrier and comparable to grass herbicide treatment. The mulch must be weighted or pinned to the ground at the corners to keep it in place and insure effective weed control.

Hand control of weeds such as pulling, digging, or hoeing, can be effective for selected weed species. Small infestations of annuals and biannual weeds such as musk thistle, Scotch thistle, and dyer's woad may be controlled in this manner. This practice is usually not effective on perennial noxious weeds. Hand control is labor intensive and persistence over several years is crucial for this type of program to be successful.

Biological

Biological control is one component that can be incorporated into a weed management program. This method uses living organisms such as animals, insects, other plants, and microorganisms to interrupt the life cycle of the weed and control it or reduce its competitive advantage. Intensive grazing can reduce or remove some weedy species in young forests or on rangeland. Unfortunately, grazing is not entirely selective and trees or range plants can be severely damaged. Matching the proper control agent and timing are important. For example, goats will feed on leafy spurge, cattle will not. Many animals will eat weeds early in the year, but not after they have become coarse and unpalatable. Pathogens or insects are only rarely used because of the possibility that they may infest non-target species, especially economically important crops.

Use biological control as part of a weed management program. When used alone, insects, pathogens, or grazing will not eradicate a weed species.

Chemical

Many serious forest and rangeland weeds do not respond to non-chemical treatment: thus, chemicals become the only viable IWM strategy available to the forest and range manager. Fortunately, safe, environmentally friendly and dependable chemical weed control for the forest and rangeland is available. Both herbicides and growth regulators are used in forest weed control. Weed control on rangeland is most often accomplished with the use of herbicides. Chemical treatments have the least affect upon soils, labor requirements are low and selective materials will allow for vigorous tree growth. Proper herbicide selection is crucial in an effective noxious weed control program. However, products that are effective on one species may be of little use in controlling others.

Serious infestations of Canada thistle, leafy spurge, purple loose strife, and perennial pepper weed will often be found in riparian areas and very near, and sometimes in shallow water. Many chemicals effective on these weeds are prohibited from being applied directly to water. Refer to the aquatic pest control section in this manual if you are doing weed control in or near waterways or ponds.

The success of a chemical treatment of weeds in forests and rangeland is affected by:

- site specific conditions, including soil class, type of terrain and aspect
- applicator skill
- the chemical applied
- the species and age of trees and weeds involved
- the time of year the application is made
- the type of equipment used
- climatic conditions at the site, most importantly wind and precipitation

Phenoxy herbicides and glyphosate are eliminated or degraded by deer, small mammals, and amphibians. Their accumulation in the animal is negligible and they do not harm animals. Likewise meat quality in game animals has not been affected by these herbicides.

Grazing Restrictions:
Follow grazing restrictions on the label when domestic grazing animals are present.

When selecting herbicides, consider the fate of each herbicide. It may

- contact the plant surface and be absorbed – adversely affecting plant growth
- contact the plant surface and not be absorbed but broken down or volatilized without adversely affecting plant growth
- not contact the plant and therefore not affect plant growth
- contact the soil and be rendered inactive because it binds to soil particles and is not absorbed by the plant
- be very water soluble and easily washed off the plant by rain without affecting the plant

Application Methods
Brush, forb and grass control is most economically managed by aerial application. Topography and terrain may restrict entry by large ground spray equipment. Foliar applications work well, but in forests shrubs and trees greater than 1.5 to 2.0 inches in diameter may be more effectively removed or thinned by injection or a cut-surface treatment. The method of herbicide application used will depend upon the:

- species present
- climate
- terrain
- proximity to water and sensitive species or crops
- equipment available
- chemical
- cost of the chemical and the particular method

Foliar Applications Spraying foliage is effective in controlling many forest species, and is recommended when controlling hard to kill noxious weeds. Aerial and ground equipment is used in spraying. Backpack sprayers apply three to ten gallons per acre, while aerial spraying requires 5 to 10 gallons per acre of mixed product.

Because many forest and rangeland herbicide applications are conducted on large areas, sometimes by plane or helicopter, drift must be eliminated or controlled. Without drift control damage can occur to non-target plants in nearby watersheds, the herbicide may contaminate water, and private property may be damaged with careless application. Always read and follow the instructions on the label. Doing so reduces risks to the applicator, others, animals and nearby properties and of course, it is the law.

A major barrier to uptake of foliar applied products is a waxy layer on the surface of the leaf known as the cuticle. Pesticide labels will tell you if a surfactant or adjuvant should be added to the mix in order for the plant to better absorb the herbicide.

Spot treatments are especially useful in controlling noxious weeds and avoiding drift. When doing spot treatments, mixing and loading may be done at the application site. To avoid water contamination be sure to mix and load herbicides away from waterways, lakes, or wells. Use a nurse tank to supply the water rather than filling spray tanks directly from a water source.

Wicks, applicators or weed wipers are sometimes used to apply herbicides to foliage. This application method reduces the potential for drift and is effective in areas where there are environmental concerns near water or sensitive species.

2,4-D, dichlorprop, triclopyr, imazapyr, glyphosate, dicamba, picloram, and products in the sulfonylurea family are effective foliar applied herbicides. In the forest, selectivity may occur among deciduous species, but conifers lack selectivity. In rangelands, products that do not harm grasses are preferred. Many chemicals such as glyphosate plus imazapyr are more effective used in combination than either is when used alone. Contact a University of Nevada Cooperative Extension or Nevada Department of Agriculture office for information about these herbicides and their mixing and uses.

Basal Application Trunks of trees and brush can be treated to selectively control woody weed species. Low-volatile ester of 2,4-D, dichlorprop, or triclopyr, singly or in combination may be used in diesel or stove oil as the carrier. The bottom 15 to 18 inches of the trunk must be soaked to be effective. Application in spring gives the best top kill, while summer and fall treatments control sprouts. Winter treatments require greater concentrations of product to be effective. In all cases, it usually takes 1 to 2 years to completely kill a woody plant. Low-volume and thinline basal bark treatments use triclopyr products in increasingly greater concentrations to control small woody plants less than 6 inches in diameter. The thinline application uses Garlon 4 without dilution as a thin stream applied to all sides of the trunk.

Cut-surface or-stump and Other Applications Trunks that are frilled or hacked at intervals around the trunk and stumps can be treated with herbicides, usually concentrated amine formulations, imazapyr or glyphosate, to kill woody species and prevent sprouting. Cut-stump treatments have been a common means to control brushy/woody species such as salt cedar (tamarisk). Season affects how well a chemical works with this treatment. 2,4-D amine products work best during the spring when the movement of sap is upward. Dicamba and others are effective when the sap is moving down into the roots during the fall. Imazapyr and glyphosate work best during the growing season June through November. Many products are labeled for direct injection. Conifer stands are commonly thinned using injection methods.

Soil Active Herbicides Several herbicides are active when applied to the soil where they form a barrier to sprouting weeds or are absorbed by the roots of weeds. Rainfall, snowmelt, and irrigation move them into the soil. They may breakdown more quickly during warm, moist conditions because of increased microbial activity. They may be leached from the soil with excessive precipitation. Atrazine is used pre- and post-plant in conifers to control annuals and some perennial weeds. Because atrazine and its related chemicals are water-soluble and easily contaminate water, including groundwater, they must be applied at the proper rate. As they are found as a contaminate in water, they may be discontinued in the

future. Hexazinone gives both pre- and post-emergence control of annuals and perennial herbaceous species.

Herbicides may be registered for general woody species control in a variety of on-farm and non-farm applications. Many are non-selective, while others may exhibit selectivity, especially for conifers. If you intend to use a product in forest or rangeland weed control make sure it is registered and labeled for that application; otherwise, it is an illegal application.

Products containing the following chemicals may be registered for forest or range weed control. Be sure to read the label when selecting a product. As registrations change over time, this list may change. To find out whether a product is registered for forest or range weed control contact the Nevada Department of Agriculture at 775-688-1182.

Atrazine, clopyralid, glyphosate, picloram, 2,4-D, hexazinone, sulfometuron, metsulfuron, triclopyr, and imazapyr.

FOREST AND RANGE VERTEBRATE PESTS

Pocket Gophers can cause extensive damage to seedling. The degree of gopher activity is determined by the presence of fresh mounds. Strychnine grain (restricted use pesticide) gives excellent control and is best applied in the fall and early spring. It may be hand applied or used in burrow builder for large areas. Anticoagulants and zinc phosphide baits are also available. Synchronize programs with adjacent property owners for best results. Trapping is a commonly used non-chemical control.

Bears damage tree bark. Trap and remove troublesome animals. Provide alternate food at the time when damage occurs. Check with the Nevada Department of Wildlife for more information about their control.

Deer and rabbits consume seedlings, damage small trees and eat vegetation in forest nurseries. Use plastic or wire cylinders as tree guards to exclude deer and rabbits from individual plants. They are available commercially. Deer-proof fences and repellents are somewhat effective.

CATEGORY #3
Ornamental and Turf Pest Control

Thousands of dollars are spent each year in landscaping public buildings, plants, industrial parks, schools, parks, along streets and highways, and homes. Unfortunately, each plant may be the favorite host of one or more pests, and we cannot always be sure that pests will be a problem. There will always be a potential pest sometime between the first warm days of spring and the first hard freeze.

ORNAMENTAL AND TURF INSECTS

To spray or not to spray, all the alternatives should be considered.

1. Pest must be identified; most people do not know one insect from another. Pest managers should know: the name of the insect, its life cycle, and other hosts before they try to control it.
2. Guilt by association is not always correct. Not all insects are injurious, many are beneficial and most are just there.
3. Degree of infestation must be established. Not only the kind of insect present, but also the number of them and the insect's activity (whether beneficial, injurious, or unimportant).
4. Know what will happen if nothing is done.
   a. nothing, if parasites or predators are present.
   b. defoliation may not hurt older established trees.
   c. beauty may be destroyed.
   d. heavy scale or borer infestation, if not treated, may result in death of the plant.
5. Estimate the cost if you do spray (as opposed to removing the plant). How much to cover the cost of materials?
6. How many times must you spray?
7. Do you have the equipment (especially for tall trees)?
8. What is your purpose (arboretum or low-maintenance landscape)?
9. Know where to get help.
   a. Nevada Department of Agriculture
   b. University of Nevada Cooperative Extension offices
   c. University of Nevada, Reno
   d. Library
   e. Experienced pest managers or nurserymen

Factors affecting spray results:

1. Importance of early detection.
   a. you may not always know what to expect for all plants in your care.
   b. important to visually inspect the area in your charge frequently.
   c. when inspecting plants:
      1) look at leaf color – is it normal, changing?
      2) look for leaf damage
      3) look for signs of poor growth and loss of vigor
2. Correct timing and thorough application of sprays are necessary for good control
   a. the best pesticide applied at the wrong time, to the wrong place, in the wrong amount, will fail as a control measure.
   b. if applied at the wrong time, pests may have completed their damage
   c. if applied in the wrong place, pests cannot be controlled (for instance, spray on foliage will not control the root borer).

d. if applied in the wrong amount, control may not be effective (if the spray is too weak or not enough of the plant is covered).

3. Use the proper pesticide.
   a. few pesticides will control a majority of pests.
   b. broad spectrum: Malathion, Tempo, Sevin.
   c. narrow spectrum: systemics, miticides.
4. Contact pesticide vs. systemic vs. stomach; insecticides vs. miticides vs. herbicides vs. fungicides (exception: some fungicides are effective against mites).
5. Effect of weather
   a. Most insecticides are not effective below 50 °F.
   b. Wind will cause drift and decrease the amount of spray deposited on target.
   c. Moisture (rain during or before deposit) dries and reduces effectiveness and/or burns some plants.
   d. It is best to apply insecticides when the temperature is above 60 °F and below 95 °F, when the air is calm, and rain or heavy dew are not expected for at least 12 hours.
6. Insect flights and new generations
   a. Some pests have a number of generations each year. Learn to watch for the signs. One spray will not kill all generations.
   b. Insects have wings and will migrate.
   c. Early emergence from hibernation may mean false infestation.

Common Insect/Mite Pests

Mites – for control, use acaricides; alternate chemicals to prevent resistance.

Aphids – can utilize systemics because of sucking type mouthparts, these may also help the parasite-predator relationship.

Scales – different life cycles. Best chance for one-shot control is during the crawler stage. This is the immature scale before it settles in one place and begins to feed and develop a covering (scale).

Thrips – damage flowers such as gladiolus and snapdragons. Difficult to control.

Sod Webworm – causes extensive damage to lawns and golf greens. Tent caterpillar damages trees, roses and many shrubs. They overwinter in the egg stage; the eggs hatch; caterpillars build a web or text in the crotch of the plant, and attack the newly forming leaves.

Box Elder Bug – causes damage by sucking plant juices; overwinters as an adult. Attacks some maples.

Bees and Wasps – mostly beneficial, but nuisance to man because of sting; use residual type sprays during the night when they are inactive. Soapy sprays are also effective when applied to the nest.

Smaller European Elm Bark Beetle vs. Elm Leaf Beetle

The smaller European elm bark beetle is the vector of Dutch elm disease that we now have in Nevada. It can be readily distinguished from the elm leaf beetle by size, coloration and habits. The bark beetle's larvae are produced under the bark and feed in the cambial tissue of the tree. When they emerge as small (⅛ inch) adults, they are a reddish brown color. These newly emerged adults often feed in the leaf axils and crotches of twigs before mating and burrowing into the tree. This feeding often inoculates the tree with the disease if the bark beetles are carrying it. Trees infested with the bark beetle will appear to have been shot with a shotgun. The bark beetle itself occurs all over Nevada yet Dutch elm disease is currently restricted to Reno.

ORNAMENTAL & TURF DISEASES

Good management is the best prevention of plant disease. This statement is extremely important to remember when dealing with ornamentals and turf. Unlike production agriculture crops, plant breeding and selection for ornamental plants has been based more often on specific horticultural characteristics rather than disease resistance. Therefore, many management techniques are designed to achieve some selected norm for each ornamental and turf species. Remember to review the general and agricultural plant sections of the manual for a full development of pathological principles and concepts.

Ornamentals

The largest single problem of ornamentals is root rot that results from water logging of the root environment by inadequate drainage, improper planting, and incorrect water management. Most root rots are caused by different species of the fungi, *Phytophthora* or *Pythium*. After proper soil aeration has been restored, drenching the root zone with a fungicide such as terrazole or ridomil is sometimes warranted.

The two major bacterial diseases of ornamentals are crown gall and fireblight.

> Crown Gall – develops on large numbers of hosts. Causes abnormal growth on roots and trunks. Control with management techniques, chemical and biological agents.
>
> Fireblight – attacks a number of hosts, most notably apple, pear, and rose. Symptoms include a wilting of some portions of the plant followed by a brown to black necrotic terminal shaped as a shepherds crook. Control with pruning techniques and sprays of streptomycin and/or copper formulations.

The major fungal diseases of ornamentals cause wilts (verticillium wilt), leaf spots (*septoria* leaf spot), and powdery mildews (rose).

Alternaria and *Septoria* Leaf Spot (most bedding plants)
Circular to irregular brown lesions. Usually lower leaves affected first. Infected leaves tend to drop. Control with foliar applications of Bordeaux mixture.

Powdery Mildew (nearly all ornamentals)
White to gray powdery growth on leaves, stems, and flower bracts. Leaves are distorted and discolored. Control with Pipron or Funginex by spraying on routine spray schedule.

Turf

Use resistant varieties. Mixtures of three or more types of bluegrass can provide good resistance to the major pathogens in Nevada. Thatch or aerate to reduce general plant stress and remove a suitable environment for many fungi. Water with deep infrequent waterings. Try to water early in the morning rather than in the afternoon or evening. Maintain good soil aeration and air movement around the plant. Examine the turf often to discover disease before it becomes serious. Vigorously growing turf is usually less severely damaged and recovers quicker.

Brown Patch – *Rhizoctonia solani* – generally starts from the top of the leaf blade and works downward. Occurs in light brown patches, sometimes with characteristic "smoke ring". Fore, Heritage, Daconil 2787 for control.

Sclerotinia Dollar Spot – *Sclerotinia homeocarpa* – small, dollar-size patches. Girdling lesions at the leaf margins, rarely from the top of the leaf blade. Control with Daconil 2787 or Mertect.

Melting out – *Dreschlera* spp.and *Bipolar spp.* – The leafspot is generally an eyespot lesion on the leaf blade during cool weather. With drier, warmer weather, a root and crown disease called "melting out" can develop. Patches usually appear to be suffering from drought. Captan, Fore, Daconil 2787 used for control.

Pink Snow Mold – *Gerlachia nivalae* – disease first appears as a small circular area that rapidly expands. Crown or basal area of the dead stems appears pink or purple. The dead foliage becomes bleached in appearance. Daconil 2787, PCNB (chemicals have only been partially effective) for control.

Fairy Ring – *Marasmius areades* and *Lepiota* spp. a dark-green band of *Lepiota* (is poisonous) may or may not be present. Frequently, just behind the green band, the grass is sparse, brown, and dying from lack of water penetration. Fungicides give only partial control.

This list of the more common turf diseases in Nevada includes information about chemicals that have been registered to control the particular disease. Always be certain you are using the correct chemical for your disease problem and always **READ THE LABEL**. Always alternate the use of fungicides to reduce the possibility of selecting fungicide-resistant strains of the pathogen.

VERTEBRATE PESTS

Ground Squirrels – Damage ornamentals, consume garden crops, fruits and nuts. Use traps and anticoagulant baits for urban situations.

Meadow voles – Damage turf with tunnels and holes. These girdle plants and are active day and night, all year. Cyclic populations. Zinc phosphide baits. Snap traps work for small areas.

Rabbits – Consume ornamentals and garden plants. Exclude from areas.

ORNAMENTALS AND TURF-WEED CONTROL

I. Introduction
   A. Scope of problem
      1. Ornamental plantings – single species; mixed species
      2. Specialized plantings – nursery stock; bedding plants; tree nurseries
      3. Turf areas – single or multi-species mixes; use with respect to health and vigor of species as well as safety and health of the user

   B. Adapt control methods to each situation
      1. Use common sense and methods that are convenient and economical
      2. Amount of intimate contact with people and animals
      3. Handwork may be needed

II. Approaches to weed control
   A. Ornamental landscape plantings
      1. Bedding plants
         a. Usually annuals – problem weeds are annual and perennial
         b. Plants are generally placed in weed free area
         c. With small areas, hand-weeding is most satisfactory
         d. Large plantings will usually require pre-emergence herbicides applied shortly after planting of rooted material
            1) Second application usually necessary two to four months following
            2) Handwork will be necessary two or three times during the year
            3) Selectivity of herbicides is a problem because of the nature of bedding plants

e. Commonly used herbicides
   1) Dacthal (DCPA) – annual grasses and broadleaves – for mineral soil only apply to surface and water in – check label for species clearance
   2) Treflan (Trifluralin) – preplant and incorporate – controls annual grasses and broadleaves - check label for species clearance
   3) Eptam (EPTC) – apply postplant and incorporate – annual grasses and broadleaves - more effective on grasses - NOT around bulbs

f. Other materials
   1) Surflan (Oryzalin) – pre-emergence not incorporated – easy to over apply – not for established weeds
   2) Casoron (Dichlobenil) – for well established plants – wait at least four weeks after transplanting – deep rooted species can tolerate – doesn't move

2. Shrub and weed control – use same materials - be sure of clearance for species
3. Conifers - use same materials – use Roundup for control of perennials – keep Roundup off green tissue
4. Mixed plantings – handwork usually best

B. Turf and Groundcovers
1. Management is key to keeping areas weed free
2. Mowing height of turf is specific
   a. Cool season grasses – mow at least two inches
   b. Warm season grasses – mow no higher than one inch
3. Watering practices can be critical
   a. Over-watering brings grassy weeds
   b. Under-watering brings broadleaf weeds
4. Commonly used materials
   a. Grassy weeds
      1) DSMA – organic arsenical – primarily crabgrass control apply when crabgrass is one to two inches tall - two to four applications may be necessary – mow three times before treating - avoid drift - fescues and bentgrass may show some injury but will recover
      2) MSMA – like DSMA but more phytotoxic – more effective under high temperatures – temperatures should exceed 70 °F
      3) Tupersan - control of annual grass on new seedings of bluegrass, bentgrass and red fescue – NOT for Bermudagrass or Dichondra - do not use on golf greens – annual bluegrass is resistant – needs water for incorporation – can apply two months before weeds germinate
      4) Balan (Benefin) – broader spectrum for established turf – primarily crabgrass killer – needs 2 inches – incorporation – incorporate immediately after application
      5) Kerb (Pronamide) – common grass killer but should be used ONLY on Bermudagrass
   b. Both grass and broadleaf weeds
      1) Betasan (Bensulide) – more grass control than broadleaf – apply early spring or late fall - water incorporate immediately – only for established lawns – long residual – fairly resistant to leaching
      2) Dacthal (DCPA) – broad spectrum – apply before seed germination – NOT for established weeds reported injury on bentgrass, red fescue and dichondra – season long control
      3) Ronstar (Oxadiazon) – NOT for red fescue, bentgrass, perennial ryegrass, zoysia or dichondra – apply pre-emergence to soil surface for seed germination but can be post emergence for seedlings – grasses resistant to post emergent use – more active on broadleaves – does not leach – season long control – water incorporate

c. Broadleaf weed control
   1) Common materials are phenoxys (2,4-D, MCPA, Mecoprop) – some environmental concern
   2) Universal material is 2,4-D – use where possible – amine form – watch drift
   3) Specific materials
      a) 2,4-D – many names and formulations – broadleaf killer – wet foliage to runoff – apply when air temperature is 50 to 90 °F – avoid drift – use on established turf but avoid dichondra, bentgrass and turf with clover in it
      b) Mecoprop – apply in seedling stage – do not mow for three days preceding or three days following treatment – not for water stressed turf – avoid drift – do not apply if air temperature is more than 90 °F – do not use first cutting after treatment for mulch – safer than 2,4-D on fine leafed turf grasses – slow leaching – may be applied close to woody shrubs

d. Preplant materials
   1) Applied prior to turf seeding
   2) Two outstanding materials
      a) Roundup – systemic, nonselective - no residual – apply when weeds are actively growing – seed seven to ten days following treatment – if area has been mowed prior to application skip one mowing before treatment
      b) Phytar 560 (Cacodylic acid) – nonselective contact – apply to area after it has been mowed at one inch – complete coverage required – reapply in five days if green areas appear – no soil residual

III. Application techniques

A. Mixed species
   1. Protect desired species with plastic before spraying
   2. Use application techniques to avoid drift
   3. Use granular formulation if available

B. Turf and Groundcovers
   1. Broadcast sprays are common method
   2. Use granulars if possible
   3. Spot sprays often best solution – Roundup works well – area can be reseeded immediately however a ten day delay is suggested

IV. When chemicals are not possible or desired

A. Cultural practices
   1. Strong turf ornamentals
      a. Fertilize for species, i.e. nitrogen for grasses and phosphorus for broadleaves and woody species - may need complete fertilizer so test soil
      b. Irrigate to avoid water deficits or surpluses
   2. Use of mulches
      a. Use plastic under mulch material
      b. One to two inch depth for fine materials
      c. Three to six inch depth for coarse materials
      d. Mulch will silt in with time but weeds will be easily removed by hand
   3. Manures, composts and topsoil
      a. Seldom sterilized hence weed seed source
      b. Limit depth of manures and composts to two to three inches
   4. There may be times when weed areas are more desirable than bare soil

B. Common sense must prevail!

CATEGORY #4
Seed Treatment

Currently most seed treatment is achieved by the application of a substance to the seed surface to reduce, control, or repel disease causing organisms, insects, or other pests that attack seeds or seedlings.

The major disease problems associated with seed are caused by fungi and can be summarized as follows:

1. Seed Rot: seed decays in soil. This is usually associated with adverse soil conditions.
2. Damping off and Seedling blight: seedlings develop a lesion at the soil line and/or girdles. Sometimes infection occurs before emergence.
3. Root Rots: lesions develop on the cortex of small roots, plants are weak and often die.
4. Smuts: Smut diseases are widely distributed. These fungi occur in seed, on seed, and in the soil. Infection occurs in seedling stage, but loss occurs when the plant attempts to produce seed.

The major soil insects for that seed treatment is recommended are wireworms and seed corn maggot. Wireworms is a name applied to several species of larval click beetles found in both irrigated and dryland soil. No crop is immune to attack by wireworms, but these insects are most severe on beans, corn, potatoes, and small grains. The seed corn maggot adult looks like a small housefly that lays its eggs on organic matter. The larvae (maggot) feeds on young seedlings or sprouting seeds and may bore into plant stems below ground. These are often serious on corn, beans, cucumbers, onions, and garlic.

Two principles of pest management are utilized in seed treatment:

1. protection – a chemical barrier that protects the seed or young seedling from disease and insects.
2. eradication
   a. disinfectant – an agent that kills or inactivates organisms present on the surface of the seed.
   b. disinfectant – an agent that kills or inactivates a pathogen that has infected the seed (i.e. freeing the seed from infection).
   c. systemic – an agent that penetrates the seed and extends into the plant as it grows, repels or inactivates certain fungi or insects, thus eliminating damage from those organisms.

When seed is treated, there must be a statement in the treated seed container indicating the following:

1. that the seed has been treated.
2. the name of the chemical (pesticide) used for the seed treatment.
3. an appropriate precautionary statement indicating that the treated seed cannot be used for food, feed, or oil purposes under any circumstances.
4. Seed treated with highly toxic substances requires a skull and crossbones label and the word POISON within the precautionary statement (almost all of these materials are no longer available); always dispose of unused treated seed as you would a chemical pesticide.

There are a number of methods for applying pesticides to seed. Good coverage is essential for adequate results.

dust – dry powder formulation is applied to the seed in the planter box

dip slurry – suspension of material in water in that the seed is dipped or mixed with the measured liquid

mist – the pesticide is sprayed or misted onto the seed, usually resulting in good coverage

pelleted – the pesticide is sprayed or misted during or just before the seed is coated with a fine clay or calcium material; this is the most effective of seed treatments since the pesticide is contained and protected by the pelleting material.

Seed should only be treated with pesticide once, either commercially or by the grower. Too high an application rate or more than one application may result in reduced or complete lack of germination due to chemical toxicity. It is important that high quality certified seed be used for seed treatment, since damaged seed or seed of poor quality is a poor investment.

Seed treated crops in Nevada

1. potatoes – seed treatment is primarily for protection against "black leg" and potato seed piece decay. Captan, Dithane M-45, Maneb, and Polyram are compounds that are used routinely.
2. small grains (wheat, barley) – Vitavax is the most commonly used product, or a combination of Vitavax and Thiram. No mercurials are allowed. These products protect against smuts, bunt, rots, and damping off. Adding methoxychlor provides insect protection during preplanting storage.
3. alfalfa seed – treated with Thiram or Thiram/Captan. The seed treatment is to reduce the spread of verticillium wilt and to reduce seedling loss due to damping-off. Some pelleting with fungicides by various companies.
4. onion and garlic – control of onion smut, seed decay and/or seedling blight has been achieved using seed pelleted with Captan or Thiram. For white rot control of garlic plus other seed or seedling blights, PCNB (Terrachlor) has been partially successful.
5. vegetables – most seed treatment materials are Captan, Thiram, and Chloroneb for seed decay, damping-off and seedling blight. Insecticides used for control of seed corn maggot and onion maggot include diazinon, ethion, and chloropyrifos.

Remember to regard all treated seed as you would any other pesticide and handle it accordingly.

READ THE LABEL!

CATEGORY #5
Aquatic Pest Control

Aquatic pests are found in irrigation ditches, lakes, ornamental ponds, reservoirs, creeks, and livestock water troughs. Trash fish occasionally require control measures. However, the major pest problem in the waters of Nevada are aquatic weeds.

There are two types of aquatic vegetation that commonly become weed problems in Nevada. These are vascular plants, also known as flowering plants, and algae.

Remember: A weed is any plant growing where it is not wanted.

Algae

Algae are plants that do not have roots, stems, leaves or flowers. They reproduce by spores, division or by breaking apart (fragmentation). There are three types of algae that occur in Nevada.

1. Microscopic algae: Blooms of these algae discolor the water giving it an appearance of split pea soup. Also, they may cause red streaking at the water's surface.
2. Filamentous algae: These algae form dense mats that either float freely or are attached to sediment or debris in the water. Filamentous algae are often the first aquatic weeds to appear in the spring.
3. Chara: This alga is often confused with flowering plants because it attaches to the sediments by structures that are similar to roots. Chara has a brittle texture, consequently it is often called stonewort.

Flowering Plants

Aquatic flowering plants have stems, roots, leaves and flowers and reproduce by seeds or vegetatively, by plant parts such as rhizomes, stolons, tubers, turions (tuber-like structure) or roots. Aquatic plants are divided into four distinct groups.

1. Submersed: These plants root in the sediment and live beneath the surface of the water. The only part of the plant to extend above the surface of the water is the flower. Examples include coontail, small pondweed, elodea, and Eurasian watermilfoil.
2. Rooted floating: These flowering plants are rooted in the sediment, some species have both submersed and floating leaves, others have only floating leaves. The flowers of these plants are often large and occur on the surface of the water. Examples include spatterdock and waterlily.
3. Free floating: As the name implies, these aquatic plants live unattached, floating on or near the surface of the water, their roots take up nutrients directly from the water. Since they do not get their nutrients from soil, these plants require waters that have a high nutrient content. Examples include duckweed and watermeal.
4. Emergent: These plants grow in shallow waters, typically less that three feet deep. These are the most serious of the aquatic weeds in Nevada. This group also includes shoreline vegetation. Examples include cattails, bulrush, arrowhead, tall whitetop, and purple loosestrife.

Impacts of Aquatic Weeds

- **cause flooding by clogging ditches and canals**
- **reduce water flow**
- **reduce water quality**
- **displace native plants**
- **interfere with recreation and access**
- **effect aesthetics**
- **provide habitat for mosquitoes**

Many aquatic weed species were introduced from foreign regions without their natural enemies to keep them in check; consequently they out compete and displace native plants. Some aquatic plants cause foul smelling waterways, and various species of microscopic algae are toxic to livestock. Reduced aesthetics may devalue property in areas where ornamental ponds and streams

are infested. Flooding may occur when drainage ditches and other waterways become clogged with aquatic weeds. Severe weed infestations will trap silt, resulting in a reduced holding capacity in reservoirs and ponds. Aquatic weeds may limit or even eliminate recreational activities such as water skiing, swimming, or fishing in areas that are seriously infested. By blocking waterways and preventing proper drainage, aquatic weeds provide habitat for mosquitoes.

How Aquatic Weeds Spread

Seeds are spread by flowing water, animals, and watercraft. Aquatic weeds also disburse vegetatively and propagate by breaking apart as fragments and re-rooting and growing from the broken portion. Many species of aquatic weeds are transported to uninfested bodies of water as fragments or seeds on contaminated watercraft such as jet skis, boats, and boat trailers. This is a common means of introducing aquatic weeds to weed free lakes and waterways.

Factors Effecting Aquatic Weed Growth

- **nutrients**
- **sunlight**
- **substrate**
- **temperature**

All plants require sunlight to survive. Waters that limit light penetration because of depth or turbidity will be inhospitable to aquatic weeds, particularly algae. Nutrients such as nitrogen and phosphorus are essential for plant growth. Nutrients enter water in many ways such as erosion from unstable soils, and runoff from feedlots and urban areas. Nutrients may enter water from other means such as improper fertilizer applications. The substrate is the soil where the plants are rooted; this includes sand, silt, gravel and other material. Plants do not grow well if the temperature is too high or too low. Aquatic weeds, like all living things, require space. Rooted species may not be able to become established if desirable plants occupy the bottom and perimeter of the watercourse, pond, or lake. Avoid disturbing these areas to keep weeds in check. Bare ground around water is an invitation for aquatic weeds to establish themselves.

AQUATIC WEED MANAGEMENT

Prevention

It is nearly impossible to prevent weed spread by wild animals, or water. However we may reduce the spread of aquatic weeds by carefully inspecting and cleaning water craft and boat trailers when removing them from waters that are infested with aquatic weeds.

Aquatic weeds may be controlled by altering one, or a combination of factors that affect their growth. Nontoxic dyes are most effective in ponds that have no outflow. Dyes reduce the light available to the plant, thereby inhibiting the growth of submersed plants and algae. The dye must be applied before plants begin growing in the spring. Light penetration into deep waters is limited, waters that are three feet deep or more will have fewer aquatic weed infestations.

Prevent nutrient flow into waterways and ponds by reducing runoff and stabilizing highly erodible slopes with vegetation. Maintaining a buffer zone, where fertilizers are not applied, of at least ten feet around the edge of ponds and waterways will help prevent aquatic weed growth. If nutrients are entering a pond from an incoming stream, settling ponds may be constructed up the stream from the main pond. Nutrients trapped by the settling pond (before they reach the main pond) may be removed from the settling pond by periodic dredging.

Prevent Weed Control Methods

- **reduce nutrient inflow**
- **place rip-rap around pond edges**
- **eliminate shallow areas**
- **clean water craft**
- **line ponds or ditches**
- **construct nutrient settling ponds**

Proper planning and construction of ponds or waterways prevent aquatic weed growth. Aquatic weeds require stable soil to germinate and take root. Aquatic weed infestations may be prevented by using sand in ponds and watercourses. Sand shifts with currents and does not allow seeds to germinate. Likewise, large gravel or boulders may be used

in ponds or waterways. Emergent weed growth on the edge of ponds and waterways is prevented by piling large boulders, also known as rip-rap, in the shallow areas on the waters edge out to a depth of about three feet. By installing plastic liners, weed infestations may be prevented, however inflow of nutrient rich soils may cover the liner and provide a substrate for the weeds to take root. Irrigation ditches are often lined with concrete to prevent weed infestations, to reduce ditch maintenance, to improve flow, and to reduce loss of water by seepage.

Because of good light penetration and somewhat warmer temperatures aquatic weeds grow best in shallow areas at the waters edge. Constructing ponds with steep banks that have 1:1 or 1:1.5 slope until the water depth reaches at least three feet will prevent weed establishment. Steep banks may cause safety hazards especially for small children and the elderly.

Mechanical Control

Physically removing small infestations is effective if plants are near the shoreline. Mechanical controls include cutting, pulling, digging, and chaining weeds. Chaining is done by dragging a large chain through weed infested water with boats or tractors. Mechanical weed harvesters remove weeds that are growing in deep waters. Mechanical control of weeds shows quick results however, there are some disadvantages. Most aquatic weeds are perennial plants and will quickly grow back if root systems are not removed. This results in repeated efforts. Plants are broken apart and fragmented resulting in plant regeneration and an increased infestation. Mechanical control is often very costly and is most effective in small areas.

Burning is effective and helps to increase water flow in ditches. Green vegetation is seared and then thoroughly burnt seven to ten days later. Herbicide applications may be more effective on emergent weeds when old growth is removed by burning. This exposes new growth to the herbicide. Burning permits may be necessary in some areas.

Pond Draw-down

If it is possible, partial draw-down or draining can be effective. Roots are dried out or exposed to freezing temperatures that results in the death of the plant. For this method to be effective ponds should remain empty for extended periods, usually in winter months. Draw-down also provides easier access for mechanical weed control such as digging, or burning. It also allows access to the plants for herbicide applications.

Biological Control

Only sterile grass carp are allowed in Nevada. Permits are required any may be obtained from the Nevada Department of Wildlife.

Biological control of aquatic weeds includes the use of insects, desirable competitive vegetation, waterfowl, and fish that feed on vegetation. The most common biological method used to control aquatic weeds in Nevada is the white amur, also known as the grass carp. Grass carp are used to control submersed weeds and algae. The number of fish necessary depends on the degree of the weed infestation, species of weed, size of the pond and the size of the fish stocked. A proper balance must be maintained; if there are too many fish, the supply of food may be eliminated and fish may die. Without some vegetative growth in the pond, fish will stir up silt, resulting in cloudy, unsightly water. Too few fish may not achieve the desired results. A single grass carp can eat its weight in vegetation each day. Some weigh 30 pounds, unfortunately after they reach about six pounds consumption decreases. Grass carp feed on a variety of aquatic vegetation so the presence of desirable plants should be considered before introducing these fish.

Factors to Consider before Applying Aquatic Herbicides

- **use of the water treated**
- **species of the weed**
- **stage of plant growth**
- **effect on non-target species**
- **characteristics of the water**
  - **temperature**
  - **turbidity**
  - **depth**
  - **velocity**

Chemical Control

Aquatic weed control with herbicides is often less expensive than other control measures. However, aquatic herbicide applications include restrictions on applications to recreational waters and drinking water sources. Also there is much public opposition to pesticide applications in or near water. Finally, herbicides may affect non-target species--desirable plants, invertebrates, and fish.

After an herbicide application, natural decomposition of the dead plants material may deplete the oxygen level in the water, particularly if there is a lot of dead material. This may result in a fish kill. To eliminate this problem, no more than one-quarter to one-third of the surface area should be treated at a time. The applicator should wait two weeks before the next application to allow time for plants to adequately decompose and the oxygen level in the water to stabilize.

Vascular Plants

Herbicides labeled for aquatic use are formulated as granules and liquids. Liquid formulations are applied as spray and used for rooted floating, free-floating, and emergent weeds. Granular formulations are preferred to control submersed plants, because they sink to the bottom and perform similarly to soil treatments. Granular applications work best when applied uniformly and may be broadcast from spreaders mounted on boats. Foliar sprays are best for rooted floating plants. Herbicides that are effective on flowering plants growing in the water or on the bank include: glyphosate (Rodeo), endothall, diquat, products containing 2,4-D, and fluridone. Products may be applied by aircraft, ground rigs, or boats.

Pesticide labels may vary. Be sure the aquatic site where you wish to apply the herbicide is listed on the label.

Weeds growing on the bank, and emergent weeds present the most serious aquatic weed problem in Nevada. Weed species vary depending on moisture; cattails and bull rush grow in the water and at the waters edge, weeds that do not require as much water, such as leafy spurge, tall whitetop, and Canada thistle grow just feet away in dryer soils.

Algae

Xylene and Acrolein are available for use in flowing irrigation systems. Copper compounds are also used in flowing water. Application of copper for algae control should be done early in the season but only after the water temperature reaches at least 60 °F. Thorough dispersal of copper compounds is essential to ensure its effectiveness. Diquat and endothall are used to control algae in static, ponded water.

MANAGEMENT OF NUISANCE AND PEST FISH

Pest fish or “trash fish” are usually exotic species. They include undesirable species such as the common carp and chubs. Typically these fish are introduced into a body of water and compete for resources or prey upon native fishes, including game fish.

Occasionally, desirable species may overpopulate a body of water, exhausting the food supply resulting in stunted fish. An unusually high fish population, whether they are desirable or undesirable species, requires some type of control. Fortunately various techniques to control fish are available.

Mechanical Control

Barriers may be used to prevent movement of pest fish into new areas. Devices such as seines, nets, and traps are used to remove undesirable species. Mechanical methods are rarely effective at eradicating pest fish, but may be used to reduce their numbers. If eradication of the pest species is desired, draining the body of water or using pesticides will be necessary.

Habitat Modification

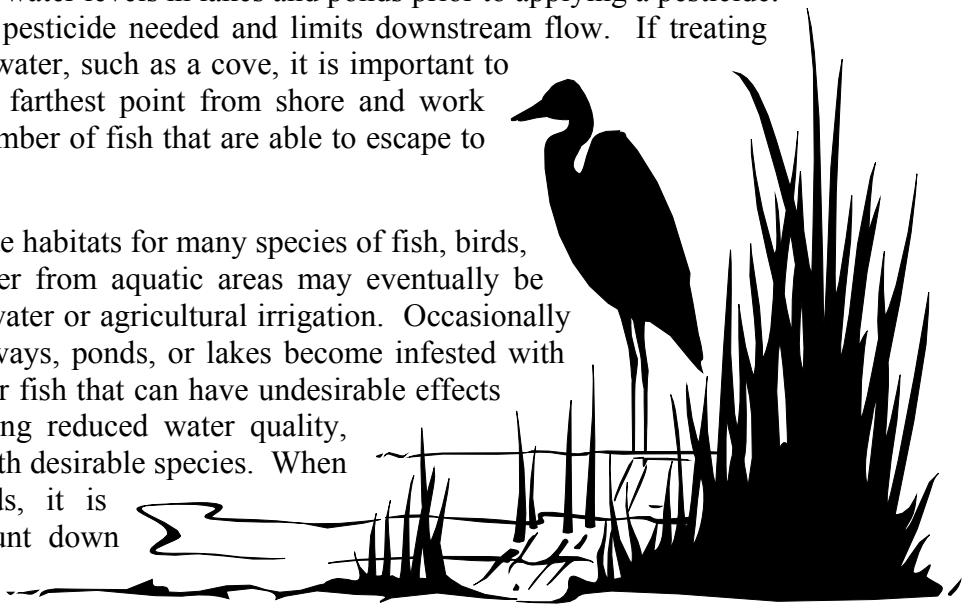
Species that have overpopulated a body of water or an undesirable fish may be eliminated from ponds, reservoirs, and lakes by draining the body of water. A partial draw down of a pond during the winter months may result in a body of water freezing solid, killing all fish in the pond.

Chemical Control

Nevada Department of Wildlife and Nevada Division of Environmental Protection should be notified before rotenone is applied for fish control.

Often, mechanical control and habitat modifications are not effective, nor practical in reducing or eradicating a fish population. Therefore a pesticide application may be necessary. The pesticide product most commonly used for control of pest fish contains the active ingredient rotenone. Various formulations such as liquids or dusts are available. Rotenone may be applied to lakes, reservoirs, ponds, or streams.

If possible, it is best to lower water levels in lakes and ponds prior to applying a pesticide. This reduces the amount of pesticide needed and limits downstream flow. If treating only a portion of a body of water, such as a cove, it is important to begin the application at the farthest point from shore and work inward. This reduces the number of fish that are able to escape to deeper, untreated waters.



Aquatic environments provide habitats for many species of fish, birds, mammals, and plants. Water from aquatic areas may eventually be used for domestic drinking water or agricultural irrigation. Occasionally aquatic areas such as waterways, ponds, or lakes become infested with pest species such as weeds or fish that can have undesirable effects on the environment, including reduced water quality, flooding, and competition with desirable species. When considering control methods, it is essential to take into account down stream effects and impacts on beneficial species.

Proper identification of the pest is essential. Assistance with species identification is available from the University of Nevada Cooperative Extension or the Nevada Department of Agriculture. Once the pest is identified, take the integrated approach for its control. Use mechanical, preventive, and chemical means. Applied properly, pesticides provide safe, economical, and beneficial results. If applied improperly, pesticide products may cause environmental harm or adverse health effects to humans, animals and desirable plants. It is essential to read pesticide labels thoroughly before purchasing and applying pesticides. Apply pesticide products according to the rates and only to sites that are listed on the label.

CATEGORY #6
Right-of-Way Pest Control

I. Introduction

A. Requires more individualistic approach

1. Right-of-ways are generally long and narrow with traverse diverse soil types, climates, vegetation communities and topographies
2. Areas of concern are generally related to transport of people, goods and services. Aesthetics become more important in and around urban areas
3. Some right-of-way areas will be restricted in size or purpose
4. Weed control is the major thrust of pest control

B. Generally requires use of multiple control practices

1. All methods can be used on all sites
2. Physical and mechanical means are short-term
3. Chemicals and biological measures result in long-term controls

C. Four factors affecting control decisions

1. Accessibility and safety of applicators
2. Adjacent vegetation
3. Livestock, wildlife, and human use
4. Cost

II. Use of chemical materials

A. Most have specific use in cropland sites

1. Few have no cropland use
2. Generally involves only dosage rate changes

B. Many formulations – liquid, wettable powder's, granulars, etc.

C. Choice of material depends upon

1. Weeds present
2. Objectives of the area – bare soil, some vegetation
3. Leach ability or lateral movement
4. Adjacent areas
5. Human, livestock or wildlife use

III. Common situations and nature of control

A. Roadsides

1. Goals – visibility, fire prevention, aesthetics
2. End products – low vegetation; visibility of signs, guard rails, crossroads, and bare areas around signposts
3. Methods
   a. Borrow pits: mowing – vegetation will shift to low growing species; expensive; aesthetically pleasing; helps reduce fire hazard
   b. At intersections: mowing and bare soil sites
   c. Guard rails: bare soil
   d. Landscaped areas: mowing, mechanical, and chemical
4. Bare area sites – many materials
   a. Commonly used materials

1) Simazine is cheap when applied at 5 to 40 lb ai./acre. It primarily controls herbaceous weeds, but with time, it may control woody perennials. At a higher rate for longer control apply the chemical in fall, winter or early spring. This chemical does not move laterally, leaches very little, and has low toxicity to fish and wildlife.
2) Atrazine is cheap. Apply at 10 to 60 lb ai./acre. It primarily controls herbaceous weeds. Unfortunately, it moves laterally and readily leaches (no application near desirable plants). It controls larger weeds but will not be as satisfactory on grasses. It is faster acting than simazine, but has a shorter residual. Hence a heavier application must be applied in fall, winter or spring. It has a low toxicity to fish and wildlife.
3) Prometon (Pramitol) is more expensive than those listed above. It kills herbaceous weeds when applied at 10 to 60 lb ai./A. Apply prometon two to three months following weed germination. It is faster acting than others, but it has a shorter residual life and needs water to incorporate it into the soil which is a problem in Nevada. It leaches and moves laterally, but has a low toxicity to wildlife

B. Railroads
1. Goals – fire prevention, safety of crews, visibility
2. End product – bare soil near tracks and information signs
3. Methods – chemicals are almost exclusively used to reduce costs
4. Commonly used materials
   a. Those previously mentioned.
   b. Diuron (Karmex), which is cheap and controls herbaceous weeds applied at 50 to 100 lb ai./A. It is applied anytime the ground is not frozen. Avoid applying it around water and near desirable plants. It doesn't move significantly and may not be effective on deep rooted perennials. It has a low toxicity to fish and wildlife.
   c. For woody species and brush control:
      1) Picloram (Tordon) kills herbaceous broadleaf and woody species. It is available in a sprayable and granular formulation. Avoid spray drift, avoid water, and do not move treated soil. Grasses are tolerant of picloram. It is relatively toxic to fish. It may be applied as granules at any time.
      2) Tebuthiuron (Graslan) is more expensive. Apply at ¾ to 8 lb ai./A before or during active growth. It must be incorporated by rain or irrigation. Do not use it near desirable vegetation and avoid water, even though it has a low toxicity to fish and wildlife. It is slow to leach and move laterally. Most grasses are tolerant of tebuthiuron.

C. Public utilities
1. Goals – fire protection, maintenance of sites, maintenance of service, public safety
2. End products – low growing materials around buildings and storage areas; visibility for servicing; fire prevention; safer public; no disruption of service
3. Methods – in storage areas and around buildings can mow; in "outland" situations areas for service must be passable but structures "fire-proofed"
4. Commonly used chemicals for weed-free areas
   a. previously mentioned materials
   b. may use short-term materials rather than mowing
      1) Paraquat (Gramoxone Super)
      2) Glyphosate (Roundup)
      3) 2,4-D for broadleaf weeds
      4) Metsulfuron (Escort) for grasses

D. New construction sites
   1. Goals – fire protection, rodent control
   2. End product – vegetation free area for short time
   3. Methods – cultural practices (mowing, tilling, and grading) - short residual chemicals may be used
   4. Commonly used chemicals
      a. simazine, atrazine or Karmex at low rates
      b. Roundup, Paraquat
      c. additional materials
         1) Oxyfluorfen (Goal) – primarily annual broadleaf weeds but some grasses and perennials during the seedling stage. Apply at ¼ to 2 lb ai./A. This product is toxic to fish and must not be grazed. It may be used in combination with Roundup as a spot spray.
         2) Cacodylic acid is recommended for use in droughty areas at 2 ½ to 7 ½ lb ai./A. Avoid drift and keep children and pets away from site during and after application. Apply when the temperature is greater than 70 °F.

E. Other sites
   1. Use materials according to their label, use common sense and know the goals of the application
   2. Chemicals generally used are covered above

IV. Vertebrate Pest Control

A. Ground squirrels – burrowing and feeding by these pests can damage rights-of-way. The best time for control is after emergence from hibernation in the early spring, but before young are on their own. Use strychnine grain bait (restricted use pesticide).

CATEGORY #7a & b
Industrial and Institutional Pest Control

INDUSTRIAL AND INSTITUTIONAL PEST CONTROL

1. Industrial includes grain elevators, warehouses, hotels, casinos, food establishments, stores, offices, operational sites.
2. Institutional – schools, rest homes, homes, hospitals.
3. Structural – those pests that destroy wood.

Management (cleanliness and sanitation) is the key to control. A good commercial vacuum cleaner is one of the most important items of equipment a manager can have.

Stored Product Insects – these pest require very definite temperature (40 to 70 °F) and humidity (40 to 70 percent) ranges to live. These factors are important to stratified layers present in grain bins. However, moisture and temperature are probably the most important factors for reproduction of stored product pests. The importance of good housekeeping cannot be overemphasized. Do not store packaged goods too long. In some situations, storing foods in double, sealed containers may be required.

Four classes of stored product insects:
Internal feeders – the larvae feed inside the grain, examples are the rice weevil and granary weevil.

External feeders – larvae enter through hole in outside shell and the larvae then eats inside the kernel. Lesser grain borer, drugstore beetle.

Scavengers – these organisms are damaged-grain eaters. The sawtooth grain beetle (most common) and the confused flour beetle are examples.

Secondary – these are mold and fungi eaters. Example is yellow meal worm; it eats products that are out of condition.

Control
Control starts in the field and lasts clear up to the time of consumption; treatment is required all along the way.

Warehouses – keep them scrupulously clean. Locate the infestation. Remove and destroy. Spray with a compound such as cypermethrin or acephate. For light infestations, remove infestation, clean and spray area with cypermethrin or acephate. Spray infested material, bring back into warehouse, and place on pallets. Spray, on a regular basis, using mist blower to get 360 degree control. Residual effect of sprays should have overlap so there is always control action. Spray cracks and crevices with a pencil sprayer.

Lightly infested grain can be utilized as animal feed.

Grain Elevators – grain should be treated with malathion as it is augered in.

Stores – locate, remove infestation and destroy. Spray shelves. Exercise extreme caution to cover and avoid contamination of unpackaged goods or exposed foods. Always cover foods with plastic or some non porous cover.

Restaurants – locate, remove, and destroy infestation. Infestation is usually found in one container or drawer. Remove all utensils, spray cabinets and drawers. Let dry. Cover with paper before reuse.

NEVER spray directly on uncovered food or utensils. All pesticides, regardless of which is used, are considered toxic. Most have residual effects.

Pests

Cockroaches – There are four of importance. (1) German cockroach is the most common. (2) American cockroach is large and red. (3) Oriental cockroach is black and shiny. Usually outside, these three enter premises in search of moisture. (4) Brown banded cockroach in certain areas is very common. German cockroach has developed a resistance to chlorinated hydrocarbons, so use organophosphate such as Orthene and/or the organophosphate with carbamates such as Bendiocarb or Propoxur. For other roaches, use a quick knock down residual compound such as permethrin.

Rats – The most common in Nevada is the Norway rat. They are good climbers, jumpers, and diggers. They contaminate 25 times as much as they eat by urination and defecation. You can detect rat urine by ultraviolet light that causes the urine to fluoresce. Control by baiting with compounds such as Warfarin, an anticoagulant, in bait stations. Rats have highly developed taste buds so they can't be poisoned with strychnine (restricted use pesticide). Always label bait stations: "Danger, Poison". Rats are vectors of insect pests (fleas) and thus disease (plague). They also harbor mites that cause rickettsial pox.

Mice – They are very prolific (have six to eight litters per year). Mice harbor mites that vector rickettsial pox. They are random feeders, so set baits or traps 10 to 15 feet apart. Use sardines, peanut butter, candy, anything that is oily. The life span of a mouse in the wild is usually less than one year. Remove food sources, line garbage cans with plastic bags, make entrance ways rodent-proof, and put garbage cans up on racks. All the foregoing will discourage rats and mice.

Spiders – The brown recluse is very rare in Nevada. It has been found only in the southern portion of state. Black widow spiders are the most common poisonous spider. Black widows can be found both inside and outside dwellings. They do not like direct sunlight, but favor cool, dark, and quiet areas. They are not aggressive. Diazinon can be used, but is not really effective as it has a short residual life. Ectiban premises spray is very good and any of the pyrethrins are good, they give quick knockdown.

Microorganisms – The only ones of importance are the fungi and water molds. They both require moisture, and damage by fungi to structures is with their hair-like mycelia. For control, dry up and aerate the area or materials. If chemical control is necessary, use phenols and oil, especially borates. Avoid breathing these products, use a respirator and protect the skin from contact with gloves and protective clothing. Correct underlying conditions such as excessive moisture and poor ventilation.

Clothes Moths – These pests eat holes in clothing and furniture. As the termite has the capability of digesting cellulose, the clothes moth is capable of digesting keratin for its protein requirements. Keratin is a protein component of all animal hair, such as wool and hair of hide-producing animals.

Mites – They can be a problem around the grounds and structures of industrial complexes and institutions. To control, one must spray not only the grasses, but also the foundations and walls of structures. Omite or Comite are compounds that may be used for mite control. Around institutions such as rest homes, do not use any volatile or misty chemical materials. Use only those that have very little or no fumigant action as most patients in these institutions suffer from some sort of respiratory ailment.

Bats – Big brown and little brown bats are the most common species found in buildings in Nevada. Nursery colonies are produced in summer. Batas can carry rabies. No chemicals are registered for bat control. Exclusion is the best control. Seal openings over ¼ inch in size in attics and vacant buildings.

Norway rats – They are not widespread in Nevada. Good climbers, jumpers and diggers, they eat a wide variety of foods. Active mainly at night, they are wary of new food items. They can transmit diseases, e.g. murine typhus, leptospiros, and plague. Exclusion is best, seal openings over ½ inch in size. Many compounds are available: anticoagulants, zinc phosphide, cholecalciferol (Vitamin D3), etc.

Roof rats – They are not widespread in Nevada. Most dwell in Las Vegas and vicinity. Excellent climbers, the are arboreal and often nest in palms, etc. They can transmit diseases especially plague. Controls are similar as for the Norway rat.

Housemice and Deermice – Housemice, common in urban residences, and deermice in rural residences occur throughout Nevada. Exclusion and sanitation are most important. Seal openings over ¼ inch to all dwellings. Anticoagulant baits and trapping are major control methods.

Ants – There are many types of ants that are very common and widespread. Most colonies contain at least three castes: queens, males, and workers. The feeding habits of ants are rather varied. Many are carnivorous, feeding on the flesh of other animals, some feed on plants, some dew, and similar substances. All ants may bite, and some bites are rather severe. Recognition of the species is important in control. Adequate control is only possible when the species and habits are considered. Satisfactory results depend on insecticides that give prolonged exposure. Formulations used are wettable powders (WP), emulsions (EC), dusts (D), granules (G) and poison baits. Products currently registered in Nevada are, but not limited to, Malathion, Sevin, Ficam, and Proprietary baits (Amdro).

Wasps – Wasps include those insects called yellow jackets, hornets, umbrella (paper) wasps, and mud daubers. Control for wasps vary with the location of the nest. It is recommended that control applications be made at dusk or at the coolest period of the day. Spray to aerial nests should be made directly into the opening and then over the entire nest. Liquid insecticides may be poured in openings of subterranean nests. Insecticides used in control are allethrin, Baygon, carbaryl, Pyrethrin, pyrethroids, and Resmethin.

Around institutions, such as rest homes, do not use any volatile or misty chemical materials. Use only those that have very little or no fumigant action as most patients in these institutions suffer from some sort of respiratory ailment.

CATEGORY #7c
Structural Pest Control (Wood Destroying Pests)

Termites – There are three types of termites, (1) subterranean, (2) dry wood and (3) damp wood, and all are social insects. They utilize fungi for protein requirements. For chemical control, use compounds such as chlorpyrifos, Isofenphos or one of the synthetic pyrethroids such as Fenvalerate or Permethrin. If soil or wood penetration is needed, use oils plus the compound. Pest Control operators must know the penetration qualities of the soil. If there is no penetration, there is no control.

It is easy to confuse ants with termites. At the junction of the thorax-abdomen, a thread-like waist with spikes indicates an ant. Also, ants have elbowed antennae. Termites have thick waists and straight beaded antennae.

1. Subterranean: there are basically three castes: worker/nymph, soldier, reproductives. They feed on sound or decaying woods, make mud tunnels that regulate moisture requirements, and harbor fungi that termites must have for their protein requirements. Tunnels in wood are usually full of debris. All termites digest cellulose with aid from a microorganisms in the gut. All are soft-bodied and require soil contact.

   Control and prevention involve three basic techniques, sanitation, proper construction, and chemical control.

2. Dry wood: they do not have a worker caste. They are most prevalent in hard woods. Their tunnels are very clean and cut across the grain of the wood. They produce very small holes leading into large galleries (always clean). Fumigation is the best control measure. For attic and wall protection, use a preventative dusting with Silica aerosol that is impregnated with a termiticidal compound, and blow it into attics and wall voids. Exposed wood can be protected by a heavy coat of paint. Voids may be filled with an approved putty; however, due to wear and tear this is not an one-hundred percent effective means of control.

   Chemical control for drywood termites is best accomplished when the location and extent of an infestation is known; especially when spot treatments are used instead of fumigation. Locating the colony(s) is usually the most difficult task when trying to control these pests. A thorough investigation must be conducted throughout the structure. Inspect all exposed areas, such as the attic, substructure, garage, window frames, and any other susceptible cellulose building material.

   Due to the extreme caution that must be used for structural or chamber fumigation, it will not be discussed here; it goes beyond the scope of this category. Fumigation is examined in a separate category.

3. Damp wood: these are the largest termites in Nevada. They are only known to occur in western Nevada. Soldiers, nymphs and primary reproductives occur in the colonies. There is no worker caste. These termites may cause structural damage, but need wood with an excessive amount of moisture present to be successful. They are often associated with rotting wood, often near soil.

Wood destroying beetles – The powder post beetle is the most important. The best control is fumigation. They are usually found in pieces of old furniture especially antiques. They require very low moisture, less than six percent before they feed. One beetle that can digest cellulose is the long horned wood boring beetle.

Carpenter ants – they only use wood for nesting sites and are introduced into houses by accident. They attack only soft or decaying wood. Ficam or Diazinon is suggested for control.

Microorganisms that damage wood are fungi. The mycelia of the fungi enter the wood cells in search of moisture. The best control for fungi is to dry damp areas and apply borates with oil.

Applicators or PCOs have to calculate spray percentages of toxicants, etc. The following is a sample problem and formula from which you can calculate what is needed.

To determine the amount of concentrate (AC) needed to make a desired dilute spray solution, multiply the number of gallons of spray solution (GSS) times the desired percent of solution (%S) in whole numbers (not percentage decimals) times the weight of water (8.34 lbs. per gallon) divided by 100 (constant) times the number of pounds active ingredient in one gallon of concentrate (#/Gal).

$$AC = \frac{GSS \times \%S \times 8.34}{100 \times \#/Gal.}$$

Sample Question:
To treat 2000 lineal feet with a 2 percent pesticide solution at 1 gallon per 2.5 lineal feet, how many gallons of 40 percent pesticide (4#/Gal) would be needed? **REMEMBER: YOU MUST FIND GALLONS NEEDED FIRST!!!!!**

Gallons Needed: $2000 \text{ ft} * \frac{1 \text{ gal}}{2.5 \text{ ft}} = 800 \text{ gal}$

THEN: $AC = \frac{800 \times 2 \times 8.34}{100 \times 4}$, AC = 33.36 Gals

CATEGORY #8
Public Health Pest Control

Judith Saum
Vector-Borne Diseases Program
Environmental Health Services
Washoe County District Health Department
www.co.washoe.nv.us/health/ehs/vbdp.html

I. Basic Terminology:

1. **Pathogen** – a microscopic organism that causes disease in living things. Examples of pathogens in humans include bacteria, viruses, fungi, protozoa, and rickettsiae.
2. **Arthropods** – invertebrate animals having jointed legs. Examples include insects and arachnids such as ticks.
3. **Zoonotic** disease – infections caused by pathogens that are transmitted from animals to humans. Transmission may be direct as in rabies, which is transmitted directly from the bite of one mammal to another; or it may be indirect by means of a vector species (i.e., **vector-borne disease**) from one vertebrate to another. Examples of disease vectors include mosquitoes, which transmit malarial parasites, and rodent fleas, which transmit plague bacteria.
4. **Vectors** – arthropod species that can transmit and cycle disease between vertebrate animals. The transmission can be biological such as in mosquitoes, which amplify viruses internally or it can be mechanical such as in house flies that carry pathogens on the hairs of their legs.
5. **Arboviruses** – viruses transmitted by arthropod species such as ticks and mosquitoes. The word is derived from "arthropod-borne". Examples of the only known arboviruses in Nevada are those vectored by mosquitoes and include St. Louis encephalitis virus (SLE), Western equine encephalomyelitis virus (WEE), and West Nile virus (WNV).
6. **Reservoir** – an animal species that harbors a pathogen usually without becoming very ill or fatally harmed. For example meadow voles and deer mice are thought to be reservoirs for plague bacteria.
7. **Host** – a living animal that provides sustenance to a parasite. For example, California ground squirrels are hosts for rodent fleas.
8. **Epizootic** - an epidemic that causes a die-off in a wild population. Epizootics from plague are not uncommon in rodent populations like the California ground squirrel.

II. Disease Prevention and Pest Control:

Plague is caused by a bacterial infection vectored to humans by rodent fleas. The bacterium involved is called *Yersinia pestis* and is easily treated with antibiotic if diagnosed early. There are three forms of plague infection in humans:

1. **Bubonic plague** results from a fleabite; it is the most common form characterized by rapid onset of fever and painful swollen lymph glands. Mortality often exceeds 50% in untreated cases of bubonic plague.
2. **Septicemic plague** results in an infection of the bloodstream. It is usually fatal if not treated.
3. **Pneumonic plague** results in a pneumonia that is associated with the highest mortality and very contagious. It requires that the victim be isolated because of easy person-to-person transmission by droplet inhalation. Domestic cats are susceptible to pneumonic plague and often transmit it to humans.

Plague is characterized by continuing cycles of infection in native rodent species with rodent fleas as vectors. Reservoir rodent species in Nevada may include deer mice, meadow voles, and some species of wood rats. The reservoir species are thought to be the source of plague-infected fleas that transfer the infection to more susceptible hosts species such as California ground squirrels, chipmunks, marmots, and wild rabbits. Plague epizootics among these susceptible species leave infected vector fleas seeking new hosts providing potential risk to humans and domestic animals.

Plague prevention involves a comprehensive approach utilizing habitat modification, sanitation, rodent proofing, trapping, toxic baits, and public education. Rodent removal should be preceded by flea control using an insecticide dust in the burrows to reduce populations of potentially infected, host-seeking fleas. In every case, the proper PPE should be worn.

Tick-Borne Diseases can be transmitted to humans by two types of ticks in Nevada and surrounding states. Hard ticks (ixodids) can vector several types of pathogens including viruses (**Colorado tick fever**), rickettsiae (**Rocky Mountain spotted fever**), and bacteria (**Lyme disease**). Soft ticks (argasids) are known to vector the bacteria that cause relapsing fever in humans.

Both types of ticks become infected when taking a blood meal from diseased hosts. Hard ticks quest for new hosts from vegetation; they quickly transfer to animal or human hosts that brush against the vegetation. These ticks are slow-feeding and can take days to complete taking a blood meal from a host. In Lyme disease both the adult and the nymphal form, which is about the size of a pinhead, are capable of transmitting disease. In endemic areas removal of leaf litter and clearing tall grass and brush around houses and at the edge of gardens may reduce the numbers of ticks. Applying acaracides at the edge of woodlands near homes can be very effective in controlling ticks. Personal protection by wearing long sleeved shirts and long pants and prompt tick removal reduces the infection rate.

Soft ticks that vector relapsing fever are found on rodents such as squirrels and chipmunks that will nest under flooring and in walls. If the rodents become scarce the ticks will take a meal from other, nearby warm-blooded animals including humans. Soft ticks feed for only about 20 minutes while the unsuspecting host is sleeping. Rodent-proofing buildings in areas where tick-borne relapsing is known to occur is key to prevention. Once an infestation has occurred removal of rodent nesting material from walls, ceiling and floors and fumigating with products containing permethrin and pyrethrins can be done but sometimes has limited effectiveness.

Hantavirus is a zoonotic disease that was first identified in the Southwest in 1993. The particular strain of virus that causes disease in the Southwest is known as "**Sin Nombre**." The primary reservoir for Sin Nombre virus is the deer mouse. The deer mouse remains unaffected by the virus, which is passed in its droppings and urine. People become infected by inhaling the virus when entering or stirring up dust in a closed structure that contains infected mouse droppings and urine. Mortality rates for Sin Nombre virus remain high at about 40%. Rodent removal using snap traps is recommended as human infection has occurred using live traps and glue boards. Opening up a rodent infested structure to air out for about 30 minutes will decrease the amount of air-borne virus in the enclosed space and decrease the risk of infection. This should be followed with wet cleanup using a phenol based disinfectant or a 10% bleach and water solution. Saturate the urine and droppings with the disinfectant or bleach solution and let the area soak for at least five minutes. Sealing up openings that allow mice to enter should be completed after the rodents have been removed.

Mosquito-borne viruses known to cause disease in humans and domestic animals in Nevada include **St. Louis encephalitis virus (SLE), Western equine encephalomyelitis virus (WEE),** and **West Nile virus (WNV).** These viruses cycle in nature between mosquitoes and birds. Humans and domestic animals such as horses are incidental hosts that are accidentally infected but have no role in the spread of the disease. Although it is rare, humans can suffer severe permanent neurologic disability or even death from these arboviruses. Even milder forms of these arboviral illnesses can be quite debilitating and can result in extended loss of work.

A comprehensive mosquito abatement program that integrates various control strategies is the best prevention for arboviral disease. These strategies include removal of standing water, biological controls such as mosquito fish, and the use of larvicides and adulticides.

Rabies is a zoonotic disease of public health concern in Nevada primarily associated with bats although it has also been found in skunks and foxes. The most recent domestic animal rabies case in Nevada is thought to have been a cow in Elko County that died of a bat strain of rabies in 1990. Daytime activity, weakness and inability to fly can be signs of rabies in bats. Rabies is almost always fatal in humans, but can easily be prevented if an exposure is followed with post exposure prophylactic shots (PEP). The rabies virus is slow-growing and results in death to the victim a few months after exposure. Since a bat bite can be invisible, the victim is often not aware of being bitten and fails to seek PEP. By the time a victim displays symptoms of rabies, PEP is no longer effective.

Exclusion from buildings is the best method of bat control. Excluding bats must be done in accordance with federal law, as bats are a protected species. Anyone doing work such as bat removal and exclusion should consider pre-exposure rabies vaccinations as a measure of personal protection.

Vaccination of domestic animals and control of stray and feral animals by animal control agencies since 1950 have resulted in reduced rabies in domestic animals in the US. However wild animal rabies has seen a steady rise since then.

Bed bugs are not associated with disease transmission in the United States. These insects are considered a public health concern because they can be a terrible nuisance and difficult to eradicate. Control of bedbugs requires that all bedding and clothing be removed and washed in hot water. Insecticide sprays and/or dusts are used for control. Applications should be made to cracks, crevices, and other places where bed bugs hide. Mattress seams and tufts, cracks along baseboards and moldings, loose carpet edges, loose wallpaper, and hollows in bed frames or other furniture should not be overlooked for treatment.

Cockroaches are a nuisance insect that may cause rare, isolated cases of food-borne illness and asthma. Cockroach control depends on maintaining strict cleanliness to remove any crumbs and other food and drink spills to eliminate food sources for cockroaches. Insecticide applications with products that are labeled for use inside a dwelling or kitchen are necessary to get rid of a cockroach infestation. Alternate classes of treatment products to prevent development of resistance in cockroaches. Follow-up treatments may be needed as cockroaches continue to hatch after the initial treatment.

For more and current information regarding public health and infectious diseases, go to the web sited for the Centers for Disease Control and Prevention, www.cdc.gov, and the Directors of Health Promotion and Education, www.dhpe.org.

CATEGORY #9
Fumigation

Nearly all fumigants are restricted use compounds; if a fumigant material is not, it should be handled as such. Most are lethal to a wide range of species, both plant and animal (including man).

In modern terminology, a fumigant is a chemical that, at a required temperature and pressure, can exist in the gaseous state in sufficient concentration to be lethal to a given pest organism. This definition implies that a fumigant acts as a gas. This definition excludes aerosols, particulate suspensions of liquids or solids dispersed in air that are unable to penetrate even a short distance into materials because their particles are deposited at the outer surface.

CHOICE OF FUMIGANTS

Many chemicals that are volatile at ordinary temperatures and sufficiently toxic to be fumigants are not used because of some unfavorable properties, the most important being chemical instability and destructive effect on materials.

1. Excessively corrosive compounds attack containers, fittings of fumigation chambers and spaces being fumigated.
2. Reactive chemicals form irreversible compounds resulting in residues. In foods, this may result in taint or formation of poisonous residues.
3. May destroy or injure plants, fruits, and vegetables. May also affect germination of some seeds.

Highly flammable compounds are not necessarily excluded if the fire and explosion can be eliminated by special techniques or inclusion of other compounds.

<u>Dosages and Concentrations</u> – important to know the difference

Dosage equals or is amount applied

Concentration is the actual amount of fumigant present in the air space in any selected part of the fumigation system at any given time

Concentration vs. Time

In the past, most fumigation treatments were recommended on the basis of dosage, given as the weight of chemical required for a certain space. This is followed by a statement of the length of the treatment in hours and the temperature or range of temperatures at which the schedule will apply. What is really important is the amount of gas acting on the insects, nematodes, weed seeds, and fungi over a certain period of time.

Before putting into practical use, each of the concentration time (ct) products must be worked out for each specific set of conditions. The ct product determinations have not as yet been worked out for all situations.

Toxicity of Fumigants to Insects
As far as is known, fumigants enter an insect mainly by way of the respiratory system. The entrance is through the spiracles situated along the sides of larvae, nymphs, and adults.

Toxicity is influenced by the rate of respiration which will vary with the temperature.

Effect of temperature

1. The range of normal fumigation is between 10 to 35 °C (50 to 95 °F).
2. Sorption – This is the tying up of fumigants by the material being fumigated. Knowledge of how little or great this is directly affects achieving a required ct. It is greatest at lower temperatures and varies dramatically between compounds and sites (what is being fumigated).
3. Pre-fumigation and post-fumigation temperatures must be managed for a successful fumigation. For instance, if it is only warm for short periods, apply the fumigant at a dosage and exposure period for the average temperature of past two to three days.

Effect of Humidity
Not as great an effect as the influence of temperature.

Effect of Moisture
As moisture content of a commodity increases, it becomes more difficult for a fumigant to penetrate.

Effect of Carbon Dioxide

1. May stimulate respiratory movements and opening of spiracles.
2. Each fumigant has an optimum amount of $C0_2$ needed to provide the best insecticidal results.
3. CO_2 may reduce fire and explosion hazards.
4. Use of $C0_2$ as a fumigant when introduced into grain storage and other structures acts as an inert insect suffocant.

Protective Stupefaction
In the use of formic acid, a sub-lethal concentration, used before the full concentration, is said to cause some insects to close their spiracles, causing "protective stupefaction". It is important in formic acid fumigation to reach the maximum concentration obtainable from the recommended dose from the start of the treatment.

Precautions and Protective Devices
Threshold Limits are stated as parts per million by volume in air.

When handling and applying fumigants, it is essential to know for each fumigant the level of concentration above which it is not safe to subject workers. It is also important to know the maximum periods of exposure, including repeated exposures during normal hours. The threshold limit value of fumigants represent conditions that nearly all workers may be exposed to without adverse effect, and may be used as guides to prevent health hazards or occupational illness, but not regarded as the fine line between safe and dangerous concentrations.

Warning Gases may be mixed with fumigants in low concentrations.

1. Most common is chloropicrin (teargas).
2. Warning gases do not have the same properties as the fumigants with which they are mixed.
3. If rapidly sorbed (removed), they may provide a false sense of security.
4. Respirator canisters may remove a warning gas and allow the passage of an odorless fumigant, such as methyl bromide, into the mask. This would be lethal.

PROPERTIES AND TYPES OF FUMIGANTS

All of the accepted fumigants used today have one or more undesirable properties. This fact shows that the "ideal" fumigant has not yet been found.

Evaporation

Fumigants have different boiling points generally in relation to their molecular weights. From a physical standpoint, fumigants may be divided into two main groups according to whether they boil above or below room or moderate outdoor temperatures (60 to 80 °F).

The low boiling point fumigants, such as methyl bromide, may be referred to as "gaseous-type" fumigants. These are kept in cylinders or cans designed to withstand the pressure exerted by the gas at the highest indoor or outdoor temperatures likely to be encountered.

The second main group of fumigants contains those with high boiling points; these are usually described as "liquid-type" or "solid-type" according to the form in that they are shipped and handled. In some kinds of work, such as grain and soil fumigation, the slow evaporation of certain liquids is an advantage because the initial flow leads to a better distribution of the gas subsequently volatilized.

In other applications, too, where personnel have to distribute the fumigants by hand, slow evaporation of the liquids or solids makes them safer to handle.

Included in the general term "solid-type" fumigants are certain materials that are not fumigants themselves, but that react to form fumigants after application. Examples are **aluminum and magnesium phosphide**, which reacts with atmospheric moisture to produce phosphine (hydrogen phosphide).

There are also some fumigants in the form of crystals and flakes that sublime to give off fumigant vapors. Examples are **paradichlorobenzene** and **napthalene**.

FUMIGATION TECHNIQUES

Individual tree fumigation – This technique refers to the use of tents to cover trees to fumigate for insect pests. This technique has been used with great success on scale insects on citrus. The most commonly used compound is methyl bromide.

Vacuum fumigation – Vacuum fumigation is a method where most of the air is removed from the area to be fumigated. The fumigant is then pumped into the evacuated area. At the reduced atmospheric pressure the fumigant penetrates materials much more rapidly, thus speeding up the process and increasing the penetration on hard to penetrate materials. This method is used primarily in plant quarantine work, tobacco and other compressed or baled materials. It cannot be used on certain sensitive plants, fruits and vegetables (primarily due to the effect of the vacuum). Fumigants used include methyl bromide and ethylene oxide.

Grain fumigation – Fumigants may be applied to grain in a variety of manners depending on the type of storage and the fumigant. Some may be applied directly into the grain as it is being placed into the storage container. Surface applications can also be made. Here the surface of the grain in the storage container is sprayed with the material or the fumigant is distributed over the top of the grain in some other manner. As the fumigant evolves, it sinks through the grain and fumigation is achieved.

Table 9.1. Commonly used fumigants

Chemical	Uses	Comments	Threshold Limit	Formulation
Acrylonitrile	Tobacco & plant products, drywood termites	injurious to plants, fresh fruits, flammable	2 ppm	liquid
Carbon disulphide	grain	very flammable & explosive	10 ppm	liquid
Chloropicrin	grains & plant products	lachymator (causes tearing of the eyes)	0.1 ppm	liquid
dichlorovos (DDVP)	insects in open spaces	does not penetrate well	0.1 ppm	liquid for spray solid
Ethylene dichloride Methyl bromide[1]	seeds & grain general fumigant	very flammable corrosive exp. rubber	10 ppm 5 ppm	liquid gas
phosphine	grain & processed food	highly flammable, corrosive	0.3 ppm	solid
Sulfuryl fluoride	dry wood termites	non-flammable	5 ppm	gas
1,2 Dichloropropane/ 1,3 Dichloropropane	soil nematicide	requires a soil seal		liquid
methyl isocyanate	general soil	injected into soil		liquid solid
dibromocholoro-propane	soil nematicide	toxic to some plants; injected or drenched into soil		liquid
Vapam	fungal disease and nematodes			liquid
Ethylene Oxide	bulk grain, vacuum fumigation of packaged materials	flammable – must be mixed with non-flammable carrier, carbon dioxide or freon gas		gas

1. Methylbromide is being phased out of use.

Greenhouse fumigation

Space fumigation – In this method, it is important that the structure being fumigated or the chamber containing the material to be fumigated is tightly sealed. If a tight seal cannot be achieved, proper levels of fumigant will not be achieved. In greenhouse fumigation, it is not uncommon to use steam pipes to vaporize the fumigants. Some materials used this way include dicofol, tetradifon, sulfotepp, and dichlorovos.

Soil Fumigation – Soil fumigation may be done on a variety of scales from small plots or garbage cans to large fields. New machinery allows large fields to be treated even under sheets. Methyl bromide is commonly used in this manner to control a number of pests. The chemical can be either released from canisters under this sheeting or directed under the sheeting through tubing. It should be remembered that the sheets need to be sealed very tightly to the ground. Other soil fumigants can be injected or drenched into the soil. Moisture, temperature, tilth, soil type, and the amount of organic matter plays an important role in soil fumigation.

FUMIGATION SAFETY

ALL FUMIGANTS CAN BE LETHAL if they are used carelessly or without adequate safety precautions.

Humans can be poisoned by inhaling the gases of fumigants and by absorption through the skin. Most commercial products have an unpleasant odor but the pure chemicals can be either odorless or have a sweet smell.

Continued intake of these chemicals, whether it is by inhalation, skin contact or other means, results in damage to liver and kidney tissues. This damage is not readily apparent to the individual, especially in the early stages, but it is irreversible and can proceed to a point where the person affected becomes unable to continue working. Instances are known where the effect has accumulated over a 20 year period leaving the victims in unemployable condition and too old to switch to non-hazardous, lighter duty work.

All workers in areas where fumigants are being used should be aware of the symptoms of light exposure to the fumigants. Such symptoms are warnings that the concentration of fumigants in the air is too high for continued safety of personnel.

Symptoms of Chronic Fumigant Poisoning

1. Headache.
2. Dizziness and equilibrium disturbances.
3. Visual disturbances.
4. Irritation of respiratory tract (leads to more “lung colds”, asthma attacks, and other lung and throat problems).
5. Narcosis (desire for sleep, drowsiness).
6. Muscle cramps, especially in arms and legs.

Note: The ingestion of alcoholic beverages will intensify the symptoms and effects of fumigant poisoning.

All areas, both those fumigated and nearby connected buildings, must be thoroughly ventilated before any person is allowed to enter. Special attention must be given to basements and pits where these gases, being heavier than air, tend to accumulate and remain in low places where they can be hazardous to any human or animal entering such areas.

CATEGORY #10
Mosquito Pest Control

Mosquitoes are flies that are annoying, vector diseases, and their presence may result in a decrease of property values. Only the female bites. They actually feed through sucking mouth parts. Male mosquitoes sometimes feed on nectar, while females may feed on either blood or plant juices. They pass through complete metamorphosis. The length of this cycle and the overwintering stage varies from species to species. *Aedes* generally overwinters as an egg, whereas *Anopheles, Culex*, and *Culiseta* overwinter as adults. Eggs of mosquitoes may be laid singly on water or in mud, in rafts on the water surface, or attached to aquatic plants. The larvae are called wrigglers, and the pupae are called tumblers. Both of these stages are aquatic and breathe through tubes to the water surface. Wrigglers are easy to control, whereas the tumblers are almost impossible to control.

There are 32 species of mosquitoes in Nevada. The most important ones include:

1. *Aedes nigromaculis* – daytime biter, will not enter houses, can vector encephalitis, very tolerant to alkaline water, five day larval period found.
2. *Aedes dorsalis* – a major pest mosquito, feeds anytime, females live up to three months, over-winters as egg.
3. *Aedes melanimon* – another major pest mosquito, most in Humboldt County and Yerington area, six to seven day larval period, found in pastures, fields, and in ditches.
4. *Aedes vexans* – day and evening biter, does not enter houses, found in swamps, stream overflows, and borrow pits. Occasionally breeds in open pastures.
5. *Aedes sierrensis* – western treehole mosquito, carries dog heartworm, occurs up to 6000 feet along the Sierras (both sides), one brood/year. In areas where this is a problem the release of sterile males can aid in control.
6. *Culex tarsalis* – evening and night biter, enters houses, principal vector of encephalitis, prefers birds, migrates readily, found in pastures and flood waters, rain pools, ornamental pools/ponds, roadside ditches, and dairy drains.
7. *Culiseta inomata* – primarily feeds on cattle, large, survives well in cool weather, found in duck clubs, pastures, ditches.
8. *Anopheles freeborni* – main vector of malaria, night biter, enters houses, found in permanent open water.
9. *Culex piplens quinguefasciatus* – (the southern house mosquito) southern Nevada species, birds are principle hosts, but does attack man and readily invades homes; breeds in artificial pools and ponds, catch basins, waste treatment ponds, and roadside ditches.

Mosquito Control History

Malaria introduced into California from Oregon in 1832 and became a major health problem by 1880.

The first mosquito project was started in 1905, 1910 saw the first anti-malaria project, and by 1921, virtual elimination of malaria was achieved. Early control was by chemicals, oil, water control, and predator fish (1921).

By 1945 chemical control was used for the most part. DDT was introduced and became the chemical of choice. Resistance to DDT and other hydrocarbon chemicals that were in use came about by 1954.

From 1954 to 1964, mosquito control was dependent upon organophosphate. By 1964, we were forced to begin looking more to other control methods.

In 1979, there were 270 cases of imported malaria and increases world wide. This was because of mosquito resistance to "older" pesticides, first to chlorinated hydrocarbons, then to the

organophosphorus compounds, and finally, cross-resistance. Resistance does not occur overnight. This problem has been wide-spread among numbers of mosquitoes including populations of *Aedes nigromaculis, Culex tarsalis*, and *C. pipens quinquefasciatus*.

MOSQUITO CONTROL

The primary goal in mosquito control is the elimination or treatment of the source. Sources must be determined, mapped, and monitored regularly along with the determination of the primary species. This should be first attempted through the use of cultural or biological methods. Cultural methods include draining, filling, flushing and lining swamps, ponds, and ditches. Biological controls include *Gambusia* affinis (mosquito fish) and *Bacillus thuringiensis* var. *israelensis* (Bti).

Mosquito fish have been used very successfully on areas with mosquitoes coming from permanent water. Two things are important in relocating mosquito fish: 1) use locally adapted stock and 2) notify the Nevada Department of Wildlife before moving fish.

Bacillus thuringiensis var. *israelensis* or Bti is a bacterial insecticide that can provide excellent control if applied from the first to early fourth instar. This timing is very critical. Once these methods have been exhausted, chemical controls can be used against both adults and larvae. It is best if control measures for both are undertaken, but the primary goal should always be control of the larvae.

Adulticides are usually applied as fogs, sprays, and as sprays from ULV (Ultra-Low Volume) sprayers. Materials used include Baygon, DDVP, chlorpyrifos, Fenthion (Baytex), Malathion, Naled (Dibrom), and a variety of natural and synthetic pyrethrins.

Larvicides can be applied as sprays or granules. The granular insecticides are best for areas with a thick vegetation cover. This is because they will readily settle through vegetation whereas sprays will not. Larvicides include: Abate, altosid (a growth regulator), DDVP, chlorpyrifos, Fenthion, malathion and oil.

With resistance always possible, alternating chemicals throughout the season is always advisable.

Chemicals Used in Mosquito Control

Propoxur (Baygon) is a carbamate used now for ten years without record of documented resistance.

Methoprene (Altosid) is an insect growth regulator that is very active, especially against floodwater mosquitoes and very safe on the environment. The disadvantage with this product is that timing of the application is extremely critical. Treatment must be made in late fourth stage because active ingredients persist only a few hours under field conditions. However, a newer microencapsulated formulation (ten microns) in water is equal to a ten percent (a.i.) spray formulation and provides several days residual.

Dimilin (Diflubenzuron or TH-6040, SLN only) is effective as a larvicide at standard rates of .01 to .05 pounds a.i. per acre; this suppresses some non-target organisms, especially cladocerans, but these populations recover as do the mosquitoes.

Synthetic pyrethroids are older synthetic pyrethrins that were highly effective against adults with little or no effect against larvae; newer synthetic pyrethroids are more stable under light and are highly effective against larvae; with very little increase in the dosage over the rate used against the larvae, good results are obtained against pupae.

Petroleum Oil Larvicides – in the 1920s, relatively effective oil formulations from special oil fractions, diesel and crankcase oils; larvicide activity can be increased by the addition of surfactants or detergents

to change the surface tension; 0.5 to 1 percent surfactants reduce the oil necessary to as little as 1-2 GPA.

West Nile Virus Management

West Nile Virus (WNV) infection is a mosquito-borne virus and is closely related to St. Louis encephalitis (SLE) virus. In 1999, the first confirmed cases in the United States were all recorded in New York City. Since then, confirmed cases of WNV in animals and humans have spread across the continental United States.

Mosquitoes that feed on infected birds pass WNV on to other birds, animals, and people. It is not spread by person-to-person contact. Healthy people of any age can become ill with the disease. It can be fatal or permanently disabling, although the majority of people who are bitten by a mosquito with WNV never develop symptoms.

Common symptoms of mild infections are fever, headache, body ache, skin rash, and swollen lymph glands. Those with a more severe infection may experience high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, paralysis, and death. In humans, the virus has an incubation period of three to ten days.

There is no human vaccine or treatment for the WNV infection. Most people fully recover from the viral infection and those with severe symptoms may have to be hospitalized to receive supportive care.

There is no vaccine for dogs or cats. However, horse owners should ensure their horses are vaccinated against WNV, Eastern Equine Encephalitis (EEE), and Western Equine Encephalitis (WEE). Consult a veterinarian for more details.

If a dead bird of a susceptible species is found, contact the county health department. The bird must be dead 24 hours or less. If maggots are present or the body is stiff, the carcass is unacceptable. Decomposed or scavenged carcasses cannot be tested. DO NOT touch the carcass with bare hands; wear rubber or latex gloves when picking up and handling it. If gloves are not available, use a plastic bag turned inside out to pick up the bird. Place each bird carcass into a plastic bag and secure it inside a second plastic bag and zip lock it shut. Double bagging prevents cross contamination and leakage. If a carcass is not testable, collect the bird and dispose of it by placing it inside a double bag and putting it in a secure garbage can or dumpster.

While there is no recommendation to limit outdoor activity, there are certain precautions to take in areas where WNV is found.

- Limit evening outdoor activity when mosquitoes are most active.
- When outdoors, wear a mosquito repellant containing 20 to 30 percent DEET for adults and no more than 10 percent for children. (Do not use repellant containing DEET on children under three.)
- Spray repellant on hands and then apply to the face. Only adults should apply repellant on a child.
- Apply repellant to exposed skin and clothing only. Do not use repellant under clothing or apply on cuts, wounds, sunburned or irritated skin.
- Wash treated clothes before wearing them again.
- Wear long-sleeved shirts and pants when outdoors for long periods of time.
- Avoid perfumes and colognes when outdoors for extended periods of time.
- Repair window screens if needed, and make sure window and door screens remain closed.

To reduce the mosquito population around homes and other structures:

- Change water every few days in bird baths, pet water bowls, and water troughs for large animals.
- Mosquito fish or gold fish can be put in large water troughs to eliminate breeding mosquitoes.
- Clean clogged roof gutters on an annual basis. Roof gutters are easily overlooked and can be an ideal breeding ground for mosquitoes.
- Aerate ornamental pools or stock them with fish. Water gardens are major mosquito producers if allowed to stagnate.
- Dispose of tin cans, ceramic pots, or similar water holding containers on your property.

For more information go to the following web sites:

Washoe District Health Department: www.co.washoe.nv.us/health
Clark County Health Department: www.cchd.org
Centers for Disease Control and Prevention (CDC): www.cdc.gov
American Mosquito control Association: www.amca.org
Nevada Department of Agriculture, Division of Animal Industry:
http://www.agri.nevada.gov/Animal_index.htm

Endangered Species

If you are conducting pest control activities in eastern Clark County, be aware that there are several endangered species in this county and that there may be some restrictions as to the chemicals that can be used and where they can be sprayed. This information can be obtained from the pesticide label.

CATEGORY #11
Nursery and Greenhouse

If you own or work in a nursery or greenhouse, your job may put you in close contact with pesticides or pesticide treated areas. Pesticides are used to control insects, weeds and diseases. Disinfectants and preservatives used to sterilize plant containers; working surfaces and equipment are considered pesticides. Plant growth regulators, such as the ones used to keep potted flowering plants compact, are also considered pesticides. Pesticides come in many forms: liquids, granules, powders, or gases, and are usually mixed with water before use. Some, like granular pesticides, may be used directly from the container. Pesticides are very useful for growing outdoor nursery stock, field-grown cut flowers, and nursery crops. Insecticides, weed killers, or fungicides may occasionally be needed to keep plants damage-free and attractive. Since your job makes it necessary for you to occasionally work around pesticides, pesticide contaminated plants or surfaces, it is important for you to know that pesticides could be dangerous if they are not handled carefully. It's up to you to learn as much as you can about the pesticides used in your nursery or greenhouse and how to protect yourself and others around you.

When you grow or take care of plants for sale, you often have a great deal of direct contact with the plants. When a pesticide is applied at your nursery or greenhouse, you must not enter the treated area until it is safe. When it is not safe to enter a treated area, there may be a warning sign telling you to stay out. In some cases, no signs will be posted and you will receive an oral warning not to enter the treated area. If a pesticide drifts onto you, or onto any other unprotected person, immediately leave the area and encourage others to do the same.

Of course, many pesticides are only slightly toxic, but even these may irritate your skin or eyes, or even cause delayed health effects. Others may be moderately or even highly toxic. Some of the less toxic pesticides can harm you if you are exposed to a very large dose. Pesticides can poison or injure you:

- If you swallow them,
- If you breathe them,
- If you get them in your eyes, or
- If you get them on your skin.

The most common method with which greenhouse and nursery workers are poisoned by pesticides is through their skin. Any opening in the skin, such as a cut, is especially vulnerable to absorbing pesticides. Skin exposure can occur if you get sprayed or splashed by a pesticide. Skin exposure can also occur if you handle plants or treated surfaces too soon after a pesticide application. After a pesticide is applied, a certain amount of time must pass before you, or anyone else, can enter the treated area without specific training and the proper safety equipment. Because greenhouses are enclosed structures, pesticides persist longer than they do in the open air. Never enter a greenhouse that has been posted with signs that tell you not to enter. If you are the applicator, follow all appropriate label instructions regarding posting and ventilation requirements. Skin exposure is not the only danger involved in entering areas with pesticide residues. If you enter a pesticide treated area too soon, you can also inhale pesticide dust or vapors.

Sometimes pesticides are applied through hoses and water lines, or even in irrigation ditches. Don't drink from, or wash with water from any hose or waterline unless you know it has not been used for applying pesticides. Swallowing pesticides rarely poisons greenhouse or nursery workers, but it has happened, usually because food or drink has been contaminated with pesticides. Keep food and drink out of the greenhouse and away from areas where pesticides are sold or stored.

Some pesticides can irritate the skin and cause allergic skin reactions. Once you have developed an allergy to one of these pesticides, even a very small exposure may cause an allergic reaction. Some of the least toxic materials are responsible for most pesticide-related injuries. For example, the commonly used herbicide glyphosate can cause minor but uncomfortable skin and eye problems.

If a highly toxic pesticide gets on your skin or in your eyes, you will probably experience discomfort immediately. But sometimes the damage caused by certain pesticides does not show up right away. Avoid low level, ongoing exposure to pesticides by washing your hands after handling treated plants, equipment or surfaces, before you eat, smoke, apply make-up or use the restroom. Always change your clothes at the end of every working day. Do not wear those clothes until they are laundered.

Sometimes new evidence may show that a pesticide previously thought to be safe can cause serious long-term health effects. Do not be careless, or encourage your employees or fellow workers to be careless, when working around any pesticide. A pesticide used in your nursery or greenhouse may be taken off the market because new findings link it to cancer, reproductive abnormalities, nerve damage or other health problems.

HANDLE PESTICIDES SAFELY

Always determine how dangerous a pesticide is to you and the environment before you handle the product. Do not depend on someone else – a supplier, boss, co-workers – to explain it to you. Read the pesticide label yourself, and if you have any questions about how hazardous it is to use or what kind of safety equipment you need to wear while handling the pesticide, don't use it until you know.

Signal Words

To determine how hazardous a pesticide is, read the signal word on the label. Most list the word **"Danger"** or **"Poison"** and **skull-and-crossbones** if it is very dangerous. One quick glance at the label of these products will tell you if the pesticide will cause you serious harm if you don't exercise extreme care while handling it. Pesticides that are less toxic but that have special hazards to the environment or to the applicator will have the signal work **"Danger"** alone. Other signal words used are **"Warning"**, which is considered a moderately toxic material, and **"Caution"**, which is the least toxic material. These signal words: "Danger", "Warning", and "Caution" only reflect the pesticides ability to cause immediate harm or illness.

Safety Equipment

The label will tell you which kinds of safety equipment you must wear. It will also tell you what kinds of exposure are most harmful. Statements such as: "avoid eye contact" or "wear protective eyewear when handling this product" tell you not to get the pesticide in your eyes. Most labels warn you against skin contamination, inhaling the pesticide, or swallowing the pesticide. The label is a legal statement; therefore the law, as well as common sense, directs you to follow the recommendations for safety equipment.

To mix, load, or apply any pesticide, you must wear chemical resistant gloves. Otherwise, no matter how careful are, you will get pesticides on your hands and forearms. Required minimum amount of protection includes a long sleeved shirt, long pants, eye protection, boots and socks. In addition, if you use pesticides with the signal words "Warning" or "Danger" your employer must supply you with a pair of coveralls to wear over your work clothes. You must wear coveralls when handling these pesticides.

If you are applying pesticides overhead, such as hanging baskets in greenhouses or tall nursery trees, your head can be exposed to pesticides. Wear a wide-brimmed hat that will protect your face and neck.

Always wear a respirator when the label indicates the need for respiratory protection. Protect you eyes with goggles, safety glasses or a facemask. Regular glasses or sunglasses are never considered adequate for the purposes of protecting your eyes.

The Applicator's Responsibility

As a pesticide applicator, you have the right to protect yourself from pesticide exposure and the responsibility to protect others and the environment from pesticides. Make sure no one is in the area to be treated. Sometimes tall plants, hanging baskets, tiered benches and equipment makes it difficult to see if there are other people around. Always check the area to be sprayed before you start the application. If you work in retail nursery, pesticide applications should take place during non-business hours, when there is less potential for a customer to become contaminated by the application. Curious customers may wander into the application area. Never place plants out for sale that has been sprayed with a pesticide until the spray is completely dried, or according to label directions.

When you are mixing and loading a pesticide, don't leave it unattended. Someone who doesn't realize that the material is hazardous could inadvertently come into contact with the concentrated or prepared material. This is particularly critical in a retail nursery setting where customers may become involved. Never make a pesticide application when the wind will make it possible for the pesticide to drift from the targeted area. Pesticide drift will contaminate adjacent areas, workers, customers and the environment. Do not allow pesticides to drift onto ponds, lakes, creeks and rivers. Leftover pesticides should never be dumped on the ground; they could easily end up in the ground or surface waters making them hazardous for use by people or wildlife. Mix only as much pesticide solution as you will need for the application, and dispose of any excess according to the label directions.

Special Considerations for Greenhouse Applications

When you apply pesticides:

- Protect yourself, others, and the environment, following label directions.
- Before you start, consider the conditions in the greenhouse. Wait until later if you need to apply a pesticide to the leaves of the plants that are wet from recent watering; the pesticide might wash off the leaves without sticking.
- If watering is scheduled to start soon, do not apply a pesticide that could be washed off the treated surface.
- Carefully check out and calibrate the application equipment; make sure there are no leaks, all parts are working properly and the application rate is accurate.
- If you need to fix the application equipment, turn it off first. Remember to keep your protective equipment on while you are fixing the equipment.
- **Never apply pesticides so they can get on people – either directly or through drift.**
- Check the area of the greenhouse where you will be working. Make sure no people or pets are nearby.
- **You are required by law to post signs at each entrance to the greenhouse area to be treated. Keep anyone not involved in the application out of the treated area during the pesticide application, and during the restricted re-entry period.**
- For some types of greenhouse applications, you must keep people out of an area that is larger than the area where you will be applying the pesticide.
- When applying a pesticide that does not require you to wear a respirator – where you will be spraying fine droplets from a distance of more than 12 inches above the plants you must keep people at least 25 feet back from the edges of the area while you are spraying. You also need to turn the greenhouse ventilation off – or at least down to "low" – so the airflow does not cause the pesticide to drift out of the target area.

- When applying pesticides from a lower height – 12 inches or less – using granules, dust, or coarse-droplet spray, you do not have to use the 25-foot setback. People must stay out of the immediate treatment area, but they can walk down nearby aisles or work at nearby benches while the application is taking place. The ventilation system may be left on during this kind of application, too. That is often necessary in a hot greenhouse to provide air circulation, cooling and prevent heat stress.

Some pesticides require extra precautions

Pesticides that require special care are those that are applied as non-fumigant smoke, mist, fog, or aerosol—or that requires you to wear a respirator. With these pesticides you must turn off the greenhouse ventilation system during the application and you must keep everyone out of the entire enclosed area where the pesticide is being applied. That area may be the entire greenhouse. Sometimes though, the area can be smaller if walls, tents, curtains, or pyramids can contain the pesticide. People must stay out of the enclosed area – whether it is the entire greenhouse or a smaller space – until the area has been thoroughly ventilated.

Fumigants require the greatest level of precautions during their use

As a general rule, all unauthorized people must stay out of the entire greenhouse during and after a fumigant application – and also out of any building that is attached to the greenhouse without an airspace between the two.

The greenhouse ventilation system must be shut off during a fumigant application.

Worker Protection Standards require that the person applying a fumigant must be in constant voice or visual contact with another trained pesticide handler during the entire application. This second person must have close at hand a set of the same personal protective equipment the applicator is wearing, in case rescue is needed.

For some fumigants, the concentration levels of the pesticide in the air must be below a threshold level before people are permitted to re-enter the greenhouse. Others require specific amounts of ventilation. Read the label to learn what is required.

The only people who may enter the greenhouse during the period when the air is still considered unsafe are trained handlers who are equipped with the required personal protective equipment.

Even those handlers are allowed in only to operate ventilation equipment or, in the case of fumigants, to adjust or remove tarps or other coverings or measure the fumigant concentration levels in the air.

COMMON PEST PROBLEMS IN NURSERIES AND GREENHOUSES

Adapted from the Idaho Landscape Association Manual for Certified Nursery and Landscape Professionals.

Injury to plants in greenhouses and nurseries can be cause by living or biotic factors such as insects and other invertebrate organisms, animals and infectious disease organisms (fungi, bacteria). Non-living or abiotic factors can also damage plants. Cultural practices and environmental conditions such as under watering, pesticide injury, rough handling of plants, hail, nutritional deficiencies and toxicities, temperature extremes in soil or air, can injure or stress plants. Injured or stressed plants are far more susceptible to abiotic and biotic damage than are healthy plants.

The Importance of Preventing Pest Problems
Pest exclusion, or preventing pests from getting established, is the most important step in avoiding pest problems. Refuse to accept infested stock from suppliers. Isolate or destroy plants that become infested. Install greenhouse screening and plastic drapes over entrances to prevent flying insect pests from entering through vents and doors. Take every precaution to prevent the spread of diseases. Plants should not be installed in an interior landscape unless they are pest free. Promote vigorous, healthy growth to reduce plant disease and insect infestations.

Problem Identification
Once a pest is established, the pest and the associated plants must be correctly identified. Contact University of Nevada Cooperative Extension professionals, books, professionals from the state department of agriculture, and other nursery and greenhouse professionals. Consult books, trade publications and fact sheets. After identifying the cause, evaluate the extent of the problem. How serious is the pest problem likely to become? How expensive are control options? Is the setting appropriate for the suggested management program? Is the pesticide product you are considering registered for use in a greenhouse or nursery setting? Deciding which action to take is based on these considerations and more. Remember that there may be more than one way to correct the pest problem. Pesticides may not always be the most effective, safest or economically sound solution.

Abiotic Factors
Many non-living factors cause plant problems, and most are preventable!

Proper culture, maintenance and handling of plants in nurseries and greenhouses will prevent most abiotic plant damage. An abiotic event such as over or under watering stresses a plant and makes it more susceptible to insect and disease organisms.

The following is a list of common abiotic factors that contribute to plant problems in nurseries and greenhouses. It is important to consider these factors when attempting to solve what you believe to be a pest problem. **Pesticides will not "cure" damage caused by abiotic factors!**

<u>COMMON ABIOTIC FACTORS WHICH CAN DAMAGE PLANTS</u>

Frost/freeze damage
Water quality: pH, salinity, and toxic element concentrations
Under watering
Over watering
Low soil aeration
Poor drainage
Wind damage
Improper maintenance
Limited root volume: "j" roots, circling roots
Soil compaction
Hail damage
High/low temperatures in air or soil
Over fertilization
Nutrient deficiency
Chemical injury
Improper soil pH

Biotic Factors
Plant problems are often blamed on living pests, often with no evidence to support the diagnosis. Living pests do cause damage to plants in greenhouses and nurseries, but they are less damaging than abiotic conditions. Biotic factors include but are not limited to arthropods (insects and related organisms), vertebrates such as ground squirrels and gophers, and organisms that cause disease. We normally reach for pesticides when attempting to control these pests. However, pesticides may not always provide the long term, effective solution we are seeking, or they are not always appropriate for the setting.

Diseases
In Nevada, fungi and bacteria cause most infectious diseases. Viruses, nematodes and mycoplasma also cause diseases. Some disease organisms attack and invade healthy plants. The majority invades only stressed plants. Diagnosis of casual agents is often difficult and may require culturing the organism in a laboratory. Check to see which diseases are common on the affected species and review their symptoms. Chemical control is not necessary or available for some disease problems. Prevention is the most important disease management tool. Learn the growing requirements of each plant species and avoid conditions that stress them. Select disease resistant varieties whenever possible. If practical, remove or destroy infected plants or plant parts. For trees and shrubs infected parts can be removed by pruning. Do not leave infected prunings, plants or soil in a greenhouse or nursery. Dispose of them immediately. When fungicides are used, rotate the products used to decrease the opportunity for resistance to develop.

Typical disease symptoms include:

Leaf Spots: Leaf spots are localized infections of leaves. Most are cause by fungi or bacteria, but some are caused by hail, insects, pesticide applications or drought stress.

Many fungal spot diseases require free moisture on the leaf surface to germinate and develop. Spots caused by fungi tend to be round in outline, while those of bacteria are often angular. Some fungi, like those that produce tar spot, produce spots that are uniformly dark. Others develop as a circular area with a dark margin. Fungi produce tiny fruiting structures. Many are dark and visible with a hard lens, particularly during periods of high humidity.

To avoid establishment of leaf spot diseases, prevent conditions that encourage extended periods of wet leaves. Encourage air circulation by leaving space between plants, particularly in greenhouses, or by pruning susceptible trees and shrubs to open up the canopy.

Rusts: Rusts are diseases caused by fungi and are named for the yellow to reddish spore masses they form on plant surfaces. Rust fungi have multiple spore stages or require more than one host to complete their lifecycle. The rust colored pustules break through the surface of leaf and stem tissue. The "rust" is easily rubbed off with your finger**.** Rust diseases occur on ash, potentilla, rose, chrysanthemum and many other ornamentals and greenhouse crops. Rust spores are spread by wind, splashing water and pruning tools. Fungicides applied in the first sign of the disease reduce its spread to uninfested plants. Some rust species develop black overwintering spores on leaves in the fall. Remove infected leaves from the nursery and greenhouse. Avoid overhead watering on plants if rust is known to be a problem.

Canker: Cankers are localized dead areas on twigs, branches and trunk. Hail, sunscald, pruning wounds, damage from improper staking and maintenance, as well as infectious agents may cause cankers. Cankers caused by disease organisms appear as sunken areas on branches and trunks. The edge of the canker often, but not always, shows a thickened area or margin. Sometimes the bark within the sunken area will split or tear as it dries out. Reproductive structures may appear on the surface of the canker. Eventually the affected bark will fall away. Cankers cause the branch beyond the infection to decline or die. Cankers are considered serious because they kill limbs, or even entire plants. Biotic causes of

cankers include fungi and bacteria. Some canker pathogens live only one season, others are perennial; some are capable of attacking healthy plants, others attack only plants under stress. The key to controlling canker diseases is to prevent them from becoming established. Select plants well adapted to the area in which they are to be planted. Keep healthy plants well watered. Avoid wounding plants. Promptly remove all cankered areas to prevent the spread of the disease to other healthy plants or plant parts. Prune six to eight inches below any sign of the infection. Disinfect pruning equipment between cuts and between plants. Common canker diseases are cytopspora canker, cypress canker, and fireblight.

Root Rots: Root rots are difficult to diagnose because the affected portion of the plant is underground. Look at the entire root system of container plants and portions of an established system in order to diagnose root rot. When a root system deteriorates as a result of root rot damage, above ground symptoms may include dieback, wilting, small leaves, dead leaves and increased seed production. These symptoms are similar to the damage caused by several abiotic disorders including over watering, herbicide damage, or mineral toxicity. Most fungi that cause root diseases occur naturally in the soil, and they usually persist for long periods of time. Infected roots may be enlarged, slimy, wet, and dark in color. To identify a specific root rot pathogen requires a laboratory analysis. Root rots can be avoided by using soil mixes that drain well and by avoiding soggy soils or soil compaction. Fungicides, fumigation and pasteurization are used to treat potting soils to prevent root rots. New research indicates that some composted soil mixes have the ability to suppress certain root rot organisms. Nursery plants with root rot should not be used in landscapes, as they can introduce the disease into the soil.

Virus Diseases: Virus diseases cause changes in plant growth or coloration, and may kill plants. Common symptoms include stunting, mottling, mosaic patterns, lack of or reduced flowering, chlorosis, or changes in the normal development of leaves and buds. Viruses are systematic and are spread by grafting, handling of diseased plants, insects, and fungi. Smokers, who pick up the disease on their hands while smoking cigarettes, can transmit some, like tobacco mosaic virus, to healthy plants. Viruses are readily transmitted by knives or pruning tools. Because there are no cures for virus diseases, the plants must be destroyed. Tomato spotted wilt (TomSWV), tomato mosaic virus (TMV), lily fleck, and dasheen mosaic are viruses that may occur on greenhouse, bedding plant crops, and ornamentals. Selecting virus free plants with known resistance to common virus diseases is the best control strategy.

Miscellaneous Diseases: Other diseases include blights, scabs, powdery mildew, smuts, galls and storage rots (commonly found on stored bulbs, corymbs, rhizomes, or tubers). Powdery mildew is a common disease in Nevada. This fungal disease has a wide host range. The mildew fungi grow over the surface of leaves, buds or fruit and secure itself to the epidermal layer. A white to gray coating appears on the leaf surface, in some cases causing the affected plant to look as though it has been dusted with white powder. Heavy infestations cause premature leaf drop, stunted growth, "witch's broom", and russeting of fruit. Many plants are susceptible to powdery mildew including euonymus, rose, apple, chrysanthemum, numerous greenhouse crops, and sycamore. Powdery mildew spreads by windborne spores. Unlike many fungi diseases, the spores do not need free water to germinate. Powdery mildew overwinters on evergreen and fallen leaves. Rain, direct sunlight and good air circulation inhibit the development of powdery mildew. Plants susceptible to powdery mildew should be placed in the nursery or greenhouse where air circulation and light penetration is best. Choose plant varieties that are resistant to powdery mildew whenever possible. Infected plants should be isolated and destroyed. Excessive fertilization and irrigation promote growth that is susceptible to powdery mildew. Avoid both, particularly on plants susceptible to powdery mildew. Once powdery mildew is established, it is usually too late for control measures to be effective. Sulfur or systemic fungicides can be applied at the onset of the disease to prevent its spread to uninfected plants.

SELECTED CULTURAL PRACTICES FOR CONTROLLING PLANT DISEASES IN NURSERIES AND GREENHOUSES

Become familiar with the common diseases of nursery and greenhouse plants. Act quickly to eliminate them.

- Inspect all plants brought on the premises and refuse to accept diseased plant materials!
- Provide good air circulation around plants.
- Avoid excessive humidity.
- Use soil that is pasteurized or otherwise pathogen free.
- Choose disease resistant varieties.
- Select plants that are well adapted to Nevada's climate.
- Avoid injuring plants.
- Practice good sanitation.
- Control weeds.

Insects

In the natural environment, where a finite number of plant species occur together, insects are normally kept in check by limited food supply, environmental conditions, and natural predators. In greenhouses and nurseries however, some insects may become pests because large numbers of susceptible plants are grown together. Abiotic stresses or other injuries make plants more susceptible to insect attack.

Insects and related arthropods are responsible for many kinds of plant disorders. Their damage is often difficult to distinguish from that caused by disease or abiotic problems. Insect injury is confirmed by finding the casual insect. However, insects found on an injured plant may have nothing to do with the damage! Sometimes, damage is observed only after the responsible insect has completed the damaging part of its lifecycle. Therefore, it is important to become familiar with insect pests commonly found on plants in the nursery and greenhouse. Effective control measures require correct identification and a thorough understanding of the pest's lifecycle and biology. An excellent source of color photographs and information on tree and shrub insects in the book *Insects that Feed on Trees and Shrubs,* by Warren Johnson and Howard Lyon.

Typical Symptoms of Insect Attack

Leaf Spots: Although leaf spots are most frequently caused by plant pathogens, sucking insects, such as leafhoppers and plant bugs may also cause them. When an insect's saliva is toxic to a plant, a dead spot may develop around the feeding site and holes may develop when the damaged tissue becomes brittle and falls out. Holes produced in this way are "BB" to pencil sized and are round. Because of the wounding, plant pathogens invade the tissue adding to the disease like symptoms.

Branch Dieback: Wood-boring insects, such as the bronze birch borer, damage plant vascular tissues, resulting in dieback of the infested limbs or branches. Branches damaged by other causes and weakened trees in general are particularly susceptible to insect borers. Diseases, environmental stresses, cultural problems, insects, or a combination of these factors may cause branch dieback.

Bronzing: From a distance, trees heavily infested with spider mites appear discolored. Close examination of infested foliage reveals a bronze discoloration of the leaves. To confirm a diagnosis of spider mite injury tap infested branches over a white piece of paper. Dislodged spider mites appear as tiny specks moving on the paper. Evergreen trees and shrubs located along dusty roadways, in areas of reflected heat, or in windy hot sites, are most susceptible to mite infestations.

Cankers and Swelling: Many beetle larvae and caterpillars bore into tree trunks or limbs, causing the infested tissues to swell or form cankers. When these swellings are cut open, insect tunnels and

sawdust-like frass is visible. Insect borers attack trees that are weakened or damaged by other causes. In some cases, borer and plant pathogens are associated with the same canker.

Locust Borer is an example of a round headed borer that causes swelling on infested tree trunks and branches of Black Locust trees.

Chewed or Skeletonized Leaves: Leaf beetles and some sawflies chew off one surface of a leaf leaving the opposite surface and veins intact. This type of damage makes leaves look like lacy skeletons. Elm leaf beetle and pear slugs are two examples of leaf skeletonizers. Most caterpillar and adult beetles chew entirely through leaves leaving small to large holes, or irregularly shaped, jagged leaf edges. If leaves are still growing when a chewing insect feeds, the leaves may later develop smooth edges around the holes. Only insect feeding causes these symptoms.

Premature Leaf Drop: plant pathogens or environmental problems generally cause premature leaf drop. However, heavy infestations of aphids, mites and scale insects can cause leaf drop.

Leaf Curling, Puckering or Rolling: The saliva of some sucking insects, particularly aphids, may cause plant leaves to curl, fold or pucker. These symptoms can be confused with plant diseases that cause similar symptoms. The causal insect may be found by inspecting the damaged area. Some caterpillars, called leaf rollers or leaf tiers, use silk threads to hold leaves in curled or rolled shapes.

Leaf Miners: Plants heavily infested with leaf miners appear brown, as if the leaves are dying. Leaf miners feed inside leaves between the upper and lower leaf surfaces. Some miners tunnel randomly through the leaf and others form chambers while feeding. Hold the leaf up to a light source and the tunnels will be easily observed. If the chambers are opened up, brown frass and a worm-like larva may be found between the leaf surfaces. Leaf miners frequently occur on greenhouse crops like chrysanthemums and cineraria, and on landscape trees, like Birch, Alder, and Poplar.

Stem and Leaf Galls: A gall is an irregular growth of tissue by the plant in response to wounding caused by pathogens or insects. The shape of the gall formed is often characteristic of the causative organism. Several arthropods form galls including gall wasps, gall midges, aphids, adelgids, eriophyid mites and sawflies. Some families of gall forming insects are so diverse that a gall forming species exists within the family for almost every common tree species. Although stem and leaf gulls may be caused by plant pathogens, leaf galls are usually caused by insects or mites. Some gall-formers are tiny, and can only be seen with a hand lens or microscope.

Gumosis or Pitch Flow: Many trees respond to trunk or twig injury by exuding sap or pitch from the injured area. This pitch flow may be a tree defense mechanism to prevent additional injury from insects and disease. Wood-boring insects and bark beetles often cause plants to exude pitch into the feeding site. Plant pathogens, environmental stress and mechanical injury can also induce pitch flow.

Root Damage: Nematodes and the larvae of some insects, such as root weevils, feed on and can seriously damage roots. Because roots are not readily visible, diagnosing insect injury to roots is difficult. The primary symptom is a gradual decline in plant vigor. The characteristic notches that the feeding adults make in leaf margins normally diagnose root weevils.

Controlling Insects in the Nursery and Greenhouse

Predators, parasites, and pathogens keep insect pests under control naturally. Ladybird beetles, lacewings, predaceous mites, parasitic wasps and other natural enemies devour or parasitize aphids, scales, and mites. Disease also reduces insect populations. Without beneficial organisms, populations of pest insects would rapidly increase. Nursery and greenhouse personnel should protect and encourage these beneficial organisms. They should learn to identify the forms of these beneficial organisms and integrate them into the pest management program. Many natural enemies for greenhouse pests are

available commercially. Biological control using natural enemies in greenhouses is widely practiced throughout the world.

Sometimes, however, cultural practices and natural enemies do not provide acceptable control of insects. In these situations, apply insecticides to suppress pest populations and prevent unacceptable damage. Insecticides are generally broad spectrum in their activity; that is, they will kill a variety of insects, including natural enemies. Whenever possible, use the least toxic pesticide available, such as horticultural spray oils (Sun Spray, Volk oil) and microbial insecticides (Bt), or insecticide soaps.

Even though an insecticide has been applied, the application may be ineffective. The following are reasons why insecticide applications may not result in control:

Correct Timing and Thorough Application: The best, safest, and most effective insecticides available will not control insects effectively if they are not applied correctly and at the proper time. Insecticides must be applied when pests are present and vulnerable, and at the rates listed on the product label. You must ensure thorough coverage of upper and lower leaf surfaces, branches or trunks.

Correct timing of sprays is important. Many insects are easiest to control when they are young. Scale insects are an example of common pests that are effectively controlled immediately after the larvae have emerged, when they are in the vulnerable "crawler" stage. During this stage, which lasts about a week, the crawlers are unprotected and easily killed. Once the larvae secrete protective coverings over themselves, they are difficult to kill. Pesticides applied after this stage are not usually effective.

Incorrect Insecticide: No insecticide controls every insect, and if the wrong chemical is used, you will get little or no control. Make sure you identify the target pest correctly and then select an appropriate pesticide.

Adverse Weather: Most insecticides do not perform efficiently or give satisfactory results when used at temperatures below 50 °F. Rain may wash off insecticides that haven't yet dried. Wind alters spray coverage, preventing sprays from reaching targets and carrying insecticides into sensitive areas that should not be treated. It's usually best to apply insecticides when temperatures are above 50 degrees F but below 95 °F, and when no rain is expected for at least 12 hours.

WEEDS

A weed is any plant growing where it is not wanted. Elm trees growing in a landscape may be desirable. Elm seedlings coming up in nursery containers are weeds.

Control weeds while they are small and immature, before they go to seed or develop extensive root systems. If allowed to produce seeds, more weeds will grow then next season. Many weed seeds can survive for years in the soil. Some seeds require light in order to germinate and grow. Disturbing the soil can bring weed seeds to the surface resulting in a new crop of weeds. Methods of controlling weeds in the nursery and greenhouse vary with the type of weeds, time of year, the crop grown, and the environment conditions present at the time.

Types of Weeds

Weed identification is the first step to effective weed control. An excellent weed identification guide is *Weeds of the West*, by Tom D. Whiston, Editor, which provides an identification key and detailed color photos of hundreds of weeds found in Nevada.

Annual weeds sprout, grow and die in one growing season. They represent the majority of weeds. Annual weeds reproduce only by seed and do not have underground reproductive roots, rhizomes or bulbs. Annual weeds are normally considered easy to control when small, but are very persistent

because of their fast growth and abundant seed production. Winter annual weeds germinate at low temperatures in late winter or early spring. They grow rapidly and go to seed in early summer. Summer annual weeds germinate later when temperatures are warmer and produce seed from the mid-season into late fall, depending upon the species. Destroy annual weeds to avoid their competition and seed production. Common annual weeds include crabgrass, pigweed, prostrate knotweed, and ragweed.

Biennial weeds also reproduce primarily by seeds, but have underground storage roots, crowns, bulbs or other organs to survive overwinter. Biennials typically form a short leafy rosette of leaves the first season, store food in a root or crown, and then go dormant for the winter. The next spring the stem elongates produces flowers and seeds, and then the plant dies. Biennials, like annuals, are most easily controlled as seedlings. Burdock, bull thistle, wild carrot, wild parsnip, and mullein are common biennial weeds.

Perennial weeds are the most difficult to control. They reproduce by seeds and usually also by vegetative parts, such as underground crowns, roots, rhizomes, stolons, tubers, and bulbs. Cultivation is not very effective in controlling perennial weeds unless the entire weed, including underground storage organ, is removed or unless new growth is removed frequently and repeatedly until all food reserves are used up. Cultivation often spreads underground parts that sprout and spread the weed colony. Canada thistle, bindweed (morning glory), and quackgrass are perennial weeds.

Weed Control Methods

There are four basic methods used for weed control: mechanical, biological, chemical, and exclusion.

Mechanical Control Physical removal or incorporation of weeds immediately reduces weed competition and improves appearance of the area. The main disadvantage is the amount of time, effort, and money it takes if weeds are established. If a little time each day or week is set aside for weeding, it should not become a chore.

Weeds are much easier to control while they are small seedlings rather than when their roots become fully established. One chop with a hoe can remove dozen or more seedling weeds, but it may require three or four chops to remove one well established older weed.

The best time to pull weeds is when the soil is loose and moist. When it is hard and dry, postpone weed pulling until the day after an irrigation or rain. Grasp weeds as close to the ground as possible in order to avoid breaking stems. New weed shoots can develop from crown and root sections if the weed breaks off.

A hoe is a cutting tool and the blade should be sharp for use. The blade should be held parallel to the soil and weeds cut right at the soil line, disturbing the soil as little as possible. That way weed seeds that are too deep to germinate will not be brought to the soil surface. Some people prefer double-action hoes designed with sharp edges on both the back and front of the blade, because they can cut weeds with both forward and reverse motions. Double-action hoes are not very effective on hard, dry soils.

Most annual seeds dry up in a few days if left where they are hoed. Do not irrigate immediately after hoeing. Prostrate succulent weeds, such as purslane and spurge, store water in their tissues and can survive several days until they can regrow new roots from stems. Remove these weeds after hoeing. Perennial weeds will usually sprout form underground organs and are best controlled by other means.

Weed hoes and tractor pulled or driver cultivators effectively bury, cut, disk or incorporate weeds. Again, cultivate weed-infected areas when the weeds are small for effective control.

Mulches Organic and inorganic mulches help control weeds. They prevent light from reaching weed seeds or seedlings. Natural organic materials, such as chipped or shredded bark, grass clippings, and pine needles are often used as mulching materials. Many inorganic mulches are available. To improve

the weed control ability of both, weed control fabric can be used under the mulch. Sheet plastic under mulch is not recommended.

- Gravel and rock are frequently used as mulches. While they do not improve the soil structure or provide nutrients, they last longer than organic mulches.
- Organic and inorganic mulches should be two to four inches deep to prevent weed growth. Greater depths can be used around trees and shrubs planted in the field, but keep the mulch back about two to four inches from trunks to ensure good air circulation and reduce the potential for crown diseases.
- Woven plastic landscape fabrics can be used as a weed barrier under mulch, especially around trees and shrubs. The fabrics allow adequate water and air movement into and out of the soil. They are usually covered with organic mulches or gravel to improve the appearance and increase the life of the fabrics, which are subject to break down when exposed to light. Even with the heaviest weed barrier fabrics, however, some weeds penetrate and grow. When mulches cover the fabrics, weed seeds can germinate and grow in the mulch above the weed barrier fabrics.

Biological Control At present, there are no methods of utilizing biological control of weeds in nursery and greenhouse production. Insects that feed on specific weeds appear to hold the best promise. Numerous weed-feeding insect species have been introduced into the United States to control selected species of weeds. Recent work with plant pathogens has demonstrated some potential for weed control. A newly discovered race of the fungus *Verticillium dahliae* attacks seedlings of velvetleaf, a common mid-west weed.

Chemical Control The effectiveness and selectivity of herbicides are affected by environmental factors. Air and soil temperatures, humidity, rainfall or irrigation, and wind all influence the effectiveness of herbicides. Some herbicides are not absorbed or translocated (moved from one part of the plant to another) at low temperatures. High temperatures cause some herbicides to volatilize, reducing the chemicals' effectiveness and increasing the potential for herbicide vapors damaging nearby desirable plants. This is particularly true for herbicides applied in greenhouses. Wind greatly increases the risk of herbicide drift onto desirable plants.

The type of soil can affect soil-applied herbicides by decreasing their effectiveness or increasing it to damaging levels on otherwise tolerant plants. Some herbicides are absorbed and inactivated when applied over organic mulches or to clay soils.

The age or growth cycle of a plant can change herbicide absorption and translocation within the plant. The older the plant, the less responsive it will be to herbicides. The depth and degree of establishment of a plant's root system can affect its response to soil-applied herbicides.

It is very important to read all directions and precautionary statements on herbicide labels before applying or recommending application. The herbicide label is the law. Be sure to note weather and other factors that affect the use of a particular product. Never use or recommend a herbicide for an application that is not included on the label.

Types of Herbicides

Herbicides are classified into types based upon their use and mode of action.

Pre-emergence herbicides are often referred to as "weed preventers". They kill germinating weed seeds or seedling weeds, but have little effect on established plants. They do not kill established perennial weeds that emerge from underground roots or other storage organs, but reduce the establishment of new

perennial weeds from seed. A pre-emergence weed killer is applied prior to the appearance of weeds or after established weeds are killed or removed.

Most pre-emergence herbicides are applied to the soil surface and then either watered in or mixed into the top inch of soil with a rake. Failure to water in or incorporate the herbicide often results in poor weed control. When the soil is disturbed by cultivation, the chemical barrier formed by a pre-emergence herbicide is disturbed and weed seeds can germinate and grow. The effective control of different pre-emergence herbicide varies from a few weeks to several months.

Pre-emergence weed killers are most widely used to kill weeds around perennial woody plants with well-established root systems. Some are used to control weed germination in lawns.

"Garden weed preventers" are recommended for use around established vegetables and flowers. These are applied after seeds have germinated and the first crop of weeds has been removed. With some flowers and vegetables, weed preventers can be applied immediately after transplanting. Some species, however, are stunted or damaged unless you allow their root systems to become established for at least two weeks before applying the herbicide.

Pre-emergence, "crabgrass preventers" are available for use on lawns. These products are applied in late winter or early spring to prevent the germination of crabgrass and other warm weather summer weeds. These products are often combined with fertilizers.
Post-emergence herbicides kill established weeds but may or may not prevent new weeds from developing from seeds or underground organs. These herbicides are divided into two types: Contact and Translocated. Contact herbicides kill only those plant parts with which they make contact. Translocated herbicides are absorbed by roots, stems or leaves and are moved throughout the plant. Contact weed killers are effective in controlling small weeds and annual weeds. Translocated herbicides provide good control of perennial weeds because the chemical is moved into underground storage organs.

Selective herbicides are designed to kill only certain plants, leaving others undamaged. They damage desirable plants if applied incorrectly. Common mistakes include applying more than the recommended rate, applying the herbicide when temperatures are too high, applying it to the wrong soil type, or applying it before plant root systems have become established.

Non-selective herbicides are toxic to all plants. They are used where it is desirable to kill all vegetation or where application can be directed away from desirable plants. Non-selective herbicides are often used to kill weeds before planting or replanting. When applying in an established landscape, special application methods or equipment (such as wipers) can be used. Desirable plants can be covered to prevent the herbicide from contacting them. Diquat and glyphosate (Roundup) are examples of non-selective herbicides.

Soil Sterilants are herbicides that are applied to the soil to prevent any plants from growing in an area for a prolonged period of time (several months to several years.) Although, sterilants are useful for driveways and along fencerows, take care to avoid contacting the roots of desirable plants. Large trees and shrubs have root systems that can extend far beyond their drip lines. Soil sterilants should never be applied to areas where you plan to plant in the future.

A particular herbicide may fit one or more of the categories listed above. Broadleaf lawn weed killers, for example, are popular selective, post-emergence, translocated herbicides. They kill broadleaf weeds growing in lawns, but have little effect on most grasses. Toxicity to grass is most likely to occur during hot, mid-summer weather. Because they will also kill broadleaf ornamental plants, it is important to prevent spray drift onto adjoining trees, shrubs, flowers and vegetables. Like most pre-emergence

herbicides, lawn weed killers are most effective when weeds are growing actively. If rain or irrigation occurs within 24 hours after application, herbicides can be washed off before they are completely absorbed by the weeds. Examples of selective broadleaf weed killers are MCPP, 2, 4-D, dicamba and Trimec.

Selective, translocated, post-emergent herbicides are available to control some grassy weeds around trees, shrubs and flowers. If applied when grasses are young and actively growing, they effectively kill or suppress certain grasses without damaging most broad leaf plants, although, some broad leaf plants may be damaged. All herbicides must be applied only around desirable plants specifically listed on the label.

Sprayer Precaution

Because it's very difficult to remove all herbicide residues from sprayers, even with repeated rinsing, you should use one sprayer for herbicides and a separate sprayer for other pesticides.

Making Weed Control Decisions

1. Identify the weeds or types of weeds present.
2. Identify all plants in the treatment area.
3. Select the method of control appropriate for the setting that will effectively kill the weeds without harm to desirable plants. Choose the safest control methods and chemicals available for the crop, applicator and the environment.
4. If a herbicide is selected READ THE ENTIRE LABEL and follow all label instructions and precautions.
5. Follow all safety procedures when handling the pesticide. Spray on a calm, cool day to prevent drift and volatilization from injuring non-target plants.
6. Be sure you have the necessary application equipment to apply the herbicide correctly and that the equipment is in good, operating condition.

CATEGORY #12
Wood Preservatives

Nearly everywhere wood is used today, it's made to last longer through the use of chemical preservatives. Preservatives protect wood in telephone poles and signs, in wood bridges, piers and pilings, under trains, and in fences, walls and buildings.

The wood preservative industry extends from the chemical plants where chemical preservatives are manufactured, to the shops and millworks where they are applied. Everyday, thousands of people work with wood preservatives in heavy industry, at home or on farms, for utility companies and railroads, at dock yards, and on construction jobs. Everyone benefits from the use of wood preservatives, except when those chemicals are used carelessly. The costs can be high to those who get sick, and to the environment we all share.

PESTS THAT DAMAGE WOOD

Under proper use conditions, wood can give centuries of good service. But under unfavorable conditions, wood may readily be damaged and destroyed by fungi, insects and marine borers. These pests can attack in may ways, using the wood for food or shelter. Consequently, wood must be protected to ensure maximum service life when used under conditions favorable to these pests.

A. WOOD DESTROYING FUNGI – Both the sapwood and heartwood of most tree species are susceptible to decay. Decay fungi may grow in the interior of the wood or appear on wood surfaces as fan-shaped patches of fine, threadlike, cottony growths or as root-like shapes. Fungi produce spores that can infect moist wood during storage, processing, and use. The fungi that grow on wood have the following basic requirements:

- Favorable Temperature - between 50 °F and 90 °F
- Adequate Moisture – (fungi won't attack wood with a moisture content [M.C.]; decay fungi require a wood moisture content of about 30 percent).

  Fungal strands grow throughout the wood, digest parts of it as food, and eventually destroy the strength of the wood. Decay will stop when the temperature of the wood is either too low or too high, or when the moisture content is drier than the fungus requirements.

  Wood decay fungi can be grouped into three major groups:

  1. Brown Rot Fungi: break down the cellulose component of wood for food leaving a brown residue of lignin. Brown-rotted wood can be greatly weakened even before decay can be seen: Brown-rot fungi are probably the most important cause of decay of softwood species used in above-ground construction in the United States. "Brown-rot", when dry, is sometimes called dry-rot; that is a poor term in that wood must have a high moisture content for fungi to cause decay. The final stage of wood decay caused by brown-rot fungi can be identified by:
     a. the dark brown color of the wood
     b. excessive shrinkage
     c. cross-grain cracking
     d. ease with that the dry wood substance can be crushed to powder
  2. White Rot Fungi: break down both lignin and cellulose and have a bleaching effect that may make the damaged wood appear whiter than normal.
  3. Soft Rot Fungi: usually attack green (water-saturated) wood, causing a gradual softening from the surface inward that resembles brown rot.

4. Other wood inhabiting fungi:
   a. Sapstaining Fungi penetrate and discolor sapwood, particularly of the soft-wood species. Typical sapstain cannot be removed by brushing or planing. Strength of the wood is little affected, but the wood may not be fit for uses where appearance is important. Southern pine beetles often carry blue stain fungi into trees that may cause the wood of infected trees to be stained before they are cut.
   b. Mold Fungi first become noticeable as green, yellow, brown, or black fuzzy or powdery surface growths on softwoods. As with sapstains, molds do not reduce wood strength; however, they can increase the capacity of wood to absorb moisture, thereby opening the door to attack by decay fungi.

B. INSECTS
1. Termites use wood for food and shelter and are the most destructive of all wood insects.
   a. Subterranean Termites build tunnels through earth and around obstructions to get to a source of wood. They require a constant source of moisture that is usually obtained from the soil.
      1) Evidence of the presence of subterranean termites may be noted by:
         a) the swarming of winged forms and discarded wings observed after swarming
         b) earthen shelter tubes built over masonry or other foundations to a source of wood
         c) the presence of white workers when termite shelter tubes are broken open
         d) the hollowed-out condition of badly infected wood products
   b. Drywood Termites – After swarming, drywood termites enter cracks and crevices in dry, sound wood. In excavating their galleries, they occasionally discharge oval-shaped pellets through temporary openings in the wood face. The ability of the drywood termite to live in dry wood without direct contact with the soil increases its menace. However, it reproduces slowly and does not destroy wood as quickly as the subterranean termite.
   c. Dampwood Termites are serious pests along the Pacific Coast and do not require contact with soil, but need wood with a high moisture content.

C. CARPENTER ANTS may be black or red. They usually live in stumps, trees, or logs, but often damage poles or structural timbers set in the ground. Carpenter ants use wood for shelter not for food, preferring wood that is naturally soft or has softened by decay. The galleries are large, smooth and, unlike those of termites, free of refuse and powdery wood. Mounds of sawdust indicate their presence.
1. General physical differences between ants and termites:
   a. ants have elbowed antennae; termites do not
   b. ants have a "wasp (narrow) waist", where termites are broad
   c. ants' wings have few veins and their hind wings are different in shape and size; those of termites have many veins and the front and hind wings are similar in size and shape.

D. BEETLES
1. Powder Post or Lyctus Beetles attack both freshly cut and seasoned hardwood and softwoods. Adults lay eggs in the wood pores, while the larvae burrow through the wood making tunnels from 1/16 inch to 1/12 inch in diameter. The tunnels are left packed with powder. After a larval period (from 2 to 12 months or longer) and a much shorter pupal stage, newly formed adults chew round 1/16-inch holes through the wood surface and emerge to lay eggs.
2. Anobiid Beetles attack softwoods in damp and poorly ventilated spaces beneath buildings.
3. Roundhead Borers are longhorn beetles that damage seasoned pine timbers. Their tunneling may weaken structural timbers, framing members, and other wooden parts of

buildings. Larvae may reduce sapwood to a powdery or sawdust-like consistency. They make a ticking or gnawing sound while working in the wood. Adult beetles make a ¼ inch diameter, oval emergence hole in the surface of the wood.

4. Flatheaded Borers infest live trees as well as recently felled and dead, standing, softwood trees. They can cause considerable damage in rustic structures and some manufactured products by mining into sapwood and heartwood. Typical damage consists of rather shallow, long, winding galleries that are packed with fine powder. Most of the adult beetles are metallic in color.
5. Marine Borers cause extensive damage to submerged portions of marine pilings, wharf timbers, and wooden boats. They include:
   a. Shipworm
   b. Pholad mollusks
   c. Crustacean borers

CONTROL OF PESTS THAT DAMAGE WOOD

If wood is to be used where it will be subject to pest attack, it must be protected. This protection can be achieved by control of moisture content, use of a wood that is naturally resistant to the pests, and chemical treatment.

A. Moisture Control – the moisture content of living trees, and wood products obtained from them, range from about 30 percent to more than 200 percent. Much of this moisture must be removed to:
   1. reduce oxygen content and temperatures necessary for growth of fungi
   2. reduce damage by insects
   3. reduce shrinkage
   4. reduce weight and increase strength
   5. prepare wood for chemical preservative treatment

B. Use of Naturally Resistant Wood – the sapwood of all native tree species and the heartwood of most species have allowed natural resistance to decay. The heartwood of cedar, junipers, redwood, locusts, and post oak are resistant but not immune to attack by decay fungi and insects.

C. Chemical Control – The proper application of preservatives can protect wood from decay and stain fungi, insects, and marine borers. The effectiveness of preservative treatment depends on the chemical formulation selected, method of application, sapwood to heartwood proportions, moisture content of wood, preservative retention, chemical penetration and distribution.
   1. Types of Preservatives fall into three broad categories: creosote and creosote solutions, oil-borne preservatives (pentachlorophenol), and waterborne preservatives (inorganic arsenicals).
      a. Creosote and Creosote Solutions – oily byproduct of making coke from bituminous coal, used for railroad ties, large timbers, fence posts, poles and pilings.
         1) Advantages:
            - toxic to wood-destroying fungi, insects, and some marine borers
            - low volatility
            - ease of handling and applying
         2) Disadvantages:
            - dark colored, oily, unpaintable surface
            - strong odor
            - tends to bleed from wood surface
            - toxic fumes prevents use in houses and other living areas

b. Oilborne Preservatives (Pentachlorophenol) – tributyltin, copper and zinc napthenate are generally insoluble in water and are dissolved in petroleum or other organic solvents. Used commercially to treat poles, lumber, cross arms, timbers and fence posts.

1) Advantages:
- toxic to fungi, insects
- can be dissolved in oils with a wide range of viscosities, vapor pressure and colors
- low solubility
- can be glued
- easy to use and handle

2) Disadvantages:
- may leave an oily unpaintable surface
- some applications may provide less physical protection to wood than creosote
- should not be used in homes or living areas because of toxic fumes
- toxic and irritating to plants, animals and humans

c. Waterborne Preservatives Borates are primarily used for lumber, plywood, fence posts, poles, pilings and timbers.

1) Advantages:
- treatment presents no hazard from fire or explosion
- wood surface is left clean and is paintable
- safe for interior use
- leach resistant; no odor

2) Disadvantages:
- unless wood is re-dried after treatment, it is subject to warping
- does not protect from weathering

d. Alternative Preservatives

1) Collectively, all of the ACQ products are sometimes referred to as alkaline copper quat preservatives.
   a) Ammoniacal Copper Quat (ACQ - Types A, B and C) – Wood treated using this preservative is marketed under the brand name ACQ Preserve by Chemical Specialities, Inc. or CSI.
   b) Amine Copper Quat (ACQ-D) – Similar active ingredients to ACQ-A but uses ethanolamine instead of ammonia to act as the treating solution carrier. Lumber treated with this preservative is marketed as NatureWood by Osmose.
2) Copper Azole-Type A (CBA-A) – Another new generation wood preservative that contains copper and boron. Wolmanized Natural Select by Arch Wood Protection (formerly Hickson).
3) Borate Oxide (SBX).–.A class of wood preservatives that contain boron as the active ingredient. Borate compounds include sodium octaborate, sodium tetraborate, sodium pentaborate, and boric acid. Borate oxide preservatives are water soluble and do leach. They are not recommended for wood in soil or constant water contact. Brand name products containing borate compounds include AdvanceGuard lumber by Osmose and SmartGuard products from Louisiana Pacific Corporation.

METHODS OF APPLYING WOOD PRESERVATIVES

A. PRESSURE PROCESSES – the basic principle involves the placement of wood materials in an airtight, steel cylinder or retort and immersing it in a preservative under pressure to force the preservative into the wood.

1. Two Pressure Treatment Processes:
   a. full-cell
   b. empty-cell

B. NON-PRESSURE PROCESS

1. Brushing, Spraying and Pouring Treatments
   Creosote – oil-borne or water-borne salts are applied to the surfaces of the wood product to be treated.
2. Dipping –immersing wood in a preservative solution for several seconds to minutes.
3. Cold Soaking –soaking dried wood for two to seven days in a vat containing an unheated liquid oil preservative.
4. Steeping –submerging wood into a tank full of an inorganic, arsenical salt at atmospheric temperature for several days or weeks.
5. Hot and Cold Bath (Thermal Process) – with two tanks, the wood product first is submersed into a hot solution of preservative or boiling water, followed by its immersion into a tank of cold solution.

USING WOOD PRESERVATIVES SAFELY

In November, 1986, federal regulations administered by the Environmental Protection Agency (EPA) restricted the sale and use of certain preservatives to ensure only properly trained applicators, or persons under their direct supervision, have access to these chemicals. Additional restrictions were imposed in the 1996 Wood Preserving Resource Conservation and Recovery Act. Wood preservatives affected by these regulations are:

1. Creosote
2. Pentachlorophenol
3. Inorganic Arsenicals EPA approved labels on pesticide products, including wood preservatives, are the primary source of information on regulations affecting the worker. March 17, 2003, residential uses of chromated cooper arsenate (CCA)-treated wood were voluntarily cancelled. Alternatives include using wood pressure treated with ammonical cooper quat (ACQ), cooper boron agole (CBA), cedar redwood, metal or plastic materials.

The label covers:

1. application methods
2. precautions for workers
3. emergency first aid for high-level exposure
4. disposal instructions for used pesticide solutions and containers

The label also has the force of law, and is enforced by state regulatory agencies. The label should be *readily* available, and all responsible should be familiar with the label's contents. Other sources of information include material safety data sheets that are supplied by the manufacturer.

Handlers of wood preservatives should know:

1. The health risks in working with these chemicals and the symptoms of overexposure
2. Basic safety, personal hygiene, and worker protection requirements to minimize or eliminate exposure risks
3. Environmental concerns and best management practices including proper waste disposal

When accidents do happen:

1. emergency first aid
2. emergency spill response

HEALTH EFFECTS

Basic to understanding health risks is knowing the routes of exposure. Wood preservatives can enter the body in one of three ways:

1. through the skin
2. by breathing it into the lungs
3. by swallowing it

Nearly every inch of your body is covered and protected by skin. But, the skin is like a sponge, it absorbs surprising amounts of what it touches; and when the skin is sweaty, it absorbs even more.

Eyes are especially vulnerable to damage from contact with chemical preservatives. Injury to the eyes often may be permanent.

You breathe dozens of times a minute; whatever that air contains enters the bloodstream very quickly. Many wood preservatives have a strong odor and taste, so it's unlikely a person would swallow a dangerous amount; but, less than a cup can cause death.

The more likely forms of exposure are from:

1. skin contact
2. inhalation of vapors, dust or particles, when protective clothing isn't worn and other precautions aren't observed.

Acute symptoms occur from exposure to high concentrations of chemicals. These symptoms are the same for all three chemicals.

1. headaches
2. nausea
3. increased perspiration

The above acute symptoms are usually noticed soon after exposure and are usually treatable if first aid response is quick.

In contrast to acute symptoms, some symptoms or health problems emerge only after a prolonged time or repeated exposure. These symptoms are called chronic. Chronic exposure can also aggravate existing health problems with skin, kidneys, liver or lungs. Awareness of these symptoms helps you protect your health and perhaps your life.

Beyond headaches, dizziness, and nausea, other symptoms and health risks are specific to each chemical.

1. CREOSOTE—phased out, but treated materials are still in use.
   a. Acute Symptoms – irritates the skin, may burn like a sunburn. Vapors and fumes may irritate the respiratory system.
   b. Chronic Symptoms – prolonged and repeated exposure may lead to dermatitis and permanent sensitivity. Some cases of chronic creosote exposure have been associated with skin cancer. Laboratory studies also show that creosote can pose a risk of genetic damage.
2. PENTACHLOROPHENOL
   a. Acute Symptoms – ingestion of Penta solutions, inhalation of concentrated vapors or excessive skin contact with Penta may lead to fever, headache, weakness, dizziness, nausea and profuse sweating. In extreme cases, loss of coordination and convulsions can occur. Higher levels of exposure can be fatal.
   b. Chronic Symptoms – Penta exposure may result in skin disorders like chloracne. Excessive poisoning may also cause damage to the kidneys, liver, and the central nervous system. Laboratory studies show that Penta can cause birth defects. Pregnant women must not be exposed to this chemical. In addition, Penta contains the dioxin contaminant Hexadioxin that has been shown in laboratory studies to pose risks of cancer.

3. INORGANIC ARSENICALS—phased out.
   a. Acute Symptoms – If swallowed, high concentrations may cause nausea, headaches, diarrhea, and abdominal pain. Extreme symptoms include dizziness, muscle spasms, delirium and convulsions.
   b. Chronic Symptoms – Chronic effects can include liver damage, loss of hair and fingernails, anemia and skin disorders. Long-term inhalation has been linked to lung cancer in humans. In a variety of studies, chronic exposure to arsenic compounds has been linked to risks of skin cancer, genetic damage, adverse reproductive effects, disturbances in behavior and damage to the central nervous system.

WORKER PROTECTION

Wood preservatives have been classified "restricted-use" based on the potential human risk from chronic toxicity; in other words, exposure over time. Applicators as a group are most likely to be exposed over time. Consequently, applicators need to know what precautions are required and then use those precautions as a normal and routine part of their work with wood preservatives.

Exposure can occur in a variety of ways:

1. during mixing and handling of chemicals
2. working around spray or dip operations
3. handling freshly treated wood
4. cleaning and servicing of equipment
5. disposing of waste materials

Risks are directly related to the degree of exposure. Most risks come with the application of the chemical and its volatilization, or evaporation, soon after the treatment occurs. A closed-system for mixing and delivering preservative and mechanically handling treated wood help reduce potential exposure, but they don't eliminate the possibility of exposure.

Exposure can be reduced by:

1. wearing proper protective clothing
2. practicing effective personal hygiene
3. observing plant safety precautions

Protective Clothing blocks the Routes of Entry

Unprotected skin can absorb chemicals whenever you come in contact with chemical concentrate or solutions, mists, fumes, vapors, or treated wood itself. Skin on certain parts of the body such as the forearm, the groin, and just below the eyes absorb chemicals more easily.

Shirts and pants must completely cover the arms and legs; coveralls being a convenient alternative. Long sleeves do make a difference. Workers in a sapstain operation who used long sleeves exclusively showed a 40 percent reduction in urine levels of Penta after three weeks of long sleeve use.

Wear gloves made from an impermeable material. Other situations may require aprons, boots, or even a full impermeable material suit. Unfortunately, hot weather can make this type of clothing uncomfortable to wear. But remember, the hotter the weather, the more your skin will absorb.

Impermeable clothing materials considered suitable for use with Creosote, Penta, and Inorganic Arsenicals are:

1. Neoprene
2. Polyvinyl Chloride (PVC)

3. Polyvinyl Acetate (PVA)
4. NBR compounds

Non-impermeable material include leather that will not adequately protect your skin.
Goggles or face masks are needed to protect eyes from vapors, splashes, and spills during handling, maintenance, and clean out of chemicals. To protect the lungs, a face mask, dust mask, or a respirator may be needed.

Sawing, drilling, or machining treated wood may create sawdust that contains harmful amounts of preservative. If the job is small and can be done outside, a dust mask may be sufficient protection for your lungs. But if the work is done in a confined space, a respirator may be required. Other situations that may require use of a respirator include:

1. opening or entering pressure treatment cylinders
2. cleaning or repairing tanks and vats
3. when using spray applicators, especially in poorly ventilated areas or when visible mist is present
4. and for arsenic treatment plant workers, if the level of exposure exceeds permissible limits

Be sure your respirator is properly fitted and maintained. Seek training in the correct use of and fit of your respirator. Replace worn out or damaged equipment immediately. Appropriate respirators may vary by chemical; however, all respirators must be OSHA/NIOSH approved.

Chemical overexposure affects people differently. Tolerance levels vary from one person to another, so if you are more sensitive than average, increase your level of protection.

The product label lists protective clothing. **DO NOT WEAR LESS THAN THE LABEL INDICATES.**

Other precautions for workers are also described on the label. These are work habits that can significantly reduce the risks of chronic exposure to wood preservative chemicals. General precautions include:

1. Don't eat, drink or smoke in the work area.
2. Wash your hands often, especially before using the restroom, eating or smoking. Use only a mild soap, not an abrasive one.
3. Remove your gloves to handle paperwork, phones or other equipment.
4. Be careful when putting your gloves back on.
5. Leave your work clothes, boots, gloves and other protective gear at the plant.
6. If you must launder work clothes at home, do them separately from other household laundry.

Protective clothing and these precautions are insurance against harmful chemical contact, both from accidental and day-to-day exposure.

FIRSTS AID
First aid information on the chemical in use must be readily available. Product labels give basic first aid directions, as do Material Safety Data Sheets (MSDS) supplied by the chemical manufacturers. Know and post the phone number of your nearest poison control center that is prepared to give advice 24 hours per day.

In an emergency, remember to send someone to call or get help while you treat the victim. Most accidents involve chemical splashes on skin or eyes, or inhalation of fumes, spray mist, or dust. The following general steps describe treatment for accidental exposure to wood preservatives:

1. Skin contact – remove contaminated clothing, immediately wash affected area with mild soap and cool water. Hot water opens pores and allows even deeper chemical penetration. Do not scrub skin, but wash until there is no "soapy" feeling left. Consult physician if skin irritation persists.
2. Eye contact – flush eyes with running water. Lift upper and lower eyelids for complete irrigation and continue for 15 to 20 minutes. Then see a physician.
3. Inhalation – move victim to fresh air and apply artificial respiration, if necessary. Get medical help immediately.
4. Ingestion – if preservative has been swallowed, call your local poison control center for advice.
   a. If the victim is conscious and Creosote or Penta was swallowed, have them drink one or two glasses of water. Then induce vomiting by giving syrup of ipecac or touching the back of the throat. After vomiting ceases, administer two tablespoons of "USP Drug Grade" activated charcoal in water.
   b. If an arsenical has been swallowed, drink large quantities of water or milk, if available. With arsenical ingestion, the victim tends to vomit involuntarily. Get professional medical help immediately. Lay an unconscious victim on his side, with the head lower than the torso. This will help prevent choking. Keep the victim warm and check breathing regularly until help arrives.

Never attempt to give anything by mouth to an unconscious person.
Never induce vomiting in an unconscious person.

ENVIRONMENTAL EFFECTS

People are not the only ones who can suffer from the careless use of wood preservatives. A community's health and environment may also suffer. Creosote, Penta, and the Inorganic Arsenicals are toxic. They must be toxic to kill the microorganisms that cause decay, and to repel insects that destroy wood. Unfortunately, these chemicals are not selective and other plant and animal life can also be harmed.

Careless use of wood preservatives over the years has polluted surface and ground waters in many parts of the country. From obvious sources such as spills or illegal discharge of chemicals into ditches, storm drains, or sewers, and from less obvious sources, such as unconfined drippings from freshly treated wood. Contaminated runoff can pollute lakes, streams, and wetlands, and damage habitat for fish and wildlife. Specific effects vary, but Penta, Creosote, and Inorganic Arsenicals are all toxic to fish and other wildlife. Penta, for example, is extremely toxic to fish. Exposure to Penta concentrations in the parts-per-billion (PPB) range can cause death within minutes for many species of salmon and trout.

Groundwater pollution is more hidden, but it too can be a serious problem. In many communities, groundwater is the only source of drinking water. Cleanup, where possible, is difficult and costly. Groundwater contamination can persist for years. Testing has documented contamination in public and private wells at levels exceeding health advisories. Groundwater is typically affected by contamination of the overlying soil. Applying preservatives on unpaved or unprotected soil, chemical spills, overflow from tanks and holding ponds, and improper disposal; all of these can be causes of soil contamination. If proper precautions are not taken, soil may become saturated with preservatives. In fact, soil contamination has been documented at depths of 60 feet. From the soil, contaminating chemicals may leach into the groundwater and eventually migrate to drinking water wells. To reduce the chance of environmental contamination, protective measures can be part of your plant design and operation. Some general common sense precautions include:

1. apply or mix preservatives only in a contained area
2. allow freshly-treated wood to drip for a reasonable time in a roofed and contained enclosure
3. recapture contaminated runoff for future recycling or disposal
4. don't burn treated wood except in an approved incineration facility; toxic gases may be produced
5. dispose of wastes properly

EMERGENCY SPILL RESPONSE

Working with toxic chemicals places a responsibility on you to protect the health and environmental quality of your surrounding community. Spills are usually caused by negligent actions such as overfilling tanks or incorrect valve settings, but spills also happen as a result of vandalism, or from illegal dumping to avoid the procedure of proper disposal.

Response to any spill, must be **immediate**. Prompt action can save cleanup time, money, possible legal action, even life. Although most businesses have emergency response procedures, some general steps for effective spill response are:

1. Protect life and property. Warn others in the vicinity and evacuate, if necessary. Provide protective equipment to on-site personnel. Keep unauthorized people out of the area.
2. Secure the source of the spill. When a spill or leak is evident, use common sense to act quickly and stop the flow. Shutting down any mechanical delivery system can prevent jam-ups and possible injury.
3. Contain the spill. Block off drains, culverts and ditches. Surround the spilled chemical with dirt, sand, booms or commercial absorbents.
4. Contact authorities immediately. Send someone to inform your plant manager or supervisors as soon as possible. Call fire, police, highway or water departments, if needed.
5. Clean-up the spill.
6. Properly dispose of spill material.

Spills must be reported if:

1. they involve more than 1 lb. of Creosote
2. they involve more than 10 lbs. of Penta
3. they involve more than 1 lb. of an Inorganic Arsenical

Failure to report may result in a $500 fine or up to one year imprisonment. In some states, workers may be held personally accountable for failure to report or act upon knowledge of improper disposal or spillage.

CONCLUSION

Wood preservative chemicals have the potential for poisoning people and the environment.

1. Be aware of the symptoms of wood preservative poisoning
2. Observe precautions and use protective clothing to keep chemicals:
   a. off your skin and hair
   b. out of your eyes
   c. out of the air you breathe
3. Learn basic first aid
4. Protect your environment
5. Dispose of waste properly
6. In an emergency, know your spill response procedure

In November 1986, use of the three wood preservatives was restricted to certified applicators or to persons under their direct supervision. Regulations requiring protective clothing and precautions also went into effect.

The wood preservative section was developed by Mediatek, Inc., for the Environmental Protection Agency, as a training aid for individuals seeking certification for the use of wood preservatives. (1986).

CATEGORY #13
M-44 Predatory Pest Control

United States Department of Agriculture
Animal and Plant Health Inspection Service

ADC DIRECTIVE M-44 DEVICE USE AND RESTRICTIONS

I. PURPOSE To establish guidelines for the use of the M-44 device by ADC personnel.

II. POLICY The M-44 device may be used to reduce damage caused by wild canids in accordance with EPA use restrictions. M-44 devices and capsules produced by the Pocatello Supply Depot are for official ADC use only.

III. REFERENCE The Federal Insecticide, Fungicide, and Rodenticide Act as amended
M-44 Cyanide Capsules
M-44 Use Restrictions
EPA Registration No. 56228-15

1. Use of the M-44 device shall conform to all applicable federal, state, and local laws and regulations.

2. Applicators shall be subject to such other regulations and restrictions as may be prescribed from time-to-time by the U.S. Environmental Protection Agency (EPA).

3. Each applicator of the M-44 device shall be trained in: (1) safe handling of the capsules and device, (2) proper use of the antidote kit, (3) proper placement of the device, and (4) necessary record keeping.

4. M-44 devices and sodium cyanide capsules shall not be sold or transferred to, or entrusted to the care of any person not supervised or monitored by Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS), or any agency not working under a WS cooperative agreement.

5. The M-44 device shall only be used to take wild canids: (1) suspected of preying on livestock or poultry; (2) suspected of preying on federally designated threatened or endangered species; or (3) that are vectors of a communicable disease.

6. The M-44 device shall not be used solely to take animals for the value of their fur.

7. The M-44 device shall only be used on or within seven miles of a ranch unit or allotment where losses due to predation by wild canids are occurring or where losses can be reasonably expected to occur based upon recurrent prior experience of predation on the ranch unit or allotment. Full documentation of livestock depredation, including evidence that such losses were caused by wild canids, will be required before applications of the M- 44 are undertaken. This use restriction is not applicable when wild canids are controlled to protect federally designated threatened or endangered species or are vectors of a communicable disease.

8. The M-44 device shall not be used: (1) in areas within national forests or other federal lands set aside for recreational use, (2) in areas where exposure to the public and family and pets is probable, (3) in prairie dog towns, or (4) except for the protection of federally designated threatened or endangered species, in national or state parks; national or state monuments; federally designated wilderness areas; and wildlife refuge areas.

9. The M-44 device shall not be used in areas where federally listed threatened or endangered animal species might be adversely affected. Each applicator shall be issued a map, prepared by or in consultation with the U.S. Fish and Wildlife Service, which clearly indicates such areas.

10. One person other than the individual applicator shall have knowledge of the exact placement location of all M-44 devices in the field.

11. In areas where more than one governmental agency is authorized to place M-44 devices, the agencies shall exchange placement information and other relevant facts to ensure that the maximum number of M-44s allowed is not exceeded.

12. The M-44 device shall not be placed within 200 feet of any lake, stream, or other body of water, provided that natural depression areas which catch and hold rainfall for short periods of time shall not be considered "bodies of water" for purposes of this restriction.

13. The M-44 device shall not be placed in areas where food crops are planted.

14. The M-44 device shall be placed at least at a 50-foot distance or at such a greater distance from any public road or pathway as may be necessary to remove it from sight of persons and domestic animals using any such public road or pathway.

15. The maximum density of M-44s placed in any 100 acre pasture land areas shall not exceed ten; and the density in any one square mile of open range shall not exceed 12.

16. No M-44 device shall be placed within 30 feet of a livestock carcass used as a draw station. No more than four M-44 devices shall be placed per draw station and no more than five draw stations shall be operated per square mile.

17. Supervisors of applicators shall check the records, warning signs, and M-44 devices of each applicator at least once a year to verify that all applicable laws, regulations, and restrictions are being strictly followed.

18. Each M-44 device shall be inspected at least once every week, weather permitting access, to check for interference or unusual conditions and shall be serviced as required.

19. Damaged or nonfunctional M-44 devices shall be removed from the field.

20. An M-44 device shall be removed from an area if, after 30 days, there is no sign that a target predator has visited the site.

21. All persons authorized to possess and use sodium cyanide capsules and M-44 devices shall store such capsules and devices under lock and key.

22. Used sodium cyanide capsules shall be disposed of by deep burial or at a proper landfill site. Incineration may be used instead of burial for disposal. Place the capsules in an incinerator or refuse holes and burn until the capsules are completely consumed. Capsules may be incinerated using either wood or diesel fuel.

23. Bilingual warning signs in English and Spanish shall be used in all areas containing M-44 devices. All such signs shall be removed when M-44 devices are removed.
    a. Main entrances or commonly used access points to areas in which M-44 devices are set shall be posted with warning signs to alert the public to the toxic nature of the cyanide and to the

danger to pets. Signs shall be inspected weekly to ensure their continued presence and ensure that they are conspicuous and legible.

b. An elevated sign shall be placed within 25 feet of each individual M-44 device warning persons not to handle the device.

24. Each authorized or licensed applicator shall carry an antidote kit on his person when placing and/or inspecting M-44 devices. The kit shall contain at least six pearls of amyl nitrite and instructions on their use. Each authorized or licensed applicator shall also carry on his person instructions for obtaining medical assistance in the event of accidental exposure to sodium cyanide.

25. In all areas where the use of the M-44 device is anticipated, local medical people shall be notified of the intended use. This notification may be through a poison control center, local medical society, the Public Health Service, or directly to a doctor or hospital. They shall be advised of the antidotal and first-aid measures required for treatment of cyanide poisoning. It shall be the responsibility of the supervisor to perform this function.

26. Each authorized M-44 applicator shall keep records dealing with the placement of the device and the results of each placement. Such records shall include, but need not be limited to:
    a. The number of devices placed.
    b. The location of each device placed.
    c. The date of each placement, as well as the date of each inspection.
    d. The number and location of devices which have been discharged and the apparent reason for each discharge.
    e. Species of animals taken.
    f. All accidents or injuries to humans or domestic animals.

March 9, 2004

PREDATOR PEST CONTROL

Coyotes

In Nevada the most common predator is the coyote. They will den at any altitude, and will eat anything from watermelon to livestock. The main problem is in eastern Nevada, where coyotes take many lambs, and work on calves at calving time. They are becoming pests in urban areas as predators of small pets. The largest population of coyotes in the U.S. is located just two miles from our nation's second largest city, Los Angeles. Coyotes mate in January, and have a 64 day gestation period. They give birth to six to ten pups in a litter.

Very few controls are available. The M-44 cyanide cartridge device is the only control besides traps that can be used in Nevada. Placement must be at least three miles from any habitation. A habitation is considered to be any county, state, or federal roadway and any dwellings of man or his animals (barns, etc.). This makes the M-44 device difficult to place. Devices must be visited at least once a week, and there are 26 restrictions included in the use of the M-44. The product is registered in the state of Nevada.

Mountain Lions

This is the largest of Nevada's carnivorous predators. It has two to five kittens every other year. Their diet consists of deer, rodents and livestock. Livestock killers are not very common, but when a mountain lion does become a livestock killer, help should be sought from the U.S. Fish and Wildlife Service.

No chemical control is allowed. Few problems exists when mountain lions remains in the wild; it is of little danger to man. It is a trophy animal and permits must be obtained to take it. Permits should be sought from Nevada Department of Wildlife.

Skunks
Skunks are beneficial in that they eat insects. However, they can cause problems when they eat bees, chickens, or eggs. They are a serious problem to bee keepers. They also transmit rabies, a serious medical problem. Skunks normally have one litter per year, but occasionally there is a second litter. Litters usually consist of five to eight kittens

Use crushed naphthalene crystals to get a skunk out from under structures. Live trap skunks. Use a completely covered trap and the skunk will not spray. Bait the trap with a piece of meat, cantaloupe, fruit or dog food.

Bobcats
Bobcats mainly eat rodents and birds, but they will also prey on young lambs and fawns. The bobcat mates in February, has a 50 day gestation period, and gives birth to two to four kittens.

No chemical control is allowed. However, bobcats are hunted and trapped for pets. One needs a trapping license to trap bobcats. Information can be obtained from the Nevada Fish and Wildlife Department.

Feral Dogs
Feral dogs are pets that have become wild. They are extremely vicious to livestock. They run in packs and have no fear of man. They should be controlled with any means at hand. Feral dogs do 70 percent of the predations to farm flocks.

Badgers
Badgers are beneficial as they eat rodents. However, they are pests because they can damage fields and ditch banks by digging after their rodent prey. This damages alfalfa fields and ditch borders.

Badgers may be trapped or shot and gas cartridges may be used.

Foxes
Foxes do very little damage, although they will sometimes eat young lambs and chickens.

Weasels
Not common in Nevada, they are predators of all kind of fowl. They may be shot or trapped.

NOTE: Most predators are beneficial to some extent, and therefore, one should apply control measures only as a last resort, and then only with the help of the Nevada Department of Wildlife or the U.S. Fish and Wildlife Service.

Rabies is an acute encephalomyelitis (inflammation of the brain) that is caused by the rabies virus and can be transmitted by any animal that has salivary glands. There are three stages: prodomal, excitative and paralytic. The incubation period is 15 to 50 days. Many mammals, including the predators discussed above, can carry and transmit rabies to other animals including man. Any animal suspected of having rabies must be handled with extreme care. The county health service and local animal damage control should be contacted immediately. Avoid contact with any potentially rabid animal.

CATEGORY # 14
Chemigation

Chemigation is the application of any chemical through irrigation water. This includes insecticides, herbicides, fumigants, nematicides, fertilizers, soil amendments, and other compounds. In Nevada, by far the most common form of chemigation is fertigation (the application of fertilizers through irrigation water). This category will deal with the aspect of the application of pesticides through irrigation water. For information about calibrating your chemigation equipment, see "Calibration of Chemigation Equipment" under the "Guidelines for the Safe Use of Pesticides" section. The term, chemigation, will be used for the application of pesticides through irrigation water in this writing.

Chemigation offers several distinct advantages in comparison to conventional application methods.

- Soil compaction is avoided, as heavy spray equipment never enters the field.
- Crops are not damaged by root pruning, breaking of leaves, or bending over the shoots, as occurs with conventional spray equipment and techniques.
- Less equipment may be required to apply the pesticides.
- Less energy is expended in applying the chemical.
- Less labor is needed to apply and supervise the pesticide application.
- Capitol, maintenance and labor costs are reduced.
- The application of pesticides can be more carefully regulated and monitored.
- The pesticides can be more evenly distributed throughout the target site, preventing "skipping" through the field.
- Pesticides can be applied to the crop or soil when crop or soil conditions would otherwise prohibit entry into the field with conventional spray equipment.
- Less mixing and loading, reducing applicator exposure.

History

Fertilizers have been applied through many types of irrigation systems for many years. With the introduction of center pivots and linear move (wheel lines) irrigation systems, the application of various pesticides has become more wide spread. Significant advancements have been made to the designs of equipment to enhance chemigation including under-canopy spray heads to apply insecticides to the under sides of leaves, and high-speed gearboxes for the drive units. This enables the irrigation equipment to move faster across the field for a light application of pesticide(s). Center pivots and linear moves have peculiar traits that affect pesticide application that are not common to other irrigation methods. They do not require the presence of people in the field during irrigation, and are capable of quick, small, and very uniform applications of water and therefore pesticides. Furthermore, these systems wet the leaves of the crop that surface (flood or furrow) irrigation does not.

Use of drip and micro irrigation have boomed in the last few years. This has stimulated a parallel growth in chemigation. An increasingly wide range of fungicides, herbicides, and insecticides are injected through drip and micro irrigation systems in the United States. The extent of this type of chemigation appears to be largely dependent on the crop, and is, at least commercially, more prevalent and sophisticated on row crops (vegetables) and vineyards.

Energy Conservation

Chemigation offers a considerable number of benefits in terms of energy conservation. The most obvious savings occur because vehicles do not need to traverse a field to apply pesticides. Chemigation allows growers to increase yields and/or crop quality. With some forms of irrigation, notably drip and center pivots, systemic insecticides can be applied to the crop as soon as an insect infestation occurs.

The soil does not have to dry out for tractor access after irrigation or rainfall, for example. Pesticides can be applied quickly before the disease or insect infestation spreads. This minimizes damage, reduces the amount of pesticide that must be applied, reduces applicator exposure, and maximizes the overall effectiveness of the application, in a timely manner.

SAFETY

Safety is an essential consideration of sound chemigation practices. In Nevada, most chemigation is taking place using wells. Groundwater is the primary source of irrigation water and drinking water. Because groundwater is drinking water, there are federal, state, and local laws protecting it. These laws also protect the environment and workers from pesticide contamination. This section provides information on the regulations that pertain to chemigation, so that the environment, including groundwater, and workers are not jeopardized by this practice. The regulations specific to chemigation involve several issues:

- Chemigation hardware
- Pesticide labeling
- Pesticide notification and /or posting

Since chemigation is relatively new, there is little legislation specific to chemigation. In addition, laws and regulations may not be uniform between federal, state, and local agencies. Prior regulations pertaining to general pesticide use and application still apply to pesticide chemigation. **The label is the law**. In Nevada, the Department of Conservation and Natural Resources, Division of Environmental Protection (NDEP) has a non-degradation policy to all waters (including groundwater). If a person is chemigating without the proper safety equipment required by the pesticide label, and the application results in the contamination of the water (either surface or ground) the appropriate federal, state, and local laws will be enforced. Pesticide applicators are liable for damages to the environment, including groundwater, and for worker safety and can be fined or imprisoned for applying pesticides illegally. The applicator will also be liable for any clean up that may be required. When a pesticide contaminates groundwater, it takes a very long time for it to break down because of low microbial activity, cool temperatures, and no sunlight. Pesticide in groundwater may contaminate domestic wells and community drinking water supplies. Again, an effective way to ensure that the waters of the State are protected while pesticides are being applied through an irrigation system is to **read and follow all chemigation requirements on the label**. Stay within the law, follow pesticide label directions and apply pesticides in a safe and cautious manner. This protects the applicator, workers and the environment. Growers should contact the Nevada Department of Agriculture (NDOA) for more details regarding chemigation regulations at 702-486-4690. The NDEP should be contacted for water pollution control law information at 702-687-4670 ext. 3137 or ext. 3138.

<u>Chemigation Safety Hardware</u>
The following sketch is of a chemigation layout that includes the United States Environmental Protection Agency's (EPA) required safety devices.

Chemigation figure 1. Chemigation station layout

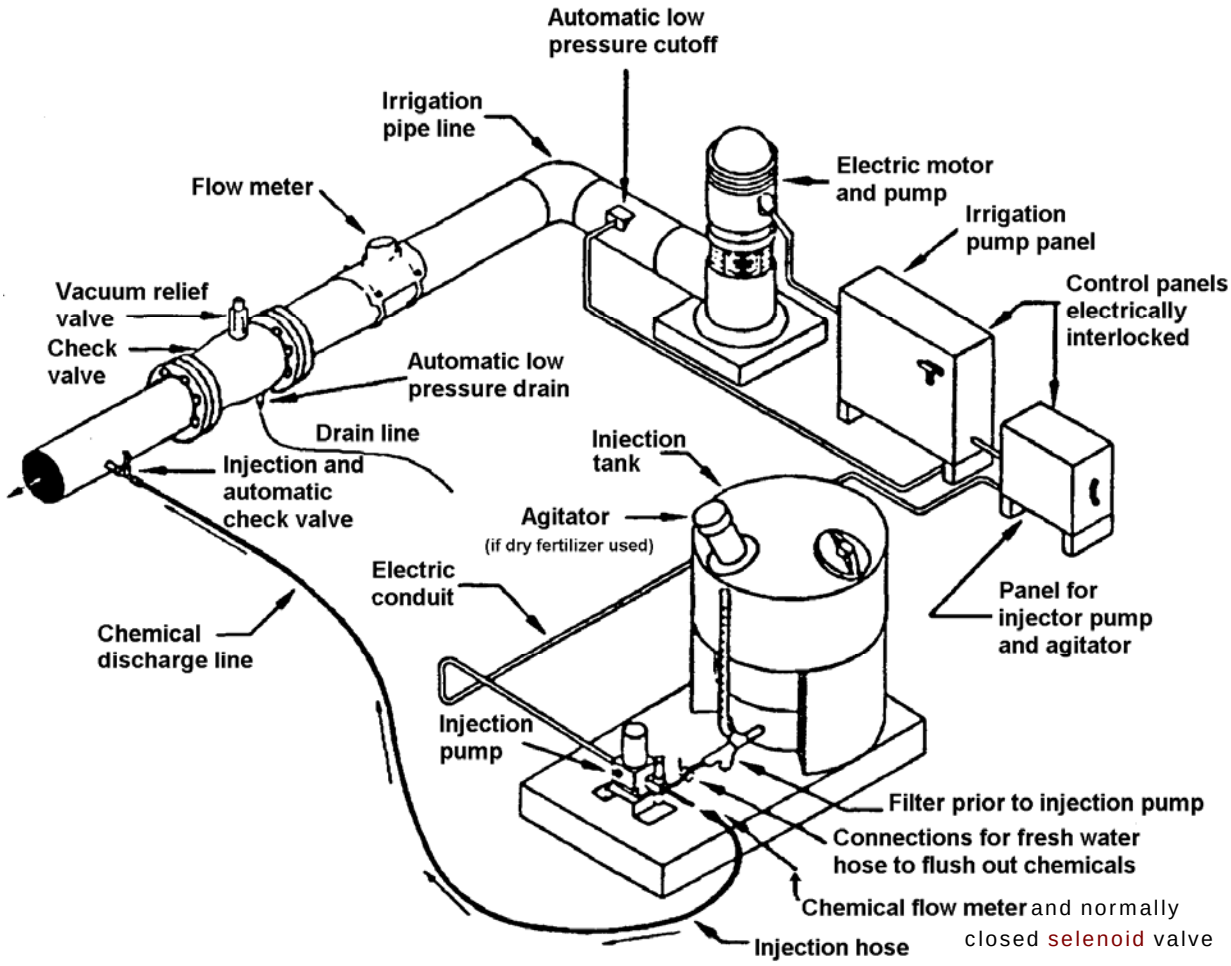


Table 14.1. Descriptions of required safety devices

Devices	Description/Location	Purpose
Irrigation check valve*	Between well and injection points	Prevents pesticide from flowing backwards and entering the water source
Injection line check valve	At the injection point and is a one way valve with a 10 psi spring that closes when not under pressure	Prevents water from flowing backwards into the chemical tank, that causes the tank to overflow
Vacuum relief valve	Between the check valve and the well	Prevents vacuum when pump shuts off; reduces chance of backflow
Low pressure cutoff	On irrigation pipeline	Turns off injector power when irrigation water pressure is low
Low pressure drain*	Between well and irrigation line check valve	Discharges any water that might leak through the check valve after irrigation pump is shut off
Normally closed solenoid valve*	Between injection pump and pesticide tank	Prevents tank from emptying unless injector is working
Interlock	Between injection pump and irrigation pump panels/power	Prevents injection if irrigation pump stops

Note: Devices marked with an asterisk (*) can be substituted **only** by an approved alternative device declared effective March 1989 by the EPA (Table 14.2).

The devices in Table 14.1 are required according to the EPA Label Improvement Program (LIP) that became effective in April 1988. They protect groundwater from accidental contamination. In some cases, if there is no possibility of water source contamination (e.g., the injection point is downstream of an air gap), some of the above mentioned devices may not be required. Regardless, these devices provide common sense ways to minimize spills, contamination, and operator hazards.

Protecting the water supply from contamination should be a top priority when setting up pesticide injection equipment. Without the proper safety equipment (Table 14.1), any of the following three scenarios could be hazardous to water supplies:

1. An unexpected shutdown of the irrigation pump could cause concentrated pesticides and water to be drawn into the well and aquifer.
2. The irrigation pump shuts down while the pesticide injection pump continues to operate. This can cause pesticides to backflow into the well and groundwater supply, or force high levels of pesticides to flow into the irrigation pipe and distribution system, damaging the crop and environment.
3. The pesticide injection system stops while the irrigation pump continues to operate. This causes water to backflow through the pesticide supply tank and overflow onto the ground.

Table 14.2. Approved alternative devices for chemigation equipment.

Original Device	Approved Alternative Device
Normally closed, solenoid-operated valve located on the intake side of the injection pump	Spring-loaded check valve with a minimum of 10 psi cracking pressure
	Normally closed hydraulically opened check valve
	Functional vacuum relief valve located in the pesticide injection line between the positive displacement pesticide injection pump and the check valve.
Functional main water line check valve and main water line low pressure drain	Gooseneck pipe loop located in the main water line immediately downstream of the irrigation water pump
Positive displacement pesticide injection pump	Venturi system including those inserted directly into the main water line, those installed in a bypass system, and those bypass systems boosted with an auxiliary water pump
Vacuum relief valve	Combination air and vacuum relief valve

EPA and Nevada laws require chemigation equipment to have both electrical interlocks and backflow devices to protect water sources. The following is a description of the required chemigation safety devices.

Check Valves and Vacuum Relief Valves

Check and vacuum relief valves (anti-siphon devices) are required on the irrigation pipeline. They keep water and/or pesticide and water from back flowing or siphoning back into the irrigation water source should the irrigation pump shut down. Both of these valves are to be located between the irrigation pump outlet and the point of pesticide injection. The check valve must have a positive closing action and a watertight seal. It should be easy to repair and maintain. The vacuum relief valve allows air into the pipeline when the water flow stops, preventing creation of a vacuum that could lead to siphoning.

A second backflow device (in addition to, or in place of, a normally closed solenoid valve) in the pesticide injection line is needed for two purposes: 1) to prevent the water from flowing into the pesticide supply tank when the pesticide injector is shut off, and 2) to prevent gravity flow from the pesticide supply tank into the irrigation pipeline after an unexpected shutdown. This backflow device is

required to be spring loaded, and have a minimum of 10 psi cracking pressure. This device is generally preferred by growers, throughout the United States, over the normally closed, solenoid-operated valve located on the intake side of the injection pump. Several manufactures sell a combination check valve/injection port device that is located at the discharge end of the chemical hose. This combination device provides the safety feature required by EPA, and also places the pesticide into the midstream of the irrigation water flow, that provides better chemical mixing.

Low Pressure Cutoff
Low-pressure cutoff turns off the power to the injectors in the event the water pressure drops in the main irrigation line.

Low Pressure Drain
An automatic low-pressure drain is for monitoring check valve performance. This device should be placed on the bottom side of the irrigation pipeline. In the event that the mainline check valve leaks slowly, the water or pesticide and water will drain away from, rather than flow into, the water supply. The location of the drain should be at least 20 feet from the well, and located between the irrigation pump and the mainline check valve. In some cases placement of the valve may be more feasible downstream of the mainline check valve. However, it should always be placed on the irrigation pipeline before the point of injection.

Solenoid Valve
A normally closed solenoid valve can be electrically interlocked with the engine or motor driving the pesticide injection pump. This valve, located on the inlet side of the injection pump, provides a positive shut-off on the pesticide injection line. Therefore, neither the pesticide nor the water can flow in either direction if the pesticide pump stops.

Interlock
Electrical interlock connects the irrigation pump to the chemical injection device so in the event of an irrigation pump failure, the pesticide injection pump will also stop. This will prevent pumping the pesticide from the supply tank into the irrigation pipeline after the irrigation pump stops.

For internal combustion engines, the pesticide injection pump can be belted to the drive shaft or an accessory pulley of the engine. Other possibilities include operating the injection pump off of the engine electrical system (12-volt). **In all cases, it is essential that if the irrigation pump stops, the pesticide injection also stops**. In addition to interlocks, additional protection is provided by a low pressure shut off switch that turns off the pump should water pressure drop and the pesticide is no longer being applied at label rates. This switch triggers all other pumps to shut off.

<u>Pesticide Labels</u>
According to the EPA LIP that deals specifically with pesticides that are chemigated, labels must provide detailed information regarding application rates, re-entry intervals, personal protective equipment and clothes, etc. Each pesticide label must **state that the pesticide product can be chemigated and applicators must adhere to the instructions provided on the pesticide container labels**. Chemicals are registered in each state for specific crops and methods of application. Special local needs (24c), emergency exemptions (sec. 18), or special use permits are sometimes issued for non-registered applications. In these instances additional requirements may be required on supplemental labels. In Nevada, for more information on special labeling requirements, supplemental labels, 24c registrations, sec. 18 registrations, or special use permits, the Chief Chemist for the NDOA can be contacted at 775-688-1180.

Pesticide Notification or Posting

Before starting the application of certain pesticides (category I or those pesticides with the label signal word DANGER) through the irrigation system, the label will require that a sign be posted at "... any part of a treated area [that] is within 300 feet of sensitive areas such as residential areas, labor camps, businesses, day care centers, hospitals, in-patient clinics, nursing homes or any public area such as schools, parks, playgrounds, or other public facilities not including public roads, or when the chemigated area is open to the public such as golf courses or retail greenhouses." "The signs shall be placed" at all usual points of entry and along likely routes of approach from the sensitive area "or if there is no usual point of entry," then "signs must be posted in the corners of the treated area and in any other location affording maximum visibility to sensitive areas." The sign shall consist of letters "at least 2 ½ inches tall, and all letters and the symbol shall be a color that sharply contrast with their immediate background. At the top of the sign shall be the words KEEP OUT, followed by an octagonal stop sign symbol at least 8 inches in diameter containing the word STOP. Below the symbol shall be the words PESTICIDES IN IRRIGATION WATER." Gempler's Direct Agri Supply Specialists may be able to supply a sign that meets the above requirements. Gempler's can be contacted at 1-800-382-8473.

At this time, Nevada has no specific regulations pertaining to posting other than the general labeling requirements printed on the label. All labeling requirements pertaining to chemigation, field reentry, posting (both for the Farm Worker Protection Standard (WPS) and chemigation), equipment cleaning, Personal Protective Equipment (PPE), notification, endangered species, WPS requirements, and groundwater concerns still must be followed. NOTE: Posting required for chemigation does not replace other posting and reentry interval requirements for the WPS.

Proper Materials for Hardware

Hoses

In most cases, hoses should be constructed of reinforced-braided Ethyl Vinyl Acetate (EVA). EVA is:

- Flexible at a wide range of temperatures
- Capable of working at pressures up to 200 psi
- Not deteriorated by sunlight
- Chemically compatible with pesticides
- Available in thicknesses that work under suction without collapsing

Hoses should be inspected regularly for leaks and cracks. Hoses and injection equipment should be flushed at the end of every injection with clear water. When hoses and chemigation equipment are not in use they should be covered with a tarp or like material.

Fittings

When injecting pesticides into an irrigation system, the material of choice is generally 316 stainless steel, as some pesticides destroy PVC fittings. To be safe, contact the manufactures of the chemical (pesticide) and the injection equipment regarding compatibility and corrodibility of the material being injected with the equipment being used.

Tanks

Mild Steel tanks should be avoided! Tanks should be constructed of poly or fiberglass, as mild steel has the potential for corrosion. If stainless steel is used, it should be constructed of 316 stainless. There should always be an on/off valve attached to the tank itself so that the injection mechanism can be removed. An easily cleaned 40 to 80 mesh filter should be attached downstream of the on/off valve.

Containment Structures
If a pesticide could be potentially hazardous in the event of a spill, it is recommended the chemical tank be within a containment structure. A containment structure may simply be a larger poly tank that essentially acts as a "double hulled" unit (chemical tank inside the poly tank), a containment unit constructed of cinder block walls around a concrete pad, or at the very least, a soil wall around the chemical tank.

Neatness
Neatness counts! For safety reasons, it is important to maintain a neat chemigation area. With a neat chemigation area, spills and leaks are easy to identify, isolate, and correct. Messy chemigation areas encourage lax operation that is hazardous to the operator and the environment.

Chemical Safety
Always follow label instructions for safety. It is critical that the manufacturer's guidelines be followed when mixing fertilizers and pesticides together. Many fertilizers and pesticides can not be mixed together, or must be mixed in a certain order. If the manufacturer's guidelines are not followed, there is a potential for dangerous reactions.

Chemical Injectors
There are many ways to inject pesticides into irrigation systems. The choice of methods and equipment used will depend on the individual operator skills and preferences as well as initial and maintenance costs involved. The following may need to be considered when choosing the way to inject pesticides:

- Injecting liquid [e.g. flowable (F), suspended concentrate (SC), emulsifiable concentrate (EC)] versus non-liquid [e.g. wettable powders (WP), soluble powders (SP)] pesticides. Liquid pesticides may not need agitation or mixing in the field, whereas non-liquid pesticides need mixing and agitation.
- Wear on the system components. Non-liquid products increase wear to nozzles and valves compared to liquid materials.
- Potential hazards of the pesticide. All pesticides have special precautions to be followed, especially worker safety.
- Availability of power.
- Portability versus permanent installations.

Injector types
There are many injectors on the market. Some require power, and others do not. The following are examples of different types of injectors that are available. Some injectors are specific to an irrigation method (e.g. drip, open ditch, center pivot, wheel lines, and solid sets).

- In-line pressure differential
- Venturi bypass systems
- Bypass pumps
- Float valves (open canal or ditch)
- Differential pressure tank
- Nitrogen gas powered pump
- Nitrogen pressurized tank
- Water powered pumps
- Diaphragm and piston pumps

Diaphragm pumps - Diaphragm pumps have been used in the chemical industry for many years, but have only been actively marketed for chemigation during the last few years. The **advantages** of using diaphragm pumps over piston and venturi units are:

- They have a small number of moving parts.
- A limited area of the unit is exposed to the pesticide being injected.
- The design of the pump makes it easy to adjust the injection rate while the pump is running

Piston pumps – Piston pumps were the earliest available and actively marketed injection pumps for agricultural chemicals. Both single and dual piston units are available in a wide range of capacities. These types of pumps commonly have two distinct **disadvantages** for chemigation, these are:

- Piston pumps are subject to accelerated wear of the piston seals.
- Calibration of piston pumps is relatively time consuming.

HERBICIDE, FUNGICIDE, AND INSECTICIDE INJECTION

Chemigation Advantages

Injecting crop protection chemicals through the irrigation water of an irrigation system has advantages over traditional aerial and ground spraying. The advantages are:

- Injecting pesticides uses less energy than traditional application techniques (i.e., less fuel, labor, and equipment wear).
- Sometimes there are not additional equipment requirements, as injecting pesticides can generally use the same equipment as injecting fertilizers.
- Injecting pesticides is more flexible than traditional applications. Operators do not have to worry about wet fields and equipment entry constraints.
- Injecting pesticides through irrigation systems allows for split applications in smaller doses rather than one large dose. This may allow for more prolonged protection against pests and diseases throughout the season.
- Many of the hazards associated with traditional applications, worker protection, are reduced because chemical concentrations are less when applied through irrigation water.
- Injection through a drip irrigation system is better able to get the pesticide(s) where it is needed (e.g., the top 2 inches of soil).

Chemigation Disadvantages

- Pesticides applications take longer than traditional applications. For sprinkler systems, favorable weather conditions over a longer period of time are critical and virtually impossible to guarantee (no wind). With sprinkler systems (solid sets, wheel lines, center pivots, micro sprinklers, etc.) wind will significantly affect the irrigation water uniformity, and consequently the pesticide application uniformity that could cause serious problems with a crop. Sprinklers that spray onto chemical tanks, irrigation pumps, roads, surface water, etc. should be turned off.
- Chemigation is generally limited to center pivots, wheel lines, or drip irrigation systems, as these systems do not require personnel in the field to perform the irrigation.
- Sometimes, additional equipment is necessary, as smaller injectors may be needed because of the lower injection rates compared to fertilizers.
- Pesticide injection require greater management input for accurate and safe operations regarding equipment calibration, pesticide handling, and proper functioning safety devices and equipment.

- Pesticide injection can increase environmental hazards in terms of contamination and worker safety. If irritations are not managed properly while pesticides are being injected the following may occur:
    - Surface water supplies may become contaminated.
    - There may be excessive deep percolation, resulting in groundwater contamination.
    - If safety devices fail (backflow prevention devices), then groundwater supplies can be contaminated.
    - Drift and/or runoff of the water-pesticide mixture onto non-target areas.
    - Injecting a pre-emergent herbicide may require an unnecessary irrigation.

Herbigation

The following three factors should be considered when selecting herbicides for chemigation:

1) **Solubility -** Herbicides with greater solubility move deeper with irrigation water.
2) **Adsorption** – Herbicides are held onto clay soils and organic matter to a varying degree. Therefore if a herbicide is tightly adsorbed it may not be available to kill weeds with deeper roots. Also, contrarily, if the pesticide does not adsorb well, it may move with the water and damage crop roots or contaminates groundwater.
3) **Volatility** – This represents the likelihood of the chemical to transform into a gas. If the pesticide volatilizes, it is then unavailable to kill the targeted plants or weeds.

Total herbicide movement throughout the soil profile depends on the volatility, solubility, and adsorption.

Pre-emergence herbicides should be applied with enough water to distribute them in the top 2 ½ inches of soil. The applicator should be familiar with the soil type to that the herbicide is being applied, as sandy soils require less water (about .5 inches) and less of the herbicide to be effective. Furrow and flood irrigation methods are incapable of applying such a small amount of water uniformly.

With highly volatile herbicides, the herbicide should be applied to dry soil. When applied to wet soil, more of the herbicide will be lost through volatilization. Herbicides **should not** be applied at the end of the irrigation cycle, after the soil has been wetted.

Post-emergence herbicides should generally be applied in a low volume of water, preferably less than one-half inch. If more than one-half inch of water is applied with sprinklers, the herbicide will be washed from the leaf surface.

Fungigation

The accuracy of fungigation is not as critical as herbigation because there is less chance of crop or plant injury from higher application rates. The most important concept with successful fungigation is an adequate coverage. This may be affected by the fungicide formulation, the amount of water applied, and the irrigation uniformity. For irrigation systems that wet the leaves of the crop or plants (solid sets, wheel lines, center pivots, micro sprinklers, etc.), fungigation can be extremely successful for several reasons.

- The fungicide is applied at a time of maximum leaf wetness when the fungus is most active.
- Nearly complete coverage can be achieved due to the redistribution of the fungicide on the leaf with successive droplets.
- There is great reduction of innoculum in the field by complete coverage of plants and organic litter on the soil surface.

Insectigation

Insectigation is most widely used with solid sets, wheel lines, and center pivot sprinkler systems. New technology has changed the way insecticides are used in chemigation. Many insects are found on the under sides of the leaves. Researchers have found that LEPA (Low Energy Precision Application) nozzles can successfully apply insecticides and miticides to the underside of crop leaves, where insects and mites are found. With this new technology, chemical manufactures have been able to allow the chemigation of certain insecticides and miticides.

Insecticides can be injected undiluted or they may be diluted with water or oil. Read the pesticide label for specific directions on how to apply the insecticide or miticide through an irrigation system.